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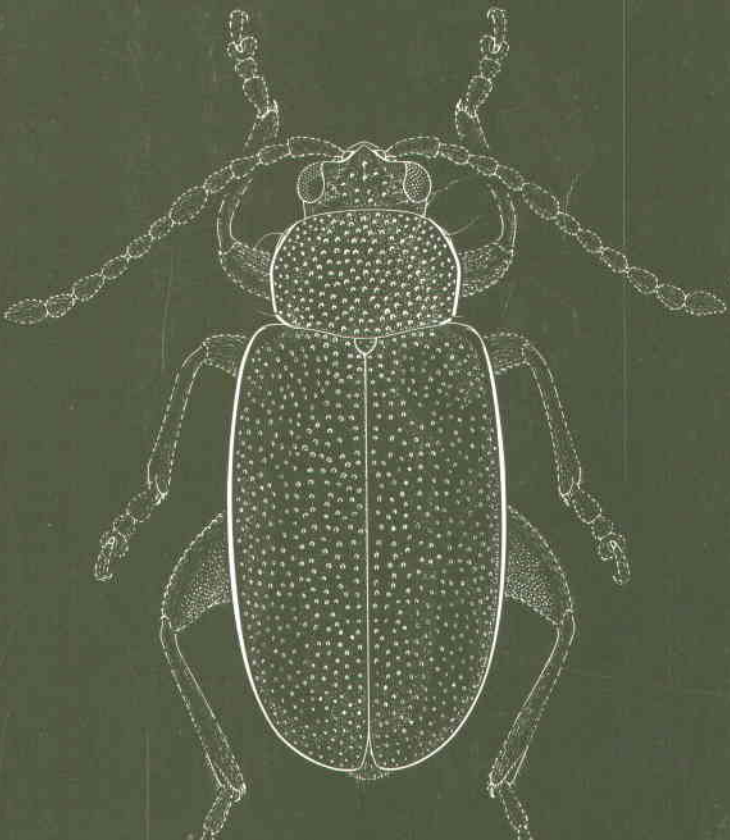
Canadian beetles (Coleoptera)

injurious to crops, ornamentals, stored products, and buildings



Anthony Davis

Canadian beetles (Coleoptera)

injurious to crops, ornamentals, stored products, and buildings

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INTRODUCTION

Beetles belong to the order Coleoptera, the most diverse order of living organisms in the world. The estimated 9116 species in Canada (Campbell et al. 1979) constitute an important element of the fauna. This diversity is reflected in the variety of feeding habits within the order, which includes species that are phytophagous (e.g., Chrysomelidae, Scolytidae), predaceous (e.g., most Carabidae), scavengers (e.g., Silphidae), and fungivorous (e.g., Cryptophagidae).

Fortunately, only a small percentage of Canadian beetles cause economic damage, but a number are major pests of importance to agriculture and forestry. Hinton (1945) stated that beetles are by far the most important and most numerous order of insects attacking stored products.

Beetles undergo complete metamorphosis and have four distinct life history stages (i.e., egg, larva, pupa, and adult). Either or both of the two feeding stages may be of potential economic importance. In some species the adults and larvae feed on the same host or product (e.g., *Leptinotarsa*), though not necessarily on the same host structures (e.g., *Epitrix*), whereas in other species the two stages that feed attack completely different food sources (e.g., *Phyllophaga*). In fact, in some species, one stage may be a pest and the other beneficial (e.g., *Epicauta*).

The aim of this manual is to provide a comprehensive inventory of the species of beetles that have been reported as agricultural, ornamental, stored-product, and noxious pests in Canada or that have been reported as pests elsewhere and are known to occur in Canada. In broad definitions, agricultural pests are responsible for yield or market value reduction of annual crops, truck crops, vegetable gardens, fruit crops, livestock, and other agricultural products; ornamental pests are destructive to ornamental shrubs, flower gardens, greenhouse plants, and house plants; and stored-product pests damage or contaminate stored food or fabrics. Although beetles are rarely directly noxious to humans, the carabid *Nomius pygmaeus* may fit into this group. Not included in this publication are species important only to the forest industry, although species known to damage furniture and structural timbers in buildings are included. Species frequently intercepted at ports of entry in Canada are not included unless the species is known or suspected to be established in Canada. We have also excluded species that are frequently reported to enter homes in search of overwintering quarters, with the exception of species that may damage household effects when present in large numbers.

This inventory is intended to provide entomologists, pest control researchers, agriculturists, and students with a compendium of essential information on the actual or potential pest species of beetles known to occur in Canada. The only previous work of this nature, encompassing the Canada-wide pest species of beetles, was Beirne's (1971) work on the insect pests of annual crop plants. However, the scope of his publication was limited to annual crop plants and to a summary of the Canadian literature. He did not attempt to solve taxonomic problems or sort out distributional irregularities in the summarized literature.

The literature incorporated in this publication was searched in a number of ways. The preliminary step involved a page by page search of CIPR (Canadian Insect Pest Review) and its successor, CAIPR (Canadian Agricultural Insect Pest Review). In addition, all Canadian entomological periodicals as well as publications of federal and provincial departments of agriculture were searched, and each article title was perused. To obtain additional information on aspects of the biology of the species from the world-wide literature, searches of the AGRICOLA data base were made using, as key word descriptors, generic names of pest species obtained from the Canadian literature. This data base contains bibliographic entries from 1970 to the present. The system allows for qualifiers to be used in the search such as subject, language, and geographic restrictions. The cited references in all pertinent articles were also searched. The cut-off date for literature was December 1981, although a number of more recent publications that came to our attention were included. The purpose of this publication is to provide an inventory of essential information and not to review the literature in its entirety. Therefore, preference was given to the most recent literature containing accounts of the biology of the species. Publications dealing with such subjects as morphology, physiology, genetics, and control are not included.

The families of Coleoptera are arranged in alphabetical order, and within each family the species are arranged in alphabetical order of the Latin name. Common family and generic synonyms are treated in the index. The approved English (Werner et al. 1982) and French (Benoit 1975) common family names, respectively, are listed under the Latin names of families, where applicable. Estimates of the number of species of a family were taken from Lawrence (1982) for the world and Campbell et al. (1979) for Canada.

The names of the species were derived from the most recent taxonomic revision of the taxa. The specific names are often followed by one or more synonyms in parentheses, which might be encountered in the literature. Synonyms reported as "of authors, not" or "of authors" signify that the name also applies to a valid species, but was misapplied to the species discussed. The statement "in part" denotes a synonym that was misapplied to more than one species. No attempt has been made to include all possible synonyms, since an analysis of complete synonymy is beyond the scope of this publication. Directly under the specific names are the English (Werner et al. 1982) and French (Benoit 1975) approved common names, respectively, when available. These are occasionally followed by unapproved common names, in parentheses, that occur in the literature. Infrequently, approved common names are not available while unapproved common names have been used in the literature. These names are then listed in parentheses below the Latin names. Unapproved common names and synonyms are included only to help the reader interpret older works and are not intended to be used as accepted names for the species.

The distribution, by province, is given for each species discussed. This is based on records from the literature and on data from specimen labels in the Canadian National Collection (CNC) housed by the Biosystematics Research Centre. Data from poorly known species or species groups and from groups that have not been curated in recent years, in the CNC, have not been included. The provincial records are listed from west to east followed by the territorial records, respectively (i.e., British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Northwest Territories, and Yukon Territory). Occasionally, species are reported from Labrador. When this occurs, Labrador is treated as a unique area and listed between Newfoundland and the Northwest Territories. When the distribution within a province is well defined and restricted to a specific area, a location qualifier is occasionally used (e.g., southwestern) preceding the province or territory name to which it applies. Distributional records followed by a question mark are doubtful and are discussed in the section entitled "comments". Occasionally, the literature gives the distribution by region and does not specify the province or territory (e.g., Canada, Maritime Provinces, Prairie Provinces, eastern Canada). If specific provinces or territories are given elsewhere in the literature or collection, then the provinces or territories are listed instead of the region; if not, the region is reported.

For those species that are known, or suspected, to have been introduced into North America from elsewhere, we have included a section entitled "Origin". In this section their origin or known recent distribution outside North America is discussed, and their introduction into North America and spread in Canada is documented. When known, the dates and locations of the first North American, Canadian, and provincial records are included, as well as the probable source of the introduction.

The importance of each pest species to humans is discussed under the heading entitled "Economic injury". These sections include information on cultivated hosts and products attacked, nature of the damage, life history stages responsible for the damage, seasonal occurrence of the injury, host organs attacked, role of the species in spreading disease, medical importance of the species, and relative importance in Canada.

The section entitled "Biology" provides information on the life history, seasonal distribution of the life-history stages, and ecology of the species. The ecology of the species may include biotic (e.g., predator, prey, host), abiotic (e.g., climatic, phenological, substrate), and intraspecific (e.g., behavior, pheromones) relationships. In some cases, biological aspects of the species are unknown or unreported. Whenever possible, the biology of a species in Canada is summarized with supplemental information from outside Canada. However, when Canadian data are not available, non-Canadian data are used, and the geographic origin of the data is given.

Distributional irregularities, doubtful records, and taxonomic problems are discussed in the section entitled "Comments". Occasionally, valid species believed to be erroneously reported from Canada are incorporated in the species accounts. However, only these sections are used to detail the misapplied records, and the known aspects of their origin, economic injury, and biology from their actual range are omitted.

This publication attempts to reflect current knowledge on the taxonomy and general biology of the species. However, misidentifications occur in the literature and material studied, and although care was taken to eliminate discrepancies, some errors may occur. The manuscript was reviewed by the staff of the Coleoptera Section of the Biosystematics Research Centre and sent out to acknowledged experts on specific taxa, whenever possible, to ensure the validity of provided information and to check for omissions.

This publication deals with 547 species and subspecies in 35 families.

ANOBIIDAE death watch beetles

Most species of this family feed on dead wood, but some are among the most destructive pests of stored products. Damage is caused primarily by larval feeding and, to a lesser extent, by emergence holes and feeding of the adults. The family occurs primarily in tropical areas, and only a few cosmopolitan species are economically important in Canada. There are about 1600 species known, of which about 80 are estimated to occur in Canada.

Anobium punctatum (De Geer)
furniture beetle (European death watch beetle, death watch beetle)
anobie ponctué (m).

Distribution: British Columbia, Ontario, Quebec, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: The furniture beetle is an accidental introduction from Europe (Smith 1954).

Economic injury: This species belongs to a group of insects known as powder-post beetles, which according to Metcalf et al. (1951), are second only to termites as destroyers of seasoned wood. *Anobium punctatum* occurs in furniture and in the frames and flooring of buildings; injury is apparently most serious in old, partly decayed wood or in antique furniture (Baker 1972). The insect caused extensive damage in houses and barns in Ontario, attacking furniture as well as hardwood flooring and structural timbers (MacNay 1952). Spencer (1958) reported increasingly frequent infestations in Vancouver homes, and recently, serious damage has been reported to homes in St. John's, Newfoundland. Infestations generally arise from antique furniture and spread to the house itself (Spencer 1954, 1958). Williams and Mauldin (1974) found that softwoods or hardwoods with a high proportion of sapwood are most susceptible to attacks by *A. punctatum*.

Damage is caused by the larvae that riddle the wood with tunnels reducing it to a mere shell (Spencer 1947, Smith 1954). The first signs of attack are little mounds or sprinklings of light-colored, powdery dust that come from small, round, adult exit holes (Smith 1954). There are no visible signs of larval entry into the wood. Advanced deterioration results from continuous reinfestation rather than from a single mass attack. Structural timbers may become so weakened that they sag, shake, or collapse.

Biology: According to Metcalf et al. (1951), these beetles generally overwinter in the larval stage in unheated places, with pupation occurring in the spring and the adult emergence in the spring or early summer. Adults generate a tapping noise by jerking their body forward several times in rapid succession, each time striking the lower part of the front of the head against the substrate's surface (Gibson and Twinn 1939). This noise is a sexual call and is most frequently heard in April and May, when the furniture beetle mates. According to Williams and Mauldin (1974), these beetles mate more than once. Females lay their eggs in slits, cracks, or crevices in the wood or in old emergence holes (Baker 1972). Moore (1964) reported that 53% of the eggs of *A. punctatum* were laid between 10:00 a.m. and 6:00 p.m. Spiller (1964), in New Zealand, noted that after a short preoviposition period (at least one day and in some cases several days), the eggs are deposited rapidly, with oviposition virtually completed by the 15th day following emergence. Females lived for a few days after egg-laying was completed and had a maximum life span of 24–31 days. The average fecundity was 54.8 eggs. Kelsey et al (1945), in New Zealand, showed that in different types of cages at 22.5°C and approximately 75% relative humidity (RH), the average fecundity ranged from 14.7 to 44.8 eggs per female. Under the same conditions the eggs hatched in 6–10 days on wood blocks. Bletchly (1952) reported that the optimum humidity at 20°C for incubation of eggs was 87% RH (15.5 days and 91% viability). There was no hatching at 28% RH. At 22°C and 76% RH, the average incubation period was 17.1 days; at 25°C and 76% RH it was 16.4 days; and at 22°C and 85% RH an average of 17.6 days was required. Kelsey et al (1945) and Spiller (1948) stated that egg hatching is not affected by humidity above 65% RH but is reduced by RH between 50 and 60% and does not occur at or below 45% RH (at 22.5°C). The larvae produce wandering tunnels as they feed, and at the completion of feeding they pupate in an enlarged section of their gallery, just below the surface of the wood (Smith 1954). Becker (1942) reported a greater rate of growth in younger larvae than older larvae and noted that larval growth is greatest at temperatures of 22–22.5°C, with temperature limits of 12–29°C for younger larvae and 17–27°C for older ones. Younger larvae grow best when humidity is at saturation; growth of older larvae is not affected by humidity ranges of 70% to saturation. Kelsey et al. (1945) noted that newly hatched larvae can live for long periods without food. Bletchly (1952) noted that the presence of only slight fungal decay is apparently enough to facilitate the entry and successful establishment of the first instar larva. French (1971) reported that the mean pupal period at 23–25°C was about 19–30 days and that pupae are less sensitive to humidity than are other life stages. From 1 to 3 years are required to complete the life cycle (Baker 1972).

Hymenopterous parasites include the braconid *Spathius exarator* (Linnaeus) and the pteromalids *Theocolax formiciformis* Westwood, *Entedon longiventris* Ratzeburg, *Habritys brevicornis* (Ratzeburg), and *Metacoelus mansuetor* (Gravenhorst). The mite *Pyemotes ventricosus* (Newport) is also considered to be a parasite. Predators include the larvae of *Opilo domesticus* and *Corynetes coeruleus* (Cotton and Good1937, Becker 1942, Kelsey et al.1945, Taylor 1964).

Hadrobregmus americanus (Fall)

Distribution: British Columbia.

Economic injury: Smith (1954) gave a general description of the economic injury of powder-post beetles in coastal British Columbia and stated that native species of the family Anobiidae [*H. americanus*, *H. quadrulus* (LeConte), *H. destructor* Fisher, and *H. gibbicollis* (LeConte)] are the most important in the Pacific Northwest. Property has depreciated seriously on the coast of British Columbia. Infested structural timbers may be so weakened that they sag, shake, or collapse. The insects commonly attack the understructure of buildings, and joists are particularly susceptible. Subsequently, beams, sills, posts, exposed sheathing, and subflooring are attacked. Wood with a large proportion of sapwood or open grain, under conditions of shade and poor ventilation, is more likely to be attacked. Advanced deterioration results from continuous reinfestation rather than from a single large invasion.

Injury results from larval feeding. The larvae leave no visible sign of entry into the wood, but they riddle the wood with wandering tunnels, which are filled with fine wood dust and excrement. Damage may be discovered by accumulations of light-colored powdery dust that the larvae push from small, round, adult exit holes.

Biology: The following is a brief generalization of the life history of powder-post beetles in coastal British Columbia as reported by Smith (1954). Complete development of the larvae may require several years. The mature larva pupates in an enlarged section of its gallery just beneath the surface of the wood. The adults emerge in late spring and early summer. About midsummer, the eggs are deposited where natural wood is exposed, such as in cracks, joints, rough sawing, or immediately inside the adult exit holes.

Hadrobregmus destructor Fisher

Distribution: British Columbia.

Economic injury: Spencer (1958) reported this insect in houses, summer cottages and lakeside log cabins in British Columbia and stated that infestations are generally restricted to sapwood and do not materially reduce the compression strength of the wood. For a general description of the damage caused by this native species, see the section on economic injury following *H. americanus* Fall.

Biology: The life history of this species is similar to that describing *H. americanus*.

Hadrobregmus gibbicollis (LeConte)

Distribution: British Columbia.

Economic injury: CIPR (1963) reported *H. gibbicollis* from a house in British Columbia. A general description of the economic injury caused by this native insect is given following *H. americanus*.

Biology: The life history of this species is similar to that of *H. americanus*.

Hadrobregmus quadrulus (LeConte)
(dry rot beetle)

Distribution: British Columbia.

Economic injury: According to Hatch (1962), this species is particularly attracted to wood that has developed dry rot (caused by the wood-destroying fungi *Serpula lacrymans* (Wulf.: Fr.) Schroet. and by *Poria* spp.). Spencer (1958) stated that *H. quadrulus* occurs frequently in houses but is of little consequence as it does not attack sound wood. See *H. americanus* for a general description of the damage caused by this native species.

Biology: The life history of this insect is similar to that of *H. americanus*.

Comments: See comments following *H. americanus*.

Lasioderma serricorne (Fabricius)
cigarette beetle (towbug)
lasioderme du tabac (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, Prince Edward Island, and Newfoundland.

Origin: *Lasioderma serricorne* is now cosmopolitan in distribution, but its origin is uncertain. Howe (1957) suggested that the cigarette beetle was native to the Neotropical Region. However, this insect has been in Egypt since about 1500 B.C. The earliest record from tobacco in the United States was in 1886. It was first reported from British Columbia in 1961 (Spencer 1964).

Economic injury: This is the most destructive insect pest of stored tobacco, but it also causes considerable damage to other products (Metcalf et al. 1951, Howe 1957, Sivik et al. 1957). Infestations have been extensive in tobacco warehouses and in two tobacco processing plants in Montreal, Que., in a tobacco store in Kirkland Lake, Ont., and in an organic chemistry lab in Ottawa, Ont. (MacNay 1949, 1950, 1953). Heavily infested tins of cigarettes were discovered at Arnprior, Ont. (Caesar and Ross 1929). The insect also attacked food in stores and dwellings in eastern Canada, and it occurred in upholstered furniture (MacNay 1948, 1950, 1952, 1953, 1957*b*, 1959). The cigarette beetle has been reported as a major pest of cocoa beans in tropical Africa (Monro 1969) and Hawaii (Loschiavo and Okumura 1979). According to Howe (1957), this species probably has the broadest food range of all stored- product insects and breeds on a wide variety of commodities. In addition to tobacco products, the insect is known to attack dried leaves, furniture, seeds, spices, pepper (black and red), drugs, grain and cereal products, dried insects, dried fish, dried meat, fish meal, meat meal, cayenne pepper, ginger, rhubarb, rice, figs, yeast, cakes, certain medical and aromatic compounds (roselle, licorice, cinnamon, chamomile, aniseed, and cumin), areca nuts, atta, bamboo, beans, biscuits, cassava, chickpeas, coffee beans, copra, coriander, cotton seed (both before and after harvest), cotton seed meal, dates, dried banana, dried cabbage, cowpea, dried carrot, dried fruit, groundnuts, flour, herbs, herbarium specimens, insecticides containing pyrethrum, juniper seed, licorice root, nutmeg, ginger root, raisins, leather, the stored wax of *Cocos coronata*, and wheat, among many other foodstuffs (Sheppard 1925; Gibson and Twinn 1931, 1939; Cotton and Good 1937; Metcalf et al. 1951; Cotton 1956; Howe 1957; Spencer 1964; El Halfawy 1977; Davidson and Lyon 1979). Howe (1957) further noted that injury to cloth, upholstery, paper, and books has generally been considered as incidental to attack on the furniture stuffing or on the bookbinder's paste. Because the range of the cigarette beetle is limited by low temperature and low humidity, its survival in cooler, temperate countries such as Canada depends on its ability to overwinter in warm buildings.

Injury to stored products is caused by the larvae and may result in loss of weight and quality. The resulting substandard products may also damage the reputation of the owner of the infested commodity (Howe 1957). According to Sivik et al. (1957), tobacco is injured by larvae that eat cylindrical galleries in the leaves. Loss of quality is probably the most important consequence of infestation and is due to holes in the leaves and contamination with cocoons and frass (Howe 1957). In some products (cigars and cigarettes), the holes ruin the product itself, and in others they spoil the sack or package. The larvae feed on a surface or bore into produce such as cigars, cereal grains, cocoa beans, or stored ginger root. They penetrate deeply into a stack of produce such as cocoa beans, in which there is plenty of air space but remain peripheral in closely packed materials such as meals. With *L. serricorne*, a large population may build up quickly and inflict serious injury. According to Lefkovitch and Currie (1967), the adults apparently feed readily, but these findings contradict earlier work by Howe (1957), who stated that the adults do not feed even though they can perforate tobacco and chew their way out of cocoons. Metcalf et al. (1951) noted that upholstered furniture occasionally has holes caused by larvae or adults that eat through the covers.

Biology: In North Carolina, the species overwinters in the larval stage (Sivik et al. 1957). Adults fly in the evening and during the night, mostly between 4:30 p.m. and midnight. They avoid bright daylight but at night are attracted to certain types of artificial light (Howe 1957, Canada Department of National Defence 1981). When alarmed, the beetle draws its head, prothorax, and legs closely together and feigns death for a few minutes (Sivik et al. 1957). A sex pheromone is produced by the female, the structure of which was discussed by Chuman et al. (1979). *Lasioderma serricorne* females mate several times (Sivik et al. 1957). Most eggs are laid in the early evening and during the night. Eggs are deposited singly in crevices, folds, or depressions in the food (Howe 1957). According to Lefkovitch and Currie (1967), females rarely lay eggs in the absence of suitable oviposition sites. When reared in warehouses on heat-treated, flue-cured tobacco at 29.4°C and at approximately 60% RH, females deposited an average of 42 eggs (range, 18–112) over a period of 18 days (Sivik et al. 1957). The females had deposited 66% of their eggs after 4 days following emergence and 98% within 11 days after the beginning of oviposition. Oviposition lasts an average of 8 days (range, 2–18), and the postoviposition period averaged 8 days (range, 1–36). The females lived for an average of 18 days (range, 8–42), and the males slightly longer. In Britain, Howe (1957) also described the fecundity and length of the various stages of the life cycle when the insects were reared at various temperatures and levels of humidity. Hatching required about 7 days, and the larval period required about 40 days (Sivik et al. 1957). Metcalf et al. (1951) reported an incubation period of 6–10 days at summer temperatures and a larval period of 30–50 days. There are five to six instars before the larva constructs a smooth-lined cell in which to rest. According to Howe (1957), the lower and upper limits of temperature tolerance for development of the cigarette beetle at favorable levels of humidity are just under 20 and 37.5°C. After hatching, the young larvae are negatively phototropic and extremely active; older larvae remain negatively phototropic but become less active. The lower humidity level for development was under 25% RH at 30°C, but at 20 and 37.5°C, all larvae perished at 40% RH. Larvae did not survive at 90% RH at 37.5°C. Of the numerous temperatures and levels of humidity tested, the optimum combination for larval development was at 32.5°C and 70% RH where larval development required an average of 15.7 days. The larva becomes a prepupa shortly after constructing the cocoon, and at 30°C it discards the larval skin after 2–4 days in the cocoon. According to Sivik et al. (1957), the pupal period lasts about 5 days and the complete life cycle around 52 days. Two generations and a partial third are normally produced in North Carolina. Metcalf et al. (1951) reported that the larvae pupate in silken cocoons covered with bits of their food material. From 45 to 50 days are required to complete the life cycle. Adults usually appear during the spring and again during the summer, although as many as three to six generations may be produced in a year (Canada Department of National Defence 1981). The average period spent in the pupal stage at various temperatures (from 20 to 37.5°C) ranged from 12.3 days (range, 11.3–12.8) to 4.1 days (range, 4.0–4.1), with the shortest period of 3.6 days (range, 3.2–4.0) occurring at 35°C (Howe 1957). Humidity does not appear to affect the length of the pupal period. The adults remained in their cocoon from an average of 12.1 days (range, 9.4–13.1) at 20°C to an average of 5.0 days (range, 4.5–5.4) at 37.5°C, with the shortest period of 3.5 days (range, 3.2–3.7) occurring at 32.5°C. At 30°C and 70% RH, the average period of development (hatching to emergence of the adult from the cocoon) on wheat feed was 26.1 days.

According to Howe (1965), *L. serricorne* needs high temperature and moderate relative humidity. The minimum temperature and humidity at which the species can multiply sufficiently to become a pest is 22°C and 30% RH. The optimum temperature range is 32–35°C. Howe (1957) calculated the theoretical rate of increase at 70% RH and found it to increase with temperature up to 35°C.

Howe (1957) reported the following Hymenoptera as parasites of the cigarette beetle: the bethylids *Cephalonomia gallicola* (Ashmead) and *Israelius carthami* Richards; the pteromalids *Anisopteromalus calandrae* (Howard), *Lariophagus distinguendus* (Förster) and *Choetospila elegans* Westwood; the eurytomid *Bruchophagus* sp.; and a species of *Norbanus*. The beetles *Tenebroides mauritanicus* (Linnaeus) and *Thaneroclerus buqueti* (Lefevr.); and the mites *Chortroglyphus gracilipes* Banks, *Pediculoides ventricosus* (Newport), *Cheyletus* spp., *Seiulus* sp., *Monieziella angusta*, and *Phagidia* sp. were recorded as predators. Cotton and Good (1937) reported *Aplastomorpha calandrae* (Howard), *Catolaccus anthonomi* Ashmead, *Cephalonomia quadridentata* Duchaussoy, *Lariophagus distinguendus* Foerster, *Norbanus* sp., and *Pteromalus* sp. as parasites; and the clerids *Thaneroclerus buqueti* (Lefevr.) and *T. girodi* Chevrolet, as predators. Rao (1978) reported the mite *Cheyletus eruditus* (Schrank) as a predator.

Platybregmus canadensis Fisher
(Canadian powder post beetle)
anobie du Canada (m.)

Distribution: Ontario.

Origin: This anobiid beetle was first discovered at Arthur, Ont., on 21 June 1934 (Fisher 1934).

Economic injury: *Platybregmus canadensis* was found infesting maple flooring and elm beams in the basement of a house at Arthur, Ont. (Fisher 1934).

Priobium sericeus (Say)

Distribution: Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: This insect damaged flooring and timbers in a dwelling at Charlottetown, P.E.I. (MacNay 1956), and timbers in a dwelling at Como, Que. (MacNay 1950). A survey revealed the existence of *P. sericeus* at least in western parts of southern Ontario (MacNay 1953).

Comments: This species was transferred from *Trypopitys* to *Priobium* by White (1972).

Stegobium paniceum (Linnaeus)
drugstore beetle
stégobie des pharmacies (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Economic injury: Numerous reports of the drugstore beetle in dwellings, stores, and bakeries have been received from all provinces (MacNay 1947, 1953). The species has frequently been taken in libraries, ships, mills, and warehouses (Cotton and Good 1937; MacNay 1959). *Stegobium paniceum* is a general feeder that attacks nearly all dry plant and animal products including many drugs (even those that are bitter or poisonous to humans such as aconite and belladonna), pepper, spices, seeds, flour, meal, bread, chocolate, ginger, rubbed parsley for seasoning, books, leather, dried beans and peas, breakfast food, various syrups, dog food, feather pillows, and paprika, among others (Gibson and Twinn 1931, 1939; Cotton and Good 1937; Metcalf et al. 1951; MacNay 1953; CIPR 1956, 1963; Neilson and Arrand 1958, CAIPR 1978, Davidson and Lyon 1979). The insect is said to have an even broader food range than the cigarette beetle (Metcalf et al. 1951). According to Kashef (1955), who was working in France, the species is essentially a pest of food products, especially of bread and drugs, and prefers vegetable materials that are rich in starch. The drugstore beetle does considerable damage in libraries (Cotton and Good 1937), but it is of little importance as a pest of grain and milled products (Cotton 1956).

Injury results only from the feeding by the larvae, because the adults do not feed (Kashef 1955; Canada Department of National Defence 1981).

Biology: This species is very similar to the cigarette beetle in appearance, life history, and habits (Metcalf et al. 1951, Davidson and Lyon 1979).

A sex pheromone produced by the female attracts males and stimulates the initiation of copulation (Barratt 1977). Copulatory behavior was described by Kashef (1955) and Barratt (1977). Oviposition begins about 48 hours after mating (Kashef 1955). The female deposits her eggs in or near the food material, preferably in cracks and crevices. At first the eggs are laid in groups of four to eight, and later they are laid singly. At 24°C and 45% RH, the average fecundity was 58.9 eggs (range, 23–114). Oviposition lasts for 6–12 days and is greatest during the first few days. Barratt (1977) indicated that repeated mating did not increase fecundity and that in some cases it was actually reduced. According to Kashef (1955), the respective maximum and minimum temperatures for egg-laying at 80% RH were about 38 and 10°C.

The females lived for an average of about 29 days and the males 18 days at 24°C and 45% RH. Under the same conditions, the average length of the incubation period was 9 days, the larval period 57 days, the pupal period 9 days and the complete life cycle 75 days. Four larval instars required an average of 13, 14, 11, and 19 days, respectively. The larva reportedly constructs a cocoon immediately after hatching. In pulverized products, the cocoon is made of particles held together by buccal secretions. In compacted material, the cocoon is simply a chamber excavated by the larva just below the surface. Second-generation eggs are often laid in the first-generation cocoons. The adults become sexually mature, remaining in the cocoons for 7–9 days at 24°C and 45% RH and 8–12 days at 19°C and 35% RH. The adults emerge through round holes 1.0–1.5 mm in diameter. Experiments showed that development is accelerated at higher humidity and that at 25°C the optimum RH is about 70%. There are normally two to three generations a year even though the entire life cycle may be completed in 5–6 weeks under favorable conditions (Canada Department of National Defence 1981).

According to Howe (1965), *S. paniceum* thrives at moderate temperatures and needs a high relative humidity. The minimum temperature and humidity at which the species can multiply sufficiently to be a pest is 17°C and 60% RH. The optimum temperature range is from 25 to 28°C, and the maximum rate of increase every 4 weeks is 7.5-fold.

Hymenopterous parasites of the drugstore beetle include: the eupelmid *Eupelmus urozonus* Dalman; the pteromalids *Anisopteromalus calandrae* (Howard), *Arthrolytus puncticollis*

Moeller, *Dibrachys cavus* (Walker) (= *boucheanus* Ratzeburg), *Habritys brevicornis* Ratzeburg, and *Lariophagus distinguendus* Förster; the eulophids, *Entedon longiventris* Ratzeburg and *Eulophus pelicornis* Ratzeburg; and the bethylid *Cephalonomia quadridentata* Duchaussoy (Kashef 1955). The clerids (Coleoptera) *Opilo domesticus* Sturn, *O. mollis* Linnaeus, and *Corynetes coeruleus* De Geer; and the pyemotid mite *Pyemotes ventricosus* Newport (= *Pediculoides ventricosus* Newport) are predators of the species.

Xestobium rufovillosum (De Geer)
(deathwatch beetle, knock beetle)
anobie roux (m.)

Distribution: Quebec.

Economic injury: This species is known to bore into houses in Quebec (Gibson and Twinn 1931).

Biology: *Xestobium rufovillosum* makes a tapping noise that is a sexual call most often heard during April and May, when mating occurs (Gibson and Twinn 1931). The noise is caused by the adult, which jerks its body forward several times in rapid succession, each time striking the lower part of the front of the head against the surface that it is standing on.

Xyletinus peltatus (Harris)

Distribution: Manitoba, Ontario, and Quebec.

Economic injury: *Xyletinus peltatus* is the most economically important beetle known to cause injury to structural timbers in the southeastern United States (Williams and Mauldin 1974). A survey revealed the presence of this species in southwestern Ontario (MacNay 1953). This insect causes damage similar to that of most other powder-post beetles except that it attacks the sapwood and heartwood of both hardwoods and conifers, frequently reducing the interior of seasoned wood to powder (Moore 1964, 1968; Baker 1972). Injury is usually confined to the springwood of each annual ring (Baker 1972). In damp buildings, damage to joists and flooring is often serious, and in unoccupied, closed-up buildings it may be so severe that floors collapse (Moore 1964). Such factors as wood species, wood surface features, and moisture all influence where an attack begins; high levels of moisture favor greater damage and chance of reinfestation (Williams et al. 1979). Williams and Mauldin (1974) noted a preference for yellow poplar and for some aged woods in their study of oviposition rates.

Economic injury is caused by the larvae, which, upon hatching, bore directly into the wood (Moore 1964). The larvae produce galleries that are 1.6–3.2 mm in diameter in seasoned wood. Signs of attack in new infestations may not be apparent for some time, as the larvae may feed for 1–5 years within the wood before adults emerge (Williams et al. 1979). Adults made exit holes that ranged from a mean of 1.49 to 1.87 mm in diameter, depending on the size of the adult (Moore 1964).

Biology: The life history of this species, unless otherwise indicated, is taken from Moore (1964). The flight season extended from late May until early August during which time temperatures and relative humidity fluctuated between 16.1 and 26.7°C and 70 and 85%. The peak of activity occurred during the third week of June. Adult activity began between 7:00 and 8:00 p.m., reached a peak at 9:00 p.m., and declined gradually thereafter. The beetles appear to mate only at night. Like *A. punctatum* and *L. serricorne*, mating occurs more than once (Williams and Mauldin 1974). The basic requirement for oviposition appears to be a rough surface, one that has a projection, a depression, or a piece of debris. Females frequently deposited a group of 4–6 eggs in a well-protected location. Of the various temperatures and levels of humidity tested, the optimum was 23.9°C and 95% RH. The average oviposition rate under these conditions by field-collected females was 43 (range, 8–99). The lower and upper limits of temperature tolerance for oviposition is near 12.8 and 35°C. An increase in temperature between 12.8 and 29.4°C resulted in a direct rise in the rate of egg production, but the duration of the oviposition period decreased. Humidity above 55% had no effect on the duration of egg laying. Of the temperatures and levels of humidity tested, the average longevity of field-collected males and females was greatest at 55–95%. At 55% RH, males and females lived for an average of 24 and 35 days, respectively. At 12.8°C and at 95% RH, males and females lived for an average of 28 and 42 days, respectively. A rise in temperature decreased adult longevity, but at a given temperature, a rise in RH increased longevity. Females outlived the males in all cases. Williams et al. (1979) noted that adults are rarely observed because they are nocturnal and short-lived, and because most beetles emerge during a 4–6-week period of each year. Temperature and humidity appear to have little effect on the incubation period of eggs between 23.9 and 29.4°C at 55, 75, and 95% RH. Under most of these conditions, the eggs hatched in about 14 days. Moore (1970) reported that the optimum conditions for hatching at 29°C at both 55 and 95% RH resulted in an incubation period of 10.4 days. The same author pointed out that temperature had a marked effect on the incubation period and that RH had no effect. Viability of eggs between 18.3 and 29.4°C and 55, 75, and 95% RH was in most cases above 90%. Temperatures between 18.3 and 29.4°C and RH between 55 and 95% were all more than adequate for 90% larval survival. The larvae required 6–12 days to completely penetrate the wood. In all cases, springwood was penetrated more often than summerwood. When exposed to an unpenetrable surface, the larvae were able to live within the eggshell for about 6 days and then move freely over the substrate for 9–11 days before dying. Mature larvae construct a cell in the wood in which they pupate. For the only pupa successfully reared, eclosion occurred on the 13th day. The adult began to chew an exit hole about a week after emergence from the pupal skin. Although the larvae may feed from 1 to 5 years before pupating, the life cycle, under favorable conditions, usually requires 2–3 years (Williams et al. 1979).

Williams et al. (1979) reported *X. peltatus* to be parasitized by adults of the braconid *Heterospilus longicaula* (Ashmead) and the pteromalid, *Theocolax formiciformis* Westwood. Williams (1972) observed the psocid *Liposcelis bostrychophilus* Badonnel eating the eggs. *Rhyopsocus philipsae* Sommerman and *Tapinella* prob. *africana* Badonnel are two other psocids found by the same author to be associated with beetle-infested wood.

ANTHICIDAE ant-like flower beetles

Adults of most anthicids are found on flowers or foliage and litter on the ground. Larvae are found in litter. Some species are known to be egg predators, whereas others are scavengers, but the biology of most species is unknown. Only two species are reported to be pests in Canada. The family includes approximately 3000 species world-wide, of which 45 are estimated to occur in Canada.

Anthicus floralis (Linnaeus)
narrownecked grain beetle (shiny flower beetle)

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Origin: *Anthicus floralis* is a cosmopolitan species with relationships to the Old World fauna (Werner 1964). The species was introduced into North America before 1824 and is now widely distributed.

Economic injury: MacNay (1959) reported the species as a stored product pest and (1953) as a stored grain pest in the Prairie Provinces. The insect has been reported from the following: oats (Sinha 1961, CIPR 1963); Manitoba wheat (Hinton 1945); stored barley (CIPR 1958); and water chestnuts, stored wheat, straw, and dried fruit (Cotton and Good 1937). Sinha (1961) noted that *A. floralis* feeds on fungi.

Biology: Hinton (1945) observed that the species occurs in compost heaps, where both larvae and adults feed chiefly on decaying plants, as well as on fungal spores and hyphae.

Anthicus hastatus Casey

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: CIPR (1961) reported *A. hastatus* on freshly harvested timothy seed in Manitoba.

ANTHRIBIDAE fungus weevils

Most species of this family are restricted to tropical areas of the world and are consequently of little importance in Canada. Both adults and larvae feed on seeds, fungus, or rotting wood. Only one species, which is doubtfully established, is considered to be a pest species in Canada. The family contains approximately 2600 species in the world, of which 18 are estimated to occur in Canada.

Araecerus fasciculatus (De Geer)
coffee bean weevil

Distribution: British Columbia and Ontario.

Origin: *Araecerus fasciculatus* was first recorded from eastern Canada in Toronto, Ont., in July 1975, when it was discovered in coffee beans from Indonesia (Becker 1977). The species is widespread in tropical and southern temperate areas of the world, but it is not known to be established in Canada.

Economic injury: This species has been intercepted several times at ports in British Columbia (Becker 1977) and is regularly found in a chocolate plant in Ontario (Bright, personal communication). Both larvae and adults of the coffee bean weevil are known pests of many agricultural commodities, especially coffee and cacao (Vitelli et al. 1976).

Biology: Vitelli et al. (1976) described the life cycle of this insect on a prepared diet under laboratory conditions. Pupation occurs in the food material. The adults usually emerged from the diet after 2 or 3 days, mated within 2–3 days following emergence, and began laying eggs 5–7 days after mating. An average increase of 10-fold per generation was observed for 22 consecutive generations of this weevil. Development from egg to adult required an average of 26 days at 26.7°C and 56 days at 22.2°C.

On natural foods, development of *A. fasiculatus* was improved by conditions of high moisture and temperature.

BOSTRICHIDAE powder-post beetles

Most species of this family are wood borers, both as larvae and adults, although one species, *Rhyzopertha dominica* (Fabricius), is a major pest of stored grain. Approximately 700 species of the family are known, of which 23 are estimated to occur in Canada. Few, if any, of the pest species of this family in Canada are native.

Amphicerus bicaudatus (Say) (*hamatus* Lesne)
apple twig borer

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, and Northwest Territories.

Origin: The first reported reference to this species in Canada was in Grand Bend, Ont. (CIPR 1935).

Economic injury: *Amphicerus bicaudatus* is a pest of apple in Manitoba and Ontario (MacNay and Creelman 1958). It also attacks pear and cherry (Bethune 1870). Pupae of the apple twig borer were found in elder and maple from England and the United States (Lyne 1911). Fisher (1950) also reports the species feeding on grapes.

The adults bore into the twigs of large-sized trees just above a bud, and they tunnel downwards in the pith forming a cylindrical burrow of 2.5–5.1 cm in length (Bethune 1870, Fisher 1950). These burrows appear to be for feeding as larvae have not been found inside them. Up to 10 borers have been found on a single 2- or 3-year-old tree. Injured twigs are usually broken off by the wind.

Dinoderus minutus (Fabricius)
bamboo powderpost beetle (bamboo borer)

Distribution: British Columbia, Saskatchewan, and Ontario.

Origin: This species, which is native to tropical areas, was introduced into Louisiana and Florida (Cotton 1956). It is frequently introduced into Canada.

Economic injury: *Dinoderus minutus* occurred on bamboo blinds in Ontario (CIPR 1963), in imported bamboo stakes used in greenhouses at Toronto (MacNay 1953), and in two houses in British Columbia where bamboo was used as decoration (CIPR 1962). This well-known pest of bamboo has also infested drugs, spices, cacao, corn, rice, other stored grain, flour, tobacco, dried bananas, chestnuts, and other dried vegetable material. It is not an economically important pest of stored grain in the United States (Cotton and Good 1937; Cotton 1956).

Biology: The bamboo powderpost beetle closely resembles the larger and lesser grain borers in appearance and habit (Cotton 1956). *Cerocephala dinoderi* Gahan, *Spathius bisignatus* Walker, and the beetle *Tillus notatus* Klug are considered to be parasites and predators by Cotton and Good (1937).

Polycaon stouti LeConte
Stout's bostrichid (black polycaon)

Distribution: British Columbia.

Economic injury: *Polycaon stouti* breeds in numerous native and introduced hardwood trees (Middlekauff 1974). This insect may be found far from its natural habitat, as it is frequently incorporated into furniture and interior woodwork constructed from infested stock. Adults usually attack only dead, dying, or weakened trees, but occasionally, they also attack apparently healthy trees. Reinfestation of cut or green lumber or finished wooden products has not been observed. The insect is known to attack California laurel, madrone, manzanita, eucalyptus, sycamore, redwood, live oak, maple, dead oak, apple twigs, alder, fruit trees, hickory, almond, and mahogany (Hatch 1962; Middlekauff 1974).

Damage results from the adults that bore into the wood to lay eggs and by larvae that tunnel and feed (Hatch 1962; Middlekauff 1974).

Biology: The adults tunnel into the wood and deposit the eggs in pores leading from the egg tunnel (Middlekauff 1974). Life spans may exceed two decades or more.

Rhyzopertha dominica (Fabricius)
lesser grain borer (Australian wheat weevil)
petit perceur des céréales (m.)

Distribution: British Columbia, Manitoba, Ontario, and Quebec.

Origin: The original home of the lesser grain borer is generally considered to be the Indian subregion. It is firmly established throughout the world in the areas between latitude 40° N and 40° S.

Most records from outside this area may refer to its occurrence in freshly imported material or artificially heated places. The Pacific Northwest is probably too cold for this pest to become abundant (Hatch 1962). The earliest reference of the species in Canada is 1894 (Potter 1935). The insect was cited as an established pest in the southern United States as early as 1908. Schwardt (1933) pointed out that the frequent introductions to the United States from Australian wheat during World War I apparently gave the species a new footing, which it retained and enlarged. According to Hatch (1962), the species was introduced into southern British Columbia in cereal products.

Economic injury: *Rhyzopertha dominica* is one of the smallest beetles known to attack grain in North America, but it is also one of the most injurious (Davidson and Lyon 1979). Serious damage to a wide variety of grains has been noted, particularly in the southern United States. Potter (1935) stated that the lesser grain borer is a major pest of stored grain in India, Argentina, the United States, and New South Wales (Australia). In Arkansas the lesser grain borer was reported to be primarily a pest of stored corn and rice, the two most valuable grain crops grown in that state (Schwardt 1933). Cline and Highland (1977) noted that *R. dominica* is particularly harmful to packaged food as it can bore through almost any flexible packaging material. In a few cases, the insect has been found in grain from the United States stored in Canadian elevators in the Great Lakes region, but not in the Lakehead ports on Lake Superior (MacNay 1949; 1950). CIPR (1962) reported a large population in broken rice in a brewery in British Columbia. According to Metcalf et al. (1951), the insect attacks nearly all kinds of grain as well as some other substances such as seeds, drugs, dry roots, and cork; it also chews into wood and paper boxes. Potter (1935) gave an extensive list of the recorded food material of the lesser grain borer and noted that it appears to have originally fed solely on wood, probably living wood. He also pointed out that not only the seeds of cereals are subject to attack in the field but possibly the vegetative tissues as well.

Both larvae and adults cause serious damage (Davidson and Lyon 1979). The adults cause the highest weight loss of grain soon after emergence from the pupal stage and before the peak oviposition period; they feed on both the germ and endosperm and, if left undisturbed, are capable of reducing wheat kernels to a shell of bran (Campbell and Sinha 1976). Four or more beetles are frequently found in a single kernel of corn (Potter 1935). Golebiowska (1969) noted that young larvae in Poland feed mainly on grain debris and dust formed by adults and cannot attack undamaged grain until after the first instar. Campbell and Sinha (1976) reported that larvae of *R. dominica* caused 17% weight loss in single kernels of wheat as compared with 60 and 4% by the granary weevil and the rusty grain beetle, respectively. Like the adults, the larvae feed on both the endosperm and germ. At least two larvae can complete their development on a single kernel of wheat. Based on the amount of food eaten and frass produced by the larvae and adults, both Golebiowska (1969) and Campbell and Sinha (1976) concluded that *R. dominica* is more destructive than either the rice or the granary weevil.

Biology: Schwardt (1933) noted that the life history of the lesser grain borer is similar to that of the rice weevil and the Angoumois grain moth. *Rhyzopertha dominica* appeared to breed more rapidly during the summer months than during the winter, even when kept in an incubator at constant temperature and RH. The eggs are usually placed in batches on the grain or singly in the frass. The batches may consist of up to 30 eggs but usually contain only from two to five eggs. Schwardt (1933) reported that the eggs were initially fastened to the surface of yeast bran, then later to the walls of adult tunnels, either singly or usually in groups of two to seven. From 300 to 500 eggs are laid by each female (Davidson and Lyon 1979). A male can copulate at least twice, and a single copulation does not appear to be sufficient to fertilize all the eggs (Potter 1935). At 25°C and 70% RH, 14 pairs of beetles produced an average of 244 eggs (10.4 eggs per day) (Howe 1950). As many as 45 eggs were produced in a single day, and the mean daily rate varied from 4 to 15. Daily oviposition is very erratic, with no definite peak of oviposition occurring. Howe (1950) reported an average oviposition of 418 eggs on wheat under optimum conditions i.e., 34°C and 14% moisture content of grain (70% RH). Females failed to oviposit on wheat of 14% moisture content at temperatures below a point between 15 and 18°C and higher than 39°C. Oviposition was reduced to one-eighth its normal rate in the absence of damaged grain, and only a few eggs were deposited in grain drier than 8% moisture content. Khare and Agrawal (1970) noted that the lesser grain borer prefers corn over wheat for oviposition. In corn, the favorite site for oviposition is at the pointed embryo end underneath the paleae of the grain (Potter 1935). Schwardt (1933), in Fayetteville, Ark., reported that the duration of the egg stage ranged from 5 to 21 days, depending on seasonable variation. The duration of the egg stage is highly affected by temperature but is not influenced by RH (Bains 1971). Of a variety of temperatures tested, the minimum mean incubation period was 5.6 days at 39°C; however, viability was greatly reduced at this high temperature, with only 25.5% of the eggs hatching. The adverse effect of high temperature on survival became noticeable at 36°C, when 71.1% of the eggs hatched as compared with 82.2% at 33°C. A rise in relative humidity increases the viability of the eggs, and the effect on viability of the interaction between temperature and RH is especially important. A temperature of about 33°C and an RH of 70–90% provide optimum conditions for egg development.

Typically, the lesser grain borer has four larval instars (Potter 1935; Howe 1950). At 26°C and 65% RH, the first instar required about 21 days (range, 8–47) to complete its development; the second instar, approximately 11 days (range, 4–29); and the third and fourth instars, about 10 days each (Potter 1935). A prepupal period of about 1.5 days was followed by a pupal period of about 6.5 days. The total development period from egg to adult averaged 58 days. At 30°C and approximately 30% RH (between September and November), the complete life cycle required 30–40 days. Howe (1950), who investigated the length of the various stages in whole-meal flour and whole-wheat grains, found that the insect developed faster on whole grain than in whole-meal flour made by grinding the same kind of grain. Pupation occurs in a cell that is an enlargement of the end of the larval tunnel (Schwardt 1933). Teneral adults remained in the pupal cells 3–5 days before chewing their way out. The newly emerged adults fed for 15 days before depositing any eggs. Bains (1971) studied the effect of temperature and moisture on the biology of *R. dominica* at temperatures of 27–39°C in combination with moisture levels of 40, 70, and 90% RH and reported the mean duration of the combined larval and pupal periods to be longest at 27°C (42.6 days) and shortest at 33°C (28.3 days). A temperature of approximately 33°C and an RH of between 70 and 90% appear to provide optimum conditions for larval and pupal development. A maximum of six generations per year were produced in the laboratory in India. Under favorable conditions, development from egg to adult takes approximately a month (Metcalf et al. 1951; Davidson and Lyon 1979). A minimum of 23°F and 30% RH are required before the insect can reproduce itself in sufficient numbers to become a pest. The optimum temperature range is from 32 to 35°C, and the maximum rate of increase every 4 weeks is 20-fold (Howe 1965).

Potter (1935) listed fungi, predacious mites (*Pediculoides, Cheyletus eruditus* Schrank), and hymenopterous parasites [a chalcid, *Lariophagus distinguendus* Förster, and possibly *Chaetospila elegans* (Westwood)] as natural enemies of the lesser grain borer. Cotton and Good (1937) also reported *Lariophagus distinguendus* Förster as a parasite of the lesser grain borer.

Scobicia declivis (LeConte)
leadcable borer

Distribution: British Columbia.

Economic injury: According to Hatch (1962), the leadcable borer breeds in the dead timber of oak, elm, maple, and other trees and occasionally attacks and kills living trees. It has also been reared from grape canes. In California the adults bore round holes through the lead sheathing of aerial cables; these holes admit moisture and cause short circuits (Metcalf et al. 1951; Hatch 1962).

BRUCHIDAE seed weevils
bruches (f.)

Species of this family are all seed feeders. Most are associated with plants of the family Leguminosae, but they also attack a variety of other plant families. Most of the species occur in the tropics, and therefore only a few are of economic importance in Canada. There are about 1500 species known, of which 20 are estimated to occur in Canada.

Acanthoscelides obtectus (Say)
bean weevil (common bean weevil)
bruche du haricot (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Origin: This insect originated in Central and South America and is now cosmopolitan in distribution. It was recorded from the United States by Say in 1831 (Hatch 1971). According to Fletcher (1898), the bean weevil was first reported as injurious in Canada in 1898, when it occurred at Strathroy in Middlesex County, Ont. First provincial records of this pest were made in Digby County, N.S., in 1937 (MacNay 1950) and at Charlottetown, P.E.I., in 1947 (MacNay 1947).

Economic injury: In Canada the bean weevil is chiefly a pest of stored beans, but in the warmer parts of the United States (south and southwest), it is a serious enemy both in the field and in storage (Dustan 1932, Goble 1960, Davidson and Lyon 1979). MacNay (1948) reported *A. obtectus* to be a common pest of stored beans, especially in dwellings, throughout eastern Canada. It has caused extensive damage in Nova Scotia since its discovery there (MacNay 1950). Beirne (1971) reported that the importance of this insect in the field is uncertain (growing beans have been attacked in New Brunswick, Quebec, Ontario, and Saskatchewan and the species is widely distributed in British Columbia) and noted that while attacked plants may become stunted and deformed, the infestation is not usually detected. According to Goble (1960), beans grown in a home garden in Ontario are more likely to be attacked than the field-grown crop. Unlike the pea weevil, *A. obtectus* breeds continuously in heated storage and may become so numerous as to reduce beans almost to a powder. In unheated storage, however, all stages of the insect are killed by cold winters, and Caesar (1927, 1938) cited this as the reason why stored beans are only occasionally attacked in Ontario. Low winter temperatures also kill overwintering adults, thus greatly reducing injury to beans in the field or garden in Ontario (Goble

1960). The most important hosts of *A. obtectus* are the various cultivars of common beans and cowpeas (Davidson and Lyon 1979). According to Goble (1960), beans and peas, particularly the white and kidney types, are attacked in storage; usually, only beans are attacked outdoors. Hatch (1971) reported many other legumes being attacked.

Larvae develop in both growing and dry seeds of beans (Beirne 1971). When growing plants are attacked, the newly hatched larvae bore through the pods into the seeds and feed until maturity (Goble 1960). The only signs of infestation are small, brown spots on the outside of the pod after the entrance holes heal over. Each larva forms a chamber or cell inside the bean, and a single bean may contain a dozen or more chambers. Seeds are often partly or completely destroyed by the larvae (Banham and Arrand 1978). After pupation, the adults chew exit holes through the seed coat and emerge (Goble 1960). Gibson and Twinn (1931, 1939) noted that adults can eat through cotton or paper bags containing stored beans. In the spring, overwintered adults feed on foliage and seedpods (Banham and Arrand 1978) and chew small areas in the pods for oviposition (Goble 1960).

Biology: If temperatures are unfavorable in the fall, the adults overwinter in the beans until spring, either in storage or in the field (Bethune 1917, Neilson 1954, Beirne 1971). The adults appear on the plants and begin feeding during blooming (Banham and Arrand 1978). The eggs are deposited on or in pods in the field and on beans in storage (Davidson and Lyon 1979). According to Metcalf et al. (1951), the female lays her eggs in loose groups of a dozen or more in cavities made along the seam in the green pods or in any natural crack in the pod. Davidson and Lyon (1979) reported one female laying over 200 eggs and noted an incubation period of 3–9 days. The larval stage has four instars and requires 12 days to 6 months to complete development. The larvae lose their legs after the first molt (Neilson 1954). Pupation occurs within the seed during the fall (Beirne 1971) and takes from 8 to 25 days for completion (Davidson and Lyon 1979). In heated storage, the adults may emerge at any time during the year and breed continuously, with six to eight generations a year (Goble 1960, Beirne 1971). The minimum temperature and humidity at which the species can multiply sufficiently to become a pest is 17°C and 30% RH. The optimum temperature range is from 27° to 31°C, and the maximum rate of increase every 4 weeks is 25-fold (Howe 1965).

Bruchidius unicolor (Olivier)

Distribution: British Columbia and Alberta.

Origin: The presence of *B. unicolor* in British Columbia has been known since 1922 (Beirne 1971).

Economic injury: This insect heavily infested seeds of sainfoin imported from British Columbia to Alberta (CIPR 1966).

Biology: Only one generation is produced each year (Beirne 1971).

Bruchus brachialis Fåhraeus
vetch bruchid
bruche des vesces (f.)

Distribution: British Columbia and Ontario.

Origin: The vetch bruchid, a cosmopolitan species native to Europe, was discovered in North America in New Jersey, in 1930 (CIPR 1955). Its presence in Canada has been known since 1950, when it was found in the Niagara Peninsula, Ont., apparently by natural dissemination from the south or southwest (Sheppard 1955). *Bruchus brachialis* was first recorded breeding in Canada in 1953 at Grand Forks, B.C. (MacNay 1953).

Economic injury: This species is only injurious to developing seeds of vetch in the pod, which are often entirely destroyed (Davidson and Lyon 1979). Injury is caused by the larvae, which enter the pods and develop in the seeds.

Biology: The species overwinters in the adult stage and, depending on temperature, emerges during April, May, and June (Davidson and Lyon 1979). The eggs are laid on the pods, and a maximum of 42 eggs have been recorded on a single pod. The incubation period is about a week. The larvae pass through four instars, completing development within the seeds in 2 weeks. Pupation occurs within the seeds, and the new adults begin to emerge 5 days later. Only one generation occurs per season.

Bruchus pisorum (Linnaeus) (*pisi* Linnaeus)
pea weevil
bruche du pois (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: The pea weevil is cosmopolitan in distribution and is thought by some workers to be an introduced species (Lochhead 1902*a*, Beirne 1971, Hatch 1971, Southgate 1979) or to be a native of

North America by others (Saunders 1879*a*; Davidson and Lyon 1979). It was reported to cause serious injury to garden peas in Pennsylvania, New Jersey, and southern New York as early as 1748 (Hatch 1971). According to Beirne (1971), careless cultivation practices led to the increase of this insect in Ontario at the end of the last century. *Bruchus pisorum* was first recorded from British Columbia in 1915 (McLeod 1951), Alberta in 1945, and Manitoba in 1946 (Beirne 1971).

Economic injury: Hatch (1971) reported this species to be the most serious pest of field or garden peas, which are the only vegetables it attacks (Banham and Arrand 1978). The pea weevil now appears to be only a minor pest of peas (Beirne 1971), but in the past, it was responsible for great losses in Ontario, causing many farmers to discontinue growing peas (Caesar 1938, Goble 1960). The most severe infestation on record resulted in the condemnation of approximately 40 ha of peas for canning in Huron County, Ont. (MacNay 1955). Goble (1960) stated that in the last few years the insect has been important only in a few locations in Ontario, especially the region from Huron County to York County, but noted that it is a potential threat to all types of peas at all times. In New Brunswick, MacNay (1956) found extensive infestation only in small gardens. It is also a sporadic pest in pea-growing areas in the southern interior of British Columbia (Banham and Arrand 1978). Infested peas are unfit for human consumption, their stock feed value is destroyed, and the seeds often either fail to germinate or they produce weak, unproductive plants (Caesar 1927, Metcalf et al. 1951, Davidson and Lyon 1979). Although development of the species may be completed in harvested seeds, the insect attacks only the green pods in the field (Davidson and Lyon 1979, Homan and O'Keefe 1979). Broken peas in the field, volunteer peas, pea hay containing infested peas, and stored infested seed are the main sources of pea weevil infestation (Davidson and Lyon 1979). According to Homan and O'Keefe (1979), peas grown for processing can usually tolerate less than one adult in 100 sweeps (180°) during the flowering period. In dry, edible and seed peas, more weevil injury is acceptable; serious economic injury can occur when the number of weevils exceeds the economic threshold (an average of up to three weevils in 50 sweeps under most field conditions during the flowering stage). Austrian winter peas, because of their often extended blooming period, are more susceptible to damage than are spring peas.

Both larvae and adults feed on the inside of the seeds (Metcalf et al. 1951), though most of the damage is caused by larvae that consume the central part of the pea (Beirne 1971, Davidson and Lyon 1979). Metcalf et al. (1951) noted that the feeding of the weevil causes the peas to become heated and that the rise in temperature speeds larval development. The only indication of infestation before the larva reaches the pupal stage is the tiny, dot-like entrance hole (Metcalf et al. 1951), which, according to Caesar (1938), soon heals over as the pea grows. The larvae become adults by the time the peas are mature, but they usually remain inside the peas until they are sown the following spring. Some adults emerge in the field or in storage (Caesar 1927, 1938; Beirne 1971). Adults do not reproduce themselves on stored peas (Homan and O'Keefe 1979). Neat, circular holes about 2.5 mm in diameter may be observed in old peas in the spring and summer (Metcalf et al. 1951). When infestations are heavy, the peas are frequently reduced to mere shells. The overwintered weevils feed on the pollen, petals, leaves, or pods of the peas.

Biology: The species overwinters in the adult stage in the seeds, either in storage or in the field, but some insects may leave the seeds in the field or in the barn, especially at harvest time, and may hibernate in and around the following: tree bark, lichens, old buildings, crevices of fence posts, debris of field and forest, and barns (Caesar 1927, Brindley 1933, Metcalf et al. 1951, Beirne 1971, Banham and Arrand 1978; Homan and O'Keefe 1979). Some adults of the overwintering generation may remain in hibernation for 2 years (Metcalf et al. 1951, Homan and O'Keefe 1979). The adults feed on pollen for approximately a week before mating and laying eggs (Brindley 1933). The pollen is necessary for sexual maturation. The female deposits her eggs on pods in all stages of development, but she prefers those that have nearly reached their maximum size but are still succulent. From 1 to 12 or more eggs (as many as 20 according to Beirne 1971) are glued by each female to an individual pod, usually singly and only on the green pod's surface (Metcalf et al. 1951, Homan and O'Keefe 1979). Brindley (1933) also discovered eggs on almost every part of the pod and flower. Homan and O'Keefe (1979) reported a fecundity of 1–300 eggs per season, and Brindley (1933) reported an average of 432 eggs (range, 92–735) per female. Oviposition continues for as long as there are fresh pods available (Homan and O'Keefe 1979). Goble (1960) reported that eggs hatch in 5–18 days, and Brindley (1933) reported an average of 8.7 days (range, 6–13).

There are four larval instars, which require an average of 41.7 days (range, 28–56) to complete their development (Brindley 1933). Other workers reported that the larvae mature in about 4–6 weeks (Metcalf et al. 1951, Goble 1960, Beirne 1971, Banham and Arrand 1978). Metcalf et al. (1951) noted that the newly hatched larva is well adapted for burrowing into the pea because it possesses spines and very short legs. After entering the pea, it loses its spines after the first molt and the legs become more reduced. Only one larva matures in each seed (Metcalf et al. 1951, Goble 1960, Banham and Arrand 1978; Homan and O'Keefe 1979). Brindley (1933) reported that several larvae often enter the same seed, and noted several instances where two individuals reached the adult stage, but only one emerged alive because the newly formed adult was killed by the larva that developed more slowly. This contradicts Dustan (1932), who reported that more than one larva is never found in a seed.

Before pupation the larva constructs an exit passage for the adult and then covers the walls of its burrow with a gluey secretion from the mouth. The nearly transparent outer skin is left intact to protect the tunnel (Metcalf et al. 1951, Homan and O'Keefe 1979). The pupal period lasts an average of 13.7 days (range, 10–18); the average life cycle was 64.1 days (range, 50–82). Emergence occurs in the seed by late summer, and the new adult usually remains there until the following spring (Banham and Arrand 1978). There is one generation each year.

Bruchus rufimanus Boheman
broadbean weevil
bruche de la gourgane (f.)

Distribution: Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: This species is occasionally found in imported beans (CIPR 1925, 1926; Sheppard 1925; CAIPR 1978) but has not become established in Canada (Gibson and Twinn 1931, 1939). *Bruchus rufimanus* occurs in California, where it attacks broad beans (Davidson and Lyon 1979). According to Metcalf et al. (1951), the insect prefers the European broad bean but also attacks peas and vetches. Injury results from larval feeding (Davidson and Lyon 1979).

Biology: The broadbean weevil is similar in habit and appearance to the pea weevil but is only about two-thirds as large (Metcalf et al. 1951). In contrast to the pea weevil, several individuals of this species can mature in a single seed. The species overwinters in the adult stage; the adults become active early in April and deposit eggs on the newly developing pods (Davidson and Lyon 1979). The period from oviposition to adult emergence requires about 19 weeks. Although some adults emerge as soon as development is completed, others may remain in the stored seeds for several months. Only one generation is produced annually.

Callosobruchus chinensis (Linnaeus)
(southern cowpea weevil)

Distribution: Saskatchewan, Manitoba, and Ontario.

Economic injury: *Callosobruchus chinensis* is occasionally found in imported beans, but it is not a pest in Canada (Gibson and Twinn 1931, 1939). MacNay (1953) noted its interception at Toronto, Ont., in household effects from Japan, and indicated that the insect is a southern species occurring mostly in field peas and occasionally in beans. The insect attacks beans in the field and then becomes a storage pest in the granary; repeated infestations may reduce the beans to fragments (Davidson and Lyon 1979). This species is associated with the seeds of several species of leguminous plants and has even been found in lotus seeds, a new family host record not only for the species but also for all Bruchidae (Kingsolver 1979). Among its extensive host list are various species of bean (*Cyamopsis, Dolichos, Vigna, Cajanus*) and vetch (Davidson and Lyon 1979).

Biology: This insect and the cowpea weevil are closely related and are more abundant in the tropics (Davidson and Lyon 1979). *Callosobruchus chinensis* needs high temperature and a moderate RH. The minimum temperature and humidity at which the species can multiply sufficiently to become a pest is 19°C and 30% RH. The optimum temperature range is from 28 to 32°C, and the maximum rate of increase every 4 weeks is 30-fold (Howe 1965).

Callosobruchus maculatus (Fabricius) (*quadrimaculatus* Fabricius) cowpea weevil (four-spotted bean weevil).

Distribution: Saskatchewan, Ontario, and Quebec.

Origin: *Callosobruchus maculatus* is probably native to some part of the Old World subtropics (Davidson and Lyon 1979).

Economic injury: The cowpea weevil is occasionally detected in imported beans, but is not a pest in Canada (Gibson and Twinn 1931, 1939). CAIPR (1978) reported this species in stored grain in Saskatchewan. The cowpea weevil occurs in the southern United States and California, with scattered records noted from some northern states, where it occurs only in stored seeds (Davidson and Lyon 1979). Metcalf et al. (1951) stated that this insect is frequently destructive to stored cowpea seeds. Infested cowpeas and beans are unfit for human consumption, and when the infestation is heavy, they are unsuitable for planting (Davidson and Lyon 1979). The same authors pointed out that cowpeas are the preferred hosts of this insect, but beans and seeds of other related plants may also be damaged. Southgate (1979) noted that a single larva of this species eats approximately a quarter of the cotyledon of an average-sized seed of cowpea but consumes virtually all the cotyledon of the smaller seed of *Phaseolus mungo* L., eliminating all possible chance for its germination.

Biology: The biology of the cowpea weevil is similar to that of its close relative, the bean weevil (Metcalf et al. 1951). The female, however, does not excavate a cavity for the eggs but glues them to maturing pods in the field or on dry seeds in storage (Davidson and Lyon 1979). The larvae have four instars and complete their development within the seed in 14 days to 9 months, depending on the ambient temperature. Larvae pupate in the seed. Up to nine generations a year have been recorded in the southern United States (Texas), but this number is considerably reduced in more northern areas. High temperature is needed for development, but the species is tolerant of low RH. According to Howe (1965), 22°C and 10% RH constitute the minimum temperature and humidity at which the insect can multiply in numbers sufficient to become a pest. The optimum temperature range is from 30 to 35°C, and the maximum rate of increase every 4 weeks is 50-fold.

BUPRESTIDAE metallic wood-boring beetles buprestes (m.)

Larvae of species of this family are all plant feeders, most boring into the roots, trunks, or branches of trees and shrubs. Other species live in stems of herbaceous plants, form galls, or are leafminers. Species belonging to this family are some of the most destructive to the forest products industry. Many adults do not feed on wood, but many feed on nectar or pollen of flowers. Most species of this family are known from tropical or arid regions of the world, but in Canada some occur north, to the tree line. The family contains about 15 000 species, of which approximately 220 occur in Canada.

Agrilus anxius Gory
bronze birch borer
agrile du bouleau (m.)

Distribution: British Columbia to Newfoundland.

Economic injury: Earlier records of damage by this species refer to ornamental birch only, and the first reports of *A. anxius* as a forest pest were by Maheux (1919) and Swaine (1918). Both authors described damage to stands of yellow and white birch along the Ottawa River watershed in 1918, and since about 1925, the insect has been commonly associated with the death of birch in forests and woodlands (Barter 1957).

More recently, the bronze birch borer has become one of the most serious enemies of woodland birch (Swaine 1914, Hutchings 1923). All birch suffer some damage but the cut-leaved varieties, particularly the cut-leaved weeping birch, are most readily attacked (Hutchings 1923, Goble 1969*a*).

Injury is a result of partial or complete girdling caused by long and winding larval galleries in the inner bark. The spiral galleries cut through the cambium layer, often just encircling smaller limbs. The injury becomes apparent as the topmost branches begin to die, leaving a characteristic dead crown. Removal of these branches at this point rarely saves the affected tree, as other larvae have invaded most of the tree by this time (Swaine 1913). Light attacks may become healed over but weaken the tree, making it more susceptible to further attack by successive generations of the borer; heavily infested trees invariably die.

Biology: In Canada the life cycle can be either 1 or 2 years long, but 2 years are usually required for full development (Barter 1957). Host condition largely governs the length of the cycle, but it may also be affected by the time of oviposition.

Adults emerge in May and June (Goble 1969*a*), and the following flight period lasts approximately 6 weeks. Eggs are laid in small crevices in the bark, and upon hatching, the first-instar larvae chew into the bark. The species has five larval instars. The larvae make a series of elongate, winding tunnels that cut the cambium layer.

Just before pupation, the larva constructs a boat-shaped cell in the woody area near the surface of the bark. Here, transformation takes place, and the adult chews its way out to emerge. The adults eat very little, taking only small pieces from leaf margins of poplar, willow, and to a lesser degree, birch.

Anderson (1944) and Barter (1957) stated that the larvae cannot survive in healthy trees. Hosts that are weakened by adverse weather conditions, old age, repeated unsuccessful attacks, or defoliation are most likely to be attacked. Even the poorest of growing trees are unsuitable as hosts, but trees that have been dead for so long that the phloem tissues are dead are also unsuitable for larval development.

Nash et al. (1951) listed eight species of larval parasites, some of which were consistently found. According to Barter (1957), egg parasitism is the highest and most consistent mortality factor directly affecting the borer population. One species, an encyrtid, and the other, a species of *Thysanus*, parasitized 55% of the eggs investigated over a 5-year period.

Agrilus auricalceus Redtenbacher [*communis rubicola* Abeille, *viridis fagi* (Ratzeberg)]
rose stem girdler
agrile du rosier (m.)

Distribution: Ontario.

Origin: Originally a native of Europe, *A. aurichalceus* was first recorded on this continent in 1913 (Garlick 1940). The earliest Canadian record was at Point Pelee, Ont., in 1927. Within a few years, the insect had spread throughout southwestern Ontario.

Economic injury: Largely a pest of roses, the rose stem girdler is also known to attack both wild and cultivated red raspberry, black and red currant, and gooseberry. The larvae make spiral tunnelings beneath the bark of cones, giving an appearance similar to the threads of a screw. Construction of the tunnels within the cane usually "girdles" the stem, causing the shoot above the point of attack to die and eventually fall off. Twinn (1936) reported the recent appearance of this species (under the name *A. viridis fagi*) as a pest in southern Ontario and noted the infestation of 6000 young rose plants in a nursery at Beamsville, which resulted in serious loss.

Biology: Habits and life history of the rose stem girdler are similar to those of the rednecked cane borer (Chamberlain and Putnam 1964). Garlick (1940) gave a short account of the biology of this beetle from southwestern Ontario.

The mature larvae pass the winter in the stem and generally emerge in June. The adults live for approximately 3 weeks, showing greatest activity in periods of hot weather. Eggs are deposited singly on the smooth new wood of the stem. Upon hatching, the larvae immediately bore into the wood and pith, sometimes forming a regular spiral of three to seven turns just under the bark. The course of the tunnel is often erratic, usually girdling and killing the stem.

Garlick (1940) records that over 90% of the larvae were parasitized in some raspberry canes. Investigations in mid autumn revealed that most of the tunnels contained hymenopterous larvae, pupae, and adults.

Agrilus politus (Say)
willow gall limb borer
agrile du saule (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Northwest Territories, and Yukon Territory.

Economic injury: According to Hutchings (1922), *A. politus* is a serious pest of hazel, though it is not as economically important as *A. ruficollis*. Everson (1978) reported the species on willow and maple on southern Vancouver Island, B.C.

Injury is caused by larval feeding (Hutchings 1922). Upon hatching, the larvae bore into the bark, packing expelled frass into the empty egg case. They tunnel side by side in the same direction lengthwise along the twig for 7–10 mm before branching out and girdling the twig near the surface. This causes an abnormal stimulation of growth, cracking of the outer bark surfaces, and the production of knotlike galls. Eventually the affected branches are killed. Adult emergence is via a D-shaped hole, quite characteristic of the genus.

Biology: Hutchings (1922) described the biology of this species. The female apparently has no preferred oviposition site, depositing her eggs singly or in small groups of two or three near the axil of a small shoot, beside a raised portion of bark or lenticel, and quite frequently on the exposed bark surfaces. The eggs are then covered with protective secretions, which are a little lighter brown than the bark and appear as scalelike objects on the branches. The eggs begin to hatch around 20 July, the incubation period being approximately 3 weeks. The protective capsule is left undisturbed as the larva hatches and penetrates directly into the bark. The larva constructs a pupal cell deep in the woody tissues of the stem. Pupation occurs from the last week in May until about the middle of June. The greatest number of adults were collected between 16 June and 20 June.

Agrilus ruficollis (Fabricius)
rednecked cane borer (rednecked Agrilus, blackberry cane borer)
agrile du framboisier (m.)

Distribution: British Columbia, Manitoba, Ontario, and Quebec.

Economic injury: The rednecked cane borer occurs widely on blackberry and raspberry in eastern Canada. A few larvae within a cane produce an irritation that generates the growth of a pithy swelling or gall of 2.5–7.6 cm in length. These swellings are usually symmetrical along the stem, being approximately one-third greater in diameter than the normal cane. Termed the raspberry gouty gall, this characteristic swelling generally causes the bark to split along its length.

This insect is often localized, doing considerable damage in only a small part of a raspberry plantation. Affected canes usually wilt and die above the point of attack.

Biology: Adult beetles appear from June to August and immediately begin feeding on the upper leaf surfaces of blackberry and raspberry, and sparingly on the purple flowering raspberry. They do, however, show a decided preference for blackberry (Hutchings 1922). The insects usually feed on the central areas of leaf surfaces, where they make holes of irregular shape and outline.

Mating starts soon after emergence, and eggs are laid on the young canes. Hatching begins in about 3 weeks, and the young larvae enter the stem by cutting spiral tunnels into the wood. Initially, they feed chiefly in the sapwood, following irregular spiral courses that frequently girdle and destroy the cane.

The slender, yellowish white grub grows to approximately 17 mm in length and then hibernates in the pith of the cane, pupating during May within an enlarged cell. After transformation, the adult gnaws its way to the surface and escapes. If disturbed, the adults feign death and dodge beneath the underside of the foliage or quickly seek other feeding grounds by short, rapid flights. The existence of small, dark excrement pellets on the leaves is a good indicator of the presence of *A. ruficollis*.

Agrilus sinuatus (Olivier)
sinuate peartree borer
agrile du poirier (m.)

Distribution: British Columbia.

Origin: Indigenous to Europe, this insect was first found in New Jersey in 1894 (Metcalf et al. 1951).

Economic injury: The sinuate peartree borer is important only in limited areas, having attracted attention in Ohio, New York, New Jersey, and adjoining states (Davidson and Lyon 1979). Lyne (1911) reported larvae in nursery stock trees imported from the United States and Japan into British Columbia. Pear is the main host, but the insect also attacks mountain ash and hawthorn (Davidson and Lyon 1979).

The larvae cause damage by forming narrow, winding burrows in the inner bark and sapwood of infested trees, resulting in discolored cankerlike areas from the base of the trunk to the small branches (Metcalf et al. 1951). Splitting and dark, dead lines in the outer bark indicate the presence of these burrows. When the insect is numerous, entire plantings of young trees are occasionally girdled and killed. The adults feed on the foliage of pear and related wild and cultivated fruit trees.

Biology: The larvae spend the first winter in the inner bark and the second winter in small cells in the sapwood, which are sealed with coarse sawdust at each end (Metcalf et al. 1951). Pupation takes place in early spring and adult emergence in late May and June. After mating, the females deposit their eggs in cracks in the bark. Only one generation is produced every 2 years (Davidson and Lyon 1979).

Buprestis aurulenta Linnaeus
golden buprestid
bupreste doré (m.)

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: Furniss and Carolin (1977) reported the golden buprestid to be the most destructive western species of *Buprestis* and to be of principal concern in buildings, particularly in the Pacific Northwest. Every et al. (1975) described this insect as one of the most familiar and destructive buprestids and noted that in Oregon, of all the flatheaded borers that it resembles, it is the only serious structural pest. In British Columbia the species is common and widely distributed, but it is seldom abundant enough to cause significant injury (Spencer 1958). This insect has damaged flooring in houses in British Columbia (Spencer 1930; MacNay 1947, 1953). The golden buprestid has been recorded from several species of pine, spruce, and fir, but it prefers Douglas fir (Every et al. 1975). Known hosts include grand fir, Douglas fir, ponderosa pine, limber pine, Jeffrey's pine, sugar pine, lodgepole pine, Monterey pine, and western red cedar (Everson 1978, Bright 1987).

Economic injury results from the larvae, which mine in boards and timbers, and from adults, which chew exit holes through finished surfaces in buildings (Furniss and Carolin 1977). Although the presence of mines may require replacement of some boards and timbers, it is only in special situations, such as wooden storage trunks, that the insect causes major structural damage. Wood may be infested in the forest, in lumberyards, and occasionally on exposed parts of wooden structures (Furniss and Carolin 1977, Bright 1987). Larval mines occur in and around the following: dead portions of living trees, stumps, exposed roots, down wood, fire scars, mechanical injuries, and, in particular, lightning-struck trees. Although the possibility of reinfestation of buildings exists (infestations may occasionally begin on older, dry, unpainted, or untreated wood but this occurrence is probably rare), most of the larval mining in houses and all of it in finished products results from infestations before manufacturing (Every et al. 1975). The larval mines, which enlarge as the larva grows, are oval in cross section, about 9.5 mm wide, 0.9–4.6 m long, and packed with powdery borings and excrement. The adult eats its way out of the wood through a small, oval exit hole. This hole is usually the first sign of damage. In buildings, beetles may not emerge for 30, 40, or even 50 years or longer after oviposition (Spencer 1958, Bright 1987). Adults usually fly away and do not inflict further damage to the wood (Every et al. 1975). Beetles emerging from timber used in construction of a building or from firewood in the basement may occasionally damage underpinnings of the building, but reinfestations are probably rare. In the field, the adults feed on the needles of Douglas fir and other conifers (Bright 1987).

Biology: The species overwinters in the larval stage, and pupation takes place in oval chambers, which are usually located near the surface of the wood (Every et al. 1975). Adult emergence generally occurs during spring and early summer under natural conditions and from late fall until late spring in buildings. Eggs are laid on trees (especially trees that are dead or dying or recently cut with the bark still on them), pitchy wood, fire scars, and occasionally in cracks of freshly sawed lumber and less often on older, dry or partly dry structural material. According to Furniss and Carolin (1977), the females deposit their eggs in flat masses wedged in the wood after feeding on coniferous needles. The adults live for about 3–5 months (Every et al. 1975). In nature, larval development is usually completed in 2–4 years.

Chrysobothris femorata (Olivier)
flatheaded appletree borer (buprestid apple-tree borer)
bupreste du pommier (m.)

Distribution: British Columbia, Saskatchewan, Ontario, Quebec, and New Brunswick.

Economic injury: This buprestid is known to attack mostly fruit trees but it also injures elm, linden, maple, mountain ash, oak, poplar, willow, and other shade trees (Neilson and Arrand 1961). Most of the damage is done to young orchard trees, particularly in newly planted orchards (Bethune 1877). A preference is also shown for more mature trees that have become weakened because of injury (Swaine 1909*b*, Bethune 1911). Twinn (1935) reported that there are often complaints of this pest in Ontario orchards, probably owing to the prevalence of weakened and unthrifty trees in winter-damaged orchards.

The larvae feed just below the bark, where they make broad tunnels, usually beginning their attack on the side exposed to the sun (Neilson and Arrand 1961). Preferred sites include upper portions of the trunk and the bases of upper branches (Swaine 1909*b*). Tunneling through the sapwood, the larvae create flattened chambers. The bark above the chambers dies and cracks, and the castings are thrust through the cracks.

Early feeding causes sap exudation, and extended feeding and the resulting girdling may kill the tree. Even if the tree does not immediately die, it does lose vigor, making it more susceptible to further attacks.

Biology: Bethune (1877) gave a brief outline of the life history of this species. During the early part of the summer, the females deposit their eggs in crevices within the bark of selected trees. The young larvae soon hatch and immediately work their way into the soft sapwood, carving a progressively larger tunnel that is characteristically flattened in cross section. Later in the season the grubs bore deeper into the heartwood, where they overwinter. In early spring they move to the surface and form the pupal cell. They spend three weeks in the pupal stage, after which the adults emerge through oval holes that they chew in the bark (Swaine 1909*b*).

Approximately 1 year is required for the completion of a generation (Neilson 1957*b*). Pupation occurs in spring, and the adult beetles emerge from mid May until July, generally remaining until early fall. Hatching may extend over several months so that all stages of development are present at one time (Neilson and Arrand 1961).

Elliot and Morley (1911) reported that a hymenopterous parasite, *Labena apicalis* Cresson, has been reared from this borer.

Dicerca divaricata (Say)
(divergent beech beetle, flatheaded cherry tree borer)
bupreste du hêtre (m.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: *Dicerca divaricata* breeds in a variety of deciduous trees (Bright, 1987). It has been reared or collected from maple, birch, redbud, ash, hophornbeam, stone fruits, oak, and elm.

Trachykele blondeli Marseul
western cedar borer
bupreste du thuja de l'ouest (m.)

Distribution: British Columbia.

Economic injury: Although the western cedar borer has caused serious concern in British Columbia because of heavy losses resulting from replacing infested poles, Hopping (1928) has shown that a large majority of poles are usually not structurally weakened by the work of the borer. Damage caused to poles after cutting is relatively small, the majority of the larvae dying as the poles become thoroughly seasoned. Poles will not become infested after cutting and peeling, and therefore infestation will not spread to poles in use or storage. The borer prefers southeastern to southwestern exposures and is limited by an altitude of about 250 m, above which the number of borers is greatly reduced and injury is negligible. It is unknown why some forest areas are especially subject to injury, whereas others are not (Furniss and Carolin 1977). The preferred host is giant arborvitae, but species of juniper and cypress and perhaps *Libocedrus decurrens* Torr. are also attacked.

Injury is caused by the larvae, which after hatching enter the cambium layer of the limb and then tunnel to the main bole, where they bore up or down the trunk and occasionally around it, following the annual rings (Hopping 1928; Bright 1987). The insects spend some time in the cambium or sapwood before entering the heartwood, where they construct a major portion of the galleries. The average length of the western cedar borer's gallery is no more than 6 m (Hopping 1928). The tunnels of nearly mature larvae are about 2.5 cm wide, narrowly elliptical in cross section, and closely packed with frass except for several centimetres directly behind the feeding larva. Apart from generally following a longitudinal path in the trunk or limb, the larva seems to show no preference in the direction of its burrows. Larval tunnels cause lower grades and culls in trees chopped for poles, shingles, boats, and other products requiring sound wood (Furniss and Carolin 1977). Adults spend their entire lives in the crowns of trees, where they feed on green cedar foliage (Hopping 1928).

Biology: Hopping (1928) described the life history of the western cedar borer. The insect spends the winter in both the adult and larval stages. Adult emergence takes place from about 12 May to about 10 June. Both sexes emerge at approximately the same time; they fly from tree to tree and rarely descend below the crown, where they feed. Mating occurs soon after emergence. Females lay their eggs from the middle of June to the middle of July and only on living trees. The eggs are inserted singly or in small groups in complete concealment under overlapping bark scales on the upper side of branches. Occasionally, they are deposited on the main stem up in the crown. The incubation period lasts 12–18 days. The duration of the larval stage is at least 2 years. At maturity the larva tunnels out to within 1 to 3 cm of the surface and constructs a pupal cell. The pupal site is often several centimetres out into a limb, but it is also near scars at the base of the tree or in the main stem up in the crown. Pupation takes place in late summer and requires about 20 days. The beetle stays in the pupal cell from September to May of the following year.

BYRRHIDAE pill beetles

Larvae of this family are, as far as we know, plant feeders that live in soil and feed on mosses, liverworts, lichens, and grass roots. Few species, if any, are of economic importance. Pill beetles are almost restricted to temperate or arctic areas of the northern and southern hemispheres. There are about 300 species known, of which about 36 occur in Canada.

Byrrhus americanus LeConte
byrrhe pilule (m.)

Distribution: Alberta, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Labrador.

Economic injury: Larvae of *Byrrhus americanus* were moderately abundant in New Brunswick and Nova Scotia, but injury was noticeable only when pulling up bits of turf (CIPR 1936).

Cytilus alternatus Say
(pill beetle)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Northwest Territories, and Yukon Territory.

Economic injury: Lindquist and Ingram (1968) reported an unusual infestation of *C. alternatus* that injured red pine seedlings at the Provincial Forest Nursery at Gogama in northern Ontario. The infestation was limited to a low-lying area with dense moss cover and resulted in killing approximately 50% of seedlings in an area covering almost 10 m^2. The dead seedlings were removed by the time the first larvae were detected on 24 July. After this, light mortality was noted until 28 August. The larvae apparently feed on the roots or root collar, and the damage caused the seedlings to turn yellow and then brown. The injured seedlings were readily lifted from the ground. Because the insect appears to prefer wet, moss-covered locations, it is not likely to pose a serious threat to forest nursery stock in Ontario. On the other hand, as the dark gray larvae are difficult to detect and their feeding is not obvious, the species may be more widespread and injurious than is currently known.

Biology: Based on the study by Lindquist and Ingram (1968), the larvae are found in Ontario throughout most of July and early August. They apparently prefer wet, moss-covered sites and live on or in the soil under the moss. When disturbed, they curl up into a ball and remain immobile. The larvae pupate in the soil in August, and the new adults begin to appear toward the latter part of the month. The adults retract their appendages against their bodies when disturbed and feign death. They were observed throughout the nursery until late fall.

BYTURIDAE fruitworm beetles

Both larvae and adults of the genus *Byturus* feed on plants of the genus *Rubus*. There are only about 25 species known in this family from North America, Eurasia, and the Greater Sunda Islands. Only one species is known to occur in Canada.

Byturus unicolor Say
raspberry fruitworm (eastern raspberry fruitworm, western raspberry fruitworm)
byture des framboises (m.) (byture du Pacifique (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland, Yukon Territory, and Northwest Territories.

Economic injury: According to Chamberlain and Putnam (1964) and Schaefers et al. (1978), *B. unicolor* is a serious pest of raspberry, blackberry, and loganberry. The adults skeletonize the young leaves, destroy the blossom clusters, and eat holes in the expanding blossoms, often chewing through the calyx and eating the bud contents. The larvae feed within the flower buds and developing fruit, where they feed primarily on the torus. In raspberries, the larvae are found between the berry and the receptacle. Larval attacks on the carpels cause damaged tissue in which fungi can develop (Mundinger 1948). Considerable damage is caused to the fruit by the larvae and may result in premature drop. The larvae, which usually remain in the torus during handpicking, may contaminate the fruit during mechanical harvesting.

Biology: Cram and Neilson (1978) described the life history of the species in British Columbia, and Mundinger (1948) in New York State. Adults of this species overwinter in the soil and emerge in late April and early May to begin feeding on the new leaves, blossoms, and berries. Single eggs are commonly laid along the tips of the sepals on the enlarged blossom buds and later on the green berries (Chamberlain and Putnam 1964). Upon hatching, the larvae enter the blossoms or young berries and feed on the fruit receptacles. Larvae mature about the middle of July and then drop to the ground, where they pupate in cells in the soil. Transformation to the adult stage takes place in late summer, but the adults remain in the pupal cells until the following spring. Only one generation is produced per year.

Comments: This species was recently studied by Springer and Goodrich (1983), who placed the eastern raspberry fruitworm, *Byturus rubi* Barber, and the western raspberry fruitworm, *Byturus bakeri* Barber, in synonymy with *Byturus unicolor* Say.

CARABIDAE **predaceous ground beetles and tiger beetles carabes (m.)**

Most adults and larvae of this family are active predators, but a few species have become adapted to plant feeding. This family contains about 30 000 species and is well represented in all faunal regions. About 900 species occur in Canada.

Clivina fossor (Linnaeus)

Distribution: British Columbia, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Origin: This European introduction was first found in eastern Canada in 1915 (Lindroth 1961).

Economic injury: The species has been reported to attack corn seeds in British Columbia (CAIPR 1975). It is also known to be a pest of strawberry in Europe (Lindroth 1945).

Biology: In North America, this carabid is often found in parks and gardens on cultivated, usually clayish soils (Lindroth 1961). According to studies conducted in Belgium (Desender 1983), adults are most abundant during May. First-instar larvae are prevalent during July and August. Second- and third-instar larvae can be found from August throughout the winter. The species may overwinter either as larvae or adults.

Clivina impressifrons LeConte
slender seedcorn beetle (slender seedcorn ground beetle)

Distribution: Southern Ontario and Quebec.

Economic injury: This ground beetle is reported to attack seed corn in Ontario (CAIPR 1969, 1971, 1972; Wressel 1970). The beetle, however, only attacks the corn during cold, wet springs, when germination is delayed and growth is slow (CIPR 1958). According to Phillips (1909), the insect attacks corn as soon as it is planted and starts to germinate. The germ of the seed is consumed, leaving only the empty hull. As many as five beetles have been reported to feed on a single kernel. The young plants occasionally push through the soil surface only to die later because of the destruction of the kernel or an inadequate root system. Damage to seeds by this species, and subsequent failure to germinate, is often attributed to excessive moisture, cool weather, or inferior seed.

Biology: Phillips (1909) made observations on the life history and ecology of the species in Ohio. Larvae, pupae, and adults were found throughout the summer. It is probable that the eggs are deposited below the soil surface, although oviposition was not observed. Dissected females contained a maximum of three or four mature eggs from early spring to late summer. Larvae in confinement fed on a variety of small larvae and on pupae of other ground beetles, as well as on their own species. Larvae and pupae were found at depths of a few centimetres to 60 cm, depending on the moisture content of the soil. Pupation took place in an oblong earthen cell and lasted 9–10 days. Hibernation occurs in the adult stage. The preferred habitat for this species appears to be low, swampy, peaty soils with a high moisture content.

Harpalus rufipes (De Geer)
(strawberry seed beetle)

Distribution: Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This Palaearctic species is a fairly recent introduction into North America. It has been known in Prince Edward Island since 1937, Nova Scotia since 1938, New Brunswick since 1939, Quebec since 1941, and Newfoundland since 1949 (Lindroth 1968).

Economic injury: The adults and larvae of this species, although partly carnivorous, are known to be important pests of strawberry (Hinton 1941). In Canada, reports vary from occasional injury (CAIPR 1970) to severe damage (CAIPR 1978). Usually only the endosperm of the strawberry is eaten, and the husk is rejected (Briggs 1965). Adults have also been known to seriously damage raspberry crops and young plants and seeds in tree nurseries (Hinton 1941). Although the species is not considered an important pest of stored products, adults and larvae have also been reported to feed on bread and uncooked flour (Hinton 1941). Morrison (1941) reported an infestation in a house in Nova Scotia where these beetles were numerous and troublesome but caused little damage.

Biology: The biology of *H. rufipes* has been described in Great Britain (Briggs 1965). Oviposition occurred from the second or third week in July and continued until September or early October. In captivity, 19 females laid an average of 84 eggs. Egg-laying periods varied from 38 to 78 days, with a mean of 57 days. Observations in the field revealed eggs in groups of one to four near the surface of weedy soils. The incubation period in the laboratory varied from 14 to 21 days, depending on temperature.

The species has three larval instars, and larval development required more than 1 year. The earliest first-instar larvae were found in late August, and the earliest second instars were observed from the end of August to the end of September. Third-instar larvae were not observed until April, but they predominated by May. In the laboratory, few larvae molted below 10°C. This finding supports the contention that no molting took place from November to April in the field. In August to December, some first- and second-instar larvae were active on the soil surface. In August, all larvae were within the top 15 cm of soil. By March and April the majority of larvae were below 15 cm, with some as deep as 46 cm. It was at these depths that pupation occurred in July and August. In the laboratory the pupal period lasted 12–22 days.

Teneral adults were observed from early July to early June the following year. Some of the earliest emerging females laid eggs the same year, but most did not oviposit until the year following emergence, and some laid eggs again the next year. Adult longevity was thought to be more than 2 years. High temperatures were found to increase adult activity, which started in early April and declined in early October, with peaks in June and August. An analysis of summer habitat distribution showed that adults were more abundant in grassy situations than in weedy arable land or strawberry beds during the fruiting season. Overwintering adults were all at depths of 10–20 cm in the soil, usually in grassy situations.

The proctotrupid *Proctotrupes gladiator* Haliday and the parthenogenetic braconid *Microctonus caudatus* (Thompson) are parasites of this species (Luff 1976). Hinton (1941) listed a fly, *Viviania cinerea* Fallén, and a nematode, *Gordius harpali-ruficornis* Diesing, as additional parasites of this species.

Nomius pygmaeus (Dejean)
stink beetle
carabe pygmée (m.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, Nova Scotia, and Northwest Territories.

Economic injury: This species, when attracted by lights, may fly into houses where it becomes a nuisance by giving off a strong, fetid odor (Lindroth 1961) when crushed or excited (Gibson and Twinn 1939). Individuals may render a room uninhabitable for weeks, with the smell persisting for months (Spencer 1953). Forest fires have been cited as being responsible for driving this beetle out of forests in Ontario (MacNay 1955) and British Columbia (Spencer 1953).

Biology: This beetle is a forest species and is absent from the prairie. Specimens have been collected under bark (Lindroth 1961).

Stenolophus lecontei (Chaudoir)
seedcorn beetle
carabe du maïs (m.)

Distribution: Ontario, Quebec, and Nova Scotia.

Economic injury: Both adults and larvae of this species have been reported damaging corn seed in Ontario (MacNay 1954*b*, CIPR 1957, Wressell 1970). This injury only occurs when seed of low vitality has been planted or when cold weather delays germination (Metcalf et al. 1962).

Biology: According to Lindroth (1968), the natural habitat of this species is probably on sand or clay near water. This carabid probably overwinters as an adult.

CERAMBYCIDAE long-horned beetles or timber beetles longicornes (m.)

Species of this family are all plant feeders. Most larvae are wood borers living in roots, trunks, limbs, and stems of trees and shrubs. Other species feed on herbaceous plants. Adults are often found feeding on nectar or pollen of flowers. This family of Coleoptera is one of the most destructive to the forest products industry and to orchards. Species of the family are known from all faunal regions except arctic and alpine tundra, but they are best represented in the wet tropics. About 35 000 species are known, of which approximately 380 occur in Canada.

Arhopalus productus (LeConte)
new house borer

Distribution: British Columbia, Alberta, Saskatchewan, and Northwest Territories.

Economic injury: In British Columbia, larvae and emerging adults riddled four buildings that were constructed from timber from fire-scorched trees (Spencer 1954).

Callidium cicatricosum Mannerheim (*subopacum* Swaine)

Distribution: British Columbia and Yukon Territory.

Economic injury: *Callidium cicatricosum* emerged from logs of a cabin in Kamloops, B.C. (MacNay 1959).

Callidium violaceum (Linnaeus)
(wood borer)
callidie violacée (f.)

Distribution: Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Economic injury: This species infested the timbers of a building in Ontario (MacNay 1955) and seriously damaged a house in Newfoundland (MacNay 1958). *Callidium violaceum* has also been reported to occur in buildings in Newfoundland (CAIPR 1973, 1976–1978).

Desmocerus palliatus (Förster)
(elder borer, cloaked knottyhorn, elderberry borer)
desmocère à manteau (m.)

Distribution: Ontario, Quebec, and Newfoundland.

Economic injury: *Desmocerus palliatus* has been reported as plentiful in Newfoundland (CAIPR 1978) where it attacked elderberry shrubs (CIPR 1962 (first record); CAIPR 1976, 1977) and golden alders (CAIPR 1973). A heavy infestation of elder trees was noted in Quebec (CIPR 1960), and in Ontario the insect was observed on common alder and the flowers of swamp elderberry (CIPR 1958).

Elaphidionoides villosus (Fabricius)
twig pruner (oak twig-pruner)
coupe-rameau du chêne (m.)

Distribution: Manitoba, Ontario, and Quebec.

Economic injury: According to Swaine and Hutchings (1926), *E. villosus* is often numerous in eastern Canada, pruning the twigs of oak. Maple, hickory, locust, basswood, redbud, and even poison-ivy are additional hosts (Gosling 1981). The young larvae tunnel under the bark and later into the centre of the twigs. The twigs are so weakened by this damage that they readily break off during a windstorm. The injury is potentially serious when many twigs have fallen off (Swaine 1914).

Biology: The eggs are deposited in midsummer on the smaller branches of the host plant (Swaine and Hutchings 1926). Adults are active from mid June through July. In Michigan the species has a 2-year life cycle, with adults present only in odd-numbered years (Gosling 1981).

Comments: Gosling (1981) states that most of the damage attributed to this species is actually done by a related species, *Elaphidionoides parallelus* (Newman).

Glycobius speciosus (Say)
sugar maple borer
perceur de l'érable (m.)

Distribution: Ontario and Quebec.

Economic injury: Swaine and Hutchings (1926) reported the species as a common enemy of sugar maple in eastern Canada. Infestations have been as high as 60 and 75% and have resulted in the death or severe weakening of some trees (Hutchings 1925, 1926). The injury is caused by larvae that tunnel in the inner bark and sapwood (Swaine and Hutchings 1926). The shallow larval tunnels usually slant upwards and often measure over 0.6 m long and 2 cm wide at their end (Hutchings 1925, Swaine and Hutchings 1926). Infested branches or trunks are more or less completely girdled and either severely weakened or killed. Injury caused by the young larvae in the fall may be indicated by protruding sawdust and that of the older larvae by unsightly scars (the bark above the tunnels becomes detached and falls off, exposing the tunnel scars beneath). After pupation, the adult emerges through an oval hole in the bark about 13 mm in diameter.

Biology: Hutchings (1925) reported that young larvae overwinter in the bark. Larval development requires 2 years, during which time the tunnels are continuously widened (Maheux 1922). A pupal cell is made near the corky tissue by the mature larva at the approach of winter. The adults appear in June and July and lay their eggs in midsummer in slits in the trunk or branches of apparently healthy sugar maple trees (Swaine and Hutchings 1926). Maheux (1922) reported the incubation period to be several days.

Gracilia minuta (Fabricius)

Distribution: Ontario and Quebec.

Economic injury: Monro (1935) reported this insect to be very destructive to basket-making and related industries. It has destroyed baskets and mannequins made of wicker and stored in warehouses. *Gracilia minuta* has been found to infest packing materials entering the port of Montreal. Adults and pupae were detected in hoops of willow on a cask of china from Stoke-on-Trent, England. The species occurs most commonly on willow and apparently only attacks dying or recently cut parts of a tree. It is of little importance as a forest insect.

Hylotrupes bajulus (Linnaeus)
old house borer
perceur du vieux bois (m.)

Distribution: Ontario.

Origin: According to Robinson and Cannon (1979), the old house borer was probably introduced into the United States about 200 years ago in wood from England or western Europe. Adults were collected as early as 1875 in Pennsylvania. Moore (1978) stated that the species is thought to have originated in North Africa.

Economic injury: Moore (1978) and Robinson and Cannon (1979) described the economic injury of *H. bajulus*. The species is an important structural insect pest in the eastern United States. The old house borer may spoil the appearance of wood, and when neglected for some time under optimum conditions, may seriously weaken structural timbers. Reinfestation beyond the first generation is rare in centrally heated, well-ventilated occupied dwellings. However, under sufficiently humid conditions, repeated reinfestations may occur causing serious damage. The insect is most often found in wood framing in crawl spaces, basements, and storage areas in the southern portion of the beetle's range and in attic framing in the northern areas. Contrary to its name, the old house borer usually occurs in houses less than 10 years old. An August mean temperature of about 23°C might be a useful criterion for predicting the future distribution of the insect in North America. Although *H. bajulus* occurs in barns, fence posts, and rustic buildings, it has not as yet been detected in unprocessed logs or in stumps in the United States.

The larvae cause damage by feeding on the sapwood portions of well-seasoned or relatively unseasoned softwood timber (pine, fir, and spruce). Newly hatched larvae bore into the wood a short distance and then begin tunneling parallel to the wood grain. Injury is greatest in the outermost sapwood of new wood because of its higher protein content. Pine is more often attacked because it usually has a higher protein content than spruce or fir. The heartwood is not attacked. Larvae are capable of digesting wood-cell walls (primary cellulose) as well as the cell contents (mostly starches, sugars, and proteins) and attack wood that has been decayed by fungi. There are virtually no signs of infestation during the early stages of attack. After 2–3 years, however, the larvae are large enough that the rhythmic ticking or rasping sound made by the larvae feeding can be heard from a distance of 1 m. The tunnels, which are packed with powdery frass, are oval in cross section and may be up to 9 mm in diameter. Although infested wood may be severely tunneled, the larvae seldom break through the surface. As virtually all the sapwood may be reduced to powdery frass, the extent of structural damage depends on the proportion of sapwood to heartwood.

The adult emergence holes, through which frass may be expelled, are oval and range from 6 to 12 mm in diameter. Moore (1978) stated that these exit holes are made by adults, but Robinson and Cannon (1979) reported them to be the work of larvae. When emerging, adults may bore through such building components as hardboard, plywood, siding, trim, plasterboard, hardwood flooring, and ceramic tile.

Biology: The following account of the life history of the old house borer is taken from Moore (1978) and Robinson and Cannon (1979). The insect overwinters in the larval stage, during which time there is a decline in feeding activity. In the spring, feeding becomes more regular, and after a short time the older larvae construct pupal cells in the tunnel below the future exit hole. Pupation requires from 3 to 6 weeks, after which the adults remain in the wood for several days to many weeks before emerging. In the southern area of the insect's range, adults may be observed in flight from April to October and in the northern areas from June to September. The greatest adult activity is during the daytime, at temperatures between 25 and 35°C. Mating begins soon after emergence and occurs frequently during the female's life span. Several (from two to five) batches of eggs are deposited in cracks, crevices, or between two surfaces of wood. Higgs and Evans (1978) noted that egg-laying behavior is mediated by pheromones produced in the frass of the larvae. Stacks of lumber and houses that are being built provide ideal oviposition sites as opposed to painted or otherwise finished wood surfaces, which are not attractive for oviposition. Robinson and Cannon (1979) reported an average fecundity per female of about 175 eggs, with as many as 256 recorded, but Moore (1978) reported an average of 40–50 eggs per female, with a maximum of 150–200 eggs. Under ideal conditions, adult longevity is about 15 days. The incubation period is 9 days to 2 weeks.

Larval development is rather slow during the first year, and from 3 to 6 years are usually required to complete their development. Under optimum conditions, the period may be as short as 2 years – air temperature 29.4–31.1°C, RH 80–90%, wood moisture content 10–12% (Robinson and Cannon 1979) or 15–25% (Moore 1978), and high nutrient content of the wood – and may extend to more than 10 years under unfavorable conditions (e.g., from 12 to 15 years may be required to complete one generation in very dry wood such as in attics).

Leiopus alpha (Say)

Distribution: Ontario and Quebec.

Economic injury: This species is said to breed in apple (Wickham 1898).

Megacyllene robiniae (Förster)
locust borer
cyllène du robinier (f.)

Distribution: Ontario, Quebec, and Nova Scotia.

Economic injury: The locust borer attacks primarily black locust and may cause severe damage (Metcalf et al. 1951, Goble 1969*a*, Wollerman et al. 1969). Hutchings (1917) described the insect as the worst enemy of black locust, with very serious injury occurring throughout Ontario and Quebec. Its attack is insidious, and considerable damage is frequently done before the injury is even noticed. Reports of injury by *M. robiniae* in the literature include the following: caused frequent injury to black locust (or acacia, as it is sometimes called in eastern Canada) (Swaine and Hutchings 1926); heavily infested ornamental black locust in Quebec (MacNay 1959); caused serious injury to a grove of honey-locust trees in Ontario (CAIPR 1970); and has been common and injurious in Nova Scotia (CAIPR 1978). In the eastern United States, Metcalf et al. (1951) reported it to be so numerous as to prevent profitable growing of the black locust. Black locusts are more likely to suffer severe injury when growing in the open (Metcalf et al. 1951, Goble 1969*a*). Trees that grow rapidly escape serious injury.

The damage is caused by larvae that burrow through the bark, sapwood, and heartwood (Metcalf et al. 1951, Goble 1969*a*). The burrows, which are sometimes 1.3 cm in diameter, are irregular in direction and extend upward from the point of entrance (Swaine and Hutchings 1926, Metcalf et al. 1951). They may be so numerous in the trunks as to markedly degrade the value of black locust timber (Wollerman et al. 1969). Young locust trees may be either killed by girdling or so weakened that they frequently break over during a wind. Continuous attack, in spite of profusive sprouting by roots and lower trunks, may severely limit growth. Bethune (1899) stated that trees usually survive, although the branches and limbs of older trees may be so perforated that they break off during violent storms. Injury may be indicated by badly distorted trunks and branches, by swollen areas on the trunk with bark that is often cracked open, by discolored and blackened wood in and around the exposed burrows, and by frass extruding from the injured areas (Swaine 1914, Swaine and Hutchings 1926, Metcalf et al. 1951).

The beetles feed on the pollen of goldenrod and a few other allied plants (Metcalf et al. 1951, Goble 1969*a*).

Biology: The insects overwinter as very small larvae in cells within the inner bark or barely to the sapwood (Metcalf et al. 1951, Hutchings 1917). They resume feeding in the spring and reach maturity about midsummer, at which time they excavate a pupal chamber in the wood (Metcalf et al. 1951). Most of the insect's life is spent in the larval stage, with about 167 days spent in the inactive winter stage and about 137 days in the active stage (Wollerman et al. 1969). In laboratory rearings the larvae lived for an average of 60 days (range, 41–115) and pupated in an average of 13 days (range, 5–17). Hutchings (1917) reported that after pupation, the adult escapes by chewing its way through the frass plug at the outer end of the resting cell. Adult emergence takes place in late August and September (Goble 1969*a*).

The new adults are quite active and fly readily from tree to tree (Metcalf et al. 1951). The adults feed, mate, and deposit their eggs singly in crevices in the bark of the black locust in sunny locations during late August and September (Metcalf et al. 1951, Goble 1969*a*, Wollerman et al. 1969). Although feeding does not influence the number of eggs laid, it does increase the adult's life span (Wollerman et al. 1969). Adults reared in the laboratory lived for an average of 34 days (range, 14–55), but those emerging from pupae collected in the field and fed fresh goldenrod survived for a maximum of only 15 days. Eggs hatched in 7–10 days (range, 4–14), and the period from egg to adult varied from a minimum of 50 to a maximum of 143 days (Hutchings 1917, Metcalf et al. 1951, Wollerman et al. 1969). The newly hatched larvae bore quickly into the bark (Goble 1969*a*). Only one generation is produced each year.

Meriellum proteus (Kirby)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Labrador, Northwest Territories, and Yukon Territory.

Economic injury: This insect emerged from new lumber in a house in Saskatchewan (CIPR 1964).

Monochamus carolinensis (Oliver)
(Carolina sawyer)
longicorne de la Caroline (m.)

Distribution: Ontario and Quebec.

Economic injury: This wood borer occurred in two dwellings and an office building in Ottawa, Ont. (MacNay 1948).

Monochamus notatus (Drury)
northeastern sawyer
longicorne gris (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, Prince Edward Island, and Northwest Territories.

Economic injury: MacNay (1948) reported that this wood borer occurred in a new dwelling in Ottawa, Ont.

Monochamus scutellatus (Say)
whitespotted sawyer
longicorne noir (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Labrador, Northwest Territories, and Yukon Territory.

Economic injury: *Monochamus scutellatus* emerged from a timber in a newly built home at Mount Pearl, Nfld. (CAIPR 1974). The species has also been reported from Saskatchewan (CIPR 1964).

Neoclytus muricatulus (Kirby)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Northwest Territories, and Yukon Territory.

Economic injury: This wood borer was detected in a dwelling at Pembroke, Ont. (MacNay 1948).

Oberea affinis Leng
(common cane borer)
anneleur commun (m.)

Distribution: Ontario, Quebec, and New Brunswick.

Economic injury: *Oberea affinis* is a common pest of wild and cultivated raspberry and blackberry as well as some species of thimbleberry and rose in Ontario and New Brunswick (MacNay 1948, 1949, 1951–1953; CIPR 1954, 1955, 1958, 1960). In one instance in New Brunswick a general infestation approached epidemic proportions (MacNay 1950). According to CIPR (1954), dead canes indicate the presence of larvae and ringing of cane tops the presence of adults.

Biology: Larvae live for at least 2 years (as they are often found in the second-year stages in the host plant), and adult emergence appears to be synchronized to every second year during even-numbered years (CIPR 1960). Oviposition occurs in rings in the canes.

Comments: In the only record from Quebec, the insect was reported as the raspberry cane borer in raspberry plantations (CAIPR 1969).

Oberea bimaculata (Olivier)
raspberry cane borer
anneleur du framboisier (m.)

Distribution: British Columbia, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: *Oberea bimaculata* is a serious pest that attacks wild and cultivated raspberry, blackberry, and rose (CIPR 1930, Petch 1931, Ross and Caesar 1931, Twinn 1932*b*, MacNay 1952, CAIPR 1978). Infestations on raspberries and blackberries have ranged from 30 to as high as 50% (Petch 1931, CIPR 1932, MacNay 1952). Hearle and Davidson (1928) reported a serious attack in loganberry plantations on Vancouver Island, B.C. The species was reported to cause important damage in Quebec (Davidson and Lyon 1979). The insect has also been reported on several species of wild thimbleberry (CIPR 1931) and on strawberry (Rivard et al. 1973, Paradis et al. 1979).

Damage results from the females girdling the tips of young shoots about 6 mm above and 6 mm below an egg puncture (Davidson and Lyon 1979), causing the tip of the shoot to wilt and die. The larva bores down the cane, which is entirely destroyed by the time the larva reaches the base (Brittain and Pickett 1933).

Biology: The species overwinters in the larval stage in the cane just below the point of girdling (Davidson and Lyon 1979). In the next season the larvae continue to bore in the cane until they reach the crown, where they spend the second winter at or below ground level. Pupation occurs in the spring, and the new adults begin emerging in June. The females then fly to young shoots (Gibson 1928) and deposit their eggs near the tip and girdle the cane as previously described (Davidson and Lyon 1979). Other workers have reported that the female first girdles the cane and then deposits the egg (Saunders 1873*a*, Swaine 1909*a*, Gibson 1928, Brittain and Pickett 1933). In southwestern Quebec the beetles have been observed on new shoots as early as the end of June, with oviposition continuing until the beginning of August (Rivard et al. 1975, Paradis et al. 1977). According to Davidson and Lyon (1979), the adults may be present until late August. The eggs hatch in a few days, and the larvae bore down into the cane several centimetres, before overwintering (Brittain and Pickett 1933). The life cycle of the raspberry cane borer is 2 years (CAIPR 1976, Paradis et al. 1977, Davidson and Lyon 1979).

Oberea rufficollis (Fabricius)

Distribution: Ontario and Quebec.

Economic injury: According to the CIPR (1936), adults of this species are injurious to wild and cultivated raspberry.

Biology: The main flight of the adults occurs every second year (CIPR 1936).

Oberea tripunctata (Swederus)
dogwood twig borer

Distribution: Ontario, Quebec, and New Brunswick.

Economic injury: According to Swaine (1911), the dogwood twig borer has occurred in large numbers in New Brunswick and causes damage to apple twigs similar to that caused by *O. bimaculata* to raspberry canes. Bethune (1877) reported that the species (as the raspberry borer) attacks all varieties of raspberry. The female makes two girdles 1.3 cm apart and about 15–18 cm from the top of the young shoot and lays an egg between the two girdles, which causes the tops to wilt and die. The larva burrows downward, causing the destruction of the cane.

Biology: The adults may be observed in July and the beginning of August (Bethune 1877). The female deposits her egg in between the two girdles and the egg hatches in a few days.

Oncideres cingulata (Say)
twig girdler
anneleur des rameaux (m.)

Distribution: Ontario and Quebec.

Economic injury: Twigs of hickory, persimmon, oak, poplar, sour gum, honey-locust, pear, apple, plum, linden, elm, and other deciduous shade, fruit, and nut trees are girdled by this species (Wickham 1898, Metcalf et al. 1951). The adult girdles twigs (8–19 mm in diameter and about 1 m or so in length) by cutting round and round them from the bark inward (Metcalf et al. 1951).

Opsimus quadrilineatus Mannerheim

Distribution: British Columbia.

Economic injury: *Opsimus quadrilineatus* emerged in great numbers from the logs of a cabin in British Columbia (Spencer 1958). The larvae bore into the wood and cut oval holes to the surface at maturity. The insect mainly attacks the curved surfaces of varnished and unvarnished posts and logs. Log houses that are heavily shaded are preferred to those in the open.

Biology: The adults are quite active and fly freely around a house by day and by lamplight (Spencer 1958). Females oviposit in their old tunnels and in those of the golden buprestid. The larva burrows into the wood, throwing out much frass. At maturity, it cuts an oval hole to the surface, throws out a cascade of sawdust, and then retires backward to pupate in the tunnel.

Phymatodes dimidiatus (Kirby)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Yukon Territory.

Economic injury: This wood borer infested logs in a cabin near Kamloops, B.C. (MacNay 1960). Adults emerged in numbers in late April from upright cedar posts of a dwelling in Camp Listor, B.C. (Leech 1944). Some got into the house by chewing through tarred building paper and gypsum wallboard, and others went outward through the shingles. It was thought that the timbers were infested before building.

Prionus californicus Motschulsky

Distribution: British Columbia.

Economic injury: Linsley (1962) reported that this species feeds primarily on the roots of living deciduous trees including apple, peach, cherry, and other fruit trees as well as oak, madrone, and cottonwood. Trees may be completely girdled just below ground level. Mature larvae are about 7 cm long and 2 cm in diameter, and as many as 22 have been found attacking a single apple tree.

Biology: When fully grown, the larvae leave the roots and enter the soil, where they construct pupation chambers 8–15 cm below the surface. Pupation may take place in old logs or stumps. The adults emerge in early summer. The females normally deposit 200–300 eggs, but may deposit up to 600. Three to five years are normally required to complete the life cycle (Linsley 1962).

The sarcophagid *Helicobia rapax* Walker has been reared from an adult female (Linsley 1962).

Prionus imbricornis (Linnaeus)

Distribution: Ontario.

Economic injury: Larvae have been reported to infest the roots of grape, pear, oak, and chestnut as well as some herbaceous plants, including corn (Linsley 1962).

Biology: Females deposit from 100–200 eggs in groups around the base of trees. Upon hatching, the larvae feed in the bark and then penetrate and hollow out the roots. The larval period lasts at least 3 years. Just before pupation, the larvae leave the roots and construct large, oval pupal cells within a few centimetres of the soil surface. Adults are active from June to September (Linsley 1962).

Prionus laticollis (Drury)
broadnecked root borer
perceur des racines (m.)

Distribution: Ontario and Quebec.

Economic injury: According to Benham and Farrar (1976), the broadnecked root borer causes economic damage to apple orchards in the eastern United States. Lyne (1911) reported larvae in the roots of ornamental and fruit trees in British Columbia that had come from the United States and Japan. *Prionus laticollis* attacks the roots of many trees and shrubs including apple, grape, linden, oak, pine, poplar, aspen, blackberry, cherry, chestnut, dogwood, maple, and rhododendron (Farrar and Kerr 1968).

Injury results from larval feeding; adults have not been observed to feed on either foliage or roots (Benham and Farrar 1976). The larvae bore through the bark into the interior wood of living, weakened, or dead roots of apple trees. The roots may be girdled, or the tunnels may penetrate into the wood or extend along the exterior of the root in the bark. The larvae may sever roots up to 7.6 cm in diameter. Damage to trees resembles that of nutrient deficiency, in which the leaves may be smaller and less numerous and have a yellow tinge. In severe attacks, the tree can be pushed back and forth by hand because of severe root pruning. The roots closest to the base of the trunk suffer the most frequent damage, and the more mature larvae are most often found in the root crown and in the larger roots near the crown. The larvae are thought to prefer decaying roots of trees weakened from other causes.

Biology: The life history of the broadnecked root borer is described under Rhode Island conditions by Farrar and Kerr (1968), Benham (1969), and Benham and Farrar (1976). The species overwinters as second- or third-instar larvae, depending on time of hatching. Larvae have been recovered at depths averaging 30.5 cm (range, 5–84) in the soil and at distances averaging 35.5 cm (range, 0–104) from the base of the stumps. Under ideal conditions, an estimated 3–4 years are required to complete larval development. The number of instars is unknown, although eight are estimated. The prepupae are believed to form earthen pupal cells during late May and early June at depths of up to 25 cm in the soil and within 92 cm of apple trees with decaying roots. A field-collected prepupa remained unchanged for 6 days before pupating on the seventh day. Pupae usually occurred in an earthen cell at an average soil depth of 10 cm (range, 2–25) and an average distance of 31 cm (range, 0–84) from the base of apple tree stumps with decaying roots. Pupae were collected between 20 June and 11 July. The stage required about 4 weeks.

Adults were observed above ground from the latter half of June to early August. They were collected in the soil at an average depth of 15 cm (range, 5–33). Although males fly readily, females were never observed in flight. A female-to-male sex ratio of 5.9:1 was reported for a total of 242 specimens collected in 2 years. In soil collections, however, the ratio was approximately 1:1. Adults apparently do not feed, as indicated by a high degree of atrophy in the digestive tract. The beetles mate several times, and eggs are usually deposited singly in the soil at a depth of between 1–4 cm (the ovipositor is extended into the soil to a depth of 4 cm in a series of pulsing motions). Eggs are occasionally found on the surface. The female usually lays one egg at a time, but from two to ten eggs are frequently deposited in groups held together by an adhesive material. The average number of eggs deposited by 61 field collected females was 190, although one newly mated female deposited an average of 106.5 eggs per day over an 8-day life span. In an earlier report, an average of 388 eggs were laid by 15 females. Adult longevity is approximately 1 week. The incubation period lasted more than 55 days at 15.6°C, 21.3 days at 21.1°C, and 18.8 days at 26.7°C. Newly hatched larvae spend about a month in the first instar.

Tachinid flies (near *Dexilla*) were reared from prepupae.

Psenocerus supernotatus (Say)
(American currant borer)

Distribution: Manitoba, Ontario, and Quebec.

Economic injury: *Psenocerus supernotatus* has, in many instances, proved quite injurious to cultivated varieties of currant (Saunders 1880). According to Swaine (1910), the species breeds in currant canes but is usually found in Virginia creeper and climbing bittersweet.

The larvae burrow into the heart of the stems and feed on the pith (Saunders 1880). The damage may extend through the whole length of the stalk, resulting in its death.

Biology: Saunders (1880) reported that the species overwinters in the larval stage in dead stalks. The female lays her eggs on the currant stalks early in June. The eggs soon hatch, and the larvae reach maturity before the end of the season. Pupation takes place in a chamber constructed at the end of a tunnel next to the outer bark. The beetle escapes by chewing a small, round hole through the bark.

An ichneumonid wasp and a small fly were reported as parasites of the larval stage (Saunders 1880).

Pygoleptura nigrella (Say)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, Newfoundland, Labrador, and Northwest Territories.

Economic injury: MacNay (1950) reported that this insect cuts holes in wallboard in dwellings in Montreal, Que.

Saperda bipunctata R. Hopping
saskatoon borer

Distribution: Saskatchewan and Manitoba.

Economic injury: MacNay and Creelman (1958) reported this species as a pest of apple in Manitoba.

Saperda calcarata Say
poplar borer
saperde du peuplier (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Prince Edward Island, Northwest Territories, and Yukon Territory.

Economic injury: *Saperda calcarata* is the most destructive wood borer of poplar (Metcalf et al. 1951, Drouin and Wong 1975). Swaine (1913) reported this insect to be widely distributed in Quebec and responsible for the death of many ornamental poplars. In Ontario, more than 25% of the aspen trees in a woodlot near Berwick were killed (Caesar et al. 1930). Cottrell (1962) noted extensive damage in open growing stands of trembling aspen in British Columbia; in most infestations, however, only a few trees were killed. Trembling aspen has also been reported as the principal host of this species in the parkbelt areas of Saskatchewan and in the Great Lakes states (Peterson 1948, Drouin and Wong 1975). According to Metcalf et al. (1951), the poplar borer is most injurious to Carolina poplar, cottonwood, aspen, and Lombardy poplar, but it also attacks other species of poplar and willow. Damage is more severe in smaller, isolated stands of aspen than in larger, continuous-forest stands (Peterson 1948). Infestations of natural stands are usually localized around the margins and only penetrate into the stands where the trees are scattered or openings occur. Characteristic of older poplar borer infestations is the occurrence of "brood trees," trees that are usually larger than the average in a stand and in a favorable location for oviposition. Cottrell (1962) also stated that trees on the perimeter of pure stands suffer more damage and noted that a preference is shown for trees in the 12.7–20.3-cm diameter breast high class. Drouin and Wong (1975) reported balsam poplars 5–18 years old, 45.7–2.7 m high, and 1.3–6.3 cm in basal diameter to be most susceptible to attack.

The larvae burrow through the bark, sapwood, and heartwood (Swaine 1914, de Gryse 1925, Peterson 1948, Drouin and Wong 1975). Swaine (1914) stated that the larvae burrow through the trunk in all directions and have been taken from the heartwood of the largest poplars. There may be many large burrows (as large as 2.5 cm in diameter), with openings through the bark of the trunk and large branches (Metcalf et al. 1951). Such burrows may kill or severely damage branches and the tops of trees (deGryse 1925, Swaine and Hutchings 1926). According to Peterson (1948), the larvae tunnel at an upward angle through the sapwood to the heartwood. The burrows turn abruptly along the heartwood, and when penetration is below a branch, they frequently continue along the heartwood of the branch rather than rising vertically along the heartwood of the trunk. One or more tunnels may extend as far as 30 cm above the ground or 20 cm below the ground into the main root in the heartwood of balsam poplar (Drouin and Wong 1975). Poplar borer damage usually does not kill the host, but the burrows increase the frequency of attack by diseases and secondary insects. Swaine and Hutchings (1926) indicated that extensive borings destroy much of the bark, allowing injurious fungi to enter; deGryse (1925) reported a wood rot as one of the main causes of the rapid death of infested trees, the disease becoming established in the burrows and killing the heartwood. Infested trees may also be so weakened that branches or the main trunk break off during high winds (Metcalf et al. 1951). Larval tunneling may ruin wood for lumbering purposes (deGryse 1925).

The adults attack the foliage, petioles, and bark of tender twigs of poplar and willow (Peterson 1948). They make horizontal cuts, one above the other, on the petioles and twigs. The insects eat the midribs and edges of leaves and occasionally chew jagged holes in the leaves.

Biology: The life history of *S. calcarata* in stems of trembling aspen (growing in the parkbelt areas of Saskatchewan) and in the junction of roots and stems of balsam poplar (growing on poor or disturbed sites in western Canada) was described by Peterson (1948) and Drouin and Wong (1975), respectively. The insect overwinters in the larval stage. Adults emerge from late June to late July. Males emerged 1–8 days before females. Adults begin to mate approximately a week after emergence and to lay eggs 4–10 days later. A description of the mating process is given in Garland and Worden (1969). Oviposition occurs in July and August and lasts about 6 weeks. Before oviposition, the female gnaws a crescent-shaped opening in the bark of the trunk or branch about 1.3 cm long, 0.6 cm wide, and 0.3 cm deep. She deposits one or two eggs between the bark and outer sapwood to the right or left in the puncture and seals the puncture with a secretion from the abdomen. Two or more punctures are sometimes joined together with as many as five eggs deposited in what appears to be one long puncture. As many as 26 eggs were laid by one female. Most eggs are laid on the trunk between the lower levels of the canopy and about 30 cm above the base of the tree. Adults are not attracted for oviposition in trembling aspen that has a diameter breast high of less than 5 cm. Adult longevity is quite variable, the females living for a maximum of 47 days and the males 45 days (on trembling aspen). The length of the incubation period varies from 2 to 3 weeks, becoming longer as the season progresses.

Five larval instars are thought to occur. The first instar feeds upon the inner bark and sapwood tissues, which form a small chamber. Depending on the time of oviposition, the larva either hibernates in this chamber or in a tunnel in the sapwood. The larva resumes feeding in late April or early May and enlarges the tunnel, extending it toward the heartwood. The larva continues burrowing in the heartwood until late September or early October, when it constructs a hibernation cell in the upper end of the burrow (in the case of trembling aspen) or at either end of the tunnel (in the case of balsam poplar) by sealing the open end of the tunnel with a fibrous frass plug. The fibrous plug is removed the following spring, and the larva continues to grow and extend its burrow. Mature third-year larvae are ready to enter the prepupal phase by August. Pupation is said to occur at the upper end of the larval burrow in trembling aspen; in balsam poplar, it usually occurs at one end of the tunnel, either above or below the ground. Pupation in trembling aspen begins by the middle of May, and all fourth-year larvae change to pupae by the end of May. Transformation to adults occurs by the middle of June, and emergence takes place during the latter part of June and July. Most larvae require 3 years (range, 2–4), including the year of hatching, to complete development to the prepupal phase of the last instar. In felled trembling aspen, only larvae that have reached their third year by the time the trees are cut complete development. The complete life cycle usually requires 4 years; however, adults may be produced in the third year in trees of low vigor, or in some cases, 5 years are required.

The natural mortality of *S. calcarata* is very high and quite variable, and is primarily due to infertility, climatic conditions, excessive sap flow, parasites, predators, disease, and unsuitable or insufficient food. Of these factors, climate and parasites are the most signicant. Parasites of the poplar borer include the odiniids (Diptera) *Odinia* possibly *boletina* (Zetterstedt) and *Odinia* sp.; the tachinids (Diptera) *Eutheresia* sp. and *Ptilodexia canescens* (Walker); the braconids (Hymenoptera) *Iphiaulax* sp., *Bracon* sp., *Atanycolus* sp., and *A. charus* (Riley); the gasteruptiid (Hymenoptera) *Pristaulacus rufitarsis* (Cresson); and the ichneumonids (Hymenoptera) *Pimpla* sp., *P. messor perlongus* (Cresson), *Gambrus canadensis* (Provancher), *Lampronota* sp., *Ichneumon* sp., *Campoplex sulcatellus* Viereck, *Campoplex* sp., and *Cremastus* sp. The carpenter ant, *Camponotus herculeanus* (Linnaeus), is listed as a predator.

Saperda candida Fabricius
roundheaded appletree borer
saperde du pommier (f.)

Distribution: British Columbia, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: *Saperda candida* is a serious pest of apple in eastern Canada, particularly where such native hosts as shadbush, wild crab apple, mountain ash, hawthorn, chokecherry, chokeberry, serviceberry, and juneberry are growing nearby (Brooks 1920, Caesar 1930, Brittain and Pickett 1933, Goble 1963, Hatch 1971, Davidson and Lyon 1979). This species has been considered to be the most important apple tree borer, especially in Quebec (Ross 1930). In a block of 900 trees at Rougemont, Que., the insect killed 528 trees and severely infested 111 others (Petch 1928*a*). Other records of injury to apple are given in Petch and Armstrong (1925); Caesar and Ross (1929); Twinn (1933, 1935, 1938, 1940); MacNay (1947–1952, 1954*b*); MacNay and Creelman (1958); and CAIPR (1977). The species is also injurious to pear, quince, plum, and cherry (Brooks 1920, Caesar 1930, Hatch 1971, Davidson and Lyon 1979).

Damage is caused by larvae that attack the trunk of the tree near or a short distance below ground level (Goble 1963). Although trees of any age may be attacked, damage is most severe to those from 1 to 10 years old. Infestations are often restricted to certain localities, mostly because the adults tend to lay their eggs near the place where they developed (Brooks 1920). During the first season the larvae tunnel chiefly in the inner bark, with some of them penetrating into the sapwood (Caesar 1930, Brittain and Pickett 1933). Subsequently, their circular tunnels are extended deeper and deeper into the wood, and young trees are often girdled and killed, especially when several larvae are present. The burrows are broad and irregular in form and generally extend both above and below ground level (Brooks 1920). In the northern part of the insect's range, a greater proportion of the feeding occurs beneath ground level. In small trees the larval tunnels penetrate the heartwood, often killing the tree (Petch 1928*a*, Davidson and Lyon 1979), but in older trees, they rarely extend more than 2.5 cm beneath the inner bark (Brooks 1920). Trees with damaged heartwood are so weakened that they are easily broken by winds (Davidson and Lyon 1979). Several larvae frequently feed together, and as many as 25 or 30 have been found feeding in a single tree (Brooks 1920). Injury may be indicated by retarded growth and yellow foliage; by discolored, sunken, cracked patches of bark near the base of infested trees; by much fibrous frass exuding from holes in the bark; and by round emergence holes, about the diameter of a lead pencil, in the trunk several centimetres above the ground (Petch 1928*a*, Brittain and Pickett 1933, Davidson and Lyon 1979). In addition, Brooks (1920) pointed out that injured trees are inclined to bloom freely and set heavy crops of fruit, but they often die trying to bring the crops to maturity. Damage in newly infested trees is not usually detected until the second year (Petch 1928*a*).

Adults feed on twigs, foliage, and fruits but cause little damage (Petch 1928*a*, Davidson and Lyon 1979).

Biology: The roundheaded appletree borer overwinters in the larval stage in the trunk (Goble 1963). The larvae feed for 2 or 3 years and pupate in the spring of the second or third year. Brooks (1920), working in West Virginia, stated that the larvae feed for 1–4 years and pupate at the end of an ascending gallery that extends up the trunk from several centimetres to about 60 cm above the ground; the pupal chambers are made higher in larger trees. According to Petch (1928*a*), the nearly mature larvae tunnel to the surface and then retreat about 1.3 cm, plugging the burrow before and behind them with sawdust. The pupal chamber is located about 1.3 cm beneath the bark (Brittain and Pickett 1933). Pupation takes place around the time of flowering in Nova Scotia, and the adults emerge 3 weeks later. Brooks (1920) reported a pupal period of about 20 days and noted that the adults remain in the pupal chambers for 5–10 days before emerging. According to Davidson and Lyon (1979), adults are active from late April to September, depending on latitude; they are most abundant, however, in June. In Ontario, adults emerge in May and June (Caesar 1930, Goble 1963); in Nova Scotia they emerge in early summer (Brittain and Pickett 1933); and in Quebec they emerge in June and July (Petch 1928*a*). Brooks (1920) stated that oviposition occurs soon after mating, which may take place at once or up to 10 days after emergence. Approximately 95% of the eggs are deposited in slits made by the female in the bark at the base of the tree trunk, usually within about 15 cm of the ground. The egg chambers are sealed with a gelatinous liquid. Occasionally, the eggs are deposited in the crotch of a tree or even in a branch 3–5 m above ground. Females laid an average of 22.5 eggs (range, 13–27.6) in West Virginia. From two to five eggs are usually deposited at a time, and oviposition in a given area extends over a period of 50–60 days. Brittain and Pickett (1933) reported 15 or more eggs deposited by each female over 40 or 50 days in Nova Scotia. In Ontario, oviposition continues for a period of 1–2 months (Caesar 1930, Goble 1963). Although the females are capable of flying considerable distances, they usually deposit their eggs near where they emerged. The incubation period averaged 16 days (range, 13–19) (Brooks 1920). The larvae may pass through as many as six instars. According to Davidson and Lyon (1979), the life cycle requires 2–4 years, with 3 years being the usual period.

The hymenopteran *Cenocoelius populator* Say was reported in a single instance as a parasite of *S. candida*. Undetermined carabid larvae, a hairworm, and a large spider were listed as predators.

Saperda tridentata Olivier
elm borer
saperde de l'orme (f.)

Distribution: Manitoba, Ontario, and Quebec.

Economic injury: Elm trees damaged by this species are characterized by dying branches and undersized, yellow foliage (Metcalf et al. 1951). Swaine and Hutchings (1926) noted that *S. tridentata* seems to be more injurious in the eastern states than in Canada. The species emerged from firewood and infested a home in Ontario (MacNay 1953, CIPR 1964). Both white elm and slippery elm are attacked by *S. tridentata* but not English and Scotch elms (Metcalf et al. 1951). The species apparently prefers sick trees or trees lacking in vigor because of insufficient nutrients or moisture.

The larvae bore numerous irregular galleries in the inner bark and sapwood (Metcalf et al. 1951). These galleries run in all directions and are filled with frass or brownish sawdust. Much of the sap flow is cut off by galleries running through the inner bark. The outer bark frequently becomes darkened and loosened from the tree.

Biology: Elm borers overwinter as partly grown larvae in the bark and sapwood of the tree (Metcalf et al. 1951). The larvae reach maturity late in the spring and pupate in cells in the sapwood. Adults emerge during late spring and early summer. The female deposits her eggs in cracks in the bark. Most of the larvae are approximately two-thirds grown by fall. There is probably only one generation produced each year, although two seasons may be required to complete development when conditions are unfavorable for larval growth.

Saperda vestita Say
linden borer
saperde du tilleul (f.)

Distribution: British Columbia, Manitoba, Ontario, and Quebec.

Economic injury: *Saperda vestita* attacks basswood and linden (Swaine and Hutchings 1926). The larvae bore long, irregular galleries, particularly at the base of the tree. This type of injury is especially severe on young nursery stock. Webster and Wooster (1900) reported that the larvae undermine the bark to a depth of 15–20 cm and frequently penetrate the wood an equal distance. Annular swellings are formed from the parallel rings chewed around the base of the trunks. The adults feed on the bark and on tender, succulent parts of the leaves and branches (Swaine and Hutchings 1926).

Biology: In eastern Canada, the adults emerge in midsummer from the trunk and larger branches and fly into the crown to feed (Webster and Wooster 1900, Swaine and Hutchings 1926). The female deposits two or three eggs in slight incisions made on the trunk and branches, especially near forks. One female laid as many as 90 eggs.

Xylocrius agassizi (LeConte)
(black gooseberry borer)

Distribution: British Columbia.

Economic injury: Larvae were detected in the roots of gooseberry bushes (nursery stock) imported into British Columbia from the United States (Lyne 1911).

Xylotrechus undulatus (Say)
(spruce zebra beetle)
perceur zébré de l'épinette (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Labrador, Northwest Territories, and Yukon Territory.

Economic injury: *Xylotrechus undulatus* emerged from the flooring of a house in Lumby, B.C., from the flooring of a 4-year-old schoolhouse in Kentville, Man. (MacNay 1953); from spruce lumber in a new dwelling in Fahler, Alta. (MacNay 1957*b*); and from new paneling in Ontario (CIPR 1963).

CHRYSOMELIDAE leaf beetles

This is one of the largest and most destructive families of beetles. Both larvae and adults of most species are plant feeders. Larvae may be root feeders, stem borers, leafminers, or may feed externally on the stems or leaves. Adults of many species are voracious external feeders. Many agricultural pests are included in this family, including flea beetles, the Colorado potato beetle, corn rootworms, the cereal leaf beetle, and the striped cucumber beetle, among others. Most crop plants are attacked by one or more species of the family. Some species are also important as vectors of plant diseases. This family is well represented in all faunal regions. At least 35 000 species are known, of which 720 are estimated to occur in Canada.

Acalymma vittatum (Fabricius)
striped cucumber beetle
chrysomèle rayée du concombre (f.)

Distribution: Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: The striped cucumber beetle is the most destructive pest of cucumber and closely related plants in Canada (Matthewman 1951). In approximate order of host preference, the adults attack cucumber, muskmelon, pumpkin, squash, and watermelon (Goble 1960). The adults may also attack a wide variety of wild and cultivated plants, but this general feeding is usually confined to periods that occur very early or very late in the season, when the preferred cucurbit hosts are not available (Isely 1927). In Ontario the adults feed on wild cucumber, beans, burdock, stinging nettle, pigweed, peas, radish, and curled dock early in the season and on the silk of corn and flowers of aster, sunflower, and several other plants late in the season (Caesar 1938). Marshall (1925) also reported the adults feeding on the flowers of chokecherry, raspberry, apple, cultivated cherry, and goldenrod. According to Balduf (1922), Cucurbitaceae, Rosaceae, Leguminosae, and Compositae provide the chief food sources for *A. vittatum*. Although the adults may attack a large number of plants other than cucurbits, their feeding on these other plants is rarely of economic importance, nor can the larvae develop on any of the secondary hosts (Isely 1927).

Adults damage the leaves, flowers, fruit, and crown (Munroe and Smith 1980). The most important damage is caused by the feeding of overwintered adults upon seedling plants (Isely 1927). The adults skeletonize the newly developed leaves and feed on the stems of the plants before they are well established, and may occasionally burrow into the ground and begin feeding even before they emerge (Isely 1927, Goble 1960). The adults often kill many of the seedling cucurbits before their presence is discovered (Matthewman 1951). The adults tend to be gregarious and gather in large numbers on some plants, whereas others nearby may suffer little injury (Isely 1927). Once the plants begin to send out runners, they grow so rapidly that the adults can no longer cause serious injury (Matthewman 1951). Caesar (1938) pointed out that the adults prefer the flowers to the leaves and occasionally reduce the set of fruit. Adults have been reported to feed on fruit both in the summer (Isely 1927) and fall (Goble 1960).

The larvae live in the soil where they feed on the small roots or tunnel into the main root (Matthewman 1951). According to Balduf (1922), the larvae may burrow up into the stems (several centimetres above ground level) of young plants, resulting in the death of the plant and the subsequent attack of another. The larvae, however, are not usually present when the plants are small. Vigorous plants rarely suffer significant injury, but if the soil is poor and growth is slow, the plants may be stunted or even killed (Matthewman 1951). Balduf (1922) reported some damage from larvae that feed on the vines, leaf petioles, and rinds of fruit that came in contact with the ground. The most obvious injury, however, results from the drilling of holes into the larger roots and underground stems of plants attacked (Isely 1927).

The striped cucumber beetle has been implicated as a vector of the following plant diseases: bacterial wilt of cucumbers, cucumber mosaic, cowpea mosaic, and pumpkin mosaic (Munroe and Smith 1980).

Biology: The species overwinters in the adult stage under leaves, dense grass, or other debris (Goble 1960). According to Matthewman (1951), the adults usually overwinter on sunny slopes in nearby woodlands and in fence rows instead of in the old cucurbit patches. In Ontario, the adults emerge in May and early June and immediately begin their attack on the young cucurbits, if available, or on suitable alternative hosts (Matthewman 1951). Three to four weeks are usually required for total emergence (Marshall 1925). Oviposition begins in about 2 weeks and continues into August in Ontario (Caesar 1938). Sweetman (1925), in Iowa, reported an average preoviposition period of 15 days, during which frequent mating was observed. Males were slightly in the minority (46%), but a single male may fertilize several females. Although cucurbit food is not necessary for mating, beetles feeding on it have a greater fecundity and a longer life span than those feeding on noncucurbit food. Cucurbits, however, are necessary for reproduction; according to Isely (1927), the larvae can develop on no other hosts. The eggs are deposited singly or in clusters in moist soil at or near the stem of the host plants (Caesar 1938). The oviposition period averaged 28.33 days, with a maximum of 45 days for the overwintered generation. Average oviposition rates have been reported to vary from 225 to 327 eggs, with a maximum rate of 498–1514 eggs (Balduf 1922, Marshall 1925, Sweetman 1925, Isely 1927). The incubation period lasts for about 10 days, after which the larvae attack the roots (Matthewman 1951). The overwintered adults have disappeared by August in Ontario (Marshall 1925).

According to Sweetman (1925), the larvae of the striped cucumber beetle pass through three instars and averaged 4 days in the first, 4 days in the second, and 10.5 days in the third instar. In cages, larval development averaged 26 days (range, 19–35) (Marshall 1925). Balduf (1922) stated that the larvae do not appear to burrow deeper than 5–10 cm into the soil and are always found at the various depths of the stem. The immature stages may survive for as long as 2.5 days in moist soil but soon die in dry soil. Pupation takes place in a small, earthen cell in the soil at a depth of 2.5–7.6 cm and at a distance of 1–30 cm from the feeding place of the larva (Marshall 1925). Isely (1927) reported an average prepupal period of 4 days (range, 3–5). The period between pupal cell formation and adult emergence averaged 12.4 days (range, 8–17) (Marshall 1925). The time passed from oviposition to adult emergence under laboratory conditions averaged 48.2 days. Isely (1927) reported a callow adult period of usually 1 or 2 days in the pupal cell. The new beetles begin to emerge about the first week in August in Ontario and continue to do so for several weeks (Matthewman 1951). According to Balduf (1922), the beetles continue to feed at temperatures of 15.6°C, when they can no longer fly. They become positively geotropic as the temperature drops below 15.6°C. Matthewman (1951) stated that the beetles seek hibernation quarters soon after the first frost. There is only one generation of *A. vittatum* per year in Canada (Matthewman 1951) and more than one in the south (Isely 1927).

Two species of tachinid flies, *Chaetophleps setosa* Coquillett and *Celatoria diabroticae* Shimer, parasitize the adults (parasitism as high as 45%) (Isely 1927). The braconid (Hymenoptera) *Syrrhizus diabroticae* Gahan also attacks the adults. Balduf (1922) reported a nematode, *Howardula benigma* Cobb, and two fungi, *Metarrhizium anisopliae* (Metsch.) Sorokin, attacking the adults and *Beauveria globulifera* (Spegazzini) Piccard attacking the larvae. The reduviid *Sinea diadema* (Fabricius), the pentatomid *Perillus bioculatus* (Fabricius), and the nabid *Nabis ferus* Linnaeus suck the blood of adults; the carabid *Pterostichus lucublandus* Say eats adults. According to Isely (1927), ground beetles and soldier beetles are probably the most important predators.

Comments: According to Dustan (1932), *A. vittatum* is found in all provinces in Canada. However, we have no record of the species from British Columbia or Alberta.

Altica ambiens LeConte
alder flea beetle
altise de l'aulne (f.)

Distribution: In all provinces and the Northwest Territories.

Economic injury: The leaves of alder and willow are skeletonized by both the adults and larvae, resulting in loss of tree vigor and unsightly appearance (Gerber et al. 1974). In addition to these hosts, Woods (1917) reported the species (as *A. bimarginata*) feeding on European gooseberry, white elm, and poplar in food-plant tests.

Biology: Gerber et al. (1974) summarized the biology of this species. The alder flea beetle passes the winter in the adult stage in sheltered places such as under bark or in debris. The overwintered beetles emerge in early spring and deposit their eggs on the leaves. Larval feeding continues for 4–6 weeks after the eggs hatch in early May. Pupation takes place in the soil and debris. Only one generation of the species is produced per year.

Comments: A complex of closely related species fall under the name *A. bimarginata* (Barstow and Gittins 1971). The species referred to by Woods (1917) as *A. bimarginata* was probably *A. ambiens* or possibly a mixture of both species.

Altica bimarginata Say
[willow leaf beetle (?), willow flea beetle (?)]

Distribution: In all provinces and the Northwest Territories.

Economic injury: The economic injury was described by Barstow and Gittins (1971). The species is of some minor economic importance to coyote willow (*Salix exigua* Nuttall) in northern Idaho. *Altica bimarginata* has been reported on different species of willow in many parts of western North America. Although adult feeding has usually been restricted to the foliage of coyote willow in Idaho, the insect has occasionally been observed on wild rose and evening-primrose.

Adults and larvae are active feeders and usually congregate in large numbers on their hosts. The former usually feed along the sides of the leaves (of *S. exigua*), leaving small, somewhat round holes and may eventually eat the whole leaf. The larvae are leaf skeletonizers.

Injury is indicated by stunted growth, sprouting, and an unsightly appearance.

Biology: The life history of *A. bimarginata* is summarized from Barstow and Gittins (1971). The overwintered adults emerge in late March and early April in Idaho, when the average maximum temperature is approximately 18.9°C and the average minimum temperature approximately 4.4°C. Mating begins 10–12 days after emergence. Adults mate repeatedly, and eggs are laid from late May through June. Females deposit their eggs singly or in clusters of 20 or more on or near the host plant. In the field, the largest masses of eggs were observed on the main stem, most often at the node or stem axis. Smaller egg clusters were observed on the leaves. In the laboratory, each female was shown to be able to deposit more than 400 eggs. The incubation period ranged from 4 to 7 days, with the greatest number hatching in 6 days.

The larvae pass through three instars. In northern Idaho, pupation takes place from early July to August in small, oval cells, 4–9 cm beneath the soil surface. In the laboratory the majority of adults emerged 14 days (range, 9–19) after entering the soil. The new generation of adults emerges in large numbers during late July and early August. *Altica bimarginata* is univoltine, although a partial second generation may occur in the fall. The adults overwinter in any protected site.

Only two parasites have been reared from *A. bimarginata* in the laboratory, one belonging to the family Ichneumonidae and the other to the family Braconidae. Known predators include: the carabid *Lebia*, probably *perita* Casey, that attacks larvae; carabid larvae (possibly the same species) that feed on pupae; and a reduviid, *Sinea diadema* (Fabricius), that attacks adults.

Altica canadensis Gentner
prairie flea beetle (prairie rose flea beetle)
altise du Canada (f.)

Distribution: Alberta and Manitoba.

Economic injury: Originally confined to wild rose bushes, this species has caused injury to cultivated roses in Manitoba (CIPR 1929, Gibson 1934).

Altica chalybea Illiger
grape flea beetle (grapevine flea beetle)
altise de la vigne (f.)

Distribution: Ontario and Quebec.

Economic injury: According to Isely (1920), *A. chalybea* is potentially a destructive pest of grape, causing severe injury in restricted localities. The adults, after emerging from hibernation in the spring, voraciously attack the swelling buds, boring into the sides and eating the tender parts. As the shoots expand, the adults eat holes in the leaves and often attack the tender stems. It is at this stage that the species is most destructive. The larvae are foliage feeders, feeding on the leaves of thin-leaved varieties of cultivated and wild grapes. They chew large, irregular holes through the leaves and may completely skeletonize them. On thicker leaved varieties, the larvae feed only on the upper surface, leaving chainlike, white patches. The species has also been reported on Virginia creeper. It is sometimes destructive in the Niagara district of Ontario, particularly in vineyards adjoining woods, hedgerows, or rough land (Ross and Armstrong 1949). The grape flea beetle has also been reported in destructive numbers in Quebec (CIPR 1961).

Biology: Isely (1920) described the life history of *A. chalybea* in northeastern Pennsylvania, where the species is univoltine. The overwintered adults emerged from hibernation in the spring, when the grape buds were swelling. Oviposition began soon after emergence and continued until mid June, just before the disappearance of the adults. Eggs were deposited in groups under bark or bud scales and occasionally on the upper and lower surfaces of the leaves. In the laboratory, the incubation period averaged 15.2 days (range, 13–21).

The larvae pass through three instars. At maturity, they leave the host plants and burrow into the soil and form pupal cells. After emergence, the adults feed for a while before going into hibernation. There is no evidence that the adults of the new generation mate or oviposit before overwintering. In Ontario, according to Gibson (1917), the adults hibernate beneath plant debris. In the same province, Ross and Armstrong (1949) stated that the larvae are present on the foliage in late June and July.

Altica corni Woods
(dogwood flea beetle)

Distribution: British Columbia, Manitoba, Ontario, Quebec, New Brunswick, and Northwest Territories.

Economic injury: The economic injury is summarized from Woods (1918). The natural food plants of this species all belong to the genus *Cornus*. In Maine and eastern Canada, the insect occurs most often on the red-osier dogwood and less frequently on the panicled dogwood. In food-plant tests, the adults readily ate alder, red-osier dogwood, panicled dogwood, and bunchberry. The larvae readily ate red-osier dogwood, panicled dogwood, and bunchberry; and they indifferently ate alder, Japanese rose, evening-primrose, fireweed, marsh fireweed, and beans.

The adults chew holes through the leaves. The larvae feed mostly on the underside of leaves, skeletonizing them and leaving only a network of veins.

Biology: Woods (1918) published an account of the biology of this species. The species overwinters in the adult stage in debris at the base of dogwood bushes. The insects emerge in the spring in Maine when the *Cornus* leaves are just separating from the blossom buds and are about 1.27 cm long. They mate frequently during the egg-laying season and remain paired for several hours. Eggs are usually found from the middle of June to the middle of July, with most laid in early July. The normal oviposition rate for a female is about 400 eggs. The eggs are deposited in clusters against the vein on the underside of the leaf. In insect rearings the length of the egg stage averaged 9 days (range, 7–12). Most of the overwintered adults disappear by 20 July.

The larvae have three instars. The duration of the first instar averaged 6 days (range, 4–10), the second instar averaged 5 days (range, 3–11), and the third instar averaged 4 days (range, 2–13). Larvae may be observed in the field from early June through mid July, with a few surviving into early August. When mature, the larvae enter the soil, construct a crude cell, and pupate about 2.5 cm below the surface. The length of the prepupal period averaged 6 days (range, 5–9). The pupal period averaged 7 days (range, 5–10). The new adults do not feed but go into hibernation as soon as they emerge. Only one generation is produced per year.

Known parasites are the tachinid fly *Celatoria spinosa* Coquillet, which feeds on the adults, and the fungus *Beauveria globulifera* (Spegazzini) Piccard as *Sporotrichum globuliforum* Spegazzini, which attacks the larvae, pupae, and adults.

Altica ignita Illiger
(strawberry flea beetle, fiery flea beetle, lesser grapevine flea beetle)
altise du fraisier (f.)

Distribution: Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: *Altica ignita* attacked the leaves of strawberry and injured grape and peach in the United States (Gibson 1913). The flea beetle was reported to damage the leaves of elm in New Brunswick, but this probably is a misidentified record. CIPR (1944) reported much damage to the foliage of wild grape in Quebec. According to Metcalf et al. (1951), the beetles attack strawberry, evening-primrose, other plants of the evening-primrose family, and some greenhouse plants. Most of the injury is done before the strawberries come into bloom (Metcalf et al. 1951). The leaves are riddled with small, circular holes, around which the leaves dry up and turn brown.

Biology: The species overwinters in the adult stage and emerges early in the spring (Metcalf et al. 1951). The eggs are deposited on strawberry, evening-primrose, and other plants of the evening-primrose family. There may be one or two generations annually.

Altica rosae Woods
(rose flea beetle)
altise du rosier (f.)

Distribution: Ontario, Quebec, and Nova Scotia.

Economic injury: *Altica rosae* has been recorded only from plants of the genus *Rosa* (Woods 1918). The larvae feed on the lower surface of the leaves, leaving the veins and upper epidermis intact. The adults, feeding in both spring and fall, chew small holes through the leaves. MacNay (1947) reported large numbers of this pest in a single rose plantation at Marmora, Ont.

Biology: Woods (1918) described the life history of *A. rosae* from observations made in Maine, where the species had only one generation a year. The beetles overwintered in debris around the bases of the host plants. They emerged in late May and early June and began ovipositing soon after emergence. Adults remained in copula for several hours and females were observed mating repeatedly. Eggs were deposited in clusters of about 7 eggs on the undersides of the leaves of the host plants. The incubation period of 59 eggs averaged 6.8 days (range, 6–8).

The development period of the three larval instars, excluding the subterranean prepupal period of the third-instar larvae, averaged 4.0 days (range, 3–6), 3.7 days (range, 2–6), and 4.1 days (range, 2–8), respectively. The mature third-instar larvae entered the soil and formed cells just below the soil surface. The length of the prepupal and pupal periods averaged 5.5 days (range, 3–11) and 8.2 days (range, 6–10), respectively. Adults of the new generation began to emerge about the first week in August.

Altica sylvia Malloch
blueberry flea beetle
altise de l'airelle (f.)

Distribution: Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: Maxwell and Wood (1961) reported the blueberry flea beetle to be abundant and to cause extensive damage in southern New Brunswick. The species attacks both the lowbush and highbush blueberry (CAIPR 1975).

Both the adults and larvae feed on blueberry foliage, chewing angular holes through the leaves (Maxwell and Wood 1961). In the spring the larvae feed on the expanding foliage and readily attack and severely injure blossoms.

Biology: The species overwinters in the egg stage (Maxwell and Wood 1961). The eggs hatch in the spring, and first-generation adults appear in early July.

Comments: See *A. torquata*. Parry (1977) listed *A. torquata* as a synonym of *A. sylvia*.

Altica tombacina Mannerheim (= *evicta* LeConte)
(bronze flea beetle)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, Nova Scotia, Labrador, and Northwest Territories.

Economic injury: The species has been reported to be a serious pest of fireweed on Vancouver Island, B.C. (Atkins 1964). The larvae may cause severe defoliation of this host. About two-thirds of the plants were injured over an area of approximately 26 km^2. A few larvae (possibly a misidentification) were also found to damage young roadside alders. Gibson (1913) reported the insect (as *A. evicta*) on the leaves of strawberry in British Columbia.

Biology: Little is known about the life cycle of *A. tombacina*. Atkins (1964) reported that in July, eggs and several larval instars were found on fireweed in British Columbia. Larvae collected in July pupated during the first week of August in the laboratory. Pupae have been discovered under the bark of Douglas fir (Hicks 1954).

Altica torquata LeConte
(blueberry flea beetle)

Distribution: New Brunswick.

Economic injury: The species was found CIPR (1945) to eat the foliage of blueberry over an area of approximately 1.6 ha in New Brunswick. According to Woods (1918), *A. torquata* has been taken only from the lowbush blueberry.

Both adults and larvae cause serious injury. The larvae attack the opening buds and flowers and later feed on the leaves (Woods 1918). When numerous, the larvae may cause severe damage by reducing the set of fruit or by lowering the vitality of the plant so that it produces small and sour fruit. The larvae may chew holes through the leaf or make irregular notches in the sides. The adults feed heavily on the leaves and may soon strip the plants.

Biology: The life history of *A. torquata* was described by Woods (1918). The species overwinters in the egg stage. The eggs hatch in the spring (late May and June in Maine), and the larvae go through three instars. The first instar lasts 4.5 days (range, 4–6), the second instar averaged 4 days (range, 2–5), and the third instar averaged 5 days (range, 3–8). The mature larva enters the soil and constructs a rude cell a short distance below the surface. The length of the prepupal period averaged 7 days (range, 5–12), and the pupal period averaged 11 days (range, 10–16). The new adults emerged as early as June 25 in the laboratory and fed voraciously. Mating begins about 2 weeks after emergence. The females may mate several times before completing oviposition. Copulation may last several hours. Oviposition occurs several days after mating, and the eggs are deposited singly or in groups of two or three, usually on the ground at the base of the plants. In Maine, only one generation is produced each season.

Comments: Parry (1977) listed *A. torquata* as a synonym of *A. sylvia.*

Altica ulmi Woods
(elm flea beetle)
altise de l'orme (f.)

Distribution: Ontario, Quebec, and New Brunswick.

Economic injury: The economic injury of *A. ulmi* was described by Woods (1918). The preferred food plant of this insect is the American elm, but both larvae and adults also readily feed on red elm and basswood. The adults chew holes through the leaves of their food plants, and the larvae skeletonize the underside of the leaves.

Biology: The biology of *A. ulmi* is summarized from Woods (1918). The adults overwinter in protected places at the base of the tree or under the loose bark on the trunk. In Maine the overwintered adults become active just as the elm buds are opening. The females may mate several times before the egg-laying season is over. Eggs have been found as early as 7 June but are not common until later in the month. The maximum number of eggs laid by a single female was 18, deposited between 11 June and 15 July. The eggs are laid one or two at a time on the lower surface of the leaves in the angle formed by the union of one of the secondary veins with the midrib. The eggs are sometimes streaked with excrement. Most of the overwintered adults have disappeared by mid July, although one survived as late as 10 August in the laboratory. The incubation period averaged 12 days (range, 8–19).

The larvae have three instars. The first instar lasts 7 days (range, 5–12), the second instar averaged 5 days (range, 3–8), and the third instar averaged 6 days (range, 4–12). Pupation takes place in a crude cell not far below the surface of the soil. The prepupal period averaged 5 days (range, 3–10), and the pupal period averaged 8 days (range, 6–10). The new adults feed freely on the leaves during late summer and early fall, and then seek hibernation quarters. Only one generation of the species is produced per year.

A tachinid fly, *Celatoria spinosa* Coquillet, was bred from an adult. The fungus *Beauveria globulifera* (Spegazzini) Piccard, as *Sporotrichum globuliforum* Spegazzini, is another parasite of the species. Nymphs of *Podisus modestus* have been found feeding on the larvae.

Altica woodsi Isely
(Wood's flea beetle, lesser grapevine flea beetle)
altise de Woods (f.)

Distribution: Manitoba, Ontario, and Quebec.

Economic injury: MacNay (1955) reported a large infestation of this species feeding on leaf and flower buds of grape in Manitoba. The injury of this species was described by Isely (1920). Both the adults and larvae attack wild and cultivated grapes and Virginia creeper. Thin-leaved varieties of grape are preferred by both stages.

The adults and larvae attack the lower sides of the leaves of thin-leaved varieties, riddling them with holes. On thick-leaved varieties, they attack the upper surface of the leaves and make short, irregular feeding marks, without piercing the lower surface. The larvae frequently feed on the leaf veins and flower clusters of these varieties. Young larvae usually begin feeding at the side of a leaf vein and bore upwards. In time, the leaves may become skeletonized. The larvae progress slowly, and so it is not unusual for one part of a vine to show injury while a nearby part is free from damage.

Although this species may be confused with its larger relative, the grapevine flea beetle (*A. chalybea* Illiger), the damage of *A. woodsi* is generally less severe because as a strict leaf feeder, it does not emerge early enough to attack the buds. When the species is present in large numbers, it may cause significant damage by leaf skeletonizing.

Biology: The life history of this insect is summarized from Isely (1920). The overwintered adults emerged in late May or early June in Pennsylvania, after the grape shoots had expanded and about 3 weeks after the appearance of *A. chalybea*. Mating took place intermittently from the first day the beetles were observed and for as long as they were found on the vines. The egg-laying period extended from early June through late July, when the last adults disappeared. The eggs were most frequently laid singly on the underside of grape leaves along the veins. Two or three eggs were occasionally deposited together, but it was unusual to find them on the upper surfaces of the leaves. The incubation period averaged 12.8 and 13.7 days for 2 years.

The larvae passed through three instars and averaged 6.2 and 6.4 days in the first instar, 6.5 and 6.0 days in the second instar, and 6.5 and 6.6 days in the third instar. The larval feeding period averaged 18.7 and 18.6 days. Larvae were collected on the vines in midsummer from 18 June to 8 August. Transformation in the soil averaged 16.2 and 14.5 days. The length of the various stages in the ground averaged as follows: prepupa, 4.7 days; pupa, 7.2 days; and callow adult, 2.2 days. The new adults fed until late autumn and then sought hibernation quarters. Only one generation is produced per year.

Known predators include the carabid *Lebia viridis* Say, which feeds on the eggs, larvae, and pupae; the carabids *Lebia ornata*

LeConte and *Harpalus erythropus* Dejean, which feed on pupae and prepupae; and a brown ant, *Myrmica scabrinodes schenchi* var. *emeryana* Forel, which attacks larvae and pupae.

Bromius obscurus (Linnaeus)
western grape rootworm

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, Newfoundland, Northwest Territories, and Yukon Territory.

Economic injury: This species now occurs primarily on fireweed and grape, sometimes causing injury to the latter (Hatch 1971). In the past this species has been one of the most important pests of cultivated grape in Europe (Balachowsky 1963), but its economic importance has been considerably reduced by the development of new grape hybrids.

Adults damage the leaves, making characteristic cuts 3–15 mm long. They may feed on the foliage for 3 months and have also been observed feeding on the fruits. Larvae feed on the roots.

Biology: Adults overwinter in the ground, becoming active in early May. The eggs are laid at the base of plants in early June in masses of 20 or more. As they hatch, the larvae begin feeding on roots and rootlets. When the temperature cools in the fall, the larvae move deep into the ground.

Calligrapha californica coreopsivora Brown (*elegans* Olivier)
(tickseed leaf beetle)
calligraphe élégant (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Northwest Territories.

Economic injury: According to Brown (1945), this species feeds primarily on the foliage of *Bidens frondosa* L. and *B. cernua* L., but it has also been reported feeding on cultivated *Coreopsis* sp. The species has also been reported to damage dahlia leaves (CIPR 1954). The species normally feeds on wild composites such as bur, marigold, boneset, and goldenrod (Gibson 1934).

Biology: Predators of this species include the pentatomid *Apateticus bracteatus* (Fitch) (Gibson 1934).

Calligrapha multipunctata bigsbyana (Kirby)
(willow leaf beetle)
calligraphe du saule (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Northwest Territories.

Economic injury: This insect has been reported to attack weeping willow in British Columbia (MacNay 1959) as well as a number of other species of willow and *Populus tremuloides* Michx. (Brown 1945 and Daviault 1941).

Biology: The biology of this species was studied by Daviault (1941). The willow leaf beetle overwinters in the adult stage under debris. The adults emerge in the spring when the temperature is around 52°F and begin feeding on pollen and the foliage somewhat later. Mating takes place on the plants, and oviposition begins in late May and continues until August. The eggs are laid in clusters of 50–300, usually on the underside of the leaves. The eggs hatch in 4–14 days (average 7.5), first eat the chorion of the egg, and then begin feeding on the parenchyma. The larva passes through four instars in about 30 days before dropping to the soil to pupate. Adults of the new generation emerge in about 14 days and feed on willows until the first frost appears. There is only one generation per year.

The following parasites were reared from the willow leaf beetle by Daviault (1941): the tachinid *Doryphorophaga dorsalis*, the chalcid *Erixestus winnemana*, and a braconid of the genus *Meteorus*.

Calligrapha philadelphica (Linnaeus)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: Hicks (1949) reported *C. philadelphica* from ornamental dogwood shrubs in Ottawa, Ont. The leaves were badly disfigured, which Hicks attributed primarily to larval feeding. In addition, the same author cited a record of the species feeding on silky dogwood in New York State. The native host of this species is red-osier dogwood.

Calligrapha scalaris (LeConte)

Distribution: Ontario and Quebec.

Economic injury: Brown (1945) reported that *C. scalaris* feeds on American elm. Larvae feed on basswood, but with increased mortality and somewhat stunted adults.

Calligrapha sigmoidea LeConte
(hollyhock beetle)

Distribution: Southeastern British Columbia and Alberta.

Economic injury: Hatch (1971) reported that *C. sigmoidea* defoliates cultivated hollyhock and musk mallow in British Columbia. He also reported it as occurring on *Sidalcea* sp.

Calligrapha spiraeae (Say)

Distribution: Ontario and Quebec (?).

Economic injury: *Calligrapha spiraeae* attacked ninebark in Pennsylvania (Wheeler and Hoebeke 1979). The first-instar larvae fed by making circular holes through the leaves, and older larvae fed along the leaf margin, producing a ragged appearance. Large areas of the attacked hedge were completely defoliated by late June, and by mid July, total defoliation had occurred. As soon as refoliation occurred, the adults stripped the new growth.

Biology: Wheeler and Hoebeke (1979) described the life history of *C. spiraeae* in Pennsylvania. Overwintered adults emerged in mid April after the first flush of leaves of the host plant. Most eggs were laid in mid May, irregularly arranged on the underside of the leaves. The average number of eggs in 21 clusters was 5.9 (range, 2–13). In the laboratory at 20–22°C, the incubation period averaged 5 days, and in the field, the first eggs hatched on 20 May.

Early instar larvae were numerous in the field during the first week of June. Larval development in the laboratory at 20–22°C averaged 18.9 days, with that of each of the first three instars averaging slightly more than 3 days. The duration of the fourth or final instar averaged 9.4 days, and these larvae fed on the host plant for approximately 3 days before entering the soil to pupate within 4 to 9 days.

Adults of the first generation began emerging in late June. These adults mated in early July and laid eggs that were present from the second week of July until early August. Larvae were present from mid July to late August. The second generation were present until mid October.

Eggs of *C. spiraeae* were parasitized by the pteromalid *Erixestus winnemana* Crawford.

Comments: Mullins (1976) reported the species from Quebec. However, according to Wheeler and Hoebeke (1979), the only Canadian record of *C. spiraeae* is from Wiarton, Ont., and the Quebec record is doubtful.

Cerotoma trifurcata (Förster)
bean leaf beetle
chrysomèle du haricot (f.)

Distribution: Ontario and Quebec.

Economic injury: According to Isely (1930), the bean leaf beetle is an important pest of field and garden beans, cowpeas, and soybeans. The species is more destructive in the southern parts of its range than in northern areas. Additional host plants of the bean leaf beetle include bush-clover, tick trefoil, hog-peanuts, and wild beans. The adults feed on the foliage and tender stems of the host plants, and the larvae feed on or bore into the underground stems, roots, and root nodules. Adults are particularly destructive to seedling stages of early beans in gardens and may destroy the entire stand. However, surviving plants tend to outgrow the injury. In poor soils, larval damage to the nitrogen fixing nodules may be serious. The species also feeds on alfalfa (Boiteau et al. 1979*a*) and soybeans; the adults are vectors of bean pod mottle virus (Levinson et al. 1979) and of both severe and yellow strains of cowpea mosaic virus (Jansen and Staples 1971).

Biology: Isely (1930) studied the biology of *C. trifurcata* in Arkansas, where the species has three generations a year. Kogan et al. (1974) found only two generations a year in east-central Illinois. The summary given here is based on Isely's work unless otherwise indicated. The species overwinters in the adult stage. The adults emerge in April and early May and start ovipositing in late April. According to Boiteau et al. (1979*a*), emergence occurred over 3 months in North Carolina, with 60% emerging in May, starting at a day length of 13 h and an average daily temperature of 26°C. The adults feed voraciously for several days before oviposition, the length of the preoviposition period averaging 8.9 days (range, 5–22).

Eggs were laid in the soil around the host plant. Levinson et al. (1979) found most of the eggs within 2.5 cm of the host plant taproot. Eggs were laid almost daily during the oviposition period, which varied from 1 to 67 days for 11 females. The mean duration for this period was 16.9 days, and only one individual deposited eggs for longer than 29 days. The maximum number of eggs laid by a single female was 1386. The incubation period ranged from 15 days at 20°C to 7 days at 30°C.

The larvae passed through three instars. Molting took place in earthen cells away from the roots of the host plants. Levinson et al. (1979) found that first- and second-instar larvae have a tendency to remain near the taproot of the host plant, whereas the third-instar larvae disperse up to 23 cm from the plant row. At maturity, the larvae form earthen cells 2.5–10 cm beneath the soil surface in which to pupate. The larval period averaged 16.6 days (range, 15–19) at 21°C and 8.5 days (range, 7–11) at 32°C. The mean prepupal periods were 9.9 (range, 8–11) and 4.2 days (range, 3–5) at 19° and 32°C, respectively. The pupal period at 20°C was 10 days and at 32°C averaged 4.4 days (range, 4–5). The newly transformed adults remained within the pupal cell until their cuticles hardened. Under optimum conditions, the minimum development time from egg to sexually mature adult was 26 days. Almost all the adults emerged from the soil 2.5–25 cm from the plant rows (Levinson et al. 1979). According to Boiteau et al. (1979*b*), the adults are diurnal fliers, with peak activity starting before noon and ending by 2:30–3:00 p.m. According to the same authors, the adults have three seasonal flights: field colonization, by the overwintered adults; dispersal, by first-generation beetles; and dispersal and overwintering, by second-generation beetles.

A tachinid, *Celatoria diabroticae* (Shimer), is known to parasitize *C. trifurcata.*

Chaetocnema ectypa Horn
desert corn flea beetle

Comments: In CIPR (1950), a species of *Chaetocnema* reported to be near *C. ectypa* Horn was reported to feed on the leaves and cob husks of corn in British Columbia. The species *C. ectypa* was reported from corn in the same province (CIPR 1953). According to Hatch (1971), reports of *C. ectypa* from the Pacific Northwest represent misidentifications or an undescribed species.

Chaetocnema pulicaria Melsheimer
corn flea beetle
altise du maïs (f.)

Distribution: Ontario.

Economic injury: Poos (1955) described the injury caused by *C. pulicaria.* The overwintered adults attack seedling corn in the spring, often skeletonizing the leaves to such a degree that the plants die. The adults are also important vectors of the bacterial wilt organism, *Aplanabacter stewarti* (E.F. Sm.) McC., the causal organism of Stewart's disease (bacterial wilt) in corn. The adults have also been observed feeding on the leaves of at least 20 species of Gramineae, and the larvae have been collected from among the roots of about the same number of species. In Ontario, the species has been reported in corn fields where Stewart's disease caused moderate damage (CIPR 1955).

Biology: Poos (1955) studied the life and seasonal histories of *C. pulicaria* in the area of Washington, D.C., where the species is bivoltine. The adults overwintered in the upper 2.5 cm of soil in bluegrass, orchardgrass, redtop, or timothy sod. High concentrations were found in sod near late-planted corn of the previous season. In April and early May, the beetles became generally distributed and attacked seedling corn.

Eggs were apparently deposited at the base of corn or grass plants. The incubation period under controlled conditions averaged 5.8 days (range, 4–10). On emergence, the young larvae fed on the fibrous roots of the host plant. Larvae were found in the field from 16 May until 9 October. In the laboratory the mean larval, prepupal, and pupal periods were 15.8 (range, 10–23), 2.1 (range, 1–5), and 5.3 days (range, 3–7), respectively. Although a considerable overlap of generations occurred, the adults of the first generation appeared in late June and early July, and adults of the second generation appeared in mid August.

Chelymorpha cassidea (Fabricius)
argus tortoise beetle
casside du liseron (f.)

Distribution: Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: The argus tortoise beetle feeds exclusively on species of the plant family Convolvulaceae (Chittenden 1924). According to the same author, records in the literature of other host plant species are for the most part erroneous. At the time of Chittenden's publication, recent studies had shown that *C. cassidea* preferred cultivated sweet potato over other wild species of the morning-glory family, but it was not a major pest. In Canada the species is numerous in some years, feeding on the foliage of morning-glory and other garden plants (Gibson 1934).

Biology: Chittenden (1924) described the biology of *C. cassidea*. Eggs were laid in clusters of 16–28 on the lower surfaces of leaves and probably elsewhere on the plants. The eggs were attached to the leaves by long pedicels, adhering to each other at the bases. The incubation period lasted about 10 days. The gregarious larvae fed on the underside of the leaves and matured in about 3 weeks. The pupal period lasted for 7–9 days. The species overwintered in the adult stage. *Chelymorpha cassidea* produces one generation a year in the northern portion of its range, one and a partial second in the District of Columbia, and two in the southern United States.

The eulophid *Emersouella niveipes* Girault parasitizes the eggs of this beetle, and the tachinid *Eribella exilis* (Coquillett) (as *Masicera exilis*) parasitizes the larvae. The pentatomid *Apateticus bracteatus* (Fitch) has been observed preying on the larvae.

Chrysochus auratus Fabricius
(dogbane beetle, goldsmith beetle)
chrysomèle de l'apocyn (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Atlantic Provinces (?).

Economic injury: This species, which normally occurs primarily on dogbane, has also been reported to damage cucumber and potato in Manitoba (CIPR 1942).

Comments: Beirne (1971) stated that *C. auratus* has been allegedly reported from the Atlantic Provinces.

Colaspis brunnea (Fabricius) (*flavida* Say)
grape colaspis

Distribution: Ontario and Quebec.

Economic injury: Bigger (1931) described the nature of the injury caused by *C. brunnea* and listed the host plants. This species has been reported to be a serious pest of corn over the main corn belt area of Illinois. Adults have also been observed feeding on red clover, corn, timothy, alsike clover, soybeans, alfalfa, swamp smartweed, bull-nettle, grape, strawberry, and apple. The adults chew small holes through the foliage and when abundant may skeletonize the leaf. The larvae feed on the roots and may ring or remove lengthwise strips from the root. This feeding activity may seriously damage the root hair system, resulting in wilting and possible death of the plant. Larvae have been reported from the roots of red clover, alsike clover, sweet-clover, soybeans, timothy, corn, and strawberry. Additional host plants recorded for this species include potato, beans, watermelon, okra, rose, plum, pear, wild hops, willow, and Virginia creeper. In Canada, the species has been reported from grape foliage (CIPR 1923), soybeans (MacNay 1954*b*), and corn (CAIPR 1975, Foott and Timmins 1977*b*).

Biology: Bigger (1931) studied the life history of *C. brunnea* in Illinois. Although eggs had not been found or described, it was presumed they were laid on or around the bases of the food plants during the latter part of July and during August. The eggs probably hatched during the first half of September.

The species hibernates in the larval stage, the larvae migrating down into the soil to overwintering depths of up to 30 cm during late October and early November. In the latter part of April, the larvae ascended to near the soil surface.

Pupation occurred in small, oval cells 5–7.5 cm deep in the soil, usually within 15 cm of the host plant. The pupal stage, first recorded on 5 June, lasted about 2–3 weeks. Adults were observed from 19 June to 29 August. Foott and Timmins (1977*b*) presumed that the life history in southwestern Ontario was similar to that described by Bigger.

Comments: Based on an unpublished dissertation by Parry (1977), this species probably represents a sample of several related species.

Crepidodera nana (Say) (*helxines*, of authors)
(willow flea beetle)
altise naine du saule (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Northwest Territories.

Economic injury: According to Twinn (1933), this species chewed holes in opening buds of apple in Ontario. According to literature cited by Hatch (1971), *C. nana* has been reported from elm, thorn, apple, pear, sugar beet, birch, *Prunus*, *Spiraea*, laurel, bramble, maple, and *Sphaeralcea*, some of which Hatch stated may be adventitious.

Crioceris asparagi (Linnaeus)
asparagus beetle (common asparagus beetle, blue asparagus beetle, steel blue asparagus beetle)
criocère de l'asperge (m.)

Distribution: British Columbia, Saskatchewan, Ontario, Quebec, New Brunswick, and Nova Scotia.

Origin: This Old World species was introduced into North America at Astoria, near New York City, in about 1856 (Chittenden 1917). In Canada the species was first recorded in 1898 in the Niagara Peninsula, Ont. (Fletcher 1899*a*). By 1919 the species had been reported from the Pacific Northwest and was first recorded in British Columbia at Vancouver in 1933 (Hatch 1971).

Economic injury: According to Taylor and Harcourt (1978), *C. asparagi* is the most serious pest of asparagus in eastern Canada. The same authors stated that the most damage is caused by the adults of the overwintered generation, which feed and lay eggs on the spring shoots, lessening market value of the spears. Adults and larvae of later generations feed on the ferns, reducing plant vigor. The plants are not destroyed by these later attacks since the underground parts survive, but the new shoots the next spring are weak and small

(Caesar 1938). The same author reported that the adults also attack young seedlings in freshly planted beds and injure them more seriously than the shoots in commercial beds.

Biology: According to Taylor and Harcourt (1974), adults of *C. asparagi* emerged from hibernation about the middle of May in eastern Ontario and fed on the new asparagus growth before starting oviposition. Eggs were attached singly on spears and developing foliage often in rows of two to seven. The incubation period lasted for 7–12 days; Capinera and Lilly (1975) reported 3–8 days.

The larvae feed on foliage during a 2–3-week development period, passing through four larval instars. At maturity the larvae drop to the ground and form shallow pupal cells beneath the soil surface. Within these cells the larvae form tough, silken cocoons impregnated with soil.

Adults emerge from the pupal cells in 7–10 days. The species is trivoltine, with egg-laying peaks in June, early July, and early August. Adults of the third generation overwinter in dead asparagus stalks and ground litter. In British Columbia, Neilson (1954) reported two to five generations a year. Capinera and Lilly (1975) reported two complete generations and a partial third in Massachusetts.

Taylor and Harcourt (1978) found that the duration of all stages decreased with an increase in temperature to a maximum of 32°C. They also found that eggs are more tolerant of temperature extremes than are larvae and pupae.

Insect predators of the larvae of *C. asparagi* listed by Chittenden (1917) include the lady beetles *Coleomegilla maculata* (De Geer) (as *Megilla maculata*) and *Hippodamia convergens* Guérin-Méneville; the stink bugs *Podisus maculiventris* (Say) and *Stiretrus anchorago* (Fabricius); the vespid wasp *Polistes fuscatus* (Fabricius) (as *P. pallipes* Lepeletier); and the coenagriid damselfly *Ischnura posita* (Hagen). The eulophid egg parasite *Tetrastichus asparagi* Crawford was the only important parasitoid found by Capinera and Lilly (1975).

Crioceris duodecimpunctata (Linnaeus)
spotted asparagus beetle (twelve-spotted asparagus beetle, red asparagus beetle)
criocère à douze points (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Origin: This European species was first discovered in North America at Baltimore, Md., in 1881 (Chittenden 1917). According to Fletcher (1899*a*), this species and *C. asparagi* were both discovered for the first time in Canada in 1898 in the Niagara Peninsula, Ont. The species was first recorded in British Columbia at Kelowna in 1962 (Hatch 1971).

Economic injury: According to Armand (1949), asparagus is the only crop this species is known to attack. The overwintered adults feed on the young shoots, reducing their quality and making them unfit for market. Later in the season, the adults attack plants in seedling and commercial beds, reducing their vigor, which results in smaller shoots and reduced yield in ensuing years (Armand 1949). The larvae feed inside the berry, and a single larva may attack several berries (Caesar 1938).

Biology: Beaulne (1935) described the biology of *C. duodecimpunctata*. Adults emerged from hibernation almost a week later than those of *C. asparagi*. Oviposition does not occur until the asparagus flowers have appeared, which is approximately 3–4 weeks after the beetles emerge from the soil. Eggs are laid singly on their sides, usually near the ends of the old shoots.

The larva enters a berry through the calyx and feeds on the contents, attacking several berries during its development. The larvae pass through three instars, maturing in 3–4 weeks. It then enters the ground and forms a silken cocoon in which it pupates.

According to Caesar (1938), emergence of the new generation of adults probably occurs at the beginning of August. He also stated that there are probably two generations a year in Ontario. According to Armand (1949), the second-generation adults emerge in September and go into hiding before the winter. The second-generation adults overwinter in sheltered places beneath plant debris (Banham and Arrand 1978).

The eulophid *Tetrastichus asparagi* Crawford was reported to parasitize the eggs of this species (Beaulne 1935).

Cryptocephalus sanguinicollis Suffrian

Distribution: British Columbia.

Economic injury: The insect is usually found on willow but has also been reported on blackberry, rose, strawberry, wild licorice, and prune (Hatch 1971).

Deloyala guttata (Olivier)
mottled tortoise beetle
casside tachetée (f.)

Distribution: Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: Gibson (1934) listed this species as one of the tortoise beetles that occur in gardens in numbers, feeding on the foliage of morning-glory and other garden plants.

Biology: Barrows (1979) reported on the biology of *D. guttata* based on observations made on specimens from Washington, D.C. Adults of the mottled tortoise beetle were observed copulating from one to five times. After oviposition, females defecated on the egg mass, perhaps protecting the eggs by this behavior. Thirty-three eggs hatched in a mean of 5.3 days (range, 2–7).

Larvae of *D. guttata* carry one to four loosely joined masses of exuviae and feces on their dorsa, using their abdominal urogomphi. The larvae move the mass to cover exposed areas in response to tactile stimuli. The mean duration of this stage was 22.2 days (range, 18–23). Pupae, which retain the fecal mass when attached to leaves, transformed to adults in 4.7 days (range, 3–9). Adults were observed in the field from June to September and lived for 31–105 days in the laboratory.

Diabrotica longicornis (Say)
northern corn rootworm
chrysomèle des racines du maïs (f.)

Distribution: Ontario and Quebec.

Economic injury: The larvae of the corn rootworm cause the greatest injury to corn, the only host of this stage, by damaging the root system. Newly hatched larvae feed primarily on the root hairs and outer cortical tissue, while the older larvae tunnel into the cortical parenchyma and channel into the stele (Chiang 1973). Severe infestations may substantially destroy both the main and brace roots, resulting in reduced plant vigor and weakening of the plants so that heavy rains or wind cause them to lean or lodge (Bereza 1977*b*). According to the same author, the plants respond to lodging by bending upwards, producing the typical "goose-necked" condition; lodged plants interfere with mechanical picking operations. The adults of *D. longicornis* feed on corn silk and on the soft kernels on the tips of the ears of corn (Ruppel and Dudek 1978). If the adults clip the silk before pollination, partly barren ears may result (Bereza 1977*b*). However, in Ontario, most corn is pollinated before peak adult emergence, and unless corn is planted late or a late-maturing hybrid is planted, the adults cause little damage. According to Wressell (1970), sweet corn grown in rotation with other crops is usually free from attack, whereas processing corn grown in the same field year after year is subject to damage. Adults of *D. longicornis* feed on the pollen of other plants after corn matures (Ruppel and Dudek 1978). Goble (1971*a*) reported feeding on the flowers of rose, dahlia, and marigold, often at some distance from corn fields. In addition, the species has been reported from galdiolus, okra (CAIPR 1972), alfalfa (CAIPR 1968), squash, and sunflower (Beirne 1971).

Biology: Eggs of the univoltine *D. longicornis* overwinter in the soil and hatch in June (Bereza 1977*b*). The eggs require 304–400 degree-days above a developmental threshold of 11.1°C to hatch, with a few eggs hatching during the same season in which they are laid and a few requiring two winters to hatch (Chiang 1973). The main period of egg-laying extends from late August to the first frost of October, when the females die (Bereza 1977*b*).

Newly hatched larvae migrate through the soil to nearby roots of young corn, where they feed for 3 weeks until they reach maturity in mid July and pupate in soil cells (Bereza 1977*b*). Approximately 90% of the larvae pupate at 0–5 cm beneath the soil surface, and the remainder pupate up to a depth of 22.5 cm, at distances up to 62.5 cm from the host plant (Chiang 1973).

In Ontario, adults of the new generation begin to emerge from the soil during the first week in August (Bereza 1977*b*). According to Chiang, mating may take place shortly after emergence, but some insects do not mate for up to 6 weeks after emergence. Bereza stated that females lay clusters of eggs in the soil at depths up to 5 cm at the base of the corn plants, usually among the brace roots. Adults are most active at dawn and dusk, although they are observed flying, mating, and moving on plants during daylight hours (Chiang 1973).

A tachinid fly, *Celatoria diabrotica* (Shimer), has been reared from adults (Chiang 1973).

Diabrotica undecimpunctata howardi Barber (*duodecimpunctata* Fabricius)
southern corn rootworm or spotted cucumber beetle
chrysomèle maculée du concombre (f.)

Distribution: Alberta, Saskatchewan, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: Both adults and larvae attack a large number of cultivated crops (Goble 1960). Adults are general feeders and attack most cultivated plants including all types of cucurbit, beans, corn, peas, potato, beet, eggplant, and tomato (Isely 1929, Goble 1960). The spotted cucumber beetle is generally associated with the striped cucumber beetle in its attack on cucurbits and causes similar injury, but as *D. undecimpunctata howardi* occurs in much smaller numbers, the damage is usually less severe. According to Goble (1960), the species is a more severe pest of crops such as beans and corn than of cucumber. Isely (1929), however, noted that the insect occasionally occurs in numbers large enough to destroy stands of cucumber, cantaloupe, melon, or squash. Beirne (1971) reported 100% loss to watermelon seedlings in the spring. The adults lower the market value of the fruits of pumpkin, squash, or cucumber by leaving them with a characteristic pinhole or peppershot appearance. The overwintered adults may also cause extensive injury to tobacco by puncturing the leaves and feeding on the growing tips of young plants. In addition, the midribs near the leaf base may be attacked, causing the leaves to drop off. The adults often depart from the leaves to feed on the preferred floral parts, causing a reduction in yield (Isely 1929). Feeding on the corn silk may prevent pollination and result in the loss of a full set of kernels in the ear. The insect has also been noted on the flowering heads of wheat and oats. When flowers are not available, the adults prefer the foliage of cucurbits (especially the cotyledons) to other plants and do not appear to be attracted to grasses. Garden flowers, such as dahlia and rose, for example, may also be damaged late in the season.

The larvae develop in the roots of such plants as cucurbits, corn, beans, grain, alfalfa, and many grasses (Goble 1960). The southern corn rootworm prefers to attack corn (Isely 1929). The larvae attack oats, wheat, Johnson grass, rice, rye, chess, millet, sorghum, and barnyard grass. The larvae have also been observed on sedges of the genera *Cyperus* and *Scirpus*, on the roots of goldenglow, and on peanuts. These plants are probably important when corn is unavailable. According to Davidson and Lyon (1979), the larvae tunnel in the roots, crowns, and stems and may also feed on the outside of the roots. Damage to seedling plants is particularly serious and may often necessitate replanting. Isely (1929) noted that the greatest damage to corn is caused by larvae that drill into the stem of seedling plants below the ground and above the first circle of roots. At this point they bore into the crown of the plant and eat out the "bud." Plants injured in this way are easily recognized, because the bud dries up while the remainder of the plant may remain green for some time. The pest has destroyed as much as 75% of the stand in some fields. Older corn plants may suffer stunted growth and a reduction in yield.

The insect is a vector of cucumber mosaic virus and bacterial wilt of corn and cucumber (Davidson and Lyon 1979), and of both the severe and yellow strains of cowpea mosaic virus (Jansen and Staples 1971). It is also a carrier of maize chlorotic mottle virus (MCMV), which causes corn lethal necrosis. This disease results when a plant is infected with MCMV along with either maize dwarf mozaic virus or wheat streak virus.

Biology: The adults overwinter under crop remnants (Davidson and Lyon 1979). According to Sweetman (1926), the overwintered generation emerges in early June in Iowa and immediately begins to lay eggs in soil crevices around the roots of the host plant. The average number of eggs deposited by 17 females collected in the field was 360 (range, 116–895). Most of the overwintered beetles disappear by the middle of July. The incubation period averaged 8.5 days (range, 6–13).

The larvae pass through three instars (Sweetman 1926). The time spent in the various instars (for eight larvae) during the feeding period averaged 5.7 days (range, 4–7), 8 days (range, 5–12) and 7.9 days (range, 5–10), respectively. The feeding period averaged 3 weeks. Pupation takes place within a cell in the upper 8 cm of soil. The prepupal period averaged 6.3 days (range, 5–9), the pupal period 8.5 days (range, 5–12) and the number of days the adult remained in the pupal cell averaged 1.8 days (range, 1–3).

The new adults emerge and immediately begin feeding (Sweetman 1926). Mating may be observed during the latter part of summer and early fall. Only one generation is produced each year in Iowa. Davidson and Lyon (1979) noted that two generations occur over most of the range of the striped cucumber beetle, with perhaps only one in the northern parts.

Known parasites include the nematode *Howardula benigma* (Cobb) (Elsey 1977) and the tachinid fly *Celatoria diabroticae* (Shimer); the latter develops in the abdomen of the beetle (Chittenden 1909*b*, Isely 1929). The wheel bug, *Arilus cristatus* Linnaeus, also preys on the adults (Chittenden 1909*b*).

Diabrotica virgifera virgifera LeConte
western corn rootworm

Distribution: Ontario.

Economic injury: First observed in Ontario in 1975, the western corn rootworm increases the damage caused by the northern corn rootworm (*D. longicornis* (Say) and is a more serious pest in the United States (Foott and Timmins 1977*b*). Ruppel and Dudek (1978) stated that this insect primarily damages corn that is grown without rotation; however, *D. virgifera* may also complete its immature stages on other grass hosts such as wheat, spelt, barley, foxtail millet, wheatgrass, foxtail, weeping lovegrass, sand lovegrass, and rice (Branson and Ortman 1970). Bereza (1977*b*) reported that the rootworms are not usually a problem in sandier soils. Adults prefer the silks of certain hybrids, and damage to deep-rooted, sturdy stalked hybrids is seldom of economic importance.

The greatest damage results from the underground feeding of the larvae, with only slight damage caused by the adults above ground (Bereza 1977*b*). As the larvae develop, they eat the smaller roots and tunnel in or channel and gouge the outside of the larger ones. The larvae may destroy both main and brace roots, and, during heavy infestations, burrows may extend into the centre of the stalks (Bryson et al. 1953). Severe injury may result in dwarfed and wilted stalks, early maturity, decay organisms, and leaning or lodging of plants because of lack of vigor (Bryson et al. 1953, Bereza 1977*b*). The ears of badly infested plants vary in size and weight, appear chaffy, and bear shriveled kernels (Bryson et al. 1953). Such plants may completely fail to produce ears.

The adults feed on every part of the plant growing above ground, including the silks, leaves, tassels, and soft kernels at the tips of the ears (Bryson et al. 1953, Ruppel and Dudek 1978). The beetles chew small holes through the tender leaves and skeletonize the tips and edges of the mature leaves, causing them to roll toward the midrib (Bryson et al. 1953). The most obvious injury to the corn plant results from clipping the silk. When the silk is clipped before pollination, the plants produce partly barren ears (Bereza 1977*b*). In Ontario, most of the corn has been pollinated before peak emergence, but economic injury could occur if the corn is planted late or if a late-maturing hybrid is used and the adults are present in large numbers.

Diabrotica virgifera has been implicated in the transmission of both severe and yellow strains of cowpea mosaic virus (Jansen and Staples 1971).

Biology: In Ontario, the insect passes the fall, winter, and spring in the egg stage (Bereza 1977*b*). Newly hatched larvae feed on the roots of corn for 3 or 4 weeks, until they reach maturity around mid July. At this time, they leave the roots to form cells in the soil and pupate. According to George and Hintz (1966), the larvae have three instars. In the laboratory at 20°C, the duration of the first instar averaged 11 days, the second 14 days, and the third 27 days. The duration of the pupal stage averaged 15 days, and the total duration of the immature stages averaged 64 days. Kuhlman et al. (1970) reported a day average of 7.1, 6.2, 6.9 (feeding) and 7.6 (prepupal) for the first, second, and third instars, respectively, at 22.2°C. The pupal stage averaged 10.4 days, and the total length of the immature stages averaged 38.2 days. First-generation adults appear around the first week in August (Bereza 1977*b*). Mating takes place soon after the new adults appear, although according to Ball (1957), some did not mate for up to 6 days after emergence. In Nebraska, Hill (1975) collected beetles in copula in the field and found that females lived an average of 78.2 days (range, 3–132), had a mean preoviposition period of 12.2 days (range, 9–22), and had a mean fecundity of 1087.0 eggs (range, 595–1559). The males mated several times, but the females only once. Mating apparently increases the rate at which the ovaries develop. Bereza (1977*b*) stated that after mating, the females deposit their cluster of eggs at depths of up to 5 cm at the base of corn plants, generally among brace roots. Ball (1957), in Nebraska, reported that about 23% of the eggs were deposited in the upper 5 cm of soil, 58% in the upper 10 cm, and 80% in the upper 15 cm, with the remaining 20% probably below the 1.5 cm level. In Ontario, most of the eggs are laid from late August to October (Bereza 1977*b*). The first frost usually kills the adults. Only one generation is produced per year.

The biology of the western corn rootworm is similar to that of the northern corn rootworm (Ruppel and Dudek 1978). Chiang (1973) reported interspecific pairing in the field, most often between northern males and western females. Viable eggs have been produced in the laboratory, the progeny appearing morphologically similar to the western species.

Tachinid larvae have been observed parasitizing the western corn rootworm in Illinois (Chiang 1973). Laelaptidae (*Androlaelaps* sp. and *Stratiolaelaps* sp.) are predaceous on the eggs and larvae of *D. virgifera* (Chiang 1973).

Disonycha arizonae Casey (*davisi* Schaeffer)

Distribution: Manitoba and Ontario.

Economic injury: Mitchener (1928) reported this species (as *D. davisi*), which is native on wild sand cherry, as having spread to cultivated plum and cherry in Manitoba. Blake (1933) reported the species from potato.

Disonycha pensylvanica (Illiger)

Distribution: Ontario and Quebec.

Economic injury: This species has been reported to riddle the leaves of Chinese lantern in many gardens in Ontario (CIPR 1936); it also occurs on *Polygonum* sp. (Blake 1933).

Disonycha triangularis (Say)
threespotted flea beetle (triangle flea beetle)
altise trimaculée (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Northwest Territories.

Economic injury: This well-known enemy of sugar beet has also been reported from spinach and *Amaranthus* (Blake 1933). According to Mitchener (1930), this species is the most serious limiting factor to sugar beet tonnage per hectare in Manitoba. In the CIPR (1945), *D. triangularis*, in conjunction with *Psylliodes punctulata*, was reported to destroy spinach, beet, and radish seedlings in Alberta. It has also been reported on wheat in the same province, but Gibson (1913) stated that the species has been found in wheat fields in Manitoba, with no discernible injury to the crop. More recently, the species has been reported to feed on canola in Saskatchewan (Burgess 1977*a*).

Disonycha xanthomelas (Dalman) (*xanthomelaena* Dalman)
spinach flea beetle
altise de l'épinard (f.)

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, and Northwest Territories.

Economic injury: This species has been reported to damage spinach in New Brunswick (CAIPR 1970, 1974). The larvae have been reported to occur abundantly on the leaves of sugar beet in Ontario (Caesar 1932). In the same province, the species also occurred on Swiss chard (CIPR 1944) and horseradish (CIPR 1932).

Biology: According to Gibson (1913), adults occurred in May, June, September, and October in the vicinity of Ottawa, Ont. The same author reported that the insects feed on lamb's-quarters and chickweed.

Entomoscelis americana Brown
red turnip beetle
chrysomèle du navet (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Northwest Territories, and Yukon Territory.

Economic injury: *Entomoscelis americana* is a pest of canola and mustard crops in the Prairie Provinces and British Columbia (Gerber and Lamb 1982). Only the adults cause economic damage by feeding on the cotyledons, first leaves, petioles, and stems of seedling plants in June. In late July and August the beetles damage older plants by feeding on the flowers and pods. The beetles may feed on the epidermis of the pods or may chew holes in the pod and feed on the seeds. Gerber (1976) has shown that this late-season damage by the beetles did not significantly reduce the yield in the two canola varieties tested. According to Turnock (1977), reports of damage by *E. americana* have been widespread since 1956, reflecting the increased abundance of canola. In British Columbia, according to Banham and Arrand (1978), the species is mainly injurious to cabbage, radish, and rutabaga, although it also attacks other cruciferous crops such as broccoli, Brussels sprouts, cauliflower, kale, kohlrabi, and turnip. The adults and larvae feed on the flowers and seed pods and chew large, irregular holes in the leaves of these plants. Beirne (1971) also listed horseradish, mustard, and cress as cultivated plants reportedly attacked.

Biology: Gerber and Lamb (1982) described the life history of *E. americana* in canola fields in the Prairie Provinces. The eggs are deposited in the soil during August and September. The eggs overwinter and hatch in April and early May. The larvae feed on cruciferous weeds and volunteer canola and mustard. The larval and pupal periods last 2–3 weeks and 2 weeks, respectively. Pupation occurs below the soil surface at a depth of 1–2 cm (Gerber unpublished). Adults emerge during the first 3 weeks of June and feed until the end of June, when they enter the soil to aestivate. They reemerge in late July and August, migrate to new canola fields, feed, mate, and oviposit. One generation is produced per year in Canada.

Epitrix cucumeris (Harris)
potato flea beetle
altise de la pomme de terre (f.)

Distribution: British Columbia (?), Alberta (?), Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Economic injury: Gibson (1913) described *E. cucumeris* as one of the most destructive species of flea beetles in Canada. In Ontario the species was considered to be one of the most important pests of potato (Caesar 1938). Cannon (1960*b*) reported yield reductions of up to 25% in the potato crop in Prince Edward Island, especially the early varieties. The adults feed on the underside of the leaves, chewing small holes, which results in a shot-hole appearance (Johannsen 1913). The feeding of overwintered adults damages young plants and retards growth, but the main injury is caused by the feeding of the new generation of adults, which causes the leaves to dry out and die (Cannon 1949). The preferred food plants of *E. cucumeris* are species of Solanaceae including potato, wonderberry, bittersweet, Jerusalem-cherry, horse-nettle, common nightshade, eggplant, tomato, cayenne pepper, ground-cherry, petunia, tobacco, and jimsonweed (Johannsen 1913). The same author stated that the species has also been reported feeding on cucumber, squash, watermelon, muskmelon, beans, corn, radish, turnip, cabbage, sunflower, plantain, beet, spinach, celery, raspberry, apple, sweet potato, rhubarb, and hops. According to Lochhead (1902*a*), the feeding damage of *E. cucumeris* promotes infection by the early blight fungus, *Alternaria solani* Sorauer, and the beetles may serve as vectors of the disease. The larvae of *E. cucumeris* occasionally feed on potato tubers, causing pimplelike eruptions on the surface by their shallow tunneling activity and forming slivers by their deeper excavations (Cannon 1960*b*).

Biology: Johannsen (1913) studied the life history of *E. cucumeris* in Maine. His description is supplemented with observations made by Cannon (1949, 1960*b*) in Prince Edward Island. The overwintered adults emerged in April and May and fed for a while before mating during the last 2 weeks of June. Eggs were laid singly in the soil and were present from the end of June to mid July. In Prince Edward Island, the incubation period was about 2 weeks (Cannon 1960*b*). Larvae and pupae were found among the roots of the host plants, the former mining the potato seed pieces, with the anterior half of their bodies buried within the tuber. The larval and pupal periods lasted approximately 4–5 weeks and 1 week, respectively (Cannon 1949). Adults of the new generation began to emerge about the middle of July, reaching maximum abundance by the beginning of September. These beetles fed until the first frost, when they entered hibernation. Cannon (1960*b*) stated that the beetles overwintered in the soil or under plant debris along fence rows or margins of fields and woods. According to the same author, only one generation a year is produced in Canada.

Comments: *Epitrix cucumeris* has been reported from British Columbia (Gibson 1913, CIPR 1923, MacNay 1947). However, Cannon (1960*b*) and Hodgson et al. (1974) stated that *E. cucumeris* occurs in every province except British Columbia. This discrepancy might be explained by Gentner (1944), who described a western species from Oregon and Washington, *E. tuberis*, that had previously been included in *E. cucumeris*. Hatch (1971) included references to *E. cucumeris* from British Columbia under the name *E. tuberis* Gentner. From the statements of Cannon (1960*b*) and Hodgson et al. (1974), *E. cucumeris* is inferred to be also known from Alberta. However, we have seen no specimens or references to *E. cucumeris* from that province.

Epitrix hirtipennis (Melsheimer) (*parvula*, of authors, not Fabricius)
tobacco flea beetle
altise du tabac (f.)

Distribution: Ontario, Quebec, and Nova Scotia.

Economic injury: This species has been reported to attack tobacco in Ontario (Fox and Stirrett 1952) and tomato in Quebec (CIPR 1953). In addition, host plants reported from specimen labels by White and Barber (1974) include potato, eggplant, nightshade, and jimsonweed.

Biology: According to Elsey (1977), parasitism of *E. hirtipennis* by a nematode, *Howardula* sp., resulted in a high larval mortality, a longer larval period, and reduced feeding activity.

Epitrix subcrinita LeConte
western potato flea beetle
altise de la pomme de terre de l'ouest (f.)

Distribution: British Columbia and Alberta.

Economic injury: According to Dustan (1932), the adults of *E. subcrinita* attack potato foliage by chewing small, circular holes through the lower epidermis. Serious losses result when the infestation is heavy. Preferred host plants include potato, tomato, eggplant, pepper, and beans, although the insects attack some weeds, particularly early in the season. According to MacCarthy (1953), larvae of *E. subcrinita* damage rhizomes, roots, and tubers, the last in much the same way as does *E. tuberis*. However, the surface tracks on the tubers were consistently shallower than those produced by *E. tuberis*. The species may also serve as vectors for bacterial diseases and spindle tuber (Hodgson et al. 1974).

Biology: According to Dustan (1932), the adults overwinter in sheltered situations, emerge in spring, feed initially on weeds, and later migrate to cultivated plants. Eggs are deposited in the soil around the host plant. Adults of the new generation appear in July. Probably two generations a year are produced in British Columbia.

Epitrix tuberis Gentner (*cucumeris* of authors, not Harris)
tuber flea beetle
altise des tubercules (f.)

Distribution: British Columbia and Alberta.

Economic injury: The tuber flea beetle is one of the most important insects known to attack potato in British Columbia (Banham 1970). The adults feed on the upper and lower surfaces of the leaves, on leaf petioles, and on flowers, but unless the damage is extensive, the crop yield is not reduced (Banham and Arrand 1978). As described by Banham (1970), the larvae, however, cause extensive damage to the potato tuber by making a shallow network of fine tunnels under the skin when feeding. Following the feeding damage, the abandoned tunnels become filled with brown corklike tissue requiring deep peeling of the potato. Damage by two or more larvae renders the tuber unmarketable for table use. The surface of affected tubers is covered with scabs, knobs, and deep cracks. In addition to potato, larvae and adults attack other Solanaceae such as eggplant, tomato, ground-cherry, and Chinese lantern (Hatch 1971). In the spring and fall when solanaceous plants may not be present, the beetles have been reported to feed on beans, cucumber, chard, lettuce, cabbage, Canada thistle, and chickweed (Fulton and Banham 1962).

Biology: Banham (1970) described the biology of *E. tuberis* in British Columbia, where the species undergoes two and occasionally a partial third generation a year, depending on the length of the growing season. Adults overwinter in the soil at depths down to 60 cm, depending on soil type. According to Fulton and Banham (1962), the beetles emerge from early May to late June and immediately start feeding on potato. They mate shortly after emergence and are capable of oviposition 7 days later (Neilson 1954). The females deposit eggs singly on or near developing tubers. Overwintered and new-generation females, over a period of 26–69 days, lay about 156 and 278 eggs, respectively.

Newly hatched larvae bore through the skin of the tuber and start feeding. There are detectable peaks of larval damage, but a high degree of overlap occurs between the generations. At maturity the larvae pupate in the soil (Fulton and Banham 1962). In British Columbia no predators or parasites of *E. tuberis* have been recorded, although a nematode parasite was reported in Oregon.

Erynephala puncticollis (Say)
beet leaf-beetle

Distribution: Alberta, Saskatchewan, and Manitoba.

Economic injury: Based on a report by Chittenden (1920), the beet leaf-beetle is a serious pest of sugar beet grown in alkaline areas of the Great Basin. Other hosts include garden beet, Swiss chard, lamb's-quarters, spinach, Russian thistle, and sea-blite. Damage is caused by the feeding of the overwintered adults and by larvae that defoliate young beets and, during severe infestations, mature beets. Severe damage results in a considerable reduction in sugar content or even in the death of infested sugar beets. In feeding, the beetles chew large, irregular holes through the leaves. They prefer older, outer leaves. The beetles also act as carriers of a fungal disease.

Biology: Chittenden (1920) reports the biology of this species based on observations made in Colorado. The species lives in semiarid regions, normally feeding on weeds. It becomes a pest in the spring before the normal weed hosts are available. The adults overwinter on the surface of the ground under tufts of grass and heaps of dead weeds and on other rubbish. Adults become active during March and early April and immediately begin feeding and mating. Eggs are laid on the underside of the leaves. One female may lay 300–400 eggs. Eggs hatch in 8–18 days, and the larvae complete their development in 14–29 days. When mature, the larvae burrow into the soil 2–5 cm and form pupal cells. In Colorado three generations are produced each year. Adults begin actively flying to suitable hibernation sites during September and early October.

One tachinid fly, *Hypostena* sp., was reared from the larvae (Chittenden 1920).

Fidia viticida Walsh
grape rootworm
gribouri de la vigne (m.)

Distribution: Ontario.

Economic injury: The grape rootworm is an important pest of grape in Arkansas (Isely 1942). The adults feed on the upper surface of the foliage, destroying the upper epidermis and parenchyma, often causing the remaining portion of the leaf to turn brown and drop from the plant. On thin-leaved varieties and wild grapes, the lower epidermis may also be damaged. The adults also scar the surfaces of the fruit and, when abundant, may severely reduce the value of the crop. Adults feed most actively during the first week after emergence.

Larval root feeding, although less obvious, may be more serious than the damage caused by the adults. The larvae feed on the inner bark of the larger roots and destroy the smaller roots. The smaller larvae bore under the bark of the larger roots and feed between the longitudinal root fibers, and the larger larvae feed externally on the root. During a severe infestation the larger roots are girdled, and the smaller roots are completely destroyed. Newly hatched larvae may also feed on the cane before entering the ground.

Biology: Isely (1942) described the life history of *F. viticida* in Arkansas, where the species requires 1–2 years to complete a generation. The preoviposition period ranged from 9 days to more than 2 weeks. Oviposition probably started in early June, but eggs were not abundant until the latter part of the month. The elongate, cylindrical eggs were laid on their sides, usually under bark scales, in flattened masses of 20–60. The average oviposition period is 1 month. One female laid seven egg masses over a 6-week period. A mean of 112 eggs per female was observed, with a maximum of 262 eggs. The incubation period ranged from 5 to 11 days.

After hatching, the larvae dropped to the ground and continued their development under the soil surface. The larvae of *F. viticida* passed through five instars. Larvae overwintered in the soil at depths of up to 60 cm, with a few individuals remaining in the upper 15 cm. Forty-five percent of the larvae reached maturity before winter and pupated the following spring. The remainder continued feeding until the following spring, apparently requiring a second year for development. These latter larvae required a second hibernation before they could pupate, even though some individuals formed pupal cells early in the season.

The majority of larvae pupated in May in earthen cells a few centimetres to 45 cm below the soil surface. The duration of this stage was 11–17 days. The newly transformed adults remained in the pupal cell for 2 or 3 days before emerging. Adult emergence began about the middle of May, when the blossoming period of the grape was completed; peak abundance was reached by the end of the month. Adults tended to be active on the host plants, wild and cultivated grape and Virginia creeper, in the latter part of the morning and remained inactive during the heat of the day.

Galeruca browni Blake (*externa* of authors, not Say)
peppergrass beetle
galéruque de la lépidie (f.)

Distribution: British Columbia (?), Alberta, Saskatchewan, and Manitoba.

Economic injury: According to Dustan (1932), the adults and larvae of this species (as *G. externa* Say) frequently injure cabbage and turnip. In Manitoba, according to MacNay (1953), the adults defoliated turnips by cutting the leaf petioles and eating the crowns to the ground. In the same province, Mitchener (1928) reported damage by this species to seedling cabbage, radish, turnip, and other cruciferous garden plants.

Additional host plants of *G. browni* include pepper-grass, tumble mustard, and *Arabis* spp. (Dustan 1932).

Biology: Dustan (1932) gave a brief account of the life history of this species. The eggs are deposited among the soil dust in autumn, the species overwintering in this stage. The larvae emerge in mid May and undergo a rapid development until early June, when they pupate. A new generation of adults emerge in late June, feed for a time, and then go into aestivation. After approximately a month in this state, the adults reemerge to feed and mate. Only one generation a year is produced in Manitoba.

Comments: In CIPR (1925), *G. browni* (as *externa* Say) is reported from wild mustard, radish, and field turnip in British Columbia. However, according to Blake (1945), G. *browni* does not occur in that province and the similar species, *G. rudis* LeConte, that does occur is known only from lupine.

Galerucella nymphaeae (Linnaeus)
waterlily leaf beetle
galéruque du nénuphar (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Newfoundland, Labrador, Northwest Territories, and Yukon Territory.

Economic injury: This species has been recorded from a variety of truck crops (Hatch 1971). According to Wilcox (1965), the larvae feed on *Nuphar*, *Nymphaea*, *Polygonum*, and *Myrica*. Balachowsky (1963) also records it from other aquatic plants such as *Sagittaria*, *Potamogeton*, *Lysimachia*, *Comarum*, and *Rumex*.

Biology: Balachowsky (1963) describes the life history of this species. It overwinters in the adult stage under various debris at the margins of streams, ponds, and other wet habitats. In France, the adults emerge in late April and concentrate on the leaves of *Nymphaea*, where they begin mating in early May. They lay the eggs in clumps of 12–18 on the dorsal surface of the leaves. After hatching, the larvae begin feeding on aquatic plants and never emerge. The larvae complete their growth by the end of May or early June and pupate in situ on the dorsal surface of the leaf. The adults emerge in July or August and may fly to new plants or aquatic habitats. In southern Europe two generations are produced per year.

In Europe the waterlily leaf beetle is parasitized by a chalcid, *Pleurotropis* (Balachowsky 1963).

Gastrophysa cyanea (Melsheimer)
(green dock beetle)

Distribution: British Columbia and Alberta.

Economic injury: *Gastrophysa cyanea* has attacked rhubarb in Oregon (Hatch 1971). Their normal hosts are species of the genus *Rumex* (Lawson 1950). Both adults and larvae feed on leaves, often stripping them to the midrib.

Biology: The life history of this species was described by Lawson (1950). The species overwinters in the adult stage. The adults emerge in the spring and immediately begin feeding on the lower surface of the leaves. They lay about 800–1400 eggs in groups on the lower surface of a leaf along the midrib. Eggs hatch in 5–19 days, and the first instar larvae begin chewing small holes in the leaf. The larvae pass through three instars before dropping to the ground and forming a pupal cell about 1 cm deep. Larvae require about 2 weeks to complete their development, after which the adults often remain in the pupal cell for long periods. Only one generation per year occurs in Ohio.

Gastrophysa polygoni (Linnaeus)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: In New Brunswick this species was found to attack rhubarb foliage in June (CIPR 1928). The normal hosts for this beetle are plants of the genus *Polygonum*. Sotherton (1982) reports the species to be abundant in wheat and barley fields in England, where it may become a pest if its preferred hosts, *P. aviculare* L. and *P. convolvulus* L., are present.

Biology: Sotherton (1982) reports on the biology of the species in southern England. The species overwinters in the adult stage. The adults emerge in late April or May and immediately begin feeding on the edges of leaves. Oviposition begins in May. The highest number of eggs varied from 23 to 98/m^2. First-instar larvae fed on the remains of the chorion before feeding on the plant. Later-instar larvae chewed holes in the leaves and readily moved from plant to plant. Third-instar larvae, when mature, entered the soil and prepared a pupal cell. Development from egg to adult varied from 35 to 69 days. Two generations per year were completed.

A tachinid fly, *Meigenia* sp., was reared from the larva (Sotherton 1982).

Glyptoscelis artemisiae Blake

Distribution: British Columbia and Alberta.

Economic injury: Hatch (1971) described *G. artemisiae* as a common species that occurs on sagebrush and frequently on fruit trees on irrigated land.

Biology: The larvae of *Glyptoscelis* feed on underground roots (Blake 1967).

Glyptoscelis longior LeConte

Distribution: British Columbia.

Comments: According to CIPR (1950), this species, along with two species of weevils, seriously damaged seedling apricot, peach, and cherry in British Columbia. The damage to the vegetative buds was similar to cutworm damage and resulted in the mortality of some trees. In Blake's (1967) revision of the genus *Glyptoscelis*, the species *G. longior* is not reported from British Columbia.

Glyptoscelis pubescens (Fabricius)

Distribution: Ontario.

Comments: Brittain (1914) reported that *G. pubescens* occasionally attacks apple foliage in British Columbia. MacNay and Creelman (1958), probably referring to this record, listed this species as a pest of apple in that province. In Blake's (1967) revision of the genus

Glyptoscelis, she described *G. pubescens* as occurring from Minnesota eastward. Hatch (1971) believed that Brittain's record probably referred to the species *G. artemisiae* Blake.

Graphops marcassita (Crotch)
(strawberry rootworm)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: In Manitoba, the CIPR (1961) reported that the species defoliated strawberry plants so severely that many died. In literature cited by Blake (1955) damage to the roots of strawberry occurred in August and September and was probably caused by this species.

Biology: The report cited by Blake (1955) stated that the species overwintered as a larva, pupated in May, and emerged as an adult in June.

Labidomera clivicollis (Kirby)
(milkweed labidomera)
chrysomèle de l'asclépiade (f.)

Distribution: Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: According to Gibson (1934), this beetle, which occurs abundantly on common milkweed, also attacks butterflyweed, which is grown as an ornamental. The beetles are abundant in some years on these plants and are particularly noticeable during August.

Lema trilineata (Olivier)
three-lined potato beetle
chrysomèle trirayée de la pomme de terre (f.)

Distribution: Alberta, Manitoba, Ontario, and Quebec.

Economic injury: According to Kaufmann (1967), the three-lined potato beetle was at one time a major pest of potato, but its importance has declined as a result of modern control measures. Kogan and Goeden (1970*b*) reported that the preferred hosts of this species are plants of the genus *Datura*, but also reported on the acceptability of a variety of other plants. In Ontario, Ross and Caesar (1931) reported the species to feed on the foliage and seedpods of Chinese lantern, *Physalis alkekengi* L., and other herbaceous plants, and CIPR (1961) reported it to cause heavy injury in one field of flue-cured tobacco.

From a review of the literature, other recorded host plants include species of the following genera: *Datura, Physalis, Cestrum, Chamaesaracha, Lycopersicon, Iochroma, Hyoscyamus, Salpichroa, Solandra, Solanum, Nicandra,* and *Nicotiana*. The adults chew numerous irregular holes through the leaves of the host plants, and the larvae feed gregariously on the foliage beginning at the margin and moving towards the leaf base, leaving the main veins intact (Kaufmann 1967).

Biology: Kaufmann (1967), in Kansas, and Kogan and Goeden (1970*a*), in California, reported on the life cycle of *L. trilineata* from a review of the literature and from observations made in the laboratory. The species produces two generations a year in Kansas, the first beginning in June and the second in August. Only one generation per year is produced in Manitoba (Criddle and Handford 1933).

Each of five females deposited an average of eight eggs per day (range, 0–48) in clusters during 68 days. The total number of eggs laid by individual females ranged from 290 to 558. The egg clusters were deposited on the undersides of the leaves along the midrib. Oviposition ceased with the onset of cool weather, and the incubation period varied from 3 to 5 days.

The larvae discharge feces from a dorsally situated anal opening onto their backs to form a covering over the body surface. The larvae also exude a brown material from their mouths when tactilely stimulated. This behavior serves as a defense mechanism. The species has four larval instars, the first three lasting 1–2, 1–3, 1–3 days, respectively. The final-instar larvae, after 1–5 days of development, enter the soil to form pupal cocoons in which they remained for 3–7 days as nonfeeding prepupae. The pupal period lasted for 2–7 days, and the newly transformed adults remained in the cocoons for several days before emerging.

Criddle and Handford (1933) reported that in Manitoba, adults become active in late May and almost immediately begin mating. Eggs are found in early June, and larvae hatch 13 days after oviposition. Adults go into hibernation by August.

Leptinotarsa decemlineata (Say)
Colorado potato beetle (Colorado potato bug)
doryphore de la pomme de terre (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland (?).

Economic injury: The Colorado potato beetle was one of the most important pests of potato before 1940, but since then it has been less abundant, with only occasional serious injury reported (Goble 1960). Although both the adults and larvae feed on the foliage, most of the damage is done by the larvae. After emergence from the egg, the larvae initially feed on the underside of the leaf under the eggs, cutting out small bits of tissue but not breaking through the upper epidermis (Gibson et al. 1925). The larvae then migrate to the top of the plant, where they feed on the upper surface of the young, tender leaves. The second-instar larvae prefer the more succulent portions of the leaves, leaving the midribs and larger veins untouched. However, after the next molt the larvae may feed on all the foliage, including the main stems. Most of the feeding and rapid defoliation occurs after the third molt. Unless controlled, *L. decemlineata* may soon strip and kill the plant, or stop the development of the tubers, or greatly reduce the yield. Reed (1871) stated that different varieties of potato vary in susceptibility to attack. However, when less desirable varieties are the only ones planted, they may be attacked. The species also feeds readily on many other plants belonging to the Solanaceae family (e.g., tomato, eggplant, tobacco, pepper, petunia, ground-cherry, and some weeds). McClanahan (1975) reported that the Colorado potato beetle occasionally has damaged freshly planted tomato extensively. The adults feed on the tomato stems as well as on the foliage, occasionally necessitating replanting. According to Harcourt (1963), foraging adults frequently attack tomato fruit, but the number of progeny developing on this plant is negligible. Gibson et al. (1925) listed other plants that this beetle attacks, including cultivated oats, lamb's-quarters, red currant, bittersweet, nightshade, black henbane, apple-of-Peru, thorn-apple, thoroughwort, and tobacco. Adults have also been reported to attack dahlia and salvia (CIPR 1923).

The Colorado potato beetle has been implicated in the transmission of the following potato diseases: spindle tuber, bacterial wilt, and bacterial ring rot (Philip 1977).

Biology: The Colorado potato beetle overwinters in the adult stage in the soil at a depth of 20–25 cm (Hodgson et al. 1974). According to Harcourt (1964), in Ontario overwintered adults emerge from the soil in greatest numbers about the middle of June, when potato plants begin to appear, and almost immediately fly off in search of suitable host plants on which to feed and lay eggs. Gibson et al. (1925) reported that food appears to be necessary before mating and that copulation takes place very soon after eating. Mating is followed by a short preoviposition period (Mitchener 1956). Oviposition begins within 2 or 3 days of emergence and reaches its peak during early July in Ontario (Harcourt 1963). According to Cannon (1960*a*), each female lays 300–500 eggs during a period of 4–5 weeks and then dies. However, Cannon (1951) also reported that although most of the adults appearing in the spring die in the fall, some of them may live through a second winter and even lay fertile eggs the next spring. Caesar (1927) stated that a female could lay at least 1000 eggs, but that the average was probably less than half this number. The eggs are laid in clusters of 10 or more on the undersides of leaves and hatch within 4–9 days (Philip 1977).

The larvae pass through four instars and reach maturity in 2–3 weeks (Hodgson et al. 1974). Gibson et al. (1925) reported an average length of 3.7, 2.5, 3.6, and 6.1 days for the first through the fourth instars, respectively. At maturity, the larvae drop to the ground and crawl a short distance before burrowing into the soil to a depth of 5–10 cm to form an oval cell in which they pupate (Harcourt 1964). Adults emerge 5–10 days later (Philip 1977). The summer adults emerge in early August in Ontario (Harcourt 1964) and feed on the foliage throughout the month, with little or no oviposition. The adults move to hibernation quarters in early September. Cannon (1960*a*) stated that in Canada, there is usually only one generation per year, although a second generation may develop in certain areas. According to Philip (1977), one or two generations may be produced per year in a given area; a partial third generation may emerge, depending on weather conditions and food availability.

Graham (1965) reported that *L. decemlineata* is parasitized by two species of tachinids, *Doryphorophaga doryphorae* (Riley) and *D. aberrans* Townsend. Predators of the species include the coccinellids *Anatis 15-punctata* Olivier, *Coccinella 9-notata* Herbst, *Hippodamia 13-punctata* (Linnaeus), *H. maculata* (De Geer), and *H. convergens* (Guérin-Méneville); the carabids *Calosoma calidum* (Fabricius), *Harpalus caliginosus* (Say), and *Lebia grandis* Hentz; the pentatomids *Perillus bioculatus* Fabricius, *P. bioculatus* var. *claudus*, *P. circumcinctus* (Say), *Podisus cynicus* Say, and *P. spinosus* Dallus; the reduvid *Reduvius raptatorius* (Say); and the uropodid *Uropoda americana* Riley. Fungal pathogens of *L. decemlineata* are *Beauveria bassiana* (Bals.) Vuill., *Mucor* sp., *Bacillus thuringensis*, and *Paecilomyces*.

Comments: Although Philip (1977) stated that the Colorado potato beetle is found in Newfoundland, the only record from this province is that of specimens collected in a carload of potatoes from Ontario (CAIPR 1973).

Lilioceris lilii (Scopoli)
(lily leaf beetle)
criocère du lis (m.)

Distribution: Ontario and Quebec.

Origin: According to European literature cited by Brown (1946), *L. lilii* is widely distributed in Europe and occurs in southwestern Siberia and North Africa. In 1943 the species was first found near Montreal (LeSage 1983). Brown surmised that *Lema melanocephala* Say, described from North American specimens in 1826, may represent this species.

Economic injury: Brown (1946) discussed the pest status of this species. In a 1945 Montreal infestation, the species severely damaged regal lilies. The young larvae fed on the undersides of the leaves and the mature larvae fed on the upper sides. In Europe the species is an important pest of *Lilium*, especially the Madonna lily and the martagon lily, and also occurs rarely on lily-of-the-valley, Solomon's-seal, and fritillary. CIPR (1963) reported damage to Madonna lilies in Quebec.

Biology: Brown (1946) described the life history of *L. lilii* based on a summary of European literature. The species has from one to three generations a year, and individual females may lay eggs in 2 successive years. Females lay approximately 300 eggs, which require 7–10 days to develop. The larval and pupal periods last 16–24 days and 20–22 days, respectively. Adults overwinter in vegetable debris and emerge in early spring.

Longitarsus waterhousei Kutschera (*menthaphagus* Gentner)
(mint flea beetle)

Distribution: Ontario.

Origin: According to Gentner (1928), *L. waterhousei* was probably introduced into North America on mint roots imported from England. The same author stated that mint roots were imported into the United States as early as 1870. In North America, the earliest record of injury to mint by this flea beetle was in 1922 (Gentner 1926).

Economic injury: Gentner (1926) described this species as a serious pest of cultivated mint and documented the nature of the injury. Pepper mint and spear mint are both seriously injured. In badly infested fields, the oil yield is greatly reduced. The larvae cause the most serious damage by feeding externally on the small rootlets, tunneling into the larger rootlets, and mining under the epidermis of the main root and underground stem. Larvae sometimes tunnel a short distance into the aerial stem or completely girdle the main root. Infested plants are stunted, do not produce lateral root growth, and exhibit discoloration.

Adults of *L. waterhousei* feed on both sides of the leaves, making small holes that extend to the epidermis on the opposite side. The lower leaves are attacked first, the beetles working progressively higher as the lower leaves are riddled. Damaged leaves may turn brown and drop off.

Biology: Gentner (1926) described the biology of *L. waterhousei*. The species produces one generation a year. Eggs are deposited singly on the soil surface or between soil particles, the female crawling a short distance between each deposit. Females contained a maximum of seven eggs, suggesting that eggs are matured in batches. Oviposition continues until the onset of cold weather, by which time most of the adults have died. The species overwinters in the egg stage and the eggs hatch in May.

The larvae mature after feeding for a period of about 1 month and form smooth-walled pupal cells within 7.5 cm of the soil surface. The adults emerge about 3 weeks later during July and immediately begin feeding on the mint foliage. Adult emergence extends over a period of about 3 weeks. Initially, the adults may be found feeding at any time of the day, but as the feeding period continues, they become inactive during the day, hiding among the leaf litter and soil particles, and emerging during late afternoon to feed during the night and early morning. After feeding for a period of 3 weeks, the adults mate and almost immediately begin oviposition. Males of *L. waterhousei* lack wings, and the heavy-bodied females have never been observed in flight.

Spiders and a carabid beetle, *Pterostichus* sp., have been observed preying on the adults.

Metriona bicolor (Fabricius)
golden tortoise beetle
casside dorée (f.)

Distribution: Ontario, Quebec, and Nova Scotia.

Economic injury: According to Barrows (1979), the golden tortoise beetle is sometimes an important pest of sweet potato. In Canada, Gibson (1934) described *M. bicolor* as one of the species that in some years feed in numbers on the foliage of morning-glory and other garden plants.

Biology: Barrows (1979) made observations on the life history and biology of this species from specimens collected in Washington, D.C. Some males and females were observed copulating more than once with different mates and from one to six times with the same mate when isolated in pairs. The mean incubation period for 32 eggs was 7.4 days (range, 5–8).

Larvae required a mean of 21.7 days (range, 21–25) to complete development. The larvae, using their abdominal urogomphi, carried single masses of exuviae and feces over their dorsum and were capable of moving the masses in response to tactile stimuli to protect exposed areas of the body. The larvae defecated on one side or the other of the mass, resulting in a symmetrical structure. Pupae, which retained the fecal mass, were found attached to leaves. The duration of this stage was 6.9 days (range, 6–9). Adults were observed in the field from early May to early October. In the laboratory, adults lived from 25 to 111 days.

Adults of *M. bicolor* are capable of rapid color change, which may serve to camouflage, to indicate sexual receptiveness and, in the orange phase, to mimic ladybird beetles.

Monoxia angularis (LeConte)

Distribution: British Columbia and Alberta.

Economic injury: This species has been recorded on *Chenopodium, Atriplex*, potato, and sugar beet (Hatch 1971).

Monoxia consputa (LeConte)
(sugar-beet leaf beetle)

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: Unknown. However, its unofficial common name suggests possible injury.

Monoxia debilis (LeConte)

Distribution: British Columbia, Alberta, and Manitoba.

Economic injury: Hatch (1971) reported this insect on *Chenopodium album* and sugar beet.

Neochlamisus cribripennis (LeConte)
blueberry case beetle

Distribution: Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: The species feeds exclusively on lowbush blueberry and is one of the major pests of this plant in Nova Scotia (Wood 1966). Periodically, populations build up to such an extent that nearly all the crop is lost. In late June and early July, larvae begin feeding on the leaves and sometimes completely strip the foliage. In September and October, adults feed on the stems, damaging the bark (Agriculture Canada 1975). According to Ellis and LeRoux (1964), *N. cribripennis* is a minor pest of blueberry in Ontario and Quebec.

Biology: The life cycle of the blueberry case beetle was studied by Wood (1966). Oviposition starts in May and reaches a peak by mid June. In mid June the stalked eggs are laid singly on the stem or leaf of the host plant and covered with a case of excreta. The eggs hatch in 10–14 days. The larvae pass through three instars. The motile larva retains the egg case, enlarging the case as it grows (Agriculture Canada 1975). According to Ellis and LeRoux (1964), pupation takes place from July to September within the case on the host plant. Some adults emerge from the end of July to the end of September and overwinter, whereas others emerge the following May and June having overwintered as pupae. The species produces one generation per year.

Up to 50% of the pupae of *N. cribripennis* are reportedly parasitized by the eupelmid *Eupellmella vesicularis* (Retzius) (as *Macroneura vesicularis*) (Ellis and LeRoux 1964).

Neochlamisus fragariae (Brown)
(strawberry chlamys)

Distribution: New Brunswick.

Economic injury: According to Andison (1956), *N. fragariae* is capable of causing severe defoliation in strawberry plantations. The same author stated that although the adults feed freely in spring and fall, the most serious damage is caused by the larvae, which feed on the leaves and attack the ripening fruit. According to Morgan and Maxwell (1952), the larvae, which feed on all aerial parts, prefer the leaves, sometimes almost completely devouring them and leaving only the main veins intact.

Biology: Eggs were laid singly on the undersides of leaves during late May and early June. Each egg was stalked and enclosed in a protective case of excrement (Andison 1956). The eggs hatched in about 12 days and the larvae retained the egg case and fed through an opening at one end, enlarging the case as growth demanded (CIPR 1956). Feeding larvae were not gregarious (Morgan and Maxwell 1952). Pupation occurred within the case in late July and pupae were typically found on the crowns of the plants, often in clusters of as many as four cases attached together (Morgan and Maxwell 1952). New adults appeared from mid August until the end of September and fed until cold weather forced them into hibernation in the debris under the plants (CIPR 1956).

Nodonota puncticollis (Say)
rose leaf beetle

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: This species scars developing apples and occurs on rose, grape, pear, plum, peach, raspberry, strawberry, and clover

(Hatch 1971). Species of *Nodonota*, some of which are probably referable to this species, were reported (CIPR 1956) from sour cherry, sweet cherry, pear, rose, hawthorn, plum, locust, dogwood, willow, and Chinese elm during a nursery survey in Welland County, Ont.

Biology: Schultz (1980) reported adults during June and July.

Nodonota tristis (Olivier)

Distribution: Alberta, Manitoba, and Ontario.

Economic injury: Adults of this species severely damaged the foliage and flowers of rose, raspberry, and ornamental shrubs, especially dogwood, in the vicinity of Niagara Falls, Ont. (CIPR 1932).

Odontota dorsalis (Thunberg)
locust leafminer

Distribution: Ontario.

Economic injury: The locust leafminer may cause severe injury, especially to the black locust, its principal host (Chittenden 1902, Davidson and Lyon 1979, Wheeler 1980). The species has also been reported to be an occasional pest of soybeans (Poos 1940) and as somewhat injurious to Japanese pagoda tree (Wheeler 1980). Larvae have been found mining the leaves of false indigo (Chittenden 1902), as well as an isolated golden-chain tree (Wheeler 1980). Adults may feed on a wider variety of plants including red and white oak, elm, beech, apple, birch, wild cherry, Siberian crab apple, hawthorn, raspberry, and wisteria (Chittenden 1902). McPherson and Ravlin (1982) reported that larvae of this species completed their development on early planted fields of soybeans in Virginia.

The main injury is caused by the larvae, although some damage can be attributed to the adults. Young larvae begin feeding immediately after hatching, forming a tentiform mine by eating out the inside of the leaf leaving only the upper and lower epidermis (Chittenden 1902). The larvae normally hollow out not more than one-half or at most two-thirds of a leaf before migrating to another leaf and forming new, separate mines. There are several such migrations, greatly increasing the damage. The injured part of the leaf turns brown as soon as the larva leaves the mine or pupates. In heavily infested areas the leaves turn brown as if scorched by fire. According to Davidson and Lyon (1979), locust trees die if complete defoliation occurs in 2 successive years where two sets of leaves are produced in one summer. Adults eat small, oblong holes in the tender leaves early in the season but may skeletonize the upper portion of the leaves, leaving the bottom half intact (Chittenden 1902).

Biology: *Odontota dorsalis* overwinters in the adult stage under leaves at or near the base of locust trees (Chittenden 1902). The adults emerge in early spring as soon as the locust leaves are fully developed (Butte 1968). Oviposition takes place on the underside of leaves in small clusters of three to five eggs glued together and partly covered with excrement. The first larva to hatch makes a single hole in the lower epidermis through which the other larvae, under the protection of the egg mass, enter the leaf and occupy a single mine. The larvae feed on all the mesophyll within the mine. Two to four days after hatching, the larvae leave their original mine and move along the leaf stems to form new separate mines, often some distance away and on other twigs (Chittenden 1902). Early instar larvae are found in the same mine and late instar larvae in separate mines, one mine to a leaflet (Wheeler 1980). The larval stage requires about 3 weeks. Pupation takes place within the mine and lasts 7–10 days. A new generation of adults break their way out through the thin epidermis of the leaf. Only one generation per year appears to occur in Canada.

Wheeler (1980) reported a larva and two pupae of the eulophid wasp, *Pnigalio* (?) *maculipes* (Crawford), to be parasites of larvae in the mines. The hymenopteran *Spilochalcis albifrons* (Walsh) was reared from pupae (Poos 1940). Additional parasites include *Trichogramma odontotae* Howard, *Derostenus primus* Howard, *Sympiezus uroplatae* Howard, *Spilochalcis odontotae* Howard, and *Closterocerus tricinctus* (Ashmead) (Chittenden 1902, Davidson and Lyon 1979). *Arilus cristatus* (Linnaeus) has been reported as a predator of the species (Davidson and Lyon 1979).

Ophraella sexvittata (LeConte)

Distribution: Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: According to CIPR (1923), *O. sexvittata* was reported to injure the twigs of cherry trees in Quebec. In Ohio the species commonly occurs on goldenrod (Wilcox 1954).

Comments: LeSage (personal communication) reports that this species feeds only on Compositae and does not occur in Canada. He suggests that the misidentification probably refers to *Pyrrhalta cavicollis* (LeConte).

Orsodacne atra (Ahrens) (*childreni* Kirby)

Distribution: British Columbia, Alberta, Saskatchewan, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: CIPR (1942) reported the adults of *O. atra* to feed on the blossoms of apple in Alberta and on rose in Saskatchewan. In addition, MacNay and Creelman (1958) listed *O. atra* as a pest of apple in British Columbia, and Chittenden (1897) reported it to feed on willow blossoms and on pear and cherry.

Oulema melanopus (Linnaeus)
cereal leaf beetle
criocère des céréales (f.)

Distribution: Ontario and Quebec.

Origin: According to Westdal (1966), the cereal leaf beetle is native to Siberia, Scandinavia, central Europe, Great Britain, Spain, Italy, Iran, Turkey, and North Africa. The first record of the species in North America was made in June 1962, in Berrien County, Mich. (McClanahan et al. 1967). Farmers apparently observed the insect in southwestern Michigan as early as 1959. *Oulema melanopus* was first recorded in Canada on 13 May 1965, 4.8 km west of Harrow, Ont. (CIPR 1965). Ritchot et al. (1976) reported the species to be a new pest in Quebec in 1975. The dissemination of the insect is generally to the north and east (Westdal 1966).

Economic injury: The cereal leaf beetle attacks both spring and fall grains, but the most severe injury is done to the spring grains (Ruppel 1972). Estimates of losses ranged from negligible to 75% in spring oats and to 25% in winter wheat. The species feeds exclusively on grass and is almost never found on broad-leaved plants. The preferred hosts in descending order are as follows: the small grains, including wheat, oats, barley, and speltz; such grasses as wild oats, quack grass, timothy, rye grass, orchard grass, and canary grass; other grasses and grains, including rye, wild rye, smooth brome, foxtail millet, corn, sorghum, and sudan grass; and blue grass, millet, fescue, downy brome, redtop, and rice. CAIPR (1977) reported the insect in relatively low numbers among stores of oats and barley.

Both adults and larvae attack the upper surface of the leaves and feed lengthwise between the veins (Manson and Boyce 1968). The adults chew right through the leaf tissues, causing the leaves to split lengthwise and appear tattered. The larvae rarely chew completely through the leaf. Under heavy infestations, the young plants develop a silvery appearance and look as if they have been damaged by frost (Manson and Boyce 1968). Ruppel (1972) stated that the adults show a definite preference for younger plants and even the younger growth on individual plants. The larvae cause the greatest damage because of their greater abundance. Plants that are attacked may be killed or may be so seriously injured that harvesting is not worthwhile (Manson and Boyce 1968).

Davidson and Lyon (1979) stated that the species is a vector of maize chlorotic mottle virus (MCMV) and causes the disease corn lethal necrosis.

The cereal leaf beetle is thought to be a potentially serious threat to cereal-growing areas of the Midwest (Westdal 1966).

Biology: The species overwinters in the adult stage in a variety of sheltered places, but it is usually found under trees and shrubs surrounding cultivated fields (Wressel and Hudon 1968, Ruppel 1972). Temperatures of 19°C or higher are required for the beetles to become fully active (Ruppel 1972). Adults are strong fliers and begin feeding on available grasses early in the spring. As temperatures climb, the adults first move to winter grains and then to spring grains when they become available. The newly emerged adults feed voraciously and may consume about 3.5 times their body weight in a day (Ruppel 1964). During their reproductive period, they may consume an amount equivalent to 40 times their body weight. According to Helgesen and Haynes (1972), mating starts after spring feeding and continues intermittently from mid April to June. The females oviposit anywhere on the plant, but they prefer the upper surfaces of the leaf, along the mid vein near the base (Helgesen and Haynes 1972). On corn, oviposition takes place near the midrib on the underside of the leaves (Wressel and Hudon 1968). Ruppel (1964, 1972) recorded an average oviposition of approximately 200–250 eggs per female, with a maximum of almost 400 eggs. Manson and Boyce (1968) and Ruppel (1964) reported an incubation period of 4–7 days, averaging 5 days under favorable conditions. Oviposition and hatching continue for 6–8 weeks (Westdal 1966). In Michigan, overwintered adults are numerous from mid April through late May (Ruppel 1964). Many adults may live for 40 days or longer.

The larvae pass through four instars, each lasting 2–3 days (Ruppel 1964). Feeding begins almost immediately after hatching. The larvae cover themselves with a black coat of feces and mucus, which gives them a slug-like appearance and apparently protects them from desiccation and natural enemies. When the larvae wish to move, the coating is shed. They move slowly but may progress from leaf to leaf in the smaller stages or from plant to plant in the larger stages (Ruppel 1964). According to Westdal (1966), larval development is completed in about 2 weeks, but larvae may be found during most of May and June because of the extended period of oviposition. According to Ruppel (1964), the final instar moves close to the crown of the plant and forms an ovoid cell in the top 1.5–4 cm of soil. The cell is lined with mucus, which acts as a thin membrane. Pupation takes place in 11–14 days.

In southern Michigan the first generation of beetles emerges in mid to late June (Ruppel 1972). They feed heavily for about 2 weeks on whatever green grasses, grain, or corn is available, after which they seek protected sites and become quiescent until the following spring. According to Ruppel (1972), the insects have a 97% mortality rate over the year, with the result that only about six progeny survive to reproduce the following season. Most of the mortality is due to simple attrition and occurs in the first and fourth larval instars, pupae, and overwintering adults. Only one generation of the insect is produced per season.

Known parasites include the introduced eulophid *Tetrastichus julis* (Walker), which attacks the larvae; the mymarid *Anaphes flavipes* (Förster); *Trichogramma minutum* Riley, which attacks the eggs; and the fungus *Beauveria bassiana* (Bals.) Vuill., which attacks the adults (Paschke 1965, Maltby 1967, CAIPR 1977, Davidson and Lyon 1979). According to Davidson and Lyon (1979), chalcid and ichneumonid parasites are responsible for larval population reduction in the cereal leaf beetle's native country. CAIPR (1977) reported that *T. julis* is coextensive with *O. melanopus* and quickly builds up a population to overcome it. Some predators include lady beetles, especially *Coleomegilla maculata* and *Hippodamia convergens* Guérin-Méneville, which are very important in destroying eggs and larvae; and the spotted lady beetle, *Coleomegilla maculata lengi* Timberlake, which preys on the eggs and larvae (Westdal 1966, Ruppel 1972, Davidson and Lyon 1979).

Comments: Battenfield et al. (1982) published an extensive bibliography of papers dealing with all aspects of cereal leaf beetle biology and control.

Pachybrachis obsoletus Suffrian

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: This species has been reported to cause light injury to rose foliage in Saskatchewan (CIPR 1944).

Paria canella (Fabricius)

Comments: *Paria canella* has been extensively reported to cause damage to strawberry and raspberry plantations in eastern Canada (Ross and Caesar 1919, 1921; Caesar and Ross 1922, 1927; Gibson and Ross 1922, 1940; Ross 1923; CIPR 1923, 1941, 1944; Caesar 1932; Twinn 1933). In addition, damage to greenhouse roses (Gibson and Ross 1940) has been recorded. However, according to Wilcox (1957), *P. canella* is known only from the southeastern United States and is not known to be associated with strawberry. The majority of these records probably refer to *P. fragrariae*.

Paria fragariae Wilcox (*canella* of authors, in part)
strawberry rootworm
chrysomèle du fraisier (f.)

Distribution: Quebec.

Economic injury: According to Wilcox (1957), *Paria fragariae* is the name that applies to the well-known strawberry pest. In Quebec the species has caused considerable damage to raspberry leaves in the spring (Paradis et al. 1977) and to strawberry plantations in the spring and fall (Rivard et al. 1975). According to Putman and Hikichi (1975), damage to strawberries is indicated by shot holes and leaf bronzing. Weigel and Chambers (1920) and Gibson and Ross (1940) report this species as a serious pest of roses grown in greenhouses. In the United States it has also been reported to feed on juniper and on wild crab apple.

Biology: Wilcox (1957) summarized the literature on the biology of *P. fragariae*, which has one to two generations a year, depending on location. In California and in greenhouses in the East, males are unknown, whereas elsewhere they are rare. Isolated females may reproduce parthenogenetically.

In California the oviposition period ranged from 55 to 137 days, and the average number of eggs laid per female was 125, with a maximum of 207. Eggs were deposited in crevices near the host plants, and a black substance was secreted to partly enclose the egg mass. At room temperature, the incubation period was approximately 16 days.

Larvae passed through four instars during approximately 50 days of development. Most larvae were observed in the top 7.5 cm of soil. The prepupal stage lasted 4.2 and 6.7 days at 27 and 21°C, respectively. At room temperature, pupation required 10.5 days.

Peak adult emergence occurred from mid July to mid August followed by feeding on the host plants until the onset of cold temperatures. Adults hibernated on or near the soil surface in plant debris, under soil clods, and in the crowns of strawberry plants. The overwintered adults emerged in February and were active for 29 to 43 days before oviposition.

In North Carolina, the egg, larval, and pupal periods were 7.8, 47, and 7.8 days, respectively. There was an indication that some individuals overwinter as pupae and some adults of the new generation lay eggs in the first season to produce a partial second generation.

Paria quadrinotata (Say)

Distribution: Ontario and Quebec.

Economic injury: The hosts of this species are walnut and hickory, but in their absence the species may feed on hazel, wild cherry, and mountain ash (Wilcox 1957). The same author reported the species from hawthorn, passionflower, flowering raspberry, juniper, and apple and suggests that this may be the species of *Paria* reported by many workers as a pest of apple.

Biology: According to literature cited by Wilcox (1957), the life cycle of *P. quadrinotata* is similar to that of *P. fragariae*. The beetles are active in late April and May and again in mid October.

Paria sexnotata (Say)

Comments: Fletcher (1894) reported damage by *P. sexnotata* to raspberry plantations in Ontario and strawberry beds in Quebec. However, according to Wilcox (1957), the species is known only from Pennsylvania, Kentucky, and Ohio and the host plant is red cedar.

Paria thoracica (Melsheimer) (*canella*, of authors, in part)

Distribution: Manitoba and Ontario.

Economic injury: According to Wilcox (1957), this common eastern species, which has been found frequently on goldenrod and aster, has also been reported from strawberry and clover. Wilcox, however, suspected that the record on clover may represent a secondary host that is attacked after a population buildup on goldenrod and aster.

Phaedon carri Hatch
(Carr's water-cress leaf beetle)

Distribution: Alberta, Manitoba, Ontario, Quebec, and Northwest Territories.

Economic injury: Gibson and Ross (1940) reported that *P. carri* caused injury to water-cress grown in a greenhouse near Ottawa, Ont. The larvae and adults devoured portions of the leaves.

Phyllobrotica decorata (Say)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Northwest Territories.

Economic injury: Twinn (1938) reported that this species caused injury to spinach, potato, and weeds in Saskatchewan.

Phyllotreta aerea Allard
(radish flea beetle)
altise des radis (f.)

Distribution: Ontario.

Origin: *Phyllotreta aerea*, an inhabitant of southern and south-central Europe, was first discovered in North America before 1921, in Rochester, N.Y. (Chittenden 1926). The species was first reported in Canada at Vineland, Ont., in 1937 (CIPR 1945).

Economic injury: In Ontario, the species was reported to cause extensive damage to cabbage, radish, and turnip in kitchen gardens (CIPR 1955). Twinn (1945) considered this species to be the most abundant and destructive flea beetle known to attack these plants in the province. The damage reported by Chittenden (1926) for the first North American infestation was characterized by initial attacks to the cotyledons, pitting them with holes, followed by attacks on the smaller first leaves. Seedling plants were completely destroyed. The beetles also attacked wax beans when cruciferous plants were not available.

Phyllotreta albionica LeConte
(cabbage flea beetle, Colorado cabbage flea beetle)
altise du chou (f.)

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: Glendenning (1932) reported the nature of the damage and the host plants of *P. albionica*. The favored adult hosts are probably radish and turnip, although the species has also been reported from cabbage, cauliflower, kale, Brussels sprouts, candytuft, *Alyssum* spp., *Arabis* spp., *Nasturtium*, and various cruciferous weeds. In early spring, the overwintered adults injure the seed leaves of the host plants by chewing small holes in the leaf surface. If these leaves are completely destroyed, the young plants die. Later in the season the new generation of adults attack mature plants, and when abundant, the adults may completely shred the largest leaves. Late cauliflower and kale are particularly susceptible to this type of damage. The larvae of *P. albionica* feed on the roots of the adult host plants but cause little appreciable damage.

Biology: Glendenning (1932) summarized the life history of *P. albionica* in British Columbia. The overwintered adults emerged in late March and early April and fed for about 3 months. Mating and oviposition took place during late April and May and the adults were present until the end of June. The preoviposition period lasted 5–10 days, after which eggs were deposited in the soil at depths of 2.5–5 cm around the base of the host plants. Eggs were laid in batches of 15–20, and females deposited an average of 60 eggs during a period of 3 weeks. The incubation period was assumed to be about 15–21 days.

The root-feeding larvae developed in the soil during late May, June, and July at depths of 5–15 cm. The active feeding period of the larvae lasted approximately 4 weeks. Mature larvae formed pupal cells in the soil, usually nearer the soil surface than the depths of feeding larvae. The prepupal period lasted from 10 to 12 days and the pupal stage averaged 11 days.

Adults of the new generation began to emerge in August and started feeding on the host foliage. This feeding period lasted for almost 6 weeks before the beetles went into hibernation about the middle of September. The adults hibernated in leaf litter under hedges and shrubs, in the bush, or along fencerows. The adults of this species were parasitized by the braconid *Microctonus epitricis* (Viereck) (as *Perilitus epitricis*).

Comments: Beirne (1971) reported the species from Ontario, Quebec, New Brunswick, and Newfoundland. A careful review of the literature cited by Beirne indicated that the species had been reported once as "probably this species" from Quebec (CIPR 1957), once from New Brunswick (CIPR 1938), on several occasions from Newfoundland (CIPR 1951–1956) and not at all from Ontario. Chittenden (1927) reported the species from the western United States and Canada. These records represent a misidentification and not *P. albionica*.

Phyllotreta armoraciae (Koch)
horseradish flea beetle
altise du raifort (f.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick.

Origin: This European species was first discovered in North America in 1893, in Chicago, Ill. (Chittenden and Howard 1917). The first Canadian record of this species was made in Guelph, Ont., about 1908; Montreal, Que., in 1910 (Gibson 1913); Moose Jaw, Sask., in 1944 (Burgess 1981); and Vancouver, B.C., in 1973 (Lazorko 1973).

Economic injury: The larvae mine the petioles and midribs, and the adults feed on the leaves and gouge the petioles and midribs of horseradish (as *Radicula armoracia*) (Chittenden and Howard 1917, Burgess 1980). Chittenden and Howard (1917) also described the species as partial to marsh yellow cress (as *Radicula palustris*) and reported it found on cabbage, where it was not observed feeding. Smith (1973) reported specimens on alfalfa in Wisconsin and New York and on *Raphanus* sp. in New York.

Biology: Chittenden and Howard (1917) described the biology of *P. armoraciae*. Oviposition occurred from late April or early May until early August on the petioles of young leaves. Eggs were deposited at intervals in clusters of about 22. A single female laid a total of 418 eggs. Mating frequently occurred between ovipositions, but whether or not this is necessary before deposition was not determined. The incubation period of the eggs ranged from 7 to 14 days.

Newly hatched larvae were active on the surface of the leaves for some time before entering the small, tender petioles. Severely tunneled petioles shrank, causing the leaves to wilt and die along the margins and apices. Larval periods for eight larvae ranged from 42 to 66 days.

At maturity, the larvae left the leaves and entered the soil to pupate at depths of 3–75 mm. After a prepupal period of 2–7 days, the pupal stage lasted 7–13 days. This species overwinters in the adult stage, completing one generation per year in Wisconsin.

Phyllotreta bipustulata (Fabricius)

Distribution: Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: According to Chittenden (1927), this species does occasional damage to cabbage, mustard, radish, turnip, and horseradish. Burgess (1981) reported *P. bipustulata* from near Prince Albert National Park, Sask. Smith (1973) stated that the species has been a pest in past years but has apparently been replaced by the more competitive, introduced, *P. cruciferae*. The same author gave an extensive list of host plants, some of which are cultivated, which include the following: *Barbarea verna* (Mill.) Asch.; *B. vulgaris* R. Br.; *Brassica kaber* (DC.) Wheeler; *Cardamine douglassii* (Torr.) Britt.; *Dentaria diphylla* Michx.; *Sisymbrium officinale* (L.) Scop.; *Lepidium virginicum* L.; *Rorippa palustris* (L.) Bess. (as *Radicula palustris* (L.) Moench); flowers of *Prunus virginiana* L. (as *Prunis virginiana*); *Rosa* sp.; *Capsella bursa-pastoris* (L.) Medic. (as *Bursa bursapastoria*); and wild cress.

Biology: Smith (1973) gave a brief account of the life history of *P. bipustulata*. Adults overwinter in the soil near the host plants and emerge in early spring. Eggs are laid in the soil around the host plants, and the adults are rarely encountered after June. The larvae, which are root feeders, feed throughout the summer, and adults emerge in the fall.

Graham (1965) listed the braconid *Microctonus vittatae* Muesebeck as a parasite of this species.

Phyllotreta conjuncta Gentner

Distribution: Manitoba.

Economic injury: Wylie (1979) reported this species (as *P. bipustulata*) from canola flats and volunteer canola during April and May.

Comments: This species was first reported as *P. bipustulata*, but the specimens on which the record was based were subsequently reexamined by E. Smith (personal communication) and identified as *P. conjuncta* (G. Wylie, personal communication).

Phyllotreta cruciferae (Goeze) (*columbiana* Chittenden)
(crucifer flea beetle)
altise des crucifères (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick.

Origin: According to Milliron (1953), the species described as new by Chittenden (1927), *P. columbiana*, was in fact the first North American record of the European species *P. cruciferae*. Chittenden described *P. columbiana* from specimens collected at Agassiz, B.C., in 1923. At the time of Milliron's publication, he suggested that the species had probably been reintroduced on the East Coast within the previous 10–15 years. By the 1930s, through eastward migration, the species was causing crop damage in the Canadian prairies (Kinoshita et al. 1979). In 1954 the species was reported from Ontario, probably as a result of an invasion from New York State (MacNay 1961). Subsequently, the species was reported from Quebec in 1956 and New Brunswick in 1957 (Westdal and Romanow 1972).

Economic injury: Westdal and Romanow (1972) described the injury and listed the host plants of the adults of *P. cruciferae*. The species is a serious pest of many cultivated crucifers (Tahvanainen 1972). The adults chew small holes or pits in the leaf epidermis. The feeding does not completely perforate the leaves, but the tissue beneath the injury eventually dies, resulting in a shot-hole appearance. Overwintered adults injure seedlings, damaging the cotyledons and first leaves and often destroying the plants. Light infestations on older plants are often restricted to the leaf margins, resulting in browning and curling of the edges. Severe infestations cause considerable damage to leaves, petioles, seedpods, and stems. *Phyllotreta cruciferae* is the most abundant flea beetle on canola crops in Manitoba. Cruciferous plants (particularly species of the genus *Brassica*), the major family attacked, include: Polish rape, wild mustard, Argentine rape, cabbage, cauliflower, broccoli, Brussels sprouts, kohlrabi, turnip, horseradish, hoary cress, tansy mustard, sweet alyssum, radish, and stinkweed. Flea beetle injury to beets has probably been erroneously attributed to this species. According to Kinoshita et al. (1979), the larvae of *P. cruciferae* are root feeders, which in some cases reduce the market value of cruciferous root crops and plant stands.

Biology: Westdal and Romanow (1972) and Burgess (1977*a*) studied the biology of *P. cruciferae* in Manitoba and Saskatchewan. The summary given here is based on their work unless otherwise specified. The adults overwinter in soil and plant debris, usually emerging by mid May and reaching peak abundance approximately 3 to 4 weeks later. In Saskatchewan, Burgess (1977*a*) observed the first emergence in early April. Kinoshita et al. (1979) showed that days to oviposition increased with decreasing temperature from a mean of 3.8 days at 32°C to a mean of 22 days at 20°C. The same authors also found that the threshold for oviposition was 16.7°C. Oviposition by overwintering adults in the laboratory occurred throughout the month of June, but evidence from field observations indicated that oviposition probably occurred before 15 May. Eggs were laid singly or in groups of three or four in moist soil near the roots of the host plant. The average incubation period for outdoor-caged, indoor-caged, and cell-reared eggs was 12.4 days (range, 10–15).

Based on head-capsule measurements, the species has three larval instars, the last containing an active feeding stage and a quiescent prepupal stage. Second- and third-instar larvae fed on both the root hairs and taproot of seedling plants, and a few larvae burrowed into the plant at the junction of the root and stem. The larval period for 16 larvae, including the prepupal stage, lasted 25–34 days.

The prepupal period was characterized by a cessation of feeding, a reduction in locomotor activity, and a shortening and thickening of the body. During this stage the mature larvae formed an earthen pupal chamber. The prepupal and pupal stages for 16 individuals were 3–6 and 7–9 days, respectively.

Two additional peaks of adult abundance were observed, one in mid July and another in late August or early September. These peaks probably represented early, new-generation adults combined with late overwintered adults and the peak abundance of new-generation adults, respectively. However, the possibility that these peaks represented a bivoltine condition was not ruled out. Wylie (1979), in Manitoba, found no evidence of copulation or mature eggs in females of the new generation in the fall, which suggested a univoltine life cycle. Kinoshita et al. (1979) reported one and two generations a year, in Ontario, depending on soil temperatures. Gerber and Osgood (1975) observed adults of the melyrid beetle *Collops vittatus* Say preying on the adults of *P. cruciferae* in canola plots in Manitoba. Burgess (1980) noted predation on adults by lacewing larvae and later (1982) by the damsel bug, *Nabis alternatus*. Wylie (1979, 1982) noted parasitism by the braconid *Microctonus vittatae* Muesebeck.

Phyllotreta decipiens Horn

Distribution: British Columbia and Alberta.

Economic injury: According to Chittenden (1927), the species was reported to attack radish, turnip, sugar beet, and potato.

Phyllotreta liebecki Shaeffer

Distribution: Ontario.

Economic injury: Adults of *P. liebecki* have been reported from mustard, radish, Chinese cabbage, and turnip (Smith 1973). Larvae of *P. liebecki* are leaf miners and have been reported from *Lepidium virginicum* L., *Rorippa cervipes* Greene, *Rorippa teres* (Michx.) Greene, and *Sibara virginica* (Linnaeus) Rollins in Louisiana (Chittenden 1927).

Biology: In Ontario, adults have been collected in May and June.

Phyllotreta lewisi (Crotch)

Distribution: Manitoba and Quebec.

Economic injury: According to the CIPR (1942), adults of *P. lewisi*, which are destructive to cabbage, cauliflower, turnip, kohlrabi, and radish, were observed feeding on rhubarb early in the spring in Manitoba. Hatch (1971) reported the species from radish, cabbage, and potato in Idaho. In addition, Chittenden (1927) reported the species from sugar beet, alfalfa, *Cleome*, and skunkweed in Colorado and Utah. Larvae of *P. lewisi* have been collected from the roots of *Cleome serrulata* Pursh.

Phyllotreta oregonensis (Crotch)
(Oregon flea beetle)

Comments: Chittenden (1927) reported *P. oregonensis* from Medicine Hat, Alta. The same author reported the species in

Colorado, feeding on the leaves, seed heads, and flowers of sugar beet and on the foliage and flowers of various weeds, radish, turnip, and marsh yellow cress. However, Smith (1973), in his unpublished revision of the maculate species of this genus, does not report *P. oregonensis* from Alberta. Chittenden's record from that province may represent one of Smith's unpublished new species.

Phyllotreta pusilla Horn
western black flea beetle (western cabbage flea beetle)
altise noire (f.)

Distribution: Alberta, Saskatchewan, and Manitoba.

Economic injury: Chittenden and Marsh (1920*b*) described the injury caused by this species. Although *P. pusilla* is primarily a pest of gardens, it frequently causes damage to large commercial plantings. The overwintered adults attack turnip, radish, mustard, and other cruciferous vegetables as the plants sprout in the spring. Most damage is caused by the first generation of adults during June and July. In addition to the preferred food plants mentioned above, other Cruciferae attacked by the adults include: horseradish, canola, cabbage, cauliflower, water-cress, Chinese mustard, nasturtium, pink beeplant, sweet alyssum, candytuft, common pepper-grass, hedge mustard, wild water-cress, and tansy mustard. When abundant, the adults have also been reported to attack beet, mangel-wurzel, lettuce, beans, peas, carrot, tomato, potato, and corn. The adult damage is characterized by shotlike holes in the leaves of young plants, the beetles usually feeding on the lower surface. Although the larvae feed on the roots of cruciferous vegetables, they cause little appreciable damage.

Biology: Chittenden and Marsh (1920*b*) described the biology of *P. pusilla*. In the laboratory, eggs were deposited in cracks in the soil around the roots of the host plants. A single female laid a total of 244 eggs in batches of 15–32 between the beginning of April and the middle of June. The larvae are root feeders, the young larvae feeding on root hairs and the older larvae feeding on hairs, stalks, and root branches. At maturity the larvae formed soil cells in the vicinity of the host roots for pupation. The prepupal stage lasted 4–5 days.

In Colorado, three generations a year are produced. In the northern part of the range, the species overwintered in the adult stage under soil clods and plant debris.

A braconid, *Microctonus epitricis* (Viereck) (as *Perilitus epitricis*), and unidentified nematodes and gregarines parasitized the adults.

Phyllotreta ramosa (Crotch)
western striped flea beetle

Comments: Hatch (1971) reported *P. ramosa*, a species destructive to various cruciferous crops in California, from British Columbia. However, Smith (1973), in his unpublished revision of the maculate species of *Phyllotreta*, does not include British Columbia in the distribution of the species. The species reported by Hatch may represent one of Smith's unpublished new species.

Phyllotreta robusta LeConte
(garden flea beetle)
altise des jardins (f.)

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: Chittenden (1927) reported *P. robusta* from radish in Wisconsin and from turnip in Indiana. Burgess (1977*a*) found *P. robusta* on canola in the Canadian prairies, but because the insects were not numerous, he did not consider them to be a major threat to the crop in that region. In addition, Smith (1973) listed *Brassica arvensis* (L.) Rabenh., *Lepidium* sp., *Poa pratensis* L., and *Elaeagnus cummutata* Bernh. as host plants.

Biology: The earliest and latest records of adults in the Prairie Provinces were 2 May and 3 July, respectively. One adult was found overwintering in leaf litter beneath a caragana hedge (Burgess 1977*a*).

Phyllotreta striolata (Fabricius) (*sinuata* Redtenbacher, *vittata* Fabricius)
striped flea beetle (striped cabbage flea beetle, turnip flea beetle, wavy striped flea beetle)
altise des navets (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland, and Northwest Territories.

Origin: Chittenden (1927) described this introduced species (as *P. vittata*) as an inhabitant of Europe and northern Asia. In North America, the species was first reported from "Carolina" in 1801 and reached the Pacific states by commerce or by an independent introduction (Chittenden 1923).

Economic injury: This is one of the most common and regularly occurring destructive flea beetles (Gibson 1913). According to Gibson, the overwintered adults severely injure young radish, turnip, cabbage, and other cruciferous plants by damaging the seed leaves as they appear above the ground in spring. However, as the plants develop, they are able to produce more growth than the beetles can destroy. He also stated that the larvae feed on the roots of these plants and often cause considerable injury, although their attacks may be largely confined to cruciferous weeds. According to Goble (1960), the adults eat small, shotlike holes in the leaves, often killing young plants, and the larvae are suspected of causing a pitted-type injury to the root, especially of turnip. Usually less abundant than *Phyllotreta cruciferae* and *Psylliodes punctulatus* Melsheimer on canola crops, *Phyllotreta striolata* has been reported on at least one occasion as the most abundant flea beetle (Burgess 1977*a*). *Phyllotreta striolata* is usually more abundant than *P. cruciferae* in the northern part of the canola-growing area in Saskatchewan, whereas *P. cruciferae* is now abundant in the south (Wylie 1979). Wylie (1979) reported that the species began to feed on canola in June in Manitoba and that small numbers were found on the crop in June, July, and August. In CAIPR (1978), *P. striolata* was reported to cause damage to fall canola pods in Alberta. Fox and Stirrett (1952) reported that the species caused slight damage to tobacco plants in a seedbed in Ontario. In addition to these crops, other cultivated plants reported to be attacked in Canada include cauliflower, potato (CIPR 1959), Brussels sprouts, rutabaga (CIPR 1958), tomato (CIPR 1954), mangel, broccoli, kohlrabi, cucumber, squash, pumpkin (Beirne 1971), marigold (Twinn 1935), stock, western wallflower (Gibson 1913) and alpine rock-cress (Gibson 1934). Smith (1973) listed additional host plants.

Biology: In Saskatchewan, adults of *P. striolata* overwintered and became active near the end of April (Burgess 1977*a*). Wylie (1979) found fertilized females on and after 28 April in Manitoba and stated that adults mated about 2 weeks earlier than those of *P. cruciferae*. Females deposited eggs 19–25 mm deep in the soil near the host plants (Goble 1960).

Larvae fed primarily on the fine roots, but occasionally they fed on the main root of some plants. According to Goble (1960), the larval period lasted 3–4 weeks followed by a pupal period in the soil of about 2 weeks; the adults emerged in August. However, literature cited by Burgess (1977*a*) indicated that development from egg to adult took 26 and 28 days for Japanese and Louisiana populations of this species, respectively. He also observed peak emergence of new-generation adults in the last week of July, which was approximately 1 week earlier than peak emergence of *P. cruciferae*. Gibson (1913) stated that the species had two or three generations a year. However, Burgess (1977*a*) in Saskatchewan and Wylie (1979) in Manitoba reported that evidence indicated that *P. striolata* was univoltine.

Overwintering adults were found in leaf litter beneath caragana and other hedges and in leaf litter and turf in poplar groves (Burgess 1977*a*). The same author observed that populations of overwintered adults remained high through May until the third week in June, when they began to die off.

Smith and Peterson (1950) reported the parasitic braconid *Microctonus vittatae* Muesebeck to be the principal agent in the natural control of this beetle in the northern United States and southern Canada. In addition, Elsey (1977) reported an 18.25% rate of parasitism of *P. striolata* by a nematode *Howardula* sp. The lygaeid *Geocoris bullatus* (Say) has been observed preying on this flea beetle (Burgess 1977*b*).

Phyllotreta zimmermanni (Crotch) (*sinuata* of authors, not Stephens)
(sinuate striped flea beetle, Zimmerman's flea beetle)
altise sinuée (f.)

Distribution: Alberta, Manitoba, Ontario, Quebec, Northwest Territories, and Yukon Territory.

Economic injury: According to Chittenden (1927), the larvae of *P. zimmermanni* have been observed mining the leaves of cultivated cress, and the adults have been reported to feed on cress, radish, turnip, and cabbage in Quebec. The same author also reported the adults from horseradish in Wisconsin and mustard in Virginia. Smith (1973) considered the species to be a former pest that has been replaced by the more competitive, introduced *P. cruciferae*. The major host for this species is *Humulus lupulus*, but additional host plants of the adults listed by Smith include: *Arabis* sp., alfalfa, *Barbarea vulgaris* (L.) R. Br., *Brassica nigra* (L.) Koch, *B. oleracea* L. var. *acephala* DC., clover, *Dentaria diphylla* Michx., *Fragaria* sp., hickory, *Lepidium* sp., *L. campestre* (L.) R. Br., *L. virginicum* L., pepper, pepper-grass, wild plum, potato vine, *Rorippa palustris* (L.) Bess., *Radicula* sp., tobacco, *Trifolium incarnatum* L., white turnip, and water-cress.

Biology: Smith (1973) summarized the biology of *P. zimmermanni*. Adults overwinter and emerge in early spring. The eggs are deposited on or in the upper surface of the leaves of the host plants along the midrib. Preferred host plants include *Lepidium virginicum* L. and *Arabis ludoviciana* (?). The larva mines the leaves of the host plant and is not confined to a single mine or leaf. The larvae pupate in an earthen cell just beneath the soil surface. In Missouri a single generation may require only 20–23 days in May or June. Elsey (1977) reported a low level of parasitism by a nematode, *Howardula* sp.

Plagiodera versicolora (Laicharting)
imported willow leaf beetle
chrysomèle versicolore du saule (f.)

Distribution: Ontario, Quebec, New Brunswick, and Northwest Territories.

Origin: This species is European in origin and was first discovered in North America on Staten Island, N.Y., in 1911 (Brown 1946). The first Canadian records of *P. versicolora* were made in August 1942, at Niagara Falls and Belleville, Ont., and Oka, Que. The insect appears to have entered Canada from several locations in the United States.

Economic injury: The imported willow leaf beetle has been reported to be a pest of poplar and willow (Weiss and Dickerson 1917). According to Goble (1969*b*), the species may attack weeping willow, pussy willow, Russian willow (in particular), and Lombardy poplar.

The beetles may consume all the leaf tissue, but the larvae usually attack the underside of the leaf, feeding on only the epidermis (Weiss and Dickerson 1917). In shaded areas or in confinement, however, the larvae have also been known to feed on the upper surface. According to Goble (1969*a*), the larvae may skeletonize the leaves.

Biology: The adults overwinter in hidden places such as under loose bark or in crevices in the bark (Weiss and Dickerson 1917, Goble 1969*a*). In New Jersey, the overwintered beetles first appear in late April or early May (Weiss and Dickerson 1917). Oviposition begins in early May after feeding and continues for most of the month. The eggs are deposited in masses on the underside of the leaves. The number of eggs found in 22 masses averaged 19 or more (range, 12–30). The incubation period ranges from 3 to 5 days. By early June, all the eggs had hatched and the overwintered adults were no longer to be found.

The larvae pass through five instars (Weiss and Dickerson 1917). The early stages of the larvae require about 3–5 days. The young larvae are gregarious in feeding and often form an arc or circle, with their heads pointed outward. Newly hatched larvae may feed on unhatched eggs. Older larvae disperse and feed by themselves. Pupation usually takes place on the underside of the leaves, where the mature larva attaches itself by means of a suckerlike disc at the anal extremity. The pupal period lasts from 2 to 3 days.

The first generation of beetles appears from about 10 June to the early part of July (Weiss and Dickerson 1917). These adults oviposit from the beginning of July to early August. The second generation of beetles appears from the end of July to late August. After feeding and copulating, they seek hibernation quarters. Goble (1969*a*) reported that in Ontario, two or more generations per year may occur.

The parasite *Coelopisthia rotundiventris* Girault and the hyperparasite *Pleurotropis tarsalis* Ashmead have been bred from the pupae of *P. versicolora* (Weiss and Dickerson 1917). Three nymphs of a predaceous species of Heteroptera were reported on the beetle.

Plagiometriona clavata Fabricius

Distribution: Ontario and Quebec.

Economic injury: In CIPR (1956) the adults of *P. clavata* are reported to cause severe damage to tomato transplants in an Ontario garden and have also been observed feeding on potato foliage. The same publication reported *Solanum dulcamara* L. to be a common host for both larvae and adults.

Biology: Barrows (1979) observed adults of this species from June to September in Washington, D.C. The larvae and pupae of *P. clavata* are protected by masses of feces and exuviae.

Psylliodes chrysocephala (Linnaeus)

Distribution: Newfoundland.

Origin: *Psylliodes chrysocephala* has been reported from Europe, North Africa, and northern and western Asia (Bonnemaison 1965). The species was first reported in North America at St. John's and Topsail, Nfld., about 1950 (MacNay 1952).

Economic injury: The species was first reported to attack canola in Newfoundland (MacNay 1952). According to literature cited by Brown (1967), *P. chrysocephala* is more injurious to cultivated crucifers than any other flea beetle in the Palaearctic region. The adults feed on the seed leaves of young plants, and the larvae tunnel in the stems of the plants and midribs of the leaves (MacNay 1954*a*). According to Bonnemaison (1965), the larvae are not very harmful, but during hot weather the adults damage crops. According to the same author, the adults have been implicated in the transmission of turnip crinkle virus and turnip yellow mosaic virus.

Biology: Bonnemaison (1965) summarized the biology of *P. chrysocephala* in Europe, where the species produces one generation a year. Adults emerge at the end of spring but remain in summer diapause until the end of August. After activity is resumed, the beetles feed on wild and cultivated crucifers. As the adults reach sexual maturity, the flight muscles atrophy. Adults that resume activity in mid August oviposit by the end of the month, the maximum fecundity reaching about 800 eggs. The larvae reach the third and final instar by the end of autumn. However, a later resumption in adult activity, in conjunction with adverse climatic conditions, results in a reduced or retarded oviposition. Most of these eggs do not hatch until the end of winter. Oviposition may resume again in early spring depending on temperature, although adult mortality in winter is a limiting factor. The larvae resulting from postwinter oviposition do little damage to the host plants because of the rapid plant growth at this time of year.

In Europe, eggs of *P. chrysocephala* are attacked by bacteria and by Coleoptera; the larvae are parasitized by Hymenoptera, especially *Tersilochus melanogaster* Thomson; the prepupae and pupae are attacked by nematodes and carabids; and the adults are parasitized by *Entomophthora* and gregarines.

Psylliodes punctulatus Melsheimer
hop flea beetle
altise du houblon (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, and Northwest Territories.

Economic injury: The hop flea beetle has caused extensive damage to hops in southwestern British Columbia (Hatch 1971) and to canola in the Canadian prairies (Burgess 1977*a*). Sugar beets have also suffered considerable damage (Twinn 1935). Additional hosts of the adult include radish, turnip, mangel, cabbage, cauliflower, mustard, spinach, rhubarb, clover, tomato, canola, strawberry, cucumber, nettle, dock, lamb's-quarters, seedlings of Canada thistle, pepper-grass, wild buckwheat, flixweed, bluebur, pigweed, and tumbleweed (Chittenden 1909*a*, CIPR 1953, Beirne 1971, Burgess 1977*a*).

Although the larvae and adults feed on the roots of hops and probably most of the same hosts, the main injury results from adults that feed on young plants (Chittenden 1909*a*). They eat through the skin and feed on the pulp of the leaves. The skin on the opposite side is usually left intact, but it becomes discolored and freckled as the leaf grows and expands, and it often tears and shows holes. The leaves of infested hops may be almost completely skeletonized or more or less completely stripped from the vines. When the adults occur in large numbers, they may devour the young and tender leaves as soon as they appear, doing much damage in a relatively short time. According to Quayle (*in* Chittenden 1909*a*), the adults prefer the upper surface of the leaf. Adults also attack the tender stems of beets, causing the tops to fall off and the beets to die (Chittenden 1909*a*). Adults are usually present in large numbers in the fall and may do considerable damage to mature hops. The insect is difficult to control because of its abundance in the spring, its continual reappearance, and the new daily growth of the plants.

Biology: According to Gibson (1913), the adults overwinter in sheltered places, on the ground or just beneath the surface of the soil. The overwintered adults emerge in the spring and immediately begin feeding (Chittenden 1909*a*). *Psylliodes punctulatus* is one of the first flea beetles to appear in the spring, having been collected as early as 22 March in Saskatoon (Burgess 1977*a*). These adults mate as soon as they become active and continue to do so for as long as they are present. Oviposition begins from 8 to 10 days after mating (Chittenden 1909*a*). Burgess (1977*a*) stated that the eggs are usually deposited in the soil at a depth of about 3.8 cm, that the larvae feed on the roots of the host plant, and that the period between egg-laying and adult emergence is about 72 days. Beirne (1971) reported that the eggs, larvae, and pupae are found in the soil at depths of 7.6–15.2 cm. In Saskatchewan, first-generation adults emerge in late July (Burgess 1977*a*). Chittenden (1909*a*) pointed out that the beetles emerge continuously throughout the season, although there are times when the insect is more numerous than others. Wylie (1979) observed that all females collected between August and October were unfertilized (one laboratory observation of fall copulation) and that the species is univoltine.

Chittenden (1909*a*) reported a hymenopterous parasite, probably *Perilitus schwarzii* Ashmead, the same species that he had encountered on other species of flea-beetles of the genera *Epitrix* and *Phyllotreta*. Two braconids, *Microctonus punctulatus* and *Microctonus psylliodis* Loan, parasitize this pupa in Manitoba (H.G. Wylie and C. Loan, personal communication).

Pyrrhalta cavicollis (LeConte)
cherry leaf beetle
galéruque du cerisier (f.)

Distribution: British Columbia (?), Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia.

Economic injury: This species has been reported to attack foliage of pin cherry in Alberta (CIPR 1942) and to defoliate wild red cherry in Ontario (CIPR 1940). Hatch (1971) considered *P. cavicollis* to be a pest of peach and cherry.

Cushman (1916) stated that in the northeastern United States, the natural host of this species is pin cherry. Among cultivated fruits only certain varieties of sour cherry and peach were attacked.

Adults feed almost exclusively on the underside of the leaves, chewing small, irregular holes through the lower epidermis and parenchyma and sometimes through the entire leaf. These holes may be so dense as to skeletonize the leaf. A few days after feeding, the upper epidermis becomes dry and falls out; in cases of severe injury, the whole leaf becomes dry and defoliation occurs. Adults may also feed upon the fruit, scarring and pitting it. Larvae feed in the same manner as adults but generally are found only on pin cherry. Adults preferred feeding on injured or sick trees.

Biology: Based on studies made by Cushman (1916) and Hartzell (1917) in Pennsylvania and New York, respectively, the species overwinters in the adult stage several centimetres below the surface of the ground. The adults emerge in the spring and feed for some time before mating. The females descend to the base of the trees in midsummer, where they deposit clumps of eggs among decaying leaves and other vegetable matter. The eggs hatch in 11–13 days.

Upon hatching, the larva climbs the tree and begins feeding on the underside of the leaf. There are three larval instars. The first instar usually requires 4–7 days, the second instar 3–6 days, and the third instar 3–8 days to complete its development. The total larval feeding period ranges from 10 to 20 days. When full grown, the third-instar larva leaves the tree, burrows into the soil, and constructs a pupal cell. Adults emerged from pupation in 14–28 days and began feeding on the leaves. Adults continue feeding until the fall, when they burrow into the soil to overwinter.

Comments: According to literature cited by Hatch (1971), this species has been reported from Vancouver, B.C. However, Hatch stated that the record has not been confirmed and is probably in error.

Pyrrhalta decora carbo (LeConte)
Pacific willow leaf beetle (willow leaf beetle)
galéruque du saule (f.)

Distribution: British Columbia.

Economic injury: The Pacific willow leaf beetle has denuded several hectares of trees in both the interior and coastal regions of British Columbia (Neilson and Arrand 1961). The species prefers willow and trembling aspen in the interior but seems to prefer immature red alder on the coast. The larvae attack the undersurface of the leaves, which are skeletonized, with only the veins and upper surfaces remaining.

Biology: The insect overwinters in the adult stage and may be found in early summer (Neilson and Arrand 1961). In late summer, the mature larvae pupate in rotten logs and stumps.

Pyrrhalta decora decora (Say)
gray willow leaf beetle (western willow leaf beetle)
galéruque grise du saule (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Northwest Territories.

Economic injury: The gray willow leaf beetle may cause considerable defoliation of willow and poplar (MacNay 1955, CIPR 1963). Fall (1924) inferred that the insect feeds on all species of willow and poplar, since both adults and larvae readily ate all species presented to them in food plant tests. The insect has also been reported as a pest of plum (MacNay and Creelman 1958) and has been known to cause serious injury to the flower buds of apple and pear (CIPR 1955). Some damage has also been reported on crab apple (CIPR 1951).

Both the adults and larvae skeletonize the leaves of their host plant (Fall 1924). The latter attack the underside of the leaf and feed on the mesophyll and upper and lower epidermis, leaving a network of even the finer veins. Only one larva per leaf is usually found. The adults skeletonize the leaves more coarsely than do the larvae, eating the finer veins and leaving behind only the larger veins.

Biology: Fall (1924) published a description of the life history of this species. The adults overwinter in protected places near the food plants. In Maine, they appear in early June, when willow leaves are well expanded. Feeding and mating start immediately. The eggs are usually laid in clusters of about 15 (range, 3–37) at the base of the plant in rough areas in the bark. Eggs have been found as early as 15 June and in the laboratory as late as 31 July, although only a small number were laid after July 20. The maximum oviposition rate for one female was 175. The eggs are covered with fecal matter as they are deposited. The length of the egg stage averaged 9.9 days (range, 9–18). Overwintered adults become scarce after the middle of July, although one lived as late as 10 August in the laboratory.

The larvae pass through three instars. The first instar averaged 3.4 days (range, 3–5), the second instar averaged 3.2 days (range, 3–6), and the third instar averaged 4.3 days (range, 2–6). The prepupal period averaged 5.0 days (range, 3–6), and the pupal period averaged 6.5 days (range, 6–7). The first-generation adults were common in the field by 20 August. Only one generation per year occurs.

The gray willow leaf beetle may be attacked by the parasitic fungus, *Beauveria globulifera* (Spegazzini) Picard (as *Sporotrichum globuliforum* Spegazzini).

Comments: There may have been some confusion between this species and the Pacific willow leaf beetle, *P. decora carbo* (LeConte), in British Columbia.

Pyrrhalta luteola (Mueller) (*xanthomelaena* Schrank)
elm leaf beetle
galéruque de l'orme (f.)

Distribution: Ontario, Quebec, and New Brunswick.

Origin: The elm leaf beetle is European in origin and was probably introduced into the United States around 1834 (Metcalf et al. 1951). The species was first recorded in Canada on American elm on 11 July 1945, in the city of St. Catharines, Ont. (Sheppard 1946). In 1949 *P. luteola* was reported from Milltown, N.B. (CIPR 1952).

Economic injury: According to Goble (1969*a*), the species may cause severe injury to the foliage of elm. *Pyrrhalta luteola* has been reported to cause serious damage to Chinese and American elm in Ontario and American elm in Quebec (MacNay 1954*b*). Among the various species of elm attacked are the European elms, white elm, red elm, English elm, and camperdown elm (Fall 1924, Metcalf et al. 1951). Davidson and Lyon (1979) stated that elms growing in urban areas suffer the most damage.

Both the adults and larvae attack the foliage of open-growing native and exotic elms, but the feeding of the former is of no economic importance (Agriculture Canada 1957*a*). The larvae feed on the underside of the leaves, leaving only the upper surface and coarser veins. Heavily injured leaves do, in time, turn brown and shrivel. Davidson and Lyon (1979) noted that this kind of feeding causes the leaves to die and fall prematurely. According to Metcalf et al. (1951), infested trees have many of their leaves skeletonized, and the foliage appears yellow. Heavily infested trees are badly weakened, their growth is retarded, and they are subject to bark beetle and wood borer attacks and disease. They may die if the attack is prolonged (Agriculture Canada 1957*a*, Davidson and Lyon 1979). Becker (1977) pointed out that although the larvae skeletonize the leaves, they do not usually cause serious injury.

The adults chew small holes in the leaves, but their feeding is not important (Agriculture Canada 1957*a*, Davidson and Lyon 1979). They are often found in houses and have been reported as a nuisance because they exude a light brown juice that stains curtains and windowsills (Becker 1977).

Biology: The insect overwinters in the adult stage in protected places, frequently in houses and under plant debris (Davidson and Lyon 1979). The overwintered adults appear in the spring and seek the unfolding leaves of elm trees. The eggs are laid in clusters of 5–25 on the underside of the leaves. Over 400 eggs are laid by each female. The incubation period is approximately a week. The larvae feed for about 3 or 4 weeks and then pupate in the litter or bark crevices near the base of the trunk (Agriculture Canada 1957*a*). The new adults appear in about 10 days. In Ontario these adults do some feeding and then seek suitable hibernation quarters. Davidson and Lyon (1979) reported two generations in the latitude of Columbus, Ohio, with perhaps a partial third farther south.

The chalcid wasp *Tetrastichus brevistigma* Gahan destroys pupae, and the fungus *Beauveria bassiana* (Bals.) Vuill. kills pupae and adults (Davidson and Lyon 1979).

Pyrrhalta vaccinii (Fall)
(blueberry leaf beetle)
galéruque de l'airelle (f.)

Distribution: Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: The species caused minor damage to blueberry in Nova Scotia (CIPR 1961). Fall (1924) found *P. vaccinii* only on the lowbush blueberry. In food-plant tests both the larvae and adults readily ate *Vaccinium pensilvanicum* Lam. (not Mill.), *V. myrtilloides* Michx., *V. pallidum* Ait., and *V. corymbosum* L. Both the larvae and adults appear limited to the genus *Vaccinium* L., subgenus *Cyanococcus* (A. Gray) Rydb., or true blueberries, as all other hosts were rejected.

The larvae attack only the under surface of the leaves, destroying the lower epidermis and the mesophyll (Fall 1924). A network of even the finer veins remain and the upper epidermis turns brown. The adults skeletonize the leaves in much the same way.

Biology: The life cycle of *P. vaccinii* is summarized from Fall (1924). The insect overwinters in the adult stage in the litter at the base of the host plants. The overwintered beetles appear quite early and may be observed in the field around the middle of May in eastern Maine. At this time, they begin to feed and mate on the expanding leaf buds. Feeding occurs both before and after copulation and hibernation. The beetles mate several times during the season, and oviposition begins as early as 21 May. Most of the eggs are deposited between the latter part of June and early July in crevices or rough areas at the base of the stems. The greatest number of eggs laid by a single female was 388. Most of the overwintered generation disappears by the middle of July. The length of the egg stage averaged 17.6 days (range, 14–31).

The larvae pass through three instars. The first instar averaged 4.7 days (range, 3–8), the second instar averaged 4.3 days (range, 3–6), and the third instar averaged 4.6 days (range, 2–9). The larvae are not gregarious feeders, as there is usually only one larva to a leaf. Pupation takes place in a rude cell that is constructed not far below the surface of the soil. The prepupal period averaged 5.5 days (range, 3–10), and the pupal period averaged 7.7 days (range, 6–11). All stages of *P. vaccinii* may be observed simultaneously, as the egg-laying period extends over 2 months. Adults of the new generation do not mate or lay eggs until the following summer, but they feed on the foliage well into the fall before seeking hibernation quarters.

The species is parasitized by the fungus *Beauveria globulifera* (Spegazzini) Picard (as *Sporotrichum globuliforum* Spegazzini). Both prepupae and pupae are susceptible to a wilt disease, probably bacterial in nature.

Pyrrhalta viburni (Paykull)

Distribution: Ontario and Quebec.

Origin: The species is Eurasian in origin (Becker 1979). In 1947 *P. viburni* was taken in the larval stage from *Viburnum* shrubs at Fonthill, Ont., and was reared to maturity (Sheppard 1955). The first North American breeding population of this insect was recorded during the summer of 1978, on *Viburnum opulus* L., in the Ottawa area, including Hull, Que. (Becker 1979).

Economic injury: The economic injury is summarized from Becker (1979). The beetles may cause serious injury to cultivated varieties of *Viburnum opulus* L., their preferred host. *Pyrrhalta viburni* has caused moderate damage to *V. rafinesquianum* Schult. and *V. lantana* L., and slight injury to *V. dentatum* L. and *V. trilobium* Marsh. The adults have fed on *V. lentago* L. and *V. acerifolium* L. in the laboratory. The insect appears to be restricted to species of *Viburnum* and may kill cultivated species in 2–3 years.

The adults skeletonize the leaves leaving only the midrib and larger veins. The females make holes (1 × 1 mm) in the small twigs for oviposition. Some feeding damage is done by the larvae.

Biology: Becker (1979) gave a brief account of the life history of *P. viburni*. The species overwinters in the egg stage in holes made in the twigs. The eggs hatch in May, and the larvae may be observed feeding in June. The species pupates in the ground, and the adults emerge in late July. When disturbed, the beetles readily drop from the surface of the leaves or fly away. The punctures for egg deposition are made from late summer until the first frost. There may be as many as 10 holes, and they often occur in a straight line on the underside of the twig. Several eggs are laid in each hole (usually nearest to the base of the twig); the hole is then covered with a mixture of black excrement and pieces of chewed wood mixed with mucus. The maximum oviposition is about 500 eggs. Once the eggs hatch the following year, the beetles require from 8 to 10 weeks to complete their development.

In Europe the following hymenopteron parasites are known: *Tetrastichus* sp., which attacks the eggs; *Closterocerus* sp., which attacks the larvae; and *Leiphron* sp., which attacks the adults.

Rhabdopterus deceptor Barber (*praetextus* of authors, not Say)

Distribution: Alberta, Manitoba, and Ontario.

Economic injury: According to Schultz (1977), specimen labels contained the following host data: flowers of *Spiraea*, young *Camellia*, *Callirhoe involucrata* (Torr. & A. Gray) A. Gray, *Populus deltoides* Marsh., *Quercus wirgajona*, peanuts, elm, and grape. Specimens reported by Barber (1943) were abundant and were found to do great damage to corn in Iowa.

Rhabdopterus picipes (Olivier)
cranberry rootworm
chrysomèle des racines de l'atocas (f.)

Comments: *Rhabdopterus picipes* has frequently been reported to cause economic damage in Ontario (CIPR 1946, 1947), Quebec (CIPR 1925, 1934; Petch 1926*a*; Petch and Maheux 1930), New Brunswick (CIPR 1946), and Prince Edward Island (1965). It is known to attack wild grape (CIPR 1925, 1946, 1947; Petch and Maheux 1930), rose (CIPR 1944), apple (CIPR 1925, Petch 1926*a*), raspberry (CIPR 1947), black alder (Petch and Maheux 1930), thimbleberry, ironwood, basswood, sugar maple, and stickseed (CIPR 1925). However, Paradis (1959) stated that *R. picipes* probably does not occur in Canada. This is further substantiated by the distribution given by Schultz (1977) for *R. picipes*, which includes the coastal plain from Connecticut to Florida to Louisiana, North Carolina, Tennessee, and Ohio.

Rhabdopterus praetextus (Say) (*picipes* of authors, not Olivier)

Distribution: Ontario, Quebec, Nova Scotia, and Prince Edward Island.

Economic injury: Paradis (1959) reported feeding by this species on apple trees, wild grape, and red-osier dogwood in an apple orchard in Quebec. The beetles damaged the fruit and leaves of the apple trees. Feeding scars on the fruit were restricted to the epidermis layer, which the adults removed in irregular strips. The leaves of all three plants exhibited similar damage, caused by the removal of all leaf tissue in the feeding areas, producing a lacelike appearance. The adults fed from mid June to mid July.

Saxinus saucia LeConte
(redshouldered leaf beetle)

Distribution: British Columbia.

Economic injury: In literature cited by Hatch (1971), *S. saucia* is reported to often injure fruit trees such as prune, almond, apricot, plum, and nursery stock, as well as occurring on wild rose, *Erigeron*, wild buckwheat, Christmas berry, and *Ceanothus*.

Biology: The larvae live in the nests of ants (Hatch 1971).

Syneta albida LeConte
(western fruit beetle, fruit tree leaf beetle, fruit tree leaf syneta, syneta leaf beetle)

Distribution: British Columbia.

Economic injury: This species often causes serious damage to apple, currant, cherry, gooseberry, peach, pear, plum, prune, quince, wild crab apple, and strawberry; it also feeds on the foliage of hazelnut and vine maple (Hatch 1971). According to Edwards (1953), the adults feed on the leaves, buds, flowers, and fruit, and the larvae apparently do some slight damage to rootlets. The species has also been reported from clover (Brittain 1914, Twinn 1933, CIPR 1939). On developing cherries, Neilson (1957*b*) stated that the adults eat the skin and the flesh, causing scars and deformed fruits. The same author also reported stem feeding, which may cause fruit to drop prematurely.

Biology: Neilson (1957*b*) briefly described the life history of *S. albida*. The univoltine species overwinters in the larval stage in soil cells. The larvae pupate in early spring, and the adults emerge when host buds are beginning to swell. The adults live for several months and oviposit at random on the soil. The larvae develop in the soil, feeding on fibrous roots. The native host plant of this species is probably willow (Hatch 1971).

Systena blanda Melsheimer (*taeniata* var. *blanda* Horn)
palestriped flea beetle (banded flea beetle)
altise à bandes pâles (f.)

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, and Atlantic Provinces.

Economic injury: The palestriped flea beetle is an annual pest of several garden and farm crops and may cause serious injury, usually just after the young plants have pushed through the soil (Underhill 1928). Twinn (1934*a*) noted that a variety of crops were damaged in southern Ontario, and MacNay (1954*b*) reported the destruction of 25% of the sugar beets in a field in the southwestern part of the province. Many cultivated plants and weeds are attacked, including beans (lima and stringless), sugar beet, melon, cucumber, rhubarb, tomato, potato, carrot, parsnip, corn, eggplant, soybeans, clover, cotton, pear nursery stock, apple nursery stock, *Weigela*, crepe myrtle, lettuce, okra, radish, summer savory, oats, rye, *Chrysanthemum*, alfalfa, peanuts, blackberry, turnip, cabbage, pepper, aster, Swiss chard, canola, oak, watermelon, pumpkin, peas, sweet potato, mint, beet, rutabaga, mangel, *Perilla* foliage, parsley, Russian thistle, wheat, onion, tobacco, pigweed, shepherd's-purse, ragweed, cocklebur, lamb's-quarters, henbit, giant ragweed, purslane, sorrel, and plantain (Gibson 1913, Underhill 1928, Dustan 1932, Blake 1935, CIPR 1948, Metcalf et al. 1951, Fox and Stirrett 1952). According to Underhill (1928), the insects spend most of the season feeding on weeds, and the important damage to cultivated plants occurs soon after the adults emerge in the spring and while the plants are still in the seedling stage. During this period, weeds are frequently not large enough to support the hungry adults. Injury to young crops may be so severe as to necessitate replanting.

The adults feed on the leaves of host plants, and the larvae attack the roots and seeds (Davidson and Lyon 1979). According to Dustan (1932), the palestriped flea beetle chews small, circular holes through the undersides of the leaf. When damage is severe, these holes coalesce and the leaves may turn brown and die. The beetles were reported to feed on the upper surface of the foliage, especially on the tender leaves (Underhill 1928). The larvae eat the fibrous roots and the outer cortex of the larger roots. The larvae generally feed on the roots of weeds and do not normally cause economic injury to crops. However, the larvae reportedly made small, pinlike holes in sweet potato tubers, causing a 10% crop loss. Injured corn seed frequently fails to sprout or produces a pale, weak plant (Metcalf et al. 1951).

Biology: *Systena blanda* overwinters in the adult stage (Beirne 1971). In Virginia the beetles appear during the latter part of May and normally start oviposition around 20–25 May (Underhill 1928). *Systena taeniata* (reported as a distinct species in Underhill's paper) emerges in March and early April. In cages the egg-laying period extended until 14 August. In the laboratory, first-generation beetles began to deposit eggs from 6 to 14 days after emergence. In the field the eggs are laid shallowly in the soil beneath the host plants at a depth of about 3 to 6 mm. The number of eggs laid per female averaged 84 (range, 41–216) and 68 (range, 44–114) for first-generation eggs and 153 (range, 24–256) for second-generation eggs. The incubation period took from 8 to 15 days. First-generation eggs hatched in an average of about 10.5 days, and second-generation eggs in 12–13 days.

The larvae pass through three instars (Underhill 1928). The larval period averaged 17.0 days (range, 14–19) for the first generation and 21.0 days (range, 19–22) for the second. At maturity the larvae construct an oval cell near the surface (occasionally at a depth of 1.3 cm or more) to pupate. The prepupal period averaged 3.4 days (range, 2–6) for the first generation and 3.9 days (range, 3–5) for the second. The pupal period averaged 7.9 days (range, 6–9) for the first generation and 9.6 days (range, 8–12) for the second. Feeding begins soon after emergence. In warm weather the adults are very active and are known to jump and fly readily. They feign death or hide under the host plant and in crevices in the ground. The spring adults usually disappear by the beginning of August. Their average life-span has been estimated at 49 days for the females and 34 days for the males. These adults are no longer to be found by the middle of September. Only one generation per year occurs in Canada (Dustan 1932) and two in the southern United States (Davidson and Lyon 1979).

Comments: Although Underhill (1928) reported *S. blanda* and *S. taeniata* as similar but separate species, the biology given here is based mainly on his account of *S. blanda.*

Systena frontalis (Fabricius)
(red-headed flea beetle)
altise à tête rouge (f.)

Distribution: Alberta, Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: Beirne (1971) reported the species to be a sporadically serious pest of red clover. Heavy infestations resulted in partial defoliation of turnip and potato plants in New Brunswick (CIPR 1939). *Systena frontalis* inflicted significant damage to the foliage of strawberry in southwestern Quebec (Rivard et al. 1975). In eastern Canada the insect has been very destructive to potato and beans and to such flowering plants as marsh mallow, rose mallow, and Japanese honeysuckle (Gibson 1921). According to Jacques and Peters (1971), in Iowa the species may become a minor pest of corn under such conditions as the absence of certain weeds upon which it mainly feeds (i.e., ragweed, pigweed, lamb's-quarters, dogbane, and especially, smartweed) and the presence of adults in large numbers and suitable hatching conditions. The polyphagous adults have also been recorded on lettuce, wax and other beans, soybeans, mangel, sugar beet, hop vines, young grape, sunflower, giant foxtail, velvetleaf, helichrysum, dahlia, Canada thistle, zinnia, various flowering plants in gardens, honeysuckle, aster, chrysanthemum, goldenrod, daisy, broad-leaved plantain, black bindweed, common burdock, heal-all, lady's-thumb, wild lettuce, beggarticks, cabbage, cranberry, gooseberry, mangel-wurzel, and pear leaves (Hawley 1922, Gibson 1934, Caesar and Ross 1929, CIPR 1945, Beirne 1971).

The adults cause the important damage while the larvae probably feed on the roots of the weed hosts, although they have been reported to feed and tunnel on the roots of corn (Hawley 1922, Guppy 1958, Jacques and Peters 1971). On red clover the adults attack the leaves, especially the leaflets just under the clover blossoms (Guppy 1958). The adults make small, elongate punctures through the upper surface, leaving the lower epidermis intact. The blossoms are occasionally attacked, and parts of the corollas may be chewed off. On corn the adults attack mainly the green silks but may also be found on the upper surfaces of the leaves, where they either remove the upper epidermis or skeletonize the leaf (Jacques and Peters 1971). Damage is slight, however, when compared with rootworm damage in Iowa, where the leaves of smartweed and ragweed are chewed through and may be skeletonized. The adults are often gregarious and may cause serious injury on certain plants while nearby ones are almost free of the pests (Hawley 1922). A single bean plant was host to 30 adults that fed on the upper surfaces of the leaves.

Biology: According to Hawley (1922), the species overwinters in the egg stage. The eggs hatch in May of the following year (in New York). In a corn field in Iowa, the first larvae were observed on 14 June (Jacques and Peters 1971). Larvae were no longer to be found after 17 July. Adults were collected on 24 July and were most numerous from 24–31 July. In Ontario adults were reported from July to September (MacNay 1953). As many as 20 adults were observed on the silks of a single corn plant, while many other plants were free of the insect (Jacques and Peters 1971). Frequent matings were observed in August, and some took place as late as September (Hawley 1922). After feeding, the adults enter the soil for oviposition during August and September. The eggs are scattered irregularly around the roots of the host plant at a depth of 1–5 cm. In the laboratory Jacques and Peters (1971) reported that eggs require exposure to cold before hatching and that up to 70% of the eggs hatched after being exposed for various periods at 5°C.

The larvae pass through three instars, and the time between eclosion and mature larvae was 30 days (Jacques and Peters 1971). The only adult that was reared appeared 36 days after hatching. By 10 August, the number of adults dropped to less than one per plant. The adults were no longer to be found after the silks turned brown, but they were observed as late as 1 October feeding on smartweed in a soybean field near the corn plots.

Systena hudsonias (Förster)
(smartweed flea beetle)

Distribution: Manitoba, Ontario, and Quebec.

Economic injury: The adults are general feeders. They occur most commonly on smartweed but are also known to attack clover, potato leaves, wild plants, and a wide range of vegetable and garden plants (DuPorte 1914, Lochhead 1915, Caesar et al. 1930, Parry 1977). According to Parry (1977), the larvae feed on sugar beet.

Biology: Adults have been collected from mid May to late August (Parry 1977).

Systena marginalis (Illiger)
(black margined flea beetle)

Distribution: Ontario and Quebec.

Economic injury: The species may occasionally cause considerable injury to certain forest and shade trees (Gibson 1913). According to Parry (1977), *S. marginalis* occurs on shrubs and trees including elm, hickory, oak, shadblow, alder, sweet gum, wild red cherry, red chokecherry, and hawthorn.

The adults attack the leaves and may leave only the ribs (Gibson 1913).

Biology: Adults have been collected from late March to early October (Parry 1977).

Systena pallicornis Schaeffer

Distribution: Ontario.

Economic injury: Twinn (1937) reported an outbreak of this species on bean foliage that almost destroyed some fields.

Timarcha intricata Haldeman

Distribution: Southeastern British Columbia.

Economic injury: According to Hatch (1971), this species feeds on huckleberry, thimbleberry, and strawberry and may occur as a pest of strawberry.

Zeugophora abnormis (LeConte)
(poplar leafmining beetle)

Distribution: Alberta, Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: Strickland (1920) described the damage caused by this species. It may cause severe disfigurement of the leaves. *Zeugophora abnormis* occurs most abundantly on balm-of-Gilead and is rarely observed on cottonwood. The beetles prefer sheltered trees and do the greatest damage 1.8–3 m from the ground. Leaves toward the centre of the tree usually escape injury.

Serious damage may be caused by both adults and larvae. In feeding, the adults make small groups of holes on the underside of the leaf, and sometimes they make a few smaller groups of holes on the upper side of the leaf. Although *Z. abnormis* occurs in fewer numbers per year than does *Z. scutellaris*, it is much more numerous in some years on the comparatively rare balm-of-Gilead. Many of the leaves of infested trees may be almost completely skeletonized by the work of the adults alone.

The larvae are leaf miners and are similar to those of *Z. scutellaris*, which feed on only the palisade cells just below the upper epidermis. The lower layer of cells, which forms the spongy tissue of the leaf, is never attacked and turns black about 24 h after the palisade cells have been eaten. These blackened areas may extend over the entire surface of the leaves.

Biology: A brief account of the biology of *Z. abnormis* was given by Strickland (1920). The life history of this species is similar to that of *Z. scutellaris*. Oviposition on individual leaves, however, is greater for *Z. abnormis*. Up to 50 eggs have been collected from a single leaf. Approximately 28% of the eggs failed to hatch; this sterility is normal for the species.

A minute hymenopterous parasite, identified as a mymarid, was reared from attacked eggs.

Zeugophora scutellaris Suffrian
(cottonwood leafmining beetle)

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: Strickland (1920) described the economic injury of this species. *Zeugophora scutellaris* is known to cause extensive disfigurement to the foliage of cottonwood. It is also found sparingly on other poplars. The beetles are most abundant on the smaller-leaved varieties of cottonwoods and prefer the lee side of the tree to the exposed side. Trees that are sheltered by houses incur more damage than others.

Leaf disfigurement is due mainly to the work of the larvae, though some damage is done by the adults. The larvae are leafminers that feed on the palisade cells just below the upper epidermis. The lower layer of cells that form the spongy tissue of the leaf is never attacked and turns black about 24 h after the palisade cells have been eaten. The unsightly disfigurement of attacked leaves results from this black color, which is visible through the upper epidermis. The blackened areas may extend over the entire surface of the leaves. In feeding, the adults make small groups of holes on the underside of the leaf and possibly a few groups on the upper side as well. The holes extend to the upper epidermis, which appears as a transparent membrane when exposed to light. In a few weeks the punctures become more circular in outline, and corky tissue develops around the hole.

Biology: Grave (1918), in Wyoming, reported that the insect overwinters in the larval stage at a depth of between 3.8 and 6.4 cm below ground in a small, spherical cavity. The larvae transform to pupae in the spring around the end of May (25 May to 15 June). The pupal period requires about 3 weeks or perhaps 4 in cool weather. Adults begin to appear around the middle of June in southern Alberta and begin feeding on the leaves of cottonwood (Strickland 1920). Although the adults are strong fliers, they fall to the ground and feign death when disturbed. Mating begins by 26 June. Grave (1918) pointed out that in captivity, one beetle laid eggs 10 days after it emerged. The eggs are deposited in a small cavity close to the upper epidermis of the leaf (Strickland 1920). A short, diagonal tunnel joins the cavity to a hole on the underside of the leaf. The location of each egg is marked by a tiny brown spot about 1 mm in diameter on the upper side of the leaf. Several eggs may be deposited in one leaf. In one instance up to 13 eggs were laid in one leaf, but many failed to hatch. The eggs are always deposited within 1.3 cm of the leaf margin to provide a sufficient food supply, since the young larvae are at first unable to eat through the larger veinlets.

Unlike *Z. abnormis*, this species is not gregarious, and often only one healthy larva is in one blister (Strickland 1920). The larvae, which are found with the ventral side uppermost, can move rapidly inside the mine, but on the outside of the leaf, their progress is slow. The majority of larvae are full grown by the middle of September. At this time they break through the thin upper epidermis of the leaf and fall to the ground. In captivity the larvae burrowed to a depth of about 10 cm to form a small, elliptical cell about 1.6 cm long by 12.7 mm wide. Although the larvae probably overwinter in these cells, they could not be found under infested trees, nor did captive specimens survive until spring.

Zygogramma exclamationis (Fabricius)
sunflower beetle
chrysomèle du tournesol (f.)

Distribution: Alberta, Saskatchewan, Manitoba, and northwestern Ontario.

Economic injury: According to Westdal (1975), adults and larvae of the sunflower beetle are important defoliators of the sunflower in Manitoba. Depending on the abundance of the pest, injury may vary from a few holes in the leaves to almost complete defoliation of the plant. Infestations of adults on seedlings delay maturity and reduce seed yield. Defoliation of larger plants by larvae may reduce seed yield by as much as 30%. Although the larvae are foliage feeders, they are often found feeding on flower buds (Westdal and Barrett 1955). According to Hatch (1971), *Z. exclamationis* has also been taken on potato in Idaho.

Biology: Gerber et al. (1979) studied the reproductive cycles of the sunflower beetle in Manitoba and presented a brief account of its life history. This is supplemented with observations made by Rogers (1977) in Texas and Westdal et al. (1976) in Manitoba on other aspects of the life cycle. The sunflower beetle has a one-year life cycle in Manitoba without the possibility of a partial second generation.

Adults, which overwinter in the soil, emerge during the latter part of May in Manitoba. Copulation starts within 2 days of emergence, and both sexes mate repeatedly. The preoviposition period for 13 females was 2.5 days (range, 0–5). Once oviposition begins, the females continue to lay eggs on almost a daily basis. A peak daily oviposition rate of 30–40 eggs per female was reached during the first 2 weeks. Surviving females maintained this rate for the remainder of the oviposition period. The rate, however, decreased for the group as a whole after the third week. The average number of eggs laid per female in the laboratory was 1968 (range, 260–3587), and for two successive years in outdoor cages it was 968 (range, 657–1400) and 636 (range, 132–1554). After oviposition is completed, the females usually die within a few days. The eggs hatch in about a week.

In Texas the larvae passed through four instars and required 15.1 days to develop to the prepupal stage. In Manitoba the insects required about 6 weeks to mature. The mature larvae leave the host plants and bury themselves 2–5 cm in the soil to pupate. In Manitoba, larvae are present in the field for about 6 weeks during the summer. In Texas the prepupal and pupal stages averaged 4.8 and 6.7 days, respectively. In Manitoba, adults of the new generation emerged during August and fed for a short period before returning to the soil to hibernate. There was no indication that adults of the new generation mated before hibernation. Adults of *Z. exclamationis* are diurnal, whereas larvae are nocturnal feeders, remaining hidden in terminals and leaf axils during the day.

Predators in Canada include the carabid *Lebia atriventris* Say, the pentatomid *Perillus bioculatus* Fabricius, the larvae of an unidentified chrysopid (Graham 1965), and lady beetles (Westdal et al. 1976).

CLERIDAE clerid beetles

Most species of this family are predaceous and are important in the control of insect pests, particularly wood-boring species of the families Scolytidae, Cerambycidae, and Buprestidae. A few species occur in bracket fungi, leaf litter, and bee and wasp nests. Species of the genus *Necrobia* feed on dead animal or plant matter and may feed on smoked meat-products. Species of this family are known from all faunal regions and include over 4000 species of which 60 are estimated to occur in Canada.

Necrobia rufipes (De Geer)
redlegged ham beetle (copra beetle)
nécrobie à pattes rousses (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Origin: This species is cosmopolitan in distribution.

Economic injury: This saprophagous species is usually found on the carcasses of dead animals, but it also infests stored animal and plant products (Gosling 1980). According to Metcalf et al. (1951), *N. rufipes* is the most injurious pest of well-cured and dried smoked meats and may occasionally destroy large amounts of ham and bacon. The species is most harmful to cured pork, but it is also known to feed on fish, copra, guano, tapioca, cocoa, bone meal, cheese, dried egg, beans, hides, dried fruits and nuts, and other insects and insect eggs as well as their own (Olds 1936, Metcalf et al. 1951). MacNay (1947) reported it in cured meats in a store at Hamilton, Ont. Although this insect is a major pest in warmer climates, Gibson and Twinn (1939) did not find it to be important in Ontario and British Columbia, where it occurs occasionally.

Biology: In unheated buildings, the species probably overwinters chiefly as mature larvae (Metcalf et al. 1951). The adults appear in May and June and disperse mostly by running, but also by flying. The female deposits her eggs in clusters in dry recesses of the food. According to Olds (1936), the adults may live as long as 14 months and deposit as many as 2100 eggs. Hatching occurs in 4 or 5 days in warm weather (Metcalf et al. 1951). The larvae are negatively phototropic. Pupation takes place in dry, dark crevices lined with silk. The life cycle may be completed in from 36 to 150 days or more, depending on the availability of food. The larval stage occupies about two-thirds of this time. Olds (1936) reported an average life cycle of 30–45 days.

According to Howe (1965), *N. rufipes* requires high temperature and relative humidity. The minimum temperature and RH at which the species can multiply sufficiently to become a pest is 22°C and 50% RH. The optimum temperature range is 30–34°C, and the maximum rate of increase every 4 weeks is 25-fold.

Necrobia ruficollis (Fabricius)
redshouldered ham beetle
nécrobie à col rouge (f.)

Distribution: British Columbia and Quebec.

Origin: This species is cosmopolitan in distribution throughout tropical and southern temperate regions. It is not known to be established in Canada but has often been intercepted.

Economic injury: The species is both saprophagous and predaceous and is usually found on the carcasses of dead animals. It may also infest stored animal and plant products (Knull 1951, Gosling 1980). Like the copra beetle, *N. ruficollis* reproduces in large numbers in dried coconut meat (Hatch 1962). Because copra is processed very quickly, the redshouldered ham beetle is of little economic importance, even though it occasionally escapes from copra ships in great numbers. The species is also known to infest ham, cheese, and other dried animal products.

Necrobia violacea (Linnaeus)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Newfoundland, Northwest Territories, and Yukon Territory.

Origin: *Necrobia violacea* is cosmopolitan in distribution.

Economic injury: Knull (1951) reported this species from skin and bones of dead animals, dried fish, and dermestid larvae. It is not known to be as frequent a pest of stored products as *N. rufipes* and *N. ruficollis*.

COCCINELLIDAE lady beetles coccinelles (f.)

Both larvae and adults of most species of this family are predaceous. Many of them are well known for their role in the natural control of scale insects, aphids, mealybugs, and other phytophagous insects. Only members of the subfamily Epilachninae are plant feeders. This subfamily includes the Mexican bean beetle, *Epilachna varivestis*, a major pest of beans in North America. The family Coccinellidae contains about 4500 species of which 160 are expected to occur in Canada.

Epilachna varivestis Mulsant (*corrupta* Mulsant)
Mexican bean beetle (bean lady beetle, bean ladybird, bean bug, spotted bean beetle)
coccinelle mexicaine des haricots (f.)

Distribution: British Columbia, Ontario, Quebec, and New Brunswick.

Origin: The Mexican bean beetle is native to Mexico, Guatemala, and other areas of Central America (Auclair 1959). *Epilachna varivestis* was first found in New Mexico in 1850 (Chittenden and Marsh 1920*a*). The species probably spread by natural means to the United States by long distance flight, the wind being an important factor (McLaine 1927). In Canada it was first reported from Ontario in 1927, New Brunswick in 1942, and Quebec in 1943 (Beirne 1971).

Economic injury: The Mexican bean beetle causes severe damage to beans (Metcalf et al. 1951, Bereza 1976). In some regions of the United States, entire crops have frequently been destroyed by the pest (Dustan 1932). According to Goble (1960), *E. varivestis* has inflicted damage to cultivated beans in southwestern Ontario since 1950. Reports of important damage to beans in Ontario have been made by CIPR (1931), Twinn (1943), MacNay (1951, 1953, 1954*b*); in Quebec by Doyle (1943); and in New Brunswick by MacNay (1947). Recently, the insect was reportedly injurious to beans only near Lake Huron, especially the area near Bayfield, Ont. (Goble 1971*a*, Bereza 1976). Many types of beans are attacked including white beans (Wressell 1970), soybeans (Whitfield and Ellis 1976), garden and field beans, lima beans, red kidney beans (Goble 1960), and cowpeas. It is most harmful during July and August (Metcalf et al. 1951). The Mexican bean beetle also attacks beggarticks and rattlebox (Auclair 1959); alfalfa, clover, vetch, and grasses (Dustan 1932, Metcalf et al. 1951, Goble 1960); hyacinth, mung beans, velvet beans, kudzu, sweet-clover, crimson clover, white clover, corn, grasses (e.g., rye), okra, eggplant, squash, and potato (McLaine 1927, Auclair 1959). The insect may feed but not reproduce on *Lupinus hirsutissimus* Benth., *L. excubitus* M.E. Jones, and *L. succulentus* Dougl. ex C. Koch. (Auclair 1959). Metcalf et al. (1951) reported some damage to soybeans and cowpeas where these crops were growing near heavily infested garden beans but noted no important injury in areas where they were growing alone as field crops. Bernhardt and Shepard (1979) stated that in field populations this oligophagous species commonly attacks beans in the spring and soybeans later, when other beans are unavailable.

Both the larvae and adults attack the leaves, chiefly the undersurfaces, leaving the upper surfaces more or less intact (Metcalf et al. 1951, Goble 1960, Bereza 1976). Later, the epidermis of the upper surface of the leaves dries out, giving the characteristic lacelike, skeletonized appearance of the foliage. When infestations are heavy, the stems and pods are also attacked; plants may be killed within a month after the attack begins and frequently before the crop reaches maturity. The early instar larvae are particularly destructive (Chittenden and Marsh 1920*a*).

Biology: Auclair (1959) described the biology of the Mexican bean beetle in southwestern Quebec and reviewed the pertinent literature in North America. The adults overwinter in grass, leaf litter, or rubbish, especially in nearby woodland and hedgerows (Goble 1960). Emergence begins in early June. When the humidity is low, adults may not emerge even on the warmest days of spring. On the other hand, emergence seldom occurs below 10°C and is most successful from 14 to 21°C. Although the beetles seem sluggish, they are strong fliers and disperse widely over the country in search of bean fields. Metcalf et al. (1951) pointed out that adults may be found in gardens and fields as soon as the first garden beans come up from the seeds. The adults drop to the ground when disturbed, folding their legs and secreting a drop of yellow fluid from the body joints, which apparently repels certain predators. The adults feed for 1 or 2 weeks, mate, and begin to deposit groups of eggs on the undersides of leaves (Chittenden and Marsh 1920*a*, Metcalf et al. 1951, Goble 1960). Chittenden and Marsh (1920*a*), working in Colorado, stated that the oviposition period of the overwintered beetles extends from mid June until early August, although some occasionally lay eggs throughout the summer. According to Davidson and Lyon (1979), a female may lay over 1500 eggs, but the average is approximately 460. Eggs hatch in approximately 6 days (range, 5–8). The development period of the first generation from egg to adult emergence varies from 35 to 44 days. Larvae mature in 2–5 weeks, then pupate in the shedded larval skin, which is fastened to the underside of uninjured leaves (Metcalf et al. 1951, Goble 1960). Many first-generation adults probably hibernate as successfully as second-generation adults under natural conditions. First-generation adults emerge during the last half of July and search for new host plants, even when a sufficient supply is nearby. After a preoviposition period of 5–11 days, first-generation females deposit from 394 to 890 eggs in masses of approximately 40–60 eggs in late July. It takes 41–45 days at a mean daily temperature of 20.5°C to complete the life cycle from egg to adult. The average duration of the various stages of the second generation in Ontario according to Hudson and Wood (1927) is as follows: incubation period, 7–14 days; first instar, 8.5 days; second instar, 5.5

days; third instar, 6.3 days; fourth instar, 9.8 days; and pupal stage, 12.5 days. The same authors stated that the complete life cycle required about 51 days and that the adults needed 7–10 days to gradually change color from lemon yellow to a definite copper. Adults feed heavily for a few days after emergence. Chittenden and Marsh (1920*a*) reported that a portion of the adults of the first generation and all those of the second generation start laying eggs in June of the following year. According to Metcalf et al. (1951), flight dispersal occurs chiefly in late summer and in autumn, when adults start leaving their hosts in search of hibernating quarters. The various stages greatly overlap in the field, and all stages may be observed from late July to October.

Davidson and Lyon (1979) reported that parasitic flies and wasps and predacious bugs and lady beetles are natural enemies of the Mexican bean beetle and noted that the annual release of eulophid wasps can effectively control the insect. Known parasites (Richardson 1970) include the fungi *Beauveria bassiana* (Bes.) Vuillman and *Myrothecium roridum* Tode; the tachinid flies *Clistomorpha triangulifera* (Loew), *Exoristoides slossanae* Coquillett, *Megaselia* sp., *Nemorilla maculosa* Meigen, *Paradexodes epilachnae* Aldrich, *Phorcera doryphorae* Riley, and *P. claripennis* Macquart; the sarcophagid flies *Sarcophaga latisternus* Parker, *S. rapax* Walker, and *S. reinhardi* Hul.; the chalcid wasps *Brachymeria carinatifrons* Gahan; the eulophid wasp, *Pediobius epilachnae* Rohwer; and the braconid wasp *Synaldis* sp. *Helicobia* (*Sarcophaga*) *helicis* Towns, *Lydinolydella metallica* Towns, pentatomids, reduviids, coreids, coccinellids, carabids, cicindelids, and bacteria attack *E. varivestris*. Quattlebaum and Carner (1980) reported a new, unidentified, fungal pathogen of the Mexican bean beetle.

CRYPTOPHAGIDAE **cryptophagid beetles**

Members of this family generally feed on molds, fungal spores, and decaying vegetation. There are a number of species that are often associated with stored products, but their presence is generally indicative of poor storage conditions, which promote excessive growth of mold rather than indicating damage as pests of healthy kernels. Because of their association with stored products, many of the species are distributed almost world wide. Approximately 600 species are known, of which 80 are estimated to occur in Canada.

Cryptophagus acutangulus Gyllenhal
acute-angled fungus beetle

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Newfoundland.

Origin: *Cryptophagus acutangulus* is a Holarctic species generally distributed in North America (Woodroffe and Coombs 1961).

Economic injury: *Cryptophagus acutangulus* has been reported to be associated with stored products in Canada (Sinha 1965*b*). Hinton (1945) listed several records of this species from various parts of the world (e.g., in a granary, houses, cellars, old beer and wine barrels, samples of cereal, moldy plant and animal materials) but pointed out that both larvae and adults usually feed only on fungal spores and hyphae and rarely or never on cereal products. Adults are capable of internal mechanical and external transmission of fungal spores.

Biology: The eggs of *C. acutangulus* are deposited singly, usually among or on top of fungal hyphae (Hinton 1945). Between 7 and 20 January, one female laid seven eggs. Hatching occurs in 5 or 6 days. One larva hatched on 25 January, molted on 1 or 2 February, remained in the second instar until 7 February, stopped feeding on 12 February, and pupated on 17 February. Adults emerged on 24 February. The larvae do not construct pupal cells and usually pupate in crevices or under bits of moldy food. Development from egg to adult required 30 days.

Cryptophagus bidentatus Mäklin

Distribution: British Columbia.

Economic injury: Sinha (1965*b*) reported this species to be associated with stored products in British Columbia.

Cryptophagus corticinus Thomson

Distribution: British Columbia, Ontario, and Quebec.

Economic injury: Sinha (1965*b*) reported *C. corticinus* to be associated with stored products.

Cryptophagus cellaris (Scopoli)

Distribution: Alberta, Saskatchewan, and Ontario.

Economic injury: Lepesme (1944) reported this species in cereal granaries and mills in Europe and North America on wheat, barley, oats, rice, bran, flour, bread, linseed cake, and dried fruit.

Cryptophagus croceus Zimmermann

Distribution: Ontario.

Economic injury: According to Sinha (1965*b*), this insect has been reported as associated with stored products in Ontario. It has been reported in old flour barrels and on apples in a cellar in the United States (Hinton 1945).

Cryptophagus distinguendus Sturm

Distribution: British Columbia.

Origin: Lepesme (1944) recorded this species from Europe and North Africa. Woodroffe and Coombs (1961) said that it is Holarctic in distribution.

Economic injury: *Cryptophagus distinguendus* was reported to be associated with stored products in British Columbia (Sinha 1965*b*). Hinton (1945) listed several records of the insect found in and around the following: mills, bakeries, warehouses, granaries, nests (of birds, small mammals, and ants), haystacks, vegetable refuse, dried fruit, and fungi.

Biology: Hinton (1945) reported the mite, *Uropoda marginata* Koch as a parasite of *C. distinguendus*.

Cryptophagus follax Balfour-Browne

Distribution: Nova Scotia and Prince Edward Island.

Origin: The species is probably a native of northern Europe and the British Isles (Woodroffe and Coombs 1961).

Economic injury: Heavy populations of the species have been found in at least one house on Prince Edward Island (CAIPR 1973).

Cryptophagus obsoletus Reitter

Distribution: Ontario.

Origin: Woodroffe and Coombs (1961) reported the species to be Holarctic in distribution.

Economic injury: Woodroffe and Coombs (1961) recorded the species from stored products.

Cryptophagus pilosus Gyllenhal

Distribution: British Columbia, Manitoba, and Ontario.

Origin: Woodroffe and Coombs (1961) recorded the range of this species to be Holarctic and probably cosmopolitan.

Economic injury: Like other species in the same genus, this species is often associated with stored products (Woodroffe and Coombs 1961).

Cryptophagus varus Woodroffe and Coombs
sigmoid fungus beetle

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario.

Economic injury: *Cryptophagus varus* usually feeds on fungi associated with grain (Sinha 1974). It is not a primary pest of stored grain but is an indicator of the presence of microorganisms that can cause grain deterioration (Loschiavo 1975). The species has been found in stored wheat (Sinha 1974) and barley (CIPR 1962).

CUCUJIDAE **cucujid beetles or flat bark beetles cucujides (m.)**

Species of Cucujidae are generally found under bark or in leaf litter, where they feed on fungi and decaying plant tissue. Some of the species are among the most important pests of stored products, such as the rusty grain beetle, the saw-toothed grain beetle, and the merchant grain beetle, among the most frequently encountered household pests in Canada (Loschiavo and Smith 1970; Loschiavo and Sabourin 1982). The family contains at least 1200 species world-wide, of which 45 are estimated to occur in Canada.

Ahasverus advena (Waltl)
foreign grain beetle
cucujide des grains (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia.

Economic injury: *Ahasverus advena* is the most common fungus grain beetle found in the Prairie Provinces (Watters 1976). This cosmopolitan species is commonly found in mills, warehouses, and granaries feeding on grain and farinaceous material that is damp and moldy (Cotton and Good 1937). According to Woodroffe (1962), *A. advena* occurs on a wide variety of stored products including grain, cereal products, copra, cocoa, other oilseeds, dried fruit, herbs, spices, and roots. The beetle also contaminates stored products by the presence of live individuals, body parts, cast skins, fecal material, and the introduction of fungal spores (David et al. 1974). The species is frequently found on cargo ships but is not regarded as a pest of sound grain (Monro 1969). In Manitoba, Sinha (1974) reported *A. advena* in heated wheat but not in unheated wheat and suggested that its presence is an indication of grain deterioration from molds. CAIPR (1970) reported the foreign grain beetle in pockets of moldy farm-stored grain in Saskatchewan, feeding on microorganisms associated with damp grain and causing some secondary damage. Dolinski et al. (1971) reported *A. advena* to infest triticale, a new host record. Woodroffe (1962) found that *A. advena* is capable of maintaining itself on and causing direct damage to stored products, if mold or wheat germ is present and the relative humidity is above 65%. For successful development the species seems to require a factor that is present in both molds and wheat germ.

Biology: David and Mills (1975) studied the life history of *A. advena* at 27 and 1°C and 75% RH. The preoviposition period was 3–4 days, and a peak oviposition period occurred within the first 15 days after emergence. The egg-laying rate remained low from then until 90–105 days later, when it again increased. Eggs were laid singly or occasionally in clusters of two or three, with each female laying 1–12 eggs on egg-laying days.

Eggs usually hatched in 4 or 5 days. The larvae underwent four or five molts during the 11- to 19-day larval period. The larvae formed chambers of food particles cemented together, cementing themselves to the substrate with anal secretions. They remained in this prepupal state for 1 or 2 days. The pupae were not enclosed in cases but remained attached to the last larval skin that adhered to the substrate. The pupal stage lasted 3–5 days. The entire development period from egg to adult averaged 22.5 days. Mated males and females lived an average of 159 days (range, 56–325) and 208 days (range, 45–339), respectively. Unmated males and females lived significantly longer.

Changes in relative humidity had no effect on the development of eggs, prepupae, or pupae. However, the mean development period for larvae increased as the relative humidity decreased from 92 to 66%. At high relative humidity, most larvae had four instars, but as relative humidity decreased, more larvae had five instars. At 58% RH, all larvae died as first or second instars.

David et al. (1974) studied the development and oviposition of *A. advena* on pure cultures of seven species of fungi. They found that the beetle developed successfully on *Aspergillus amstelodami* (Mangin) Thom and Church, *Penicillium citrinum* Thom, and *Cladosporium* sp.

The insects, however, did not develop on *A. flavus* Link, *A. niger* Van Tieghem, or *A. ochraceus* Wilhelm, and developed only to a limited extent on *A. candidus* Link, all stored-grain molds. Females of *A. advena* preferred to oviposit in fungi suitable for larval development. Hill (1978) found that the species also develops on *A. repens* (Corda) Sacc., *A. conicus* Blochwitz, and *A. chevalieri* Thom and Church var. *intermedius* Thom and Raper.

Cryptolestes ferrugineus (Stephens)
rusty grain beetle (rusty-red grain beetle)
cucujide roux (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Newfoundland.

Origin: Hatch (1962) considered *C. ferrugineus* to be an introduced species. It is cosmopolitan in distribution.

Economic injury: *Cryptolestes ferrugineus* is a pest of stored grain and other foodstuffs (Cotton and Good 1937). In Canada it is a major pest of stored grain, especially wheat (Watters 1969), and is the most important pest of this commodity in the Prairie Provinces (Liscombe and Watters 1962, Smith 1967). Damage is usually restricted to grain stored under high moisture conditions (Loschiavo 1975). The species has been recorded in cargo ships (Monro 1969), railroad cars (MacNay 1955), commercial flat storages (MacNay 1959), farm-stored grain, grain elevators (CAIPR 1970), and infrequently in mills, warehouses, and flour mills (MacNay 1957*b*). Other grains attacked by this species in Canada include barley, rye (CAIPR 1975), triticale (Dolinski et al. 1971), oats, and flax that is heating (CIPR 1966). Sinha (1961) reported the species to be the most common insect in heating grain. The adults and larvae feed almost exclusively on the germ and cause little weight loss to the entire kernel (Sinha 1976). However, by feeding on the vitamin-rich germ, the species causes more qualitative than quantitative loss of stored wheat. According to Rilett (1949*b*), the germ of one kernel contains enough food for the complete development of one larva at 32°C and 75% RH. However, in grain that is extensively degermed by prior generations, larvae and adults will also feed on the endosperm. Rilett also stated that first-instar larvae of this species are unable to attack whole wheat kernels that have no breaks in the bran layer. He pointed out, however, that up to 50% of wheat kernels contain small breaks in the seed coats, allowing this species to exist as a primary pest. Of the various whole grains tested by Rilett, rye was the most susceptible to attack, followed by wheat, corn, and rice, respectively. Barley, oats, sunflower, flax, and soybeans were not damaged. The species, however, could exist as a secondary pest of these grains if other stored-product pests were present (Rilett 1949*b*). Sinha (1972, 1976) found that in the laboratory, *C. ferrugineus* failed to develop and reproduce on oilseeds (flax, canola, and sunflower) and clover seed cultivars but thrived on two cultivars of millet under the same conditions. These findings imply that the rusty grain beetle is not likely to threaten the storage of oilseeds in western Canada (Sinha 1972). MacNay (1955) considered the species to be a minor food-infesting insect. In CAIPR (1974) it was reported to be a household pest that infests dried beans in Newfoundland.

Biology: The life history of *C. ferrugineus* was studied by Rilett (1949*b*) at 32°C and 75% RH. The description given here is based on Rilett's work unless otherwise specified.

Eggs were laid in small crevices, furrows, fractures, or holes in or between kernels or among debris. Females laid an average of two or three eggs per day. However, at 30°C and 70% RH, Smith (1962*b*) observed oviposition rates of 7.5 eggs per day per female in flour and 5.6 eggs per day per female in wheat kernels for the first 30 days of adult life. Bishop (1959) found that egg production increased with increased temperature and relative humidity. The egg period lasted 3–4 days at 32°C. At 43°C, eggs either failed to hatch or the larvae died immediately after eclosion (Smith 1962*b*).

Upon hatching, the newly emerged larvae sought suitable food. The larvae showed a marked preference for the germ of the kernel. If this food supply was adequate, the developing larvae remained within the excavation in the kernel, which became larger as the germ was consumed. The frass was removed from the excavation through the entrance hole. If the food supply became depleted, the larvae left their burrows and wandered to other kernels in search of more food. Smith (1972) found that the majority of wandering larvae were first or final instars. The species underwent four larval molts. The first larval instar lasted 3–4 days; the majority of second and third instars lasted 2 days (range, 2–5); and the fourth instar, the last 2 days of which were spent as inactive prepupae, lasted 5–8 days. At 65, 75, and 90% RH, the rate of larval development was inversely proportional to humidity. At 50% RH or less, mortality of first-instar larvae was high.

Although some larvae pupated in spaces between kernels, pupation usually took place in the excavation within the kernel. Before entering the quiescent prepupal stage, the entrance to the excavation was sealed with excrement and debris cemented together with silk threads. The larvae anchored themselves to the burrows by anal secretions, with the anterior portions supported with silken threads. The pupal period lasted about 4 days.

The mean development period from hatching of the egg to adult emergence varied from 64 to 20 days at temperatures ranging from 21 to 38°C and 75% RH (Smith 1962*b*). Mating took place 1–2 days after adult emergence, and oviposition started shortly thereafter. Smith (1963) found that the length of the preoviposition, oviposition, and postoviposition periods was affected by temperature – the periods were longer at the lower temperatures. Adults lived an average of 6–9 months, with a few individuals living as long as 1 year. *Cryptolestes ferrugineus* requires high temperature and is tolerant of low relative humidity. According to Howe (1965), 23°C and 10% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 32–35°C, and the maximum rate of increase every 4 weeks is 60-fold.

Although relatively inactive at temperatures of less than 21°C, adults are capable of flight at high temperatures. The adults crawl freely among grain kernels and are usually found near the floor in filled granaries (Smith 1970*b*); they tend to concentrate in moist grain and emigrate from dry grain (Watters 1969). This trait has survival value, since this species can feed, oviposit, and develop more readily in damp grain than in dry grain (Watters 1969). Dolinski and Loschiavo (1973) found that aggregations of *C. ferrugineus* were stimulated by the presence of certain fungi in moist pockets of grain. Borden et al. (1979) showed that males of *C. ferrugineus* produce an aggregation pheromone. This pheromone, in conjunction with fungal odors, may allow the species to locate suitable habitats. Sinha (1965*a*) has shown that *C. ferrugineus* is capable of surviving and developing on a diet of fungi. Under storage conditions, fungi probably serve as supplementary or alternative foods.

Smith (1970*a*) found that adults and large larvae are more resistant to temperatures below freezing than are other life-history stages and that cold-acclimation enhances larval survival. He assumed that *C. ferrugineus* probably survives the winter in these stages in the Prairie Provinces, aided by its ability to acclimatize to low temperatures.

Cryptolestes ferrugineus is parasitized by the bethylid *Cephalonomia waterstoni* Gahan (Rilett 1949*a*).

Cryptolestes pusillus (Schönherr) (*minutus* Olivier)
flat grain beetle
cucujide plat (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: *Cryptolestes pusillus* is a stored-product pest of world-wide distribution and importance (Currie 1967). According to Howe and Lefkovitch (1957), the species is more abundant in wet tropical and warm temperate regions. The species is a common insect pest of stored grains but is apparently unable to survive in sound uninjured grain, preferring grain and meal that are in poor condition or following the attack of more vigorous grain pests (Cotton 1956). The species has been reported in wheat that has started to deteriorate in Alberta (CIPR 1944). It has also been recorded in warehouses, grain elevators, and farm-stored grain in Canada (MacNay 1950–1952). In wheat the larvae feed primarily on the germ (Cotton 1956). However, Ashby (1961) observed this species under laboratory conditions feeding on the endosperm rather than the germ. According to Currie (1967), *C. pusillus* attacks the following products: dried bananas, beans, bulbs, cacao, cassava, cereal products, citrus pulp, overripe coffee berries, copra, cottonseed, cowpeas, gum dammar, maize, malt barley, filberts, nutmeg, palm kernels, peaches, rice, sago, sorghum, soybeans, sunflower seedcakes, and wheat. In Canada, the species has been described as a principal pest in flour mills (MacNay 1949, 1952, 1954*b*, 1955; CIPR 1950; Arrand and Neilson 1958). However, Currie (1967) stated that unlike *C. turcicus*, with which it is often confused, *C. pusillus* is comparatively rare in the machinery of flour mills.

Biology: Davies (1949) described the life history of *C. pusillus* (as *Laemophloeus minutus*). His work is referred to here, unless otherwise specified. At 25°C and 75% RH, the majority of females started laying eggs within 4 days of emergence, and almost all females were laying within 12 days. Eggs were laid singly in the flour or foodstuff debris, usually at the rate of a few eggs daily over a long period. The constant presence of males resulted in a considerably higher rate of egg production. Variations in the relative humidity from 55 to 90% had little effect on the oviposition rate. However, temperatures of 30 and 17°C stimulated and inhibited egg production, respectively. The greatest egg-laying rates observed by Ashby (1961) were 121 eggs in 10 days and 42 eggs in 2 days. The minimum mean egg period observed by Davies was 3.9 days at 35°C and 75% RH, although egg mortality was high at this temperature.

There are four larval instars in *C. pusillus*, although Ashby (1961) recorded some instances of three and five larval instars. After a period of active feeding, the last instar forms a cocoon fabricated from food fragments and secreted silk . In grain, Ashby (1961) reported that pupation usually occurs in the hollowed-out cavity of the kernel. The prepupa remains quiescent for a while in the cocoon before transforming to the pupa. At 30°C and 90% RH, the mean duration of the first, second, third, and fourth instars and the prepupal and pupal stages was 4.0, 3.4, 3.6, 3.1, 3.2, and 5.0 days, respectively. According to Currie (1967), development is fastest at 32.5 and 35°C, 90% RH, and becomes more prolonged as each of these conditions decreases. The same author stated that complete development takes place at temperatures between 17.5 and 37.5°C at 50% RH or above. *Cryptolestes pusillus* requires high temperature and RH. According to Howe (1965), 22°C and 60% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 28–33°C, and the maximum rate of increase every 4 weeks is 10-fold. Of the three species of *Cryptolestes* – *C. turcicus*, *C. ferrugineus*, and *C. pusillus* – the last is the least cold hardy (Currie 1967).

Currie (1967) summarized the literature on the parasites and predators of *C. pusillus*. Parasites attacking this species include *Plastonoxus westwoodi* Kieffer, *P. chittendenii* Ashmead, *Cephalonomia waterstoni* Gahan (Hymenoptera), *Mattesia dispara* Naville (Sporozoa), and *Acarophenax* sp. (Acari).

Cryptolestes turcicus (Grouvelle) (*truncatus* Casey)
(flour mill beetle)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Origin: According to Hatch (1962), *C. turcicus* is an introduced species. Specimens from North America were collected as early as 1882 (Lefkovitch 1962*b*).

Economic injury: *Cryptolestes turcicus* is commonly found in the machinery of flour and animal feed mills (Lefkovitch 1962*b*). The damage caused by this small species is difficult to assess, but the worst injury may merely be damage to the miller's reputation. Cotton and Good (1937) reported this species from waste grain, cacao, spices, dried fruit, and copra, and Howe and Lefkovitch (1957) found the species in buffer depots, warehouses, malthouses, and mills other than flour mills. In a flour mill survey in Canada's Prairie Provinces, MacNay (1957*b*) reported the species as infrequent. Smith (1962*a*) recorded *C. turcicus* from a dust-collector bin of a grain elevator in Manitoba. He suggested that the species has the potential of becoming a pest of stored grain, although this has not yet happened. Bishop (1959) stated that the rarity of North American records of *C. turcicus*, even though it is probably more common than *C. pusillus* (as *C. minutus*) in northern grain-growing areas, is probably due to its being confused with that species and *C. ferrugineus*.

Biology: Complete development of *C. turcicus* occurs at temperatures between 17 and 37°C and RH above 40%, but its optimum conditions for increase are 28°C and 90% RH (Lefkovitch 1962*b*). Tests on the susceptibility of *C. turcicus*, *C. ferrugineus*, and *C. pusillus* to cold suggested that *C. turcicus* is the most tolerant (Bishop 1959).

According to Bishop (1959), oviposition starts 1–2 days after mating, egg production being increased by the constant presence of the male. Eggs are normally laid singly or in groups of 10 or more in cracks and crevices in the food material. At 90% RH, egg production is approximately three times as great at 21 than at 32°C. Egg production also increases with higher relative humidity, the greatest increase occurring between 70 and 90% RH. At conditions near the optimum suggested by Lefkovitch (1962*b*), the egg period lasted 4 days.

There are four larval instars (Lefkovitch 1962*b*). The same author stated that the fourth larval instar secretes a tough, silken cocoon in which it pupates; the percentage of larvae that form pupal cocoons is affected by temperature and humidity. When whole grain is the food, pupation usually occurs in a hollowed-out cavity within the kernel (Bishop 1959). At the optimum conditions, a mean development time of 37.8 days is required from egg to adult of which 31.1 days are spent as a larva. Adult longevity was much greater at 21°C than at 32°C, and an increase in humidity also increased the life span (Bishop 1959).

Cryptolestes turcicus needs high temperature and relative humidity. According to Howe (1965) 21°C and 50% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 30–33°C, and the maximum rate of increase every 4 weeks is 50-fold.

In experiments on population increases of *C. turcicus* and *C. pusillus*, LeCato (1974) found that wheat was the most favorable diet and cracked food, which provided shelter and oviposition sites, was the most favorable form of diet. *Cryptolestes pusillus* was more competitive than *C. turcicus* on all diets except cracked soybean and wheat meal. Chang and Loschiavo (1971) stated that in Canada, *C. turcicus* thrives in the presence of molds associated with flour of high moisture content. They found that in prepared flour–fungi mixtures, the concentration of the fungi and larval development was inversely correlated, although larvae developed faster on naturally infested flour and prepared flour–fungi diets than on sterilized flour. This finding supports their view that fungus in the diet is beneficial to the species.

Comments: Sinha (1965*b*) listed *C. truncatus* Casey as a stored-product pest in Quebec. However, Lefkovitch (1962*a*) examined the holotype of *C. truncatus* and found it to be identical to the lectotype of *C. turcicus*. He therefore considered *C. truncatus* to be a junior synonym of *C. turcicus*.

Oryzaephilus mercator (Fauvel)
merchant grain beetle
cucujide des grains oléagineux (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, and Northwest Territories.

Origin: Loschiavo and Smith (1970) described *O. mercator* as being of tropical origin and reported the oldest known record of this species in Canada to be that of specimens from Alberta dated 1925.

Economic injury: According to Loschiavo and Smith (1970) and Loschiavo and Sabourin (1982), *O. mercator* has become firmly established as a household pest in Canada, though it has not been reported as a pest of stored grain in Canada as has *O. surinamensis*. Their survey revealed that with one exception, *O. mercator* is found exclusively in stored processed cereals. Foods infested included rolled oats, rice, flour, cake mixes, pasta, cookies, nuts, coconut, puffed rice, and candy bars made with peanuts. They also described frequent reports of this species in cargo ships where it infests copra, peanuts, and cashew nuts. In recent years, the species has been described as the most common pest of households in Alberta (Philip 1977), as the most prevalent household pest in Saskatchewan and as a frequently encountered domestic stored food pest in Prince Edward Island (CAIPR 1978). Howe (1956*a*) said that *O. surinamensis* is usually associated with starchy foods, whereas *O. mercator* is usually associated with oilseeds. Unheated granaries in western Canada probably are too cold for survival and reproduction of this species, but it remains a potential threat in feed mills, warehouses, and oil-processing mills, where oilseed hulls may be stored for prolonged periods in heated premises (Sinha 1972). In Manitoba, Sinha (1976) subsequently demonstrated that *O. mercator* successfully survived from June to October in canola and sunflower seeds stored in an unheated granary under conditions of fluctuating temperature and humidity. The temperature barely reached optimal range for development, and the species barely survived and reproduced. In a series of food preference tests using 18 household foods and oilseeds, Loschiavo (1976) found that adults of *O. mercator* were found most frequently in bran, shelled sunflower seeds, rolled oats, and brown rice. Few or no beetles were found in wheat germ flakes, cornflakes, whole canola, raisins, flour, brewer's yeast, pancake mix, shredded coconut, and crushed or pulverized canola.

Biology: The description of the life history and biology of *O. mercator* is based on the work of Howe (1956*a*), unless otherwise indicated. The preoviposition periods varied from 3 to 5 days at 33°C and 4 to 6 days at 30°C. The oviposition period lasted over 3 months, with each female laying an average of nearly 200 eggs. Curtis and Clark (1974) found that when reared on oats, egg production of *O. mercator* ranged from 80 to 338. The maximum rate of oviposition was approximately three eggs per day for 4 to 6 weeks, after which the rate declined gradually. Eggs hatched at temperatures of 17.5–40°C, but egg mortality was high below 20°C and above 37.5°C. Low humidity also increased egg mortality. Curtis and Clark (1974) found that the duration of the egg stage of *O. mercator* at 30°C and at an RH of 20 to 80% ranged from 4.1 to 4.5 days.

Typically, the species has four larval instars, with a few individuals having five. The optimum temperature range for larval development was 30–32.5°C. Reduction in relative humidity increased the length of the larval period. At temperatures outside the range of 25–32.5°C, a relative humidity of 10% resulted in total larval mortality. At 30°C and 70% RH, the mean larval developmental period was 15.4 days on wheat feed and 23.4 days on coconut meal. According to Pajni and Bedi (1973), larvae pupate without forming special chambers or cases. The length of the pupal period decreased with increased temperature. Humidity, however, had little effect on the duration of this stage. The pupal stage of this species was found to be consistently shorter than that of *O. surinamensis* (Curtis and Clark 1974). The adult life span of *O. mercator* at 30°C and at an RH of between 12 and 74% was 5–18 weeks, respectively (Arbogast 1976).

This species requires high temperatures and can tolerate low relative humidity. According to Howe (1965), 20°C and 10% RH constitute the minimum temperature and humidity at which this species can multiply in numbers sufficient to become a pest. The optimum temperature range is 31–34°C, and the maximum rate of increase every 4 weeks is 20-fold.

Oryzaephilus surinamensis is more cold hardy than this species. At 17.5°C, most individuals of *O. surinamensis* developed to the pupal stage but failed to produce adults. Curtis and Clark (1974) observed a faster development and a greater survival rate of *O. surinamensis* on diets of oats, raisins, and prunes when compared with this species. The opposite results, however, were found when almonds were the food supply.

Sinha (1965*a*) studied the development of *O. mercator* on 23 species of seedborne fungi and one species of actinomycete. He found that the species can complete development on 18 of these fungi, the minimum development period being 21 days on *Mucor sphaerosporus* Hagem.

Oryzaephilus surinamensis (Linnaeus)
sawtoothed grain beetle
cucujide dentelé des grains (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: *Oryzephilus surinamensis* is almost cosmopolitan in distribution and is an introduced species (Cotton 1956, Hatch 1962).

Economic injury: *Oryzephilus surinamensis* is a pest of stored grain and grain products and is often found in flour mills and warehouses (Cotton 1956). It is also extremely common as a pest of many kinds of foodstuffs, often attacking dried fruit and packaged foods (Monro 1969). In wheat, the larvae feed on the germ, and both the larvae and the adults may feed on grain dust (Watters 1967). According to Monro (1969), *O. surinamensis* is unable to attack sound, dry kernels but often appears in enormous numbers in grain stores after attack by other stored-product pests. The species is more common in stored oats than in stored wheat or barley and is capable of rapid population buildup in large bulks of grain or animal feeds stored in heated buildings (Watters 1976). In grain, this species is less common than *Cryptolestes ferrugineus* but is equally destructive (Sinha 1971). In CAIPR (1971), *O. surinamensis* is reported to flourish on broken and crusted seeds of flax and sunflower, even though Howe (1956*a*) considered *O. mercator* to be associated with oilseeds and *O. surinamensis* with starchy food. MacNay (1967*b*) described the sawtoothed grain beetle as the most common kitchen pest in Canada. He listed cereal, flour, meal, pasta, spaghetti, dried fruit and meat, chocolate, shelled nuts, spices, and pet foods as commodities infested by this species. Adults are able to invade packages that appear to be well sealed (Neilson and Arrand 1958). However, these reports by MacNay (1967*b*) and Neilson and Arrand (1958) are probably the result of misidentifications of *O. mercator* (S.R. Loschiavo, personal communication).

Biology: Howe (1956*a*) studied the biology of *O. surinamensis*. The summary given here is based on his work unless otherwise specified.

The minimum preoviposition periods observed were 3 and 4 days at 33 and 30°C and 70% RH, respectively. The usual duration of this period was 4–5 and 5–6 days, respectively. The oviposition period for *O. surinamensis* lasted over 2 months at the same temperatures, with the egg-laying rate reaching a maximum of 6–10 eggs per female per day. The rate was maintained for 3–4 weeks, after which it exhibited a rapid decline. Eggs are deposited loosely among the food material (Nigam et al. 1969). The average number of eggs laid by this species was 375, but this figure was reduced as the RH decreased from 80 to 20% (Curtis and Clark 1974). The same authors also found that *O. surinamensis* laid more eggs on rolled oats than on prunes, raisins, and almonds. Eggs hatched at temperatures of 17.5–40°C, the most rapid incubation occurring at 35°C and above. At 30°C and 20–80% RH, Curtis and Clark (1974) observed egg periods of 3.8–4.1 days. Nigam et al. (1969) found that a fluctuating temperature of 23–27°C accelerated the hatching of eggs when compared with a constant temperature of 25°C. At temperatures below 20°C and above 37.5°C, egg mortality was high. Low humidity also increased egg mortality.

The most rapid larval development was at 32.5°C and 90% RH. Development was quicker at a higher than at a lower level of humidity for all temperatures. At 40°C, *O. surinamensis* did not complete larval development, and mortality was high at 37.5°C. The mean period for larval development at 30°C and 70% RH was 12.5 days on wheat feed and 31.8 days on coconut meal. The species usually had four larval instars, with a few having three or five instars. With 30°C, 70% RH, and a wheat feed diet, the four instars averaged 3.0, 2.7, 2.9, and 4.3 days from first to last, respectively.

Pupation takes place in a cell constructed with food particles cemented together with a sticky secretion (McFadden 1966). The duration of the pupal stage was inversely proportional to temperature, with humidity having little effect on this stage. However, Curtis and Clark (1974) found that at 30°C, the pupal period was consistently longer at 20 and 50% RH than at 80% RH. At 17.5°C, pupae were transformed to adults but were unable to emerge from the pupal skin.

This species requires high temperature and is tolerant of a low RH. According to Howe (1965), 21°C and 10% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 31–34°C, and the maximum rate of increase every 4 weeks is 50-fold.

Nigam et al. (1969) found that adult females live longer than males; the longevity of the latter ranged from 3 to 307 days. High humidity increased the life span of both sexes. Arbogast (1976) found that the average adult life span of *O. surinamensis* was approximately 4–19 weeks at an RH of 12–74%, respectively.

Oryzaephilus surinamensis generally had a shorter life cycle and a greater survival rate than did *O. mercator* on oats, raisins, and prunes; the opposite was true on almonds (Curtis and Clark 1974). *Oryzaephilus mercator* is also less cold hardy than *O. surinamensis*.

LeCato (1975) reported predation by the red flour beetle, *Tribolium castaneum* (Herbst), on the eggs and immature stages of this species.

Comments: Before Howe's (1953) publication, which differentiated the species *O. surinamensis* and *O. mercator*, many of the records of *O. surinamensis* probably referred to *O. mercator*, but the records of the latter should be accurate (Howe 1956*a*).

CURCULIONIDAE weevils
charançons (m.)

The weevils, perhaps the most diverse family of insects, are nearly all phytophagous. The family is estimated to contain over 50 000 species, of which 1000 are estimated to occur in Canada. Larvae are often found feeding on the root system or the foliage, or boring in the plant. Most crops grown in Canada have one or more species of weevils that occasionally cause damage, but plants of the families Leguminosae and Rubiaceae are particularly subject to attack. Several species of weevils are among the most destructive pests of stored grain, whereas others are pests of trees and shrubs. In Canada the total economic loss caused by the species of this family exceeds that of any other family of beetles.

Acanthoscelidius acephalus (Say)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Prince Edward Island.

Economic injury: This species has been reported to cause considerable damage to primrose in Manitoba (CIPR 1937, 1938).

Agasphaerops nigra Horn
lily weevil

Distribution: British Columbia.

Economic injury: The economic injury of this species was described in detail by Doucette and Latta (1946). The lily weevil is a potentially serious pest in the Pacific Northwest. In 1935 *A. nigra* inflicted serious losses on *Lilium longiflorum* Thunb. in Coos County, Oreg. Wickham (1920) reported that the insect (as *Panscopus (Phymatinus) sulcirostris* Pierce) injured *Belamcanda chinensis* (L.) DC. at Quamichan Lake, Vancouver Island, B. C., in 1916. The insect also feeds on *Lilium occidentale* Purdy, *L. columbianum* Hanson ex Bak., *Fritillaria lanceolata* Pursh, and *Disporum oreganum* (S. Wats.) W. Mill.

Both larvae and adults feed on lilies. The adults chew shallow, crescent-shaped notches along the leaf margins, causing only slight damage; the larvae feed underground on the stems and in the bulbs and cause serious damage. The newly hatched larvae start feeding immediately, moving toward the stem, which they enter or follow downward to the bulb. Occasionally they feed in the leaf, forming mines. Some larvae appear to feed on the surface of the stems without attempting to burrow in, and they either reach the bulbs or die. Other larvae tunnel through the stem wall near the soil surface and then burrow up and down within the pithy interior. Such feeding frequently severs the stem and almost completely stops bulb growth. The larvae prefer stem tissue over bulb tissue, although smaller and younger plants may show more extensive injury to the bulbs possibly because the stems are not large enough to provide sufficient nourishment. Some larvae migrate downward to the bulb after feeding in the stem. The larvae may also attack stem bulblets, and a single larva may consume almost one bulblet.

Cultivated lily plantings near brushy areas of native host plants are particularly vulnerable to attack.

Biology: The life history of the lily weevil is described in Doucette and Latta (1946). The insect overwinters in both the adult and larval stages. In Oregon, adults emerge from the soil beginning in late March and early April. The adults feed voraciously during April, when their numbers increase rapidly. When disturbed, they drop to the ground and feign death. When not feeding they may be found in the debris on the soil surface near the stem. They do not enter the soil. The adults are most active in the early morning and late afternoon; they cannot fly and probably move long distances only by transport of their host. Egg-laying usually takes place throughout the month of May. The eggs are inserted singly or in groups of two or three under the epidermis of the lower leaves of the plants. One caged female oviposited a total of 479 eggs between 7 May and 18 July. In the laboratory at room temperature, the incubation period ranged from 15 to 28 days, with most of the eggs hatching in about 19–21 days after they were laid.

The larvae feed as previously described and reach maturity in September. At this time they leave the stems or bulbs to form cells in the soil at 25–38 cm below the surface. The larvae leave the bulbs earlier than they do the stems. Pupation takes place in these cells around July of the following year. Transformation to the adult stage occurs in late August or early September, the adults remaining in the larval cells until the following spring. The duration of the life cycle is 2 years.

Amotus lanei Van Dyke

Distribution: British Columbia

Economic injury: MacNay and Creelman (1958) reported this insect as a pest of peach in British Columbia.

Ampeloglypter ampelopsis (Riley) (= *ater* LeConte) (grape cane girdler)

Distribution: Ontario.

Economic injury: This species is a minor pest of grape (Davidson and Lyon 1979). In addition to wild and cultivated grapes, the beetle is also injurious to Virginia creeper (Jubb 1975). Adults become active in vineyards before blossoming, the egg-laying causing damage to the young shoots. The female makes a small hole 3 mm deep about 10–20 cm from the tip of the shoot for egg deposition and then, 2 mm further down, drills a row of shallow holes around the shoot forming the lower girdle. The upper girdle, which consists of a similar row of holes closer and deeper than those in the lower girdle, is then drilled 7.5 cm from the tip of the shoot. The shoot tip soon breaks off at this upper girdle. In heavy infestations, up to 50% of the shoots may be girdled, but damage does not normally reduce potential yields unless blossom buds are included in girdled sections. The larva burrows in the pith on either side of the egg between the two girdles, usually extending its tunnel to 7.5 cm by maturity. By mid July, the majority of girdled sections wither, dry, and fall to the ground. *Ampeloglypter ampelopsis* may become very numerous in small backyard plantings and in vineyard rows along wooded areas. Newly set vines may suffer significant injury, which may retard growth, decrease plant vigor, and make difficult normal training of the young vine. Damage to established vines, however, results in little loss of vigor. In Ontario, damage did not seem to be serious, as most girdled shoots recovered through the growth of secondary buds basal to the girdled area and many of the shoots were girdled beyond the fruit clusters (Stevenson 1966).

Biology: According to Jubb (1975), in Pennsylvania the adults hibernate under stones, trash, and leaves near the vineyard and start their attack on vines in late May and early June. Their emergence and appearance in the vineyard extend over a 3-week period. The females lay eggs for about a month, beginning soon after they first appear in the vineyard. A small hole is made in the shoot for egg deposition. The hole is then plugged with small pieces of shredded shoot collected near the opening of the hole. A lower girdle is formed, and the female then drills the upper girdle. The entire egg-laying process is completed in 3–4 h. The female usually lays only one egg per day and the maximum oviposition rate is 16 eggs. The incubation period averages about 12 days. The insect spends an average of 21 days in the larval stage. On 20 July, in Ontario, all specimens were in the larval stage (Stevenson 1966). Jubb (1975) stated that pupation occurs within tunnels in the girdled sections that drop to the ground. The pupal stage lasts for approximately 2 weeks. The new generation of adults emerges from the fallen shoot sections during the first half of August. In Ontario, the first pupae were observed on 28 July and adults on 11 August (Stevenson 1966). Transformation to adults was nearly complete by 3 September. According to Jubb (1975), the adults seek overwintering sites in September and only one generation per year occurs.

The larvae are parasitized by two species of parasitic wasps, and the eggs are preyed upon by a mite (Jubb 1975).

Comments: This species is known in most literature as *A. ater* LeConte. O'Brien and Wibmer (1982) reinstated the name *A. ampelopsis*, placing *A. ater* in synonymy.

Anametis granulata (Say)
(gray snout beetle)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: Caesar et al. (1930) reported that this species caused serious injury to young peach trees in May in Ontario, eating all the buds on several hundred trees. The adults also caused slight injury in a few apple orchards by eating the bark off the smaller branches and twigs. Fletcher (1894) noted, "They only attack the very first leaf-buds and the bark of the young trees when first set out; or when a young tree is budded and cut off near the ground, by eating the bud they destroy the tree." Fletcher (1894) reported that the insect killed 130 peach trees and ate four rows of strawberries that extended across a 2.4-ha field in Ontario.

Biology: The biology of this species is virtually unknown. According to Fletcher (1894), these beetles resemble the potato beetle in many of their habits. On warm sunny days, adults may be observed moving around and feeding; on cold, wet days, they hide in the earth at the root of the tree. When disturbed, they let themselves drop to the ground and feign death. Adults are wingless.

Anthonomus musculus Say
cranberry weevil
anthonome de l'atocas (m.)

Distribution: Ontario and Quebec.

Economic injury: CAIPR (1976) noted that the cranberry weevil clipped off strawberry blossoms in Ontario.

Anthonomus signatus Say
strawberry bud weevil
anthonome de la fleur du fraisier (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Economic injury: The strawberry bud weevil may cause serious injury to strawberry and raspberry (Paradis et al. 1979). In southwestern Quebec the insect damaged 39% of the strawberry buds in some plantations (Paradis et al. 1977). MacNay (1950) reported that the species is widely prevalent in Manitoba and that it occurs throughout eastern Canada, where it is especially injurious to neglected strawberry patches, damaging up to 60% of the buds. The weevil also attacks blackberry (Andison 1956); Gorham et al. (1931) cited one instance where 20% of the blackberry buds were destroyed on a farm in New Brunswick. *Anthonomus signatus* also occurs on wild strawberry, wild raspberry, wild blackberry, dewberry, brambles, redbud, rhododendron, rambler rose, cinquefoil, apple, milkweed, goldenrod, basswood, wild bergamot, mint, catnip and heal-all (Ross and Curran 1919, CIPR 1931, Twinn 1935, CAIPR 1975, Davidson and Lyon 1979).

Most damage is caused by the female, which cuts the stem just below the bud after oviposition, causing it to fall or to remain hanging by a thread (Chamberlain et al. 1964). This damage is completed by the time the plants blossom (as egg-laying only occurs in unopened buds), but because the berries sometimes blossom unevenly, the injury may occur over a considerable period (Brittain and Pickett 1933). The adults feed on the foliage, pollen, and petals of their host plants (Rivard et al. 1979). Their presence in the spring may be detected by the presence of small, round holes, which they chew in the petals when the first few strawberry blossoms open (Andison 1956). The larvae develop within the severed buds, feeding on pollen and the other interior parts of the bud (Ross and Curran 1919).

As opposed to staminate varieties of strawberries, pistillate varieties are relatively immune to attack (Davidson and Lyon 1979). Brittain and Pickett (1933) reported that old plantations usually suffer more damage because they usually bloom first. The side of a new plantation that is nearest to an older site usually suffers the most damage. Plantations are also affected by their proximity to wood, shrubs, grassy headlands, and fence rows.

Biology: The strawberry bud weevil overwinters in the adult stage under fallen leaves and debris (Chamberlain and Putnam 1964). The overwintered adults become active in the spring, when the first strawberry blossoms open (Andison 1956). In Quebec the adults were active on strawberries from the middle of May to the end of June, with a peak on 31 May (Rivard et al. 1979). Adults were abundant on raspberry during the second half of May, after which their numbers gradually declined. The female chews a small hole through the bud, inserting her snout to the base; she then inserts the ovipositor in the hole and lays an egg, usually among the stamens (Ross and Curran 1919). Although she occasionally makes two holes, only one egg is deposited in each bud and the stem is then girdled. In Ontario, oviposition occurred first on strawberry and later on blackberry and raspberry from 11 May to 26 June. Most of the adults had died by the time raspberry buds appeared. In experiments the incubation period averaged 6 days (range, 4–8).

Within the severed buds, the larvae feed first on the pollen and then on the interior of the bud (Ross and Curran 1919). Eventually an enclosed cell is formed in the receptacle; the larvae then seal the entrance with closely packed excreta. Most of the larvae die when the buds persist on the plants or dry out on the soil. The duration of the larval stage averaged 13 days (range, 11–16) and that of the pupal stage, 10 days (range, 6–18). In Nova Scotia, Brittain and Pickett (1933) reported an egg stage of 6–10 days, a larval stage of about 28 days, and a pupal stage of about 14 days. Ross and Curran (1919) observed the new generation of adults emerging from the buds from about 20 June throughout the greater part of July. The adults feed for a period and then apparently go into hibernation in midsummer. Brittain and Pickett (1933) noted that in Nova Scotia, the new generation appears in July and remains active for about 2 months, feeding on the foliage of strawberry, blackberry, or raspberry before going into hibernation. Only one generation is produced annually (Davidson and Lyon 1979).

Apion longirostre Olivier
hollyhock weevil

Distribution: British Columbia, Ontario, and Quebec.

Origin: This Palaearctic species, native to southern and southeastern Europe and Asia Minor, was first recorded in North America from Georgia in 1914 (Brown 1967, Lazorko 1973, Risch 1977). According to Sheppard (1955), the insect has been present in the Niagara Peninsula area since 1950, having spread by natural dispersal from the south or southwest. MacNay (1952) stated that the first Canadian record of this species was made near Chatham, Ont., in 1952, when it was found in considerable numbers on hollyhock, and by 1955 it was common in the Niagara Peninsula (MacNay 1955). In 1972 *A. longirostre* was detected for the first time in British Columbia at Osoyoos (Lazorko 1973).

Economic injury: According to Risch (1977), *A. longirostre* attacks the seeds of hollyhock, often destroying from 10 to 60% of the seeds in any given stalk. Hollyhock as well as other species of Malvaceae are attacked by this species (Hatch 1971).

Damage results from the feeding of larvae, which complete their development and become adults within the seeds (Risch 1977). Individual hollyhock plants are attacked less when growing in relative isolation within a garden plot than when growing in clumps. Tuttle (1954) reported that both males and females chew through the calyx of the unopened buds of hollyhock and feed on the petals and other parts. In British Columbia, Lazorko (1973) observed the females burrowing in the buds and both sexes making small holes in the leaves.

Biology: The insect apparently overwinters in the adult stage (Tuttle 1954). Mating occurs in early and middle summer, and the females lay their eggs in unopened flower buds (Risch 1977). The larvae burrow into the developing ovules, eat the seeds, cut circular grooves in the seed coat, and pupate (Tuttle 1954, Risch 1977). Tuttle (1954) found only one larva per seed and reported that the larvae complete their development in 4–6 weeks. The adults emerge in late summer or fall by pushing a hole through the seed in the area of the groove (Risch 1977). Only one adult emerges per seed.

Auletobius congruus (Walker)

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: Twinn (1940) first reported the species to damage strawberry patches at Salmon Arm, B.C. *Auletobius congruus* destroyed 35% of the blossoms on 0.20 ha of a farm, with damage on about 1.6 ha.

Barynotus obscurus (Fabricius)

Distribution: British Columbia, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: The first North American records of this common European species were made at Montmorency, Que., in 1937, and at Cobble Hill, B.C., in 1954 (Hatch 1971).

Economic injury: The insect attacked a few rows of young tobacco plants in Prince Edward Island (CAIPR 1970) and injured strawberry in Nova Scotia (MacNay 1957*b*). It has also been reported to damage the crown and leaf stem of small fruits in Nova Scotia (CIPR 1958).

Barypeithes pellucidus (Boheman)

Distribution: British Columbia, Ontario, Quebec, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This European insect was first detected in North America on Staten Island, N.Y., in 1886 (Hatch 1971). It was first found in the Pacific Northwest in Seattle, Wash., in 1931, and later in Victoria, B.C., in 1936.

Economic injury: *Barypeithes pellucidus* was first reported in Canada at Oak Bay, B.C., attacking the fruit and leaf buds of raspberry (MacNay 1951). This known pest of strawberry in Europe (Hatch 1971) was also reported on strawberry at Gormley, Ont. (MacNay 1950).

Biology: According to Hoffmann (1950), the larvae of *Barypithes pellucidus* feed on the roots of *Medicago lupulina* L. The insect pupates in the soil in a small cell. Adults emerge in June and feed nocturnally on the leaves of alfalfa and clover. They are sometimes found on small shrubs and trees. Oviposition was not observed but probably occurs in the spring. Only one generation per year occurs.

Cercopeus artemisiae (Pierce)
(lesser sagebrush weevil, bud weevil)
petit charançon de l'armoise (m.)

Distribution: British Columbia.

Economic injury: MacNay and Creelman (1958) reported *C. artemisiae* to be a pest of apple and peach in British Columbia. The species (as *Cryptolepidus parvulus* Van Dyke), together with *Omias saccatus* LeConte, severely injured seedling apricots, peaches, and cherries at Summerland by destroying the vegetative buds and frequently killing the trees (MacNay 1949). Brittain (1912) reported isolated cases of serious injury to young apple trees in the Okanagan Valley caused by the insect, which bores into buds and tender foliage. Ruhman (1915) noted that the species fed on buds and opening leaves of apple trees at Penticton.

Ceutorhynchus americanus Buchanan
(blue turnip weevil)
charançon bleu du navet (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia.

Economic injury: CIPR (1949) reported heavy infestations on turnip and radish in Manitoba. Adult feeding damage to the leaves is similar to that of flea beetles. The larvae make conspicuous channels on the outside of the roots.

Ceutorhynchus assimilis (Paykull)
cabbage seedpod weevil
charançon de la graine du chou (m.)

Distribution: British Columbia.

Origin: The cabbage seedpod weevil, an indigenous pest of cruciferous seed crops in Europe, was first recorded in North America in Vancouver, B.C., in May 1931 (McLeod 1953).

Economic injury: Although formerly a serious pest of cruciferous seed crops, the cabbage seedpod weevil is now of minor importance in southwestern British Columbia (Beirne 1971). The species feeds on wild and cultivated crucifers of the genera *Brassica* and *Raphanus* (Neilson 1954). These include Indian mustard, bird rape, wild radish, cabbage, cauliflower, turnip, radish, Brussels sprouts, and kohlrabi. The insect has also been reported as a pest of canola (Williams and Free 1978) and broccoli (Baker 1936) in Great Britain. The wild hosts serve to maintain weevil populations when suitable commercial hosts are unavailable (Neilson 1954). Heavy rains followed by high temperatures in March or early April induce a general emergence and increase the damage (Bonnemaison 1965). Neither the overwintered adults nor the larvae favor humid climates, but the larvae often die when they fall on extremely dry soil.

Both adults and larvae cause damage, but the main injury is caused by the larvae feeding on the flowers and burrowing into the seedpods (Beirne 1971). Each larva may damage from one to six seeds averaging about three seeds per larva (Neilson 1954).

The overwintered adults feed on nectar and bore into unopened pods (Neilson 1954). The females puncture the walls of the pod for egg-laying. These punctures also encourage the oviposition of the gall midge, *Dasineura brassicae* (Winnertz) (Bonnemaison 1965). The new generation of weevils feeds primarily on late succulent pods, stems, and foliage (Neilson 1954) and may cause some injury to immature pods.

Biology: The insect overwinters in the adult stage in the soil or under debris (Neilson 1954). It becomes active as soon as the air temperature approaches 15°C and the overwintering site becomes sufficiently humid (Bonnemaison 1965). Temperatures must reach 17–20°C before the weevils are capable of extensive flight. Around this time, the turnips are in bloom and the overwintered generation feeds on pollen for about 3–4 weeks (Neilson 1954). The females puncture the developing seedpods and deposit their eggs singly, adjacent to the seed embryos. The eggs hatch in a few days, and the larvae feed on the seed embryos for 2–3 weeks. According to Bonnemaison (1965), larval mortality varies from 2% in radish to nearly 100% in kohlrabi as a result of the degree of parasitization on the various host plants and the structure of the pods. When mature, the larvae cut a circular hole in the pod and either drop or crawl to the ground (Neilson 1954). They form an earthen cell about 2–5 cm in the soil and pupate. The pupal stage requires about 4 weeks in British Columbia (Neilson 1954) and about 10 days in Germany (Baker 1936). The new generation of adults begins to emerge around the end of July (Neilson 1954). These adults feed and then go into hibernation if a second generation is not produced. Williams and Free (1978) reported that in Great Britain, the new generation of adults does not mate, indicating the presence of only one annual generation.

Parasites of *C. assimilis* include the following Hymenoptera: *Bracon* sp. (Braconidae), *Eupelmella vesicularis* (Retzius) (Eupelmidae), *Eurytoma* sp. (Eurytomidae), *Necremnus duplicatus* Gahan (Eulophidae), *Tetrastichus* sp. (Eulophidae), *Asaphes californicus* Girault (Pteromalidae), *Habrocytus* sp. (Pteromalidae), *Trichomalus fasciatus* (Thomson) (Pteromalidae), *Zatropis* sp. (Pteromalidae), and *Megaspilus* sp. (Ceraphronidae) (Graham 1965). McLeod (1953) reported that *T. fasciatus* and *Xenocrepis pura* are the two most important parasites of this species in North America.

Ceutorhynchus erysimi (Fabricius)

Distribution: Ontario, Quebec, and Nova Scotia.

Origin: This introduced species was first detected in Canada in 1933 (Beirne 1971).

Economic injury: MacNay (1951) reported that this species caused severe damage to radish at Jordan Station in the Niagara Peninsula, Ont. It has also been found on turnip seedlings at Uxbridge and Jordan Station, Ont. (CIPR 1952).

Biology: According to Hoffmann (1954), the larvae feed on the roots of *Capsella Bursa-pastoris* L. without causing any apparent swelling. Pupation occurs in cells in the soil. In Germany, the species has been found mining the leaves of *Cheiranthus* and *Matthiola*. Adults are commonly found feeding on *Alliaria officinalis* Andrz., *Sinapis nigra* L., *S. alba* L., *Nasturtium officinale* R. Br., *Brassica cheiranthos* Vill., *Lepidium ruderale* L., and *L. latifolium* L. Adults are active from April through June.

Ceutorhynchus punctiger Gyllenhal

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, Newfoundland, and Yukon Territory.

Economic injury: *Ceutorhynchus punctiger* has been reported to damage head lettuce in the Guelph area of Ontario (CIPR 1954). It has been reported to be common in the Ottawa district, and in 1944, it was reported to attack at least 30% of the Russian dandelion at Winnipeg, Man. The insect has also been reared from common dandelion at Winnipeg. The species is often found in the United States and Europe.

Biology: According to Hoffmann (1954), larvae of this species feed on the receptacle of *Taraxacum officinale* Weber. Oviposition occurs in April on the flowers. The eggs hatch in 24–48 h, and the larvae mature in 15–20 days. Pupation takes place in small, earthern cells and often requires 46–48 days. Adults appear from the end of May to early July, depending on atmospheric conditions. Hibernation occurs in the adult stage.

Larvae of *Ceutorrhynchus punctiger* are parasitized in Europe by the braconid *Bracon maculiger* Wasmann.

Ceutorhynchus rapae Gyllenhal
cabbage curculio
charançon du chou (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario.

Origin: According to Bonnemaison (1965), *C. rapae* occurs in Europe and the USSR and was first found in Canada and the United States around 1855. Hatch (1971) reported that this species was first recorded in North America in New England, about 1855.

Economic injury: This insect is a pest of cabbage, turnip, horseradish, cauliflower, and other crucifers (Hatch 1971). Cabbage appears to be attacked primarily when other palatable crucifers are unavailable (United States Department of Agriculture 1900). The cabbage curculio prefers hedge mustard and pepper-grass as well as turnip, horseradish, and cauliflower. The adults gouge out leaves and stems, and the larvae hollow out the stems (Metcalf et al. 1951). A single stem and its branches may contain 60 or more larvae (United States Department of Agriculture 1900). Larvae are most numerous in the upper portion of stems, often feeding as high as the diameter of the stem will allow. The larvae also tunnel in the branches and, occasionally, into the leafstalks. These leafstalks are often killed, and the tunneled stems frequently break above the middle or fall over. Many hedge mustard plants are so completely tunneled in the upper parts of the stems that the plant bends over at the point of fracture, preventing development of the seeds. Adults of the new generation are often found chewing along the edges of the leaves of cauliflower and cabbage. Cabbage rot may be disseminated by this insect.

Biology: In the District of Columbia, the overwintered beetles first appear in April and begin oviposition, preferring wild plants such as hedge mustard (United States Department of Agriculture 1900). After copulation, the female punctures the stem of the host plant while it is still young and inserts her eggs in the holes. Bonnemaison (1965) reported that the adults appear about 1 month after those of the cabbage seedstalk curculio (*C. quadridens* Panzer) and that the eggs are laid under the terminal buds of the plant. Oviposition probably begins about the middle of April and continues for at least a month (United States Department of Agriculture 1900). When alarmed, the adults quickly drop from their food plants. The parent beetles nearly all disappear by the end of May. The eggs hatch in approximately 5–8 days, and the larvae begin feeding within the stems and larger leafstalks, completing their growth in about 3 weeks. They then cut their way out, usually near where the leafstalks join the stem, and enter the soil. Small, round, earthen cocoons are formed by the larvae just below the surface, where they remain for about 2 weeks before entering the pupal stage, which lasts 5–8 days. The adults had abandoned their wild hosts by the middle of June but could still be observed on cauliflower and cabbage on 21 June. The new generation apparently does not oviposit before winter, and only one generation each year occurs.

Larvae are parasitized by the chalcid *Omphale livida* Ashmead. (United States Department of Agriculture 1900).

Cleonis kirbyi (Casey)
(wallflower billbug)

Distribution: British Columbia.

Economic injury: This species attacked western wallflower roots on a seed farm on Vancouver Island, B.C. (Hatch 1971).

Cleonis piger (Scopoli)

Distribution: Ontario, Quebec, and New Brunswick.

Origin: This European species was first recorded in North America in New York State in 1929 and first appeared in the Ottawa region in the early 1940s (CIPR 1962, 1964).

Economic injury: Adults were reported to be numerous in harvested oats in Ontario and were also found in bags of field beans in Quebec (CIPR 1964). This species also feeds on Canada thistle (CIPR 1926). In Europe, it attacks beet (CIPR 1960). The larvae feed on the roots of thistle (CIPR 1964).

Biology: According to Hoffman (1950), larvae of *Cleonus piger* feed at the base of the stem of many composite plants and galls. Larvae also attack *Cirsium arvense* (L.) Scop., *C. oleracum* Scop., *Carduus nutans* L., *Silybum marianum* (L.), *Onopordum acanthium* L., *Cirsium lanceolatum* Scop., and *Arctium minus* (Hill) Bernh. Adults are found from April to September.

Coccotorus hirsutus Bruner

Distribution: Manitoba.

Economic injury: MacNay (1947) reported that *A. hirsutus* (as *Anthonomus*) fed on sand cherry in Manitoba.

Coccotorus scutellaris (LeConte)
plum gouger

Distribution: Manitoba.

Economic injury: The plum gouger is a pest of cherry and sand cherry in Manitoba (CIPR 1942, MacNay and Creelman 1958).

Biology: *Triaspis canadensis* (Provancher) (Hymenoptera: Braconidae) and *Sigalphus canadensis* are parasites of the plum gouger (Graham 1965, Gillette 1890).

Comments: According to CIPR (1954), *C. scutellaris* is part of a species complex, and the plum gouger of eastern Ontario is a different species that limits its attack to sand cherry. Brown (1966) records the plum gouger of eastern Ontario as *C. pumilae.*

Conotrachelus nenuphar (Herbst)
plum curculio
charançon de la prune (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: The plum curculio is a major pest of all stone fruits (Dustan and Davidson 1973). According to Caesar (1930), the species is usually most harmful to apricot, plum, and sweet cherry, but it frequently seriously damages apple, pear, and peach. In some instances, almost every fruit on plum and cherry trees is destroyed. The plum curculio has destroyed over 50% of the Pembina plum crop at Morden, Man., and in 1950 it was rated as the most serious pest of apple in Quebec (MacNay 1950). It is also known to attack various species of quince, gooseberry, various species of hawthorn, nectarine, haw, and the fruits of such ornamental trees and shrubs as Manchu cherry and crab apple (Petch 1927, Caesar 1930, MacNay 1948, Armstrong 1958, Goble 1963, CAIPR 1975, Calkins et al. 1976). The insect is most destructive to uncultivated and neglected orchards and to orchards near woods, thickets, long grass, weedy areas, or other debris that provide suitable hibernating quarters (Petch 1927, Caesar 1930, Dustan and Davidson 1973).

Both the adults and larvae damage the fruit. The overwintered adults begin feeding on the new shoots, blossom buds, and tender twigs, stems, and tissues of the leaves; this injury, however, is usually considered of little importance (Petch 1927, Armstrong 1958). Subsequently, the adults attack the fruit soon after it is formed, causing it to become dwarfed, knotty, and often misshapen (Petch 1927, Caesar 1930). The damage is caused principally by punctures made for oviposition, but feeding punctures are made as well (Petch 1927, Armstrong 1958), consisting of holes through the skin that permit feeding on the pulp (Dustan and Davidson 1973). Oviposition punctures consist of a round hole chewed in the skin of the young fruit in which the female deposits an egg and then makes a characteristic, crescent-shaped wound in the skin below it (Goble 1963). Malformed fruits occur when growth is retarded or stopped in the tissues immediately surrounding the injury while the rest of the fruit grows at the normal rate (Petch 1927). A single fruit may have several oviposition punctures. The injury is more evident on fast-growing summer or fall varieties, whereas the slower growing later varieties may outgrow the injury. Adults of the new generation feed on the ripening fruit, making holes of various sizes in the skin and eating the pulp surrounding the puncture, boring as deep into the fruit as the snout will go (Petch 1927, Caesar 1930, Dustan and Davidson 1973). Armstrong (1958) noted that plums attacked by adults in late summer may ripen and drop prematurely. Fruit injured by the summer generation of adults is subject to diseases, especially brown rot (Petch 1927, Caesar 1930).

The larvae develop in the fruit, feeding on the flesh usually next to the pit (Dustan and Davidson 1973). Infested plums, apricots, peaches, and apples usually drop before the larvae mature, especially when attacked early in the season (Armstrong 1958). Cherries, however, remain on the tree until ripe or overripe (Dustan and Davidson 1973). Metcalf et al. (1951) reported serious losses in peaches, plums, and cherries caused by larvae that feed in the fruit and by their presence in ripened marketed fruits. More than one larva per fruit is often present; 13 apricots collected at random on the ground contained an average of 6 larvae per fruit, with a maximum of 13 (Armstrong 1958).

Biology: The plum curculio overwinters in the adult stage under debris or just under the surface of the soil, in and around orchards (Dustan and Davidson 1973). In Ontario, emergence takes place from late April to early July, but 90% of the weevils become active by early June (Armstrong 1958). After feeding, the adults mate one or more times during a female's oviposition period. Egg-laying starts in late May or early June, soon after the fruit has set, and continues at a high rate for about 3 weeks, declining considerably around the beginning of July and ending in early August (Caesar 1930, Armstrong 1958). During this time, several fruits may be visited and several eggs deposited in a single fruit (Brittain and Pickett 1933). The female may lay 100–300 eggs (Brittain and Pickett 1933), averaging about 150 (Petch 1927). Armstrong (1958) reported that the number of viable eggs deposited by a single female averaged 75 (range, 32–188) and that the maximum oviposition over 48 h was 25 eggs. Under optimum conditions, adults may survive up to 17 months. Many feeding punctures are also made during this period. The incubation period averaged 5.5 days (range, 4–7) at mean daily temperatures varying from 19.3–23.3°C. In an incubator at a constant temperature of 27.8°C, the eggs hatched in slightly less than 3 days.

The larvae pass through four instars (Armstrong 1958). In the insectory at temperatures comparable to those of orchards, the combined egg and larval period averaged about 20 days (range, 13–49), with the majority ranging from 17 to 22 days. For an incubation period of 5 days, the larval period is then about 15 days. In apples, the larva must reach the core before the growing tissue destroys it (Petch 1927, Armstrong 1958). According to Levine and Hall (1977), the larvae do not generally complete their development in fruit that does not fall prematurely; Davidson and Lyon (1979) confirmed this for apples. The average larval feeding period in plums after they dropped was 11 days (range, 1–31) and in peaches 10 days (range, 1–35) (Armstrong 1958).

Pupation takes place in earthen cells at a depth of 1–5 cm, and from 32 to 45 days are required for mature larvae to develop to the adult and emerge from the soil (Armstrong 1958, Dustan and Davidson 1973). According to Brittain and Pickett (1933), mature larvae remain in their cells for about 2 weeks before pupating. The pupal stage requires about 2 weeks, and the newly formed adult stays in the soil for a few days longer to allow the cuticle to harden. Soil moisture is required for both larval survival and adult emergence (Armstrong 1958). The new generation emerges from late July to late October or early November (Dustan and Davidson 1973). Armstrong (1958) reported adult emergence from 12 July to 16 November. The adults feed for a short time and then seek overwintering sites at the approach of winter (Armstrong 1958, Dustan and Davidson 1973). Only one generation a year occurs in Ontario.

The braconids (Hymenoptera) *Triaspis curculionis* (Fitch) and *T. curculionis* var. *rufus* (Riley) and the ichneumonid *Tersilochus conotracheli* (Riley) are parasites of larvae of the plum curculio (Armstrong 1958, Graham 1965). Other parasites include the braconid *Triaspis kurtogaster* Martin and the tachinids (Diptera) *Myophasia* sp. prob. *aenea* Wiedemann and *Cholomyia inaequipes* Bigot. Davidson and Lyon (1979) reported that *Patasson conotracheli* (Girault) is a parasite of eggs and that the fungus *Isaria anisopliae* Metsch. attacks both the adults and larvae.

Cryptorhynchus lapathi (Linnaeus)
poplar-and-willow borer
charançon du saule (m.)

Distribution: British Columbia, Alberta, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Origin: This Eurasian species was first recorded in North America in 1882, in Williamsbridge, New York City (Gautreau 1963). *Cryptorhynchus lapathi* was first discovered in Canada in High Park, Toronto, in 1906. First records for British Columbia and Alberta were made at Kelowna in 1924 (Neilson and Arrand 1961) and at Ptolemy Creek in 1961 (Gautreau 1963), respectively. Kusch (1962) stated that the species may have been established in Alberta for at least 2 years before its discovery.

Economic injury: Swaine and Hutchings (1926) reported the insect to cause heavy damage to poplar and willow, especially to nursery stock, fields of basket willow, and ornamental trees. According to Boisvert (1926), all species of willow, poplar, and alder are attacked in Canada and the United States, but Gautreau (1963) stated that of the many species of willow in Alberta, only sandbar willow and blueberry willow are known hosts. The average mortality of willow in the most heavily infested areas of southern Alberta has been estimated at about 40%. Birch (CIPR 1960) and aspen (CAIPR 1973) are also attacked.

Both adults and larvae feed on the trees, but the main injury is caused by the larvae, which feed chiefly on the bark and cambium of its host (Boisvert 1926). The adults feed on young shoots and then cut oviposition holes in the corky part of the older bark, often near scarred areas (Swaine and Hutchings 1926). The larvae begin their feeding immediately after hatching, boring inward from the oviposition hole to the wood and then tunneling along the circumference of the trunk or branch (Boisvert 1926). In the fall the young larvae feed first upon the soft tissue of the inner bark and outer layer of sapwood (Gerber et al. 1974), causing little injury before hibernation (Boisvert 1926). Feeding is resumed in the spring, and the larvae girdle the trunk or branch, killing all or part of the tree (Gerber et al. 1974). The poplar-and-willow borer is most numerous in the trunk and lower limbs. Boisvert (1926) described the tunnels as sinuous, irregular, and becoming larger in diameter as the borer matures. The larvae bore into the pith to pupate. Damage to branches may be more extensive, since they are more easily girdled. Injury to branches and limbs is indicated by knotty swellings, splitting, and breaking; by the appearance of sawdust and sap that exude at points of attack; and by wilted foliage (Metcalf et al. 1951). Heavily attacked trees have honeycombed and distorted stems, and less infested trees have moist dust oozing from cracked areas in the bark (CIPR 1960). The entire trunk may be covered with galleries that cut off food and severely damage or kill the tree (Boisvert 1926). The bark above affected areas may die or fall off, leaving the wood susceptible to attacks of fungi and bacteria. Poplars often have black rot following this injury. Wind usually blows over infested trees (Gerber et al. 1974). Trees 2–12 years old (Boisvert 1926) or with a diameter of 5–10 cm (Gautreau 1963) are most commonly attacked.

Biology: The species overwinters in the adult stage in duff beneath infested trees and in the immature larval stage in the sapwood under the bark (Gautreau 1963, Neilson and Arrand 1961). Gautreau (1963) reported collecting pupae from infested trees in late April. The overwintered weevils emerge in May and June in British Columbia, and the overwintered larvae resume feeding when tree growth begins in the spring (Neilson and Arrand 1961). According to Gautreau (1963), adults were found mating from June to August, with larvae first appearing around the beginning of July. When the overwintered larvae reach maturity in June, they bore into the heart of the tree and pupate (Neilson and Arrand 1961). Boisvert (1926) stated that the larvae spend 12–15 days in an enlarged gallery in the heartwood during which time pupation occurs. First-generation adults emerge during July and August (Neilson and Arrand 1961). When disturbed, the adults feign death and drop to the ground (Boisvert 1926). Mating takes place around the end of August and continues for about 2 weeks or longer. Two weeks later, the female deposits 5–30 eggs. These eggs are deposited either singly or in groups of two to four in slits in the corky bark (Neilson and Arrand 1961). The eggs hatch in 18–20 days (Boisvert 1926). The larvae feed for a short time and go into hibernation in October. Gerber et al. (1974) reported that some adults may overwinter a second time and lay eggs the following year. The life cycle requires 2–3 years, depending on temperature. Because the generations overlap, all stages of the species are present throughout the year. Boisvert (1926) also reported that two seasons are required to complete the life cycle, but Neilson and Arrand (1961) and Goble (1969*a*) stated that one generation occurs each year.

Geoderces incomptus (Horn)
woods weevil

Distribution: British Columbia, Saskatchewan, Ontario, New Brunswick, and Nova Scotia.

Economic injury: Chamberlain and Putnam (1964) reported the woods weevil to be a serious pest of raspberry and other small fruits in coastal British Columbia. The species severely injured most of a 17-ha block of strawberries in the Fraser Valley (CAIPR 1971). In addition to strawberry and cane fruits, the insect attacks ornamentals and seedling conifers (Gerber et al. 1974).

Most of the damage results from larvae that feed on the roots (Gerber et al. 1974); the adults attack the unopened buds and leaves of the host plant (Chamberlain and Putnam 1964). According to Cram and Neilson (1978), the larvae attack the side rootlets leaving the main vertical roots, which appear stripped. Chamberlain and Putnam (1964) reported that the larvae tunneled in the large fleshy roots. The plants may be killed or so weakened that they wilt in hot, dry weather (Gerber et al. 1974, Cram and Neilson 1978).

The adults often destroy the unopened buds of dormant canes from mid March to early April (Chamberlain and Putnam 1964), but their feeding on raspberry buds in the very early spring is usually limited to a small area of the planting (Cram and Neilson 1978). Gerber et al. (1974) reported that the adults chew the edges of the leaves. The leaves or unopened buds are also attacked after dark (Chamberlain and Putnam 1964).

The woods weevil is usually injurious to fields that are located near wooded areas or that are somewhat limited in area (Cram and

Neilson 1978). The presence of the insect may be indicated by leaf notching in strawberry or bud damage in raspberry.

Biology: The life history of the species is unpredictable (Cram and Neilson 1978). *Nemocestes incomptus* overwinters in the larval stage in the ground or in the adult stage at the bases of the canes (Chamberlain and Putnam 1964). Cram and Neilson (1978) reported that many adults remain in the soil in the fall, emerging very early in the spring. The beetles make their appearance at irregular times (from September to October, March to April, and intermittently in summer) and oviposit from March to October (Cram 1962, Gerber et al. 1974). Both larvae and adults may be found at all times during the year (Cram and Neilson 1978). The larvae burrow deep into the soil (escaping dry periods), and mature larvae are commonly found at a depth of up to 0.6 m in strawberry fields. Pupation also occurs at these depths. The life history of the woods weevil is similar to that of *Otiorhynchus* spp., and only one generation per year occurs (Gerber et al. 1974).

Adults are parasitized in culture by the fungus *Beauveria bassiana* (Bals.) Vuill.

Metarrhizium anisopliae (Metochn.) Sorskin (Cram 1972).

Comments: O'Brien reported this species only from California but noted a species named *G. horni* from more northern areas across the northern United States.

Geoderces puncticollis Casey (*montanus* Van Dyke)

Distribution: British Columbia.

Economic injury: CIPR (1958) reported that the species (as *N. montanus*) attacks strawberry in British Columbia.

Hylobius pinicola (Couper)
(Couper's collar weevil)
charançon pinicole (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Newfoundland, Northwest Territories, and Yukon Territory.

Economic injury: This species injured Scots pine and red pine at Colliers Ridge and the Avalon Peninsula, Nfld. (MacNay 1956).

Hylobius radicis Buchanan
pine root collar weevil
charançon du collet du pin (m.)

Distribution: Quebec and Newfoundland.

Economic injury: In Newfoundland the species severely damaged ornamental pine plantings (CAIPR 1969) and injured and killed jack pine hedges (CIPR 1962).

Hypera meles (Fabricius)
clover head weevil
charançon des fleurs du trèfle (m.)

Distribution: Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Origin: The first North American record of this European species was made at Rockaway Beach, N.Y., in 1907 (Detwiler 1923, Davidson and Lyon 1979).

Economic injury: The clover head weevil has attacked and caused substantial reduction in seed yield to red, white, alsike, ladino, and crimson clovers (MacNay 1950, Davidson and Lyon 1979). Beirne (1971) reported the insect on alfalfa and on the flowers of dandelion and wild strawberry. Adults have also been observed in large numbers on the foliage of Kentucky Wonder pole beans and black wax pencil beans (Thompson and Goble 1945). In Europe the species has been injurious to alfalfa, black medick, *Medicago falcata* L., red clover, and crimson clover (Detwiler 1923).

Both the adults and larvae feed on the blossoms of clover (Detwiler 1923). The latter eat the whole of the floret and do little damage unless the crop is grown for seed. The larvae of *H. meles* may be confused with those of the lesser clover leaf weevil (*Hypera nigrirostris* Fabricius), as the two species are similar in their early instars. The adults have not been observed in numbers large enough to cause significant injury. In the laboratory the adults characteristically attack the base of the clover leaflet, cutting it off from the petiole. On beans the adults prefer to attack the midrib and leaf stem area of the foliage (Thompson and Goble 1945, Beirne 1971). Damage may result in broken and skeletonized leaves (Thompson and Goble 1945).

Biology: The biology of this species (in New York) was described by Detwiler (1923). The adults overwinter in sheltered places on or near the ground, among the host plants or in debris. Oviposition normally begins in May and is extended over a considerable period. A cavity is made under a horizontal cut (about 0.5 mm) through the epidermis of the clover stalk or petiole. From one to a dozen or more eggs are deposited in the cavity. As many as 25 eggs have been reported from a petiole of red clover 7 cm long. The severed piece of epidermis is replaced over the cavity. This covering may effectively conceal the eggs (until the lid dries) and protects them from desiccation. The eggs hatch in 8.5–13 days.

The larvae pass through four instars and usually require 4 days in each of the first three instars and 8 days in the fourth. Fourth-instar larvae were numerous on clover heads on 1 July. The larvae are full grown in about 20 days and usually spend an additional 2 or 3 days resting in the cocoon before pupation. The cocoon is spun in the heads of clover and ordinarily measures about 4.8 mm in length and about 3.4 mm in width. From 5 to 9 days are spent in the pupal stage. The newly transformed adult remains in the cocoon for about 2 days (range, 0–4) before emerging. During this time, a considerable part of the cocoon may be eaten. It was noted that adults may appear in 39–46 days after oviposition. Field-collected larvae emerged as first-generation adults in July. Adults collected during late August actively oviposited, and eggs were observed as late as 15 September. There appears to be only one generation per year, with part of a second each year.

According to Graham (1965), the braconid (Hymenoptera) *Microctonus aethiops* (Nees) is a parasite of this species.

Hypera nigrirostris (Fabricius)
lesser clover leaf weevil
charançon à rostre noir (m.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This European species was first recorded in North America in 1873–1874 in eastern Massachusetts and New Hampshire (Hatch 1971). Detwiler (1923) stated that the species was probably first established in the Maritime Provinces before spreading westward. In 1884, *H. nigrirostris* caused great injury to clover at Dalhousie, N.B. The insect has been present in Quebec since 1912 (CAIPR 1970) and was first reported from Vancouver, B.C., in 1919 (Hatch 1971) and from Newfoundland in 1952 (MacNay 1954*a*). Rockwood (1920) obtained evidence from the Pacific Northwest that appears to indicate that the species is circumpolar in its range or that it has invaded this region from eastern Siberia.

Economic injury: According to Hatch (1971), since about 1910 the lesser clover leaf weevil has become one of the most serious pests of red clover in the midwestern United States. It is also of significant economic importance in clover crops throughout the agricultural regions of eastern Canada (MacNay 1954*a*). CIPR (1932) reported the insect as extremely abundant in the Maritime Provinces, in some areas infesting 15% of the clover heads. The seed yield of red, white, alsike, and ladino clovers has been significantly reduced by *H. nigrirostris* in southwestern Ontario (MacNay 1950). The species apparently prefers red clover and is most injurious when the seasons are dry, having frequently infested 90–98% of clover crops under such conditions (Mectalf et al. 1951). Additional hosts include alfalfa, sweet-clover, zigzag clover, and crimson clover (Detwiler 1923, Hatch 1971).

Injury is caused by both the larvae and adults, which eat the leaves, stems, and buds (Arrand and Neilson 1958). Larvae may completely or partly destroy the newly developing buds both in the axils and in the heads (Detwiler 1923, Metcalf et al. 1951). The larvae also feed on the stems and may occasionally burrow into them, causing that part above the tunnel to wilt and die. Fletcher (1905) stated that the larvae attack the leaves, especially those surrounding the developing flower heads. The adults riddle the leaves (Detwiler 1923) and cut small slits in the stems and buds (Metcalf et al. 1951). Damage is indicated by yellow leaves, stunted growth, and poor seed yield (MacNay 1950, Arrand and Neilson 1958).

Biology: The insect overwinters in the adult stage in sheltered places in nearby woodlands, bushy hedges, fences, and roadsides and to some extent around the crowns of the clover plants (Metcalf et al. 1951). In the spring the overwintered adults fly to the clover plants as they begin to grow. Oviposition begins after a few days of feeding and continues for about a month (from early April to early May). The eggs are laid in small slits cut in the stem or bud, at the axil of the leaf or in the terminal bud, (Metcalf et al. 1951) and, according to Detwiler (1923), subepidermally in the sheaths of the basal leaves or in the leaflets. According to Metcalf et al. (1951), the eggs are usually laid singly, although occasionally two or three eggs may be discovered in one place. The females are very prolific, depositing 200–300 eggs each (Detwiler 1923, Metcalf et al. 1951). The eggs hatch in approximately 2–3 weeks.

The larvae pass through four instars and spend 5 days in the first instar, 3 days in both the second and third instars, and 8 days in the fourth instar (Detwiler 1923). According to Metcalf et al. (1951), the larval period lasts for 20–25 days but may be longer, depending on weather conditions. The larvae pupate in cocoons that are usually spun on the heads of clover, but they may appear in the leaf axils or on the ground near the base of the plant (Detwiler 1923, Metcalf et al. 1951). After forming the cocoon, the larvae rest for 2 or 3 days before pupating (Detwiler 1923). The length of the pupal period varies from 5 to 8 days, and the newly transformed adult remains in the cocoon for an additional 2 or 3 days, often eating part of the cocoon. In New York, the first generation of adults usually appears during the first half of June. Fletcher (1905*a*) reported the appearance of first-generation adults early in July in Ontario. Metcalf et al. (1951) pointed out that the new adults feed in the clover field for about 2 or 3 weeks and then seek winter quarters by about mid July in Illinois. Only one generation of the species occurs per year, with parts of a second in some southern areas (Detwiler 1923, Davidson and Lyon 1979).

According to Davidson and Lyon (1979), the most numerous parasite of this species is the braconid *Bracon mellitor* Say. The fungus *Empusa sphaerosperma* Fres. attacks both larvae and pupae. The ichneumonid *Bathyplectes exigua* Gravenhorst parasitizes the larvae and pupates in the cocoon of its host (Detwiler 1923). A species of *Microbracon* and a small fly, *Anisia* sp. near *variabilis* Coq., parasitize the larvae. Rockwood (1920) reported that a pteromalid parasite, *Dibrachoides dynastes* Förster, attacks the pupae within the cocoons.

Hypera postica (Gyllenhal)
alfalfa weevil
charançon postiche de la luzerne (m.)

Distribution: Alberta, Saskatchewan, Ontario, Quebec, and Nova Scotia.

Origin: This European species was first detected in North America in 1904 in an alfalfa field a few kilometres from Salt Lake City, Utah (Hobbs 1956). In 1954 the species was recorded from Manyberries, Alta. (the first Canadian record) and from southwestern and south-central Saskatchewan (MacNay 1954*b*, 1958). The presence of the host-specific parasite *Bathyplectes curculionis* (Thomson) in 1954 suggests that the insect occurred in Alberta for at least a year before its discovery (MacNay 1954*b*, Hobbs et al. 1959). Within the next decade, the alfalfa weevil spread approximately 160 km north of the Canada–United States border (Craig 1973). *Hypera postica* was first recorded in southwestern Ontario in 1967 (Harcourt 1975) and in Quebec in 1968, near Lake Champlain in Missisquoi County (Perron 1969). According to Beirne (1971), the species is believed to have occurred in Ontario for at least 2 years before it was discovered in the Prairie Provinces.

Economic injury: The alfalfa weevil is the most serious pest of alfalfa in North America (Harcourt 1977). The insect is especially injurious to seedling stands and alfalfa grown for seed (Philip 1977), but severe losses in both the quality and quantity of the feed also declines in older, infested stands (MacNay 1957*a*). Hatch (1971) noted that at least one cutting of hay can be destroyed during a season. According to Beirne (1971), the species spread quickly and caused economic injury to alfalfa in Alberta and Saskatchewan within 4 years of its first discovery. It reached epidemic levels in Ontario in 1969 and now poses a threat to the dairy industry throughout the southern half of the province (Harcourt et al. 1974). The species caused 50% damage to first-cut alfalfa in Essex County, 35% along Lake Erie in Welland County, and 30% in Prince Edward County and along Lake Ontario to Kingston (Goble 1969*b*). In North Bay, a 10–20% crop loss was reported (CAIPR 1971) and almost 80% of the alfalfa in fields (about 182 ha) in Missisquoi County, Que., suffered severe injury (Perron 1969). Hobbs (1956) noted that in Montana, the pest takes 5–10 years after it is discovered to cause severe damage, after which it continues to injure seriously alfalfa hay and seed fields. This important and rapidly spreading insect can appear abruptly anywhere within 60–96 km of its point of origin (Beirne 1971, Philip 1977).

The preferred host is alfalfa, but the species may also attack the true clovers, bur-clover, yellow sweet-clover and, rarely, vetch (Arrand and Neilson 1958, Bereza 1977*a*). According to Bereza (1977*a*), the clovers are not significantly injured. Adults reportedly caused some damage to soybeans in two fields adjacent to alfalfa following a second cutting in Ontario (Whitfield and Ellis 1976).

Injury is caused by the feeding of adults and larvae on the stems, growing tips, leaves, and buds (Philip 1977, Davidson and Lyon 1979). Most of the damage is caused by the larvae, which feed for 3 or 4 days inside the stem and then crawl to the tips of alfalfa to feed first on the developing leaf and flower buds and later on the lower leaves (Bereza 1977*a*, Harcourt 1977, Philip 1977). Miller and Guppy (1971) noted that the first- and second-instar larvae feed largely on the unopened florets, where they are often completely hidden. The older larvae feed on both the buds and leaves, but leaf feeding is more apparent and constitutes the main food source during the fourth instar. The tips of the new growth are skeletonized or shredded, and this damage increases from early spring until shortly before the first cutting (Metcalf et al. 1951). The later instars skeletonize the developed leaves, destroying all but the leaf veins and stems during a heavy infestation (Bereza 1977*a*). When the leaves are badly shredded, the alfalfa field takes on a grayish white or frosted appearance (Harcourt 1977, Harcourt et al. 1977). Although the species attacks mainly first-growth alfalfa in Ontario, enough larvae may remain after the first cutting to injure early second growth (Miller and Guppy 1971, Harcourt and Guppy 1976). Miller and Guppy (1971) reported that high densities of larvae are limited to a 6–8-week period in the spring and summer in Ontario. The insect appears to be well synchronized with its host in Ontario, as the peak larval attack frequently coincides with the late bud stage of the first crop (Harcourt 1977). When spring is dry and warm, the life stages develop faster and the alfalfa sustains much more damage before it can be cut (CAIPR 1977). When the weather is cool, the eggs accumulate in the field, and the larvae may not attack until the alfalfa is ready to be harvested (Hamlin et al. 1949). Larval populations resulting from eggs laid by overwintered adults in July, August, and September are generally small and do not cause important damage (Miller and Guppy 1971).

The adults do not usually cause serious feeding injury. They eat long slits or narrow longitudinal notches from the leaf margins inward, giving the leaves a ragged appearance (Miller and Guppy 1971, Bereza 1977*a*). They also feed on the outer skin of the stems and new shoots, eating away the epidermis in irregular patches. Serious injury occasionally results from the many egg-laying punctures in the stems (Philip 1977).

Biology: The alfalfa weevil overwinters chiefly in the adult stage in the crowns of alfalfa plants or under debris in and around alfalfa fields (Hobbs 1956, Bereza 1977*a*, Davidson and Lyon 1979). Overwintering eggs have also been reported (Ellis 1973, Davidson and Lyon 1979). In Ontario, the overwintered adults become active during April and early May, feed for a brief period and mate (Bereza 1977*a*). Egg-laying begins shortly after emergence; the first eggs are deposited in the dead stems and ground litter, the later eggs in the green stems of the plants as growth begins (Miller et al. 1972, Harcourt et al. 1977). More eggs are deposited in the stems and fewer in the litter as the season advances (Hamlin et al. 1949). According to Harcourt et al. (1977), oviposition in Ontario peaks around the middle of May, when new growth attains a height of 25 cm. Miller and Guppy (1971) noted that oviposition continues intermittently during July and early August and again increases around the end of August and beginning of September. The eggs are deposited in clusters of 1–40 eggs in small punctures that are chewed out of the stem by the female (Metcalf et al. 1951, Arrand and Neilson 1958, Miller et al. 1972, Bereza 1977*a*, Dowell and Horn 1977, Harcourt et al. 1977). Most egg clusters are placed in the pithy part of growing alfalfa stems (Hamlin et al. 1949). Each puncture is capped with macerated plant tissue after the cluster has been inserted (Harcourt et al. 1977). According to Metcalf et al. (1951), each female deposits 600–800 eggs in the spring. Davidson and Lyon (1979), however, stated that the average oviposition is about 400 eggs. The incubation period usually lasts 8–12 days (Miller and Guppy 1971), but when the weather is cool, the eggs collect in the stems and await favorable temperatures before they all hatch at about the same time (Bereza 1977*a*). The larvae begin hatching around the end of May (Harcourt et al. 1977) but do not become numerous until the first-growth alfalfa produces buds (Davidson and Lyon 1979).

The larvae pass through four instars and complete their development in about 2 weeks (Miller and Guppy 1971, Miller et al. 1972, Dowell and Horn 1977). The larvae have also been reported to reach maturity in about 3 weeks (Harcourt et al. 1977), in 3–4 weeks (Arrand and Neilson 1958, Bereza 1977*a*), and in 50–60 days (Philip 1977). As previously mentioned, the young larvae crawl to the terminal growth where they feed within the buds, whereas the older larvae feed mostly on the leaves (Miller et al. 1972). The mature larvae construct delicate netlike cocoons in the foliage (two-thirds) or ground litter (one-third) (Harcourt and Guppy 1975, Harcourt et al. 1977). In the western United States, the larvae prefer to spin their cocoons in the litter, whereas in the eastern states they prefer to pupate on the host plant (Harcourt and Guppy 1975). Both Craig (1973) and Philip (1977) reported that the larvae drop to the ground to pupate in western Canada. The prepupal period begins with the spinning of silk and ends after a period of quiescence (about 2 days) following construction of the cocoon; failure to spin cocoons is associated with high humidity (Miller and Guppy 1971, Guppy and Mukerji 1974). The new adults emerge 1 or 2 weeks later, at which time the overwintered adults begin to disappear (Bereza 1977*a*).

The new adults feed for 2–3 weeks before entering aestivation (Miller et al. 1972). They become active again in late fall when they feed, mate, and lay a few eggs before cold weather brings all activity to a halt (Miller and Guppy 1971). According to Harcourt et al. (1977), the eggs fail to survive the winter, but Davidson and Lyon (1979) reported that fall-laid eggs do overwinter and hatch the following spring, although viability is low when winter temperatures are low. Only one generation per year occurs, with parts of a second generation appearing in some areas.

The fungus *Entomophthora phytonomi* Arthur (= *E. sphaerosperma* Fres.) attacks all larval instars – larval mortality averaged 92% according to CAIPR (1977) – and the cocoon stage, and is the principal determinant of intrageneration survival (Harcourt et al. 1977). Two introduced species of ichneumonid wasps, *Bathyplectes curculionis* (Thomson) and *B. anurus* (Thomson), attack the larvae and have parasitized about 90% of the larvae on first-crop alfalfa (Davidson and Lyon 1979). The introduced mymarids *Anaphes pratensis* Förster and *Patasson luna* (Girault) are egg parasites (Hamlin et al. 1949, Mailloux and Pilon 1970). The introduced eulophid *Tetrastichus incertus* (Ratzeburg) attacks mainly third- and fourth-instar larvae (occasionally near 100% are parasitized) (Rivard 1972). Pupal parasites include the ichneumonid *Gelis* sp. and the chalcid *Spilochalcis albifrons* (Walsh) (Poinar 1963). The introduced braconid *Microctonus aethiopoides* Loan parasitizes the adults (Davidson and Lyon 1979); Abu and Ellis (1976) reported parasitism of 76–82%). Ellis (1973) reported that the native species *Fidiobia rugosifrons* (Crawford) emerged from overwintering eggs. The introduced ichneumonid *Bathyplectes stenostigma* (Thomson) parasitizes alfalfa weevil larvae (Dowell 1977). Other parasites include the mermithid nematode *Hexameris arvalis* (Poinar 1962) and the braconids *Microctonus aethiops* (Nees), *M. colesi* Drea, and *M. stelleri* Loan (Drea et al. 1972).

Hypera punctata (Fabricius)
clover leaf weevil
charançon des feuilles du trèfle (m.)

Distribution: British Columbia, Alberta, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This Palaearctic species was accidentally introduced into North America from Europe (Tower and Fenton 1920). In North America it was first collected in Canada about 1850–1855 and was identified by LeConte in 1876. The insect was recorded for the first time as a destructive pest in North America in Barrington, Yates County, N.Y., in 1881. According to Kilman (1884), prevailing east winds brought large numbers of the clover leaf weevil across Lake Erie from Buffalo, N.Y., to Ridgeway, Ont., in 1884. The species was first reported in the Pacific Northwest in 1902 from Victoria, B.C. (Hatch 1971), and from Alberta in 1923 (Beirne 1971). Davidson and Lyon (1979) noted that the insect is now well established in most locations where clover and alfalfa are grown.

Economic injury: Tower and Fenton (1920) reported the clover leaf weevil as one of the most important pests of clover, but more recent works indicate that it is rarely of economic importance (Arrand and Neilson 1958, Beirne 1971). In years of excessive abundance, it is usually controlled by a fungal disease (Hudson and Wood 1923, Hatch 1971). Periodic outbreaks of this species resulting from climatic conditions unfavorable to fungal growth and possibly other factors may result in considerable damage to clover and alfalfa (Puttler and Coles 1962). Damage is most apparent in the spring and is more serious in cool, dry springs (Metcalf et al. 1951, Arrand and Neilson 1958). Ross and Caesar (1931) reported serious damage to clover during the spring in Ontario, where attacked plants were almost always defoliated. Hudson (1919*a*) noted a severe outbreak in clover and timothy fields in Ontario, which subsided in less than a week when extremely wet weather produced a fungal disease. Similar cases are described by Ross and Caesar (1919), Hudson and Wood (1923), and Starks and Thurston (1958). The principal host plants of *H. punctata* are the clovers and alfalfa (Arrand and Neilson 1958). All kinds of clover are attacked including red, crimson, ladino, alsike, white, and white Dutch, as well as sweet-clover and bush-clover (Tower and Fenton 1920, Starks and Thurston 1958, Beirne 1971). According to Metcalf et al. (1951), the larvae feed mainly on red clover, sweet-clover, and alfalfa. Both larvae and adults have been observed on beans and timothy; adults have been observed on burdock, soybeans, corn, wheat, goldenrod, and many weeds and flowering plants (Hudson 1919*a*, Tower and Fenton 1920, Metcalf et al. 1951, Arrand and Neilson 1958, Davidson and Lyon 1979). The species has also occurred on wild rice in Ontario (CIPR 1954).

Injury is caused by the feeding of both larvae and adults on foliage (Davidson and Lyon 1979). In Indiana they begin feeding as soon as the clover starts to grow in the early spring (Tower and Fenton 1920). First-instar larvae feed on the centre of the leaves, where they make small, round holes; they curl up tightly during the day under the leaf (Hudson and Wood 1923). Many of the young larvae feed within unopened leaflets at the base of the plant, where they are protected during the day. Third- and fourth-instar larvae feed only at night on the edges of the leaves and hide during the day on the ground (Hudson and Wood 1923). Tower and Fenton (1920) noted a marked increase in food consumption after the third molt. During the mild days of winter in the United States, the larvae may feed on the small leaves at the crown of the clover plant.

Adults feed actively for about 2 weeks after emergence from their cocoons and then become nearly inactive until August (Hudson and Wood 1923, Metcalf et al. 1951). Tower and Fenton (1920) reported that the weevils "rag" the clover leaves during the summer and occasionally chew the plants to the ground. The weevils usually feed at night, hiding under rubbish or in cracks in the soil during the day, but they have also been observed feeding during the day.

The pest usually only becomes abundant in a clover field during the second season (Tower and Fenton 1920).

Biology: The species overwinters mainly in the immature larval stage – in all four larval stages according to Hudson and Wood (1923) – around the crowns of the plant. The insect overwinters to a lesser extent in the egg stage and occasionally in the adult stage (Metcalf et al. 1951, Arrand and Neilson 1958). Hudson and Wood (1923) recorded the average length of each of the four larval instars at Strathroy, Ont.: 17 days in the first instar (fall observation); 21 days in the second instar (fall observation); 13 days in the third instar (spring observation); and 17 days in the fourth instar (spring observation). Somewhat shorter periods were reported by Tower and Fenton (1920) at LaFayette, Ind. Because of intermittent feeding and growth resulting from climatic changes, the length of the larval instars is extremely variable, and all larval instars may be observed during April and May. The first three instars are most numerous during April, with the third and fourth instars predominating in May. There are few active larvae remaining by the end of May, and by 20 June most have completed development and spun cocoons. Arrand and Neilson (1958) stated that the larvae begin feeding early in the spring and reach maturity by late May or June in the Okanagan, B.C. At Strathroy, Ont., larvae may be found in the field from the second week of September until the third week of June of the following year (Hudson and Wood 1923).

Newly hatched larvae spend a brief period near the egg mass before beginning their climb to the leaflets (Hudson and Wood 1923). The larvae are legless, so many fall to the ground and probably die, especially if hatching occurs during a rain or heavy wind. Later instar larvae have a habit of curling up when not feeding (Hudson and Wood 1923) and of dropping to the ground when disturbed (Tower and Fenton 1920). The young larva molts by coiling itself about a bunch of epidermal hairs and then crawling out through an opening in the head region.

The larvae stop feeding a day or two before spinning the cocoon, which takes 1 or 2 days (Hudson and Wood 1923). The oval, netlike cocoon is spun just beneath the soil or among the debris at the base of the plants (Tower and Fenton 1920, Hudson and Wood 1923, Beirne 1971, Davidson and Lyon 1979), or according to Metcalf et al. (1951), occasionally the cocoon is found on the stems of the leaves. Hudson and Wood (1923) reported a prepupal period of 3–8 days. Pupation takes from 5–16 days, after which the adults remain in the cocoon for 1–4 days (Tower and Fenton 1920, Hudson and Wood 1923). The adults escape by eating a hole in the cocoon, emerging 5–16 days after pupation (Hudson and Wood 1923).

Tower and Fenton (1920) stated that the new adults appeared from 26 May to 26 June (in 1916) and noted that other workers in the same latitude as LaFayette, Ind., found the period of emergence to extend from 9 May to 15 July, with the greatest emergence occurring during the last week in June. These adults feed actively for a short time (about 2 weeks), after which they become inactive until August, feeding only slightly. Sexual activity starts about the third week of August at Strathroy, Ont. (Hudson and Wood 1923, Metcalf et al. 1951). Dispersal (by flying or running) takes place toward the end of August (Hudson and Wood 1923). The adults appear to mate several times during the egg-laying season (Tower and Fenton 1920). Oviposition occurs quite regularly until the middle of November, with most of the eggs deposited in September and October (Hudson and Wood 1923).

The eggs are laid in or on various parts of the clover and alfalfa plants (Tower and Fenton 1920, Hudson and Wood 1923, Metcalf et al. 1951). The eggs were usually deposited in a puncture on the stem or leaf sheath or on the outside of these parts (Tower and Fenton 1920). When fed alfalfa in cages, the weevil inserted its eggs singly in punctures in the stem. Occasionally, several eggs were attached in a mass on the stem by means of a rapidly drying secretion. When fed clover, the weevil nearly always deposited its eggs inside the petiole or the leaf sheath. The female may deposit a mass of eggs (as many as 33) in a small cut through the side of the sheath at the base of the petiole (Tower and Fenton 1920). The eggs are also readily deposited in the stems of wheat (Hudson and Wood 1922) or in wheat and oat stubble (Hudson and Wood 1923). Oviposition usually takes place at night, but when the nights become too cold (egg laying ceases between temperatures of 7 and 10°C), it can take place at any time during the day (Tower and Fenton 1920, Hudson and Wood 1922). According to Hudson and Wood (1922), the first batch of eggs are usually infertile. Egg-laying punctures differ from feeding punctures in that they are smaller and have rough openings. The process of oviposition was well described by Hudson and Wood (1922).

In their study of over 30 pairs of beetles, Hudson and Wood (1923) reported a fecundity that varied from 34 to 667 eggs. Tower and Fenton (1920) reported a range of 74–287 eggs. Hudson and Wood (1923) reported that the adults die not long after completion of oviposition.

The incubation period varied from 14 to 42 days during August and September (Hudson and Wood 1923) and from 13 to 46 days during September and October (Tower and Fenton 1920). Eggs laid before 25 October hatched during the same fall, and hibernation occurred as first-, second-, and third-instar larvae; those laid after 25 October usually overwintered and hatched the following March. Eggs laid later (after 13 November in 1915) failed to hatch (Tower and Fenton 1920). Hatching occurs in the early fall or later in the fall, or the eggs may go through the winter or even hatch on mild days during the winter. Upon hatching, the larva makes a small hole, usually near one end of the egg, just large enough for it to pass through (Tower and Fenton 1920, Hudson and Wood 1923).

The life cycle is completed in 1 year (Tower and Fenton 1920, Hudson and Wood 1923), but under exceptional conditions, a second generation of weevils may be produced that overwinter and deposit eggs the following spring (Davidson and Lyon 1979).

The fungus *Entomophthora sphaerosperma* Fresenius attacks the larvae of the clover leaf weevil and reaches its fullest potential in fairly cool temperature and high relative humidity (Puttler and Coles 1962). Davidson and Lyon (1979) reported that warm temperature and high humidity favor the development of the fungus. According to Puttler and Coles (1962), the introduced ichneumonid (Hymenoptera) *Biolysia tristis* (Gravenhorst) may, in certain areas, exert more influence than the fungus in controlling populations of *H. punctata*. This insect is most effective during the fall and spring, and parasitization may range from 80 to 90%. Tower and Fenton (1920) reported that the larvae of *Collops quadrimaculatus* Fabricius feed on the eggs, and the tiger beetle, *Cicindela repanda* Dej., probably attacks the larvae. A tachinid egg was collected from a larva, but the adult was not reared.

Lepesoma luteus Horn

Distribution: British Columbia and Saskatchewan.

Economic injury: Venables (1947) reported that *D. luteus* damaged the leaves of cultivated raspberry in 1906. Injury was both distinctive and uniform, as *D. luteus* entirely removed three or four long, narrow areas on each side of the midrib extending from the margin to the midrib. The insects confined their attack to the large leaves near the bases of the canes.

Biology: The species is nocturnal in habit, feeding in large numbers at night and hiding during the day under the surface of the soil and under the dead leaves around the crown of the canes (Venables 1947).

Listronotus oregonensis (LeConte)
carrot weevil
charançon de la carotte (m.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, and Quebec.

Origin: According to MacNay (1961), the carrot weevil is native to North America. The insect was first collected in Ontario in 1908 (Stevenson 1976) and later in 1955 (Perron 1971). In Quebec, *L. oregonensis* was found for the first time in 1967, but it was not recognized or identified until 1970 (Perron 1971).

Economic injury: The carrot weevil has only recently become a pest of economic importance in Ontario and Quebec (Martel et al. 1975). The species is usually found in organic soils where carrots are grown on a large scale. Although the insect has been confined almost exclusively to the organic soil areas of the Bradford and Holland Marshes, and has also been found in Thedford, Ont., it has now spread in the direction of Keswick (Wressell 1970, CAIPR 1971, Perron 1971). Its firm establishment in the organic soil regions of southwestern Quebec has also been noted, as well as its expanding distribution (CAIPR 1973, Martel and Hudon 1974). Early-seeded carrots (May and early June in the Holland Marsh) are subject to the most serious injury, especially in fields where second-year plants are found (CAIPR 1971, Stevenson 1976). At the Holland Marsh, MacNay (1959) reported losses in early carrots that ranged as high as 70%, and the CAIPR (1971) noted injury that averaged 63% in an unsprayed plot and 23% in an adjacent commercial planting. In the organic soil areas of southwestern Quebec (Sherrington, Saint-Michel, and Sainte-Clotilde), damage ranged from 2 to 22%, representing several thousand hectares (Perron 1971). Hudon and Martel (1975) also reported serious damage to early crops in southwestern Quebec and observed the insect, for the first time in the province, in mineral soil causing from 25 to 30% damage in a carrot field near L'Assomption. The species occasionally causes severe injury to celery (CAIPR 1972, Stevenson 1976). Parsley, hymicha, parsnip, dill, plantain, dock, wild carrot, and a number of weeds are additional hosts (Semel 1957, Goble 1960, Davidson and Lyon 1979).

The principal damage results from the larvae, which bore into the roots of carrots; the adults attack carrot foliage but do not cause serious damage (Goble 1960). The young larvae feed on the inside of the stem and then tunnel down into the root. Some occasionally emerge and crawl into the soil where they enter the root. Injury is caused to the upper and outer parts of the root (unlike the carrot rust fly maggot, which has a habit of feeding further down), and each root is generally attacked by a single larva. Dead, stunted, or chlorotic plants may result from this damage (Stevenson 1976). Carrots seeded in early May in unsprayed plots at Holland Marsh began to show damage in early June, which increased rapidly and peaked in early July. CAIPR (1970) reported that peak injury in Quebec occurs during the middle of August, and CAIPR (1971) noted one instance where peak injury occurred in Quebec in late September and early October because of low temperatures. In Ontario, periods of unusually warm weather in May and the presence of early celery transplants or volunteer carrots can result in an earlier development of the new generation of carrot weevil and damage by second-generation larvae (Stevenson 1976). Davidson and Lyon (1979) stated that larval damage in celery may be done mostly to the stalks. At the Holland Marsh, celery seedlings transplanted in May and early June were moderately to severely injured, whereas those transplanted later showed some root damage but little injury above ground (Stevenson 1976). Celery was noted to withstand a certain amount of root feeding without important crop losses. Semel (1957) reported chlorosis and wilting in parsley in New York caused by the tunneling activities of carrot weevil larvae.

Biology: The adults usually overwinter in grassy roadsides, banks of ditches, and fencerows close to previously infested fields (Wright and Decker 1957, Goble 1960, Hudon and Martel 1973), although some adults overwinter in plant debris on the crop site (Stevenson 1976). The overwintering generation becomes active when soil temperature reaches 7°C (Martel and Hudon 1974). In the Bradford Marsh area, the beetles appear in late May or early June (Goble 1960). The weevils seldom fly and do not appear to go very far when they do (Wright and Decker 1957, Goble 1960, Davidson and Lyon 1979). The rows nearest overwintering sites are infested first early in the season, with the infestation becoming more widespread within the field as the season advances. According to Goble (1960), the females mate before crawling into nearby carrot plots; however, some females may be fertilized before hibernation in the fall (Wright and Decker 1958).

Martel et al. (1976) studied the life history of *L. oregonensis* at temperatures of 21 and 27°C and 60% relative humidity. Females reared on carrot slices and carrot leaves began to oviposit from 11 to 21 days after emergence. Stevenson (1976) reported oviposition as early as mid May in celery transplants in the Holland Marsh. The average date of peak oviposition in planted carrot or celery from 1973 to 1976 was 6 June, and females continued ovipositing until about 17 July. Most oviposition in seeded carrots occurs after the plants have passed the first true-leaf stage. The eggs are inserted in small cavities, which the female chews in the stem, crown, or exposed root of the plant (Wright and Decker 1957). Each female averaged 155.7 eggs (range, 7–295) on carrot slices and 175 eggs (range, 6–308) on carrot leaves (Martel et al. 1976). The larva emerges from the egg by puncturing or ripping the egg membrane with its mandibles. The incubation period averaged approximately 8 days at 21°C and 4.5 days at 27°C.

Newly hatched larvae begin feeding and tunneling immediately (Martel et al. 1976). The entrance into the carrot is blocked by feces, and the larva completes its development within the carrot. Four larval instars were reported, and larval development was completed in approximately 19 days at 21°C and 12 days at 27°C. Wright and Decker (1958) observed five larval instars. According to Martel et al. (1976), feeding stops in the fourth instar, after which the larvae emerge from the carrots and enter the prepupal stage without molting. Continual emergence of mature larvae from infested carrots at the Holland Marsh, Ont., was noted from about mid July until the end of September (Stevenson 1976). A pupal cell is formed in the soil by the prepupa "bending its body back and forth rapidly, simultaneously pushing the soil from around itself and firmly packing it" (Martel et al. 1976). The prepupal stage averaged approximately 4 days at 21°C and 5 days at 27°C. An average of approximately 9 days at 21°C and 5 days at 27°C was spent in the pupal stage (Martel et al. 1976). At the Holland Marsh, Stevenson (1976) observed that larval emergence to 50% adult eclosion required 19–26 days. At 21°C the life cycle from egg to adult averaged 40.6 ± 3.0 days (range, 35–47), and the complete life cycle (including the average preoviposition period of 17 days) was 57.6 days. At 27°C the average life cycle from egg to adult was 27.0 ± 1.4 days (range, 24–29) and the complete life cycle (including the average preoviposition period of 10 days) was 37 days (Martel et al. 1976). Wright and Decker (1958) reported the development period from egg to adult to range from 27 to 49 days.

Emergence of first-generation adults in the Holland Marsh occurred from late July until November (Stevenson 1976). There is normally a single generation per year in Ontario and Quebec, but as previously stated, exceptional conditions may favor the development of a partial second generation.

Lixus concavus Say
rhubarb curculio
charançon de la rhubarbe (m.)

Distribution: Ontario.

Economic injury: The rhubarb curculio is not a serious pest but may on occasion scar the stems of rhubarb, rendering them unsightly and unsalable (Caesar 1927, 1938; Goble 1960; Davidson and Lyon 1979). Such damage is most likely to occur on farms or in domestic gardens where the principal host, the common curled dock, is growing nearby (Caesar 1927, 1938; Goble 1960). Caesar and Ross (1922) recorded a rare instance where the species was in such abundance as to almost ruin a crop of rhubarb. *Lixus concavus* has also been reported on thistle and sunflower (Goble 1960).

Because the larvae seldom develop in the rhubarb, the damage results solely from the feeding and egg-laying punctures made in the stems and leaf ribs by the adults (Caesar 1927, 1938; Davidson and Lyon 1979). These punctures are oval or round, about 3 mm deep, and usually have gum exuding from them (Caesar 1927, 1938). The injured areas normally dry up and turn brown, although in some cases, rot sets in. As many as a dozen or more damaged areas may occur on a single stem, and such stems break readily. The beetles are limited in their economic injury because they feed during June and early July, when the marketing season is almost over. Commercial plantations are seldom injured by this insect.

Biology: The adults overwinter in protected places, apparently under debris in the area of the host plants (Caesar 1927, 1938; Goble 1960). The adults emerge around the beginning of June and feed on rhubarb and dock (Caesar 1927, 1938). Eggs are soon deposited in the stems of these plants and oviposition continues for just over a month. Larvae that hatch in rhubarb do not survive to do any damage, but those that hatch in dock bore down the stem as they mature and pupate near the soil (Goble 1960). The new adults emerge in September, feed for a short time, and then seek winter quarters (Caesar 1927, 1938).

Magdalis aenescens LeConte
bronze appletree weevil

Distribution: British Columbia.

Economic injury: MacNay and Creelman (1958) reported the species as a pest of apple in British Columbia. Damage to the foliage of fruit trees in certain orchards at Vernon was noted by CIPR (1927). The adults feed on the foliage and have been observed near the blossoms (Brittain 1914, CIPR 1925). Treherne (1914) stated that the bronze appletree weevil may be associated with the canker of the stems and trunks of apple trees.

Biology: Adults may be observed in the spring near the blossoms and on the new leaves of apple trees (Brittain 1914). According to CIPR (1925, 1927), the beetles breed in piles of prunings as well as in dead and dying trees; they attack the foliage of nearby trees. The eggs are laid in a series of tiny, closely congregated punctures in the bark (Brittain 1914).

Magdalis gracilis LeConte
(black fruit tree weevil)

Distribution: British Columbia.

Economic injury: The insect has been reported to damage the leaves of plum in British Columbia (CIPR 1954).

Merhynchites bicolor (Fabricius)
rose curculio (black-snouted rose beetle)
charançon bicolore du rosier (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Northwest Territories.

Economic injury: The rose curculio has been described as an important pest of rose in many parts of western Canada (Gibson 1934; MacNay 1946–1952, 1954*b*–1956, 1957*b*, 1958). Gerber et al. (1974) reported the species in British Columbia wherever roses are grown. CIPR (1931) noted heavy infestations in the Indian Head district of Saskatchewan, where 90% of the buds of wild rose, rugosa rose, and rugosa rose hybrids suffered damage. Robertson (1923) stated that variations in the degree of infestation among native and cultivated roses (i.e., *Rosa rugosa* Thunb., *R. acicularis* Lindl., and *R. blanda* Ait.) are a result of location as well as varietal susceptibility. Plants protected by trees are less infested, probably because *M. bicolor* prefers bright sunshine. The insect also attacks bramble fruits (Neilson and Arrand 1961, Gerber et al. 1974).

The adults cause the major damage by chewing holes in the buds of roses and brambles for feeding and oviposition (Neilson and Arrand 1961, Gerber et al. 1974, Philip 1977). According to Robertson (1923), the adult may often chew 20 or more holes in the same bud and occasionally a few in the hip. Injured buds are deformed and usually do not open, or the flowers have petals riddled with small holes (Gerber et al. 1974, Philip 1977). The adults do not harm the vigor of the plants but may considerably reduce the number of blossoms (Philip 1977).

Robertson (1923) stated that the early instar larvae live for a short time within the flowers and then proceed to the hips, where they feed on the seeds during the latter part of August.

Biology: The species overwinters in the larval stage in the soil at depths of 4–10 cm around the base of the host plants (Robertson 1923, Philip 1977). In Manitoba, pupation begins around the middle of May, and the first adults appear about 2 weeks later, becoming quite numerous by the middle of June (Robertson 1923). Gerber et al. (1974) pointed out that the roses and brambles are in bud by the time the beetles emerge in the spring. Mating begins a few days after feeding, and egg-laying starts near the end of June (Robertson 1923). The eggs are deposited in deep punctures made in the bud. Usually only one egg or, rarely, two are laid in each bud. The eggs begin to hatch around the second week of July. Most of the adults disappear in July, but some have been observed as late as 7 August because of late pupation.

The larvae live for a brief period within the flowers before moving to the hips, where development takes place rapidly (Robertson 1923). Only one fully matured larva survives in each hip. The larvae drop to the ground – beginning around 4 September (Robertson 1923) – to overwinter after completing their development inside the buds (Neilson and Arrand 1961, Gerber et al. 1974, Philip 1977). Only one generation occurs each year.

Mononychus vulpeculus (Fabricius)
iris weevil
charançon de l'iris (m.)

Distribution: Ontario and Quebec.

Economic injury: The iris weevil caused significant damage to the seedpods of cultivated iris in Ontario (Gibson 1934) and has been reported as abundant on this host in Quebec (CIPR 1937). Fyles (1910) reported a heavy infestation of this species on the seedpods of blue flag in Quebec. *Mononychus vulpeculus* attacks Japanese, European, and native varieties of iris (Gibson 1934).

Injury to the seedpods of cultivated iris is due to the feeding punctures of the adults, which lead to the development of rough, corky, irregular scars (Gibson 1934).

Biology: Known parasites include the ichneumonids (Hymenoptera) *Iseropus coelebs* (Walsh) and *Pimpla pterelas* (Say) (Graham 1965).

Omias saccatus (LeConte)
(sagebrush weevil)
charançon de l'armoise (m.)

Distribution: British Columbia.

Economic injury: This species, with *Cryptolepidus parvulus* Van Dyke, caused serious injury to seedling apricots, cherries, and peaches at Summerland, B.C., by destroying the vegetative buds and often killing the trees (MacNay 1949).

Otiorhynchus ligneus (Olivier)

Distribution: New Brunswick, Nova Scotia, and Prince Edward Island.

Origin: This species is native to the Palaearctic region and is widely distributed in central and northern Europe (Warner and Negley 1976). The first Canadian records of *O. ligneus* appear to be specimens collected from New Brunswick, in 1917, and from Nova Scotia, in 1927 (Brown 1940*b*).

Economic injury: The damage of *O. ligneus* is similar to that of other species of the genus. In Nova Scotia, the species is reported to enter dwellings but not to cause damage (Gibson and Twinn 1939). Cultivated plants attacked include lettuce in North America and peach and chrysanthemum in Europe. Additional host plants for this species include *Diplotaxis tenuifolia* (L.) DC. and *Reseda luteola* L. (Warner and Negley 1976).

Biology: This is one of the few species of *Otiorynchus* for which the males have been found in North America (Werner and Negley 1976).

Otiorhynchus ligustici (Linnaeus)
alfalfa snout beetle
charançon de la luzerne (m.)

Distribution: Wolfe Island, Ont.

Origin: *O. ligustici* is native to the Palaearctic region, where it occurs from England and Scotland, through northern and central Europe to Siberia, and south to Italy (Warner and Negley 1976). The weevil appeared in destructive numbers in the Oswego area of New York, along the eastern shore of Lake Ontario in 1933 (Herrick 1933). A specimen in the United States National Museum labeled Oswego, N.Y., 4 May 1896, suggests that the species may have been in the area many years before it was noticed (Palm 1934, Claassen and Palm 1935). The first Canadian record of *O. ligustici* is that of specimens found on Wolfe Island in the St. Lawrence River about 1965 (Becker 1977).

Economic injury: On the preferred host, alfalfa, the main damage is done by the larvae, which feed on the roots. They cut off the side roots, girdle the main tap roots, and finally cut them off (Claassen and Palm 1935). They not only feed on the surface of the taproot, often leaving a deep spiral groove, but they also bore up through the heart of the root itself, leaving a shell of the cortex intact (Palm 1934). In North America, larvae have been observed feeding on the roots of cinquefoil, various clovers, dock, goldenrod, grape, various grasses, millfoil, sorrel, strawberry, and wild carrot. Adults feed voraciously on a number of host plants, but feeding is most pronounced on alfalfa and clover. All growth of tender shoots is attacked by the adults, but much of the feeding is confined to the basal parts (Palm 1935, 1936*a*). Other cultivated plants on which adults have been observed feeding include apple, asparagus, grape, raspberry, rhubarb, and strawberry (Claassen and Palm 1935).

Biology: The life history and ecology of *O. ligustici* in New York State was investigated by Palm (1934–1936*a*), Claassen and Palm (1935), and Lincoln and Palm (1941).

The species overwinters in the adult stage in the pupal cells. Oviposition began in the latter part of May. Eggs were laid singly by the parthenogenetic females around the crown of the host plants in the upper 5 cm of the soil. In wet weather, eggs were deposited on the soil surface. The average number of eggs laid per beetle was over 300. The incubation period lasted 12–13 days at 27°C. Hatching was retarded at low soil moisture.

The newly hatched larvae began feeding on the crowns of the host plants, but they soon burrowed down to the root. In loamy soils, the taproot of alfalfa is usually severed at depths of 30–46 cm. Larvae feed at greater depths in sandy soil and have been recorded at depths of 1.5 m. At heavier population levels, larvae fed nearer the soil surface. Larvae continued to feed until the end of November, when they began to overwinter in cells in the soil at an average depth of 28 cm.

After passing through seven instars, pupation took place from the beginning of June to the end of July. The pupal stage lasted 11–61 days at 33–11°C, respectively. Transformation to adults began on 10 July, with the last recorded on 3 September. The new adults remained in the pupal cells until the following spring.

Adults emerged from the cells in late March and early April and began to appear at the soil surface by 11 April. The flightless adults fed for the first 2 weeks after emergence and then dispersed in search of oviposition sites. The peak dispersal occurred from 8 to 10 May during daylight hours. The adults were active at soil surface temperatures of 24–29°C. The 2-year life cycle may extend to 3 years for some individuals. Life cycles alternated so that some adults emerged every spring.

Larvae were parasitized by the nematode *Neoaplectana chresima*. An unknown entomophagous fungus was also observed attacking the pupae.

Otiorhynchus ovatus (Linnaeus)
strawberry root weevil (pitchy legged otiorhynchus, strawberry crown girdler, sleepy weevil)
charançon de la racine du fraisier (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This is a well known and widely distributed Palaearctic species (Warner and Negley 1976). The first North American report of this weevil was from Massachusetts, as early as 1852 (Wickham 1894).

Economic injury: Although a general feeder, *O. ovatus* frequently damages strawberry (Warner and Negley 1976). The adults are responsible for only slight feeding on the stems and margins of the leaves, similar to that produced by *O. sulcatus*, except the adults of *O. ovatus* also eat small holes in the strawberry fruit (Downes 1932). In early spring and fall, adults sometimes become a nuisance when they enter houses during their migration (Alberta Agriculture 1978). Fletcher (1899*b*) reported that the adult weevil bites humans.

Most damage is caused by the larvae, which feed on strawberry, raspberry, various clovers, grasses, and nursery evergreens (Alberta Agriculture 1978). The main injury to the host plants, as described by Treherne (1912), is caused by the larvae, which feed on the roots at all depths in the soil. Portions of the epidermis of the roots are eaten, and later the root is girdled in a spiral pattern. There is a general tendency of the larvae to burrow down to the finer roots and gradually work their way to the surface. The most serious damage is done in the spring, when the larvae are nearly full grown and can attack the main roots.

Other cultivated plants attacked by *O. ovatus* include alfalfa, apple, azalea, beans, begonia, blackberry, blueberry, borage, cabbage, carrot, cauliflower, cherry, cranberry, currant, cyclamen, grape, hops, holly, loganberry, mint, peach, pear, periwinkle, polyanthus, potato, primrose, rhododendron, rhubarb, and rose.

Biology: This parthenogenetic weevil overwinters in both the larval and adult stages. Overwintered adults emerge in spring, feed for about 2 weeks, and migrate in search of host plants around which to lay their eggs (Alberta Agriculture 1978). Overwintered larvae feed ravenously in the spring until the pupal stage is reached in early summer (Brittain 1914). The pupae form in earthen cells about 2.5–7.5 cm deep in the soil. Adults from overwintered larvae emerge later in the summer and start laying eggs shortly thereafter (Evans 1961).

The eggs are laid singly in the soil to a depth of about 1 cm, in crevices made in the soil by the crown of the plant, on particles of soil filling the crown below the surface, or under debris directly on the soil surface (Treherne 1912). The incubation period lasts approximately 2–3 weeks, and newly hatched larvae begin feeding immediately (Philip 1977). Each female is capable of laying 200–300 eggs, after which she dies (Alberta Agriculture 1978). There is some evidence that overwintered adults lay fewer eggs than newly emerged adults and that the latter lay eggs over a longer period, ceasing the first week in September (Downes 1932). Larvae that hatch from eggs laid early in the summer are transformed into adults in the fall. Larvae that hatch in late summer overwinter in the soil and are transformed late the following summer (Alberta Agriculture 1978). Larvae overwinter in earthen cells in the soil (Treherne 1912), and adults overwinter under clods and stones, among grass roots, under piles of rubbish, and even among strawberry crowns (Downes 1932).

Adults are nocturnal and gregarious (Downes 1932), remaining inactive during the day in crevices in the soil or under leaves and debris; feeding and ovipositing take place at night (Treherne 1912). According to the same author, the adults feign death when disturbed and remain inactive for some time after the disturbance. Migrations occur in early summer in search of oviposition sites and in autumn, in search of hibernation quarters (Downes 1932). A third migration in summer, before the oviposition of the new adults, may also exist (Alberta Agriculture 1978). In British Columbia the species is most prevalent on light or sandy soils (Andison 1956).

Otiorhynchus porcatus (Herbst)

Distribution: Quebec and Newfoundland.

Origin: This species is native to the Palaearctic region in central Europe (Warner and Negley 1976). A single specimen of this species was taken at Montreal, Que., in 1937 (Brown 1940*b*).

Economic injury: This species is known to attack primrose and saxifrage in Europe and lilac and viburnum in North America. The symptoms of attack and damage resemble those of *O. sulcatus* (Warner and Negley 1976).

Biology: The males of this species have been found in North America, unlike most species in the genus (Warner and Negley 1976).

Otiorhynchus raucus (Fabricius)

Distribution: Ontario.

Origin: This European species was reported as new to North America in 1936, at Fonthill, Ont. (Hicks 1947).

Economic injury: In Europe the larvae are serious pests of cultivated rhubarb and garden vegetables (Balachowsky 1963). Adults feed on the foliage and young shoots of apple, cherry, and pear and the petioles of olive. Other European hosts include clover, grape, and pine (Warner and Negley 1976). In North America *O. raucus* has been reported from arborvitae, juniper, Manitoba maple, raspberry, and spruce (Hicks 1957).

Biology: The adults of this weevil are diurnal (Balachowsky 1963).

Otiorhynchus rugifrons (Gyllenhal)

Distribution: New Brunswick, Nova Scotia, and Newfoundland.

Origin: This northern and central European species (Warner and Negley 1976) was first recorded in North America at Sydney, N.S., in 1884 (Harrington 1891).

Economic injury: *O. rugifrons* is known to be a pest of strawberry and saxifrage in Europe (Werner and Negley 1976).

Otiorhynchus rugosostriatus (Goeze)
(rough strawberry root weevil)
charançon à stries rugueuses (m.)

Distribution: British Columbia, Ontario, Quebec, and Nova Scotia.

Origin: Warner and Negley (1976) stated that this European species is widely distributed in the western part of the Palaearctic region. They also interpret Horn's (1876) *O. rugifrons* as the first North American record of *O. rugosostriatus* from the central Atlantic states.

Economic injury: Injury caused by this weevil is similar to that of the black vine weevil. This weevil is occasionally a pest of strawberry when sod is broken for planting (Cram and Neilson 1978). This species has also been reported to feed on cyclamen, holly, privet, rose, raspberry, and primrose (Warner and Negley 1976).

Biology: The life history of this species is similar to that of the black vine weevil. However, the eggs are not laid until early August and adults often appear later than do those of *O. sulcatus* (Cram and Neilson 1978).

Otiorhynchus singularis (Linnaeus)
(clay-colored weevil, raspberry weevil)
charançon gris des racines (m.)

Distribution: British Columbia, Ontario to Nova Scotia, and Newfoundland.

Origin: This weevil is native to the cooler western and central regions of Europe (Warner and Negley 1976). Under the synonym *O. picipes*, the species was first recorded in North America in 1872 from Essex, Mass. The first Canadian records are probably the specimens collected in Montreal, Que., and Guelph, Ont., in 1902 and 1904, respectively (Brown 1940*b*).

Economic injury: This species is a serious pest of raspberry and other small fruits, ornamentals, and seedling conifers (Gerber et al. 1974). Like *O. ovatus* and *O. sulcatus*, the larvae of this weevil attack the roots, and the adults feed on the foliage of a variety of host plants. The greatest damage is by the nocturnal feeding of the adults, which at times completely strips the foliage (Andison 1941). The adults feed on raspberry buds early in the spring, inhibiting the growth of lateral fruiting arms later in the season (Cram and Neilson 1978). Other plants attacked by this species in North America include apple, campanula, holly, iris, laurel, primrose, rhododendron, and strawberry.

Biology: The life history, which is similar to that of *O. ovatus*, was outlined by Andison (1941) at Victoria, B.C. The adults emerged from the soil earlier than did those of *O. ovatus* and started feeding immediately. During the late spring and early summer, the eggs were laid in the soil by the parthenogenetic females. They overwintered as half- to full-grown larvae, forming the pupal cell in March. Some of the adults that emerged in the spring had not completed oviposition by September and overwintered as adults. These continued to lay eggs the following spring. Light soils are especially favorable to the development of this species, although it has been known to attack plants grown in clay soils.

Otiorhynchus sulcatus (Fabricius)
black vine weevil (Taxus weevil, cyclamen grub, black grape-vine weevil)
charançon noir de la vigne (m.)

Distribution: British Columbia, Saskatchewan to Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This introduced species is widely distributed in northern and central Europe as far south as France and Italy (Warner and Negley 1976). Hagen (1890) gave evidence that this species has been known in North America since 1831.

Economic injury: The main damage is caused by the larvae feeding on cane fruits, ornamentals, nursery stock, and greenhouse plants (Gerber et al. 1974). The larvae feed on root hairs and bark; they tunnel into large fleshy roots or girdle roots and bark, moving up to the plant crown (Neilson 1957*a*). The plants wilt, weaken, and sometimes die. The larvae also tunnel into the plant crown at soil level. The adults injure the plants by chewing characteristic notches on the edge of the leaves (Gerber et al. 1974). Some of the plants attacked include arborvitae, azalea, begonia, blackberry, blueberry, clematis, clover, cranberry, cyclamen, dracaena, ferns, gloxinia, grape, grasses, juniper, hemlock, holly, loganberry, polyanthus, potato, primrose, raspberry, rhododendron, rose, *Spiraea* sp., strawberry, wallflower, and yew. Warner and Negley (1976) stated that the larvae of this species have been recorded from over 100 plant species. The adults of this genus generally feed on a wider range of plants than the larvae.

Biology: This weevil is flightless (Goble 1969*a*) and parthenogenetic (Cram 1970), producing one generation a year (Cram 1965). Winter is spent mostly in the larval stage (Chamberlain et al. 1964), but a few adults may survive until spring in protected headlands or old buildings (Cram and Neilson 1978). Pupation occurs in a cell made in the soil (Cram and Neilson 1978). Adults emerge in early June and lay eggs from July to mid September (Chamberlain and Putnam 1964). Adults feed for about a month before laying eggs (Cram and Neilson 1978). Individuals in confinement have laid as many as 470 eggs, with an average of 300 per weevil (Downes 1932). Females that survive the winter may continue to lay eggs the next spring and summer (Cram 1965).

The adults of *O. sulcatus* are nocturnal and confine their activities to microclimates, where the humidity is near saturation (e.g., the damp soil under plant debris during the day and relatively dense foliage at night) (Cram 1965). Andison (1956) suggested that this species prefers heavier soil types than the congeneric species *O. ovatus*.

Zimmermann (1982) showed that the entomopathogenic fungus *Metarrhizium anisopliae* (Metsch.) Sorok. can infect young eggs.

Panscopus aequalis (Horn)

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: MacNay and Creelman (1958) reported the species to be a pest of peach in British Columbia.

Pantomorus cervinus (Boheman) (*fulleri* Horn, *godmani* Crotch)
Fuller rose beetle
charançon du rosier (m.)

Distribution: Ontario.

Origin: This species is probably native to the Neotropical region and was probably introduced from Mexico (Chittenden 1901).

Economic injury: The Fuller rose beetle is primarily a greenhouse pest and often severely damages and destroys roses and various other greenhouse plants (Chittenden 1901; Gibson and Ross 1922, 1940; Gibson 1934). Although the insect has been recorded as a garden pest of canna, azalea, rose, and other flowering plants in the United States, it has not as yet been injurious outdoors in Canada (Gibson 1934). Fletcher (1890) stated that *P. cervinus* may be found in greenhouses from the Atlantic to the Pacific coast. In 1889 a serious infestation in an Ottawa greenhouse occurred in which the adults attacked the foliage of roses and lilies, and the larvae attacked the roots of roses and begonias (Gibson and Ross 1922, 1940). Abutilon and plumbago have been attacked in other greenhouses in Canada. Roses are the preferred hosts, with geraniums and perhaps lilies next (Fletcher 1890, Chittenden 1901). Additional hosts reported from the United States include rose-mallow, dracaena, orange, lemon, cape jasmine, Java plum, *Achyranthes*, cissus, inchplant, carnation, primrose, oak, camellia, and palm (Chittenden 1901).

The main damage is caused by the larvae, which feed on the roots; the adults attack the foliage, buds, and flowers. The larvae feed first on the fine roots and then, as they grow, on the larger ones until there is nothing left but a few stubs (Chittenden 1901, Gibson 1928). Wood that has been attacked by larvae is weak and spindly, with an unhealthy color and few flowers (Fletcher 1890). Such plants seldom recover. The adults feed principally on the leaves, but do more damage by severing them than by the amount of foliage they eat (Chittenden 1901). It was noted that the adults often trim off, as quickly as they appeared, the new shoots of a plant that was permitted to stand alone.

Biology: The nocturnal adult is usually quiescent during the day, hiding under or among the leaves of its host plant or clinging to the twigs or smaller branches so that it is not readily seen (Fletcher 1890, Chittenden 1901). At night the adults are very active and feed voraciously. The adults are flightless (Gibson and Ross 1922, 1940) and depend on humans for their dispersal (Chittenden 1901). When disturbed the adults drop to the ground, draw their legs and antennae tightly to their bodies, and feign death for a considerable period, resembling, because of their color, a small lump of dry earth (Fletcher 1890, Chittenden 1901). The parent beetles are long-lived and have been kept in confinement for almost 3 months (Fletcher 1890). According to Chittenden (1901), the beetles are often found congregated around the plants in November and December.

The eggs are laid in flattened batches made up of several contiguous rows, with 10–60 eggs per batch (Fletcher 1890, Chittenden 1901). The usual site of oviposition appears to be at the base of the plant just above the ground, where the eggs are pushed between the loose bark and the stem; some eggs may also be deposited around the main stem just at the surface of the ground. The eggs hatch in about a month (Gibson and Ross 1922, 1940).

On hatching, the pale yellow larvae burrow immediately into the soil and begin feeding (Fletcher 1890; Chittenden 1901; Gibson and Ross 1922, 1940). According to Chittenden (1901), the larval stage is passed entirely in the ground and requires 1–3 months. Pupation also occurs in the ground, the adults emerging in about 3 weeks (Fletcher 1890). Because *P. cervinus* prefers to live indoors, the duration of each stage is variable (Chittenden 1901). All stages may be detected during the winter and early spring, with most injury occurring in December.

A wireworm, doubtfully referred to as *Drasterius amabilis* Lec., preys upon the larval stage of the Fuller rose beetle (Chittenden 1901).

Paraptochus sp. (or near)

Distribution: British Columbia.

Economic injury: According to MacNay and Creelman (1958), the insect is a pest of cherry (or wild cherry) in British Columbia.

Pentarthrum huttoni Wollaston
charançon des parquets (m.)

Distribution: Quebec and Newfoundland.

Origin: This European species (Great Britain, Belgium, The Netherlands, and France) was first discovered in North America in 1934, in flooring in Quebec City, Que. (MacNay 1954*a*).

Economic injury: Warner (1952) estimated a severe infestation from the small piece of old, rotten floorboard received from Quebec. Less than 6.5 cm^2 of flooring contained four larvae and 8–10 adults, and the wood was nearly reduced to fine powder. The insect commonly infests floorboards, but in Europe it has been reported from the hollows of worm-eaten wood of chests, casks, and other wooden cases and on *Broussonetia papyrifera* (L.) L'Her. In England, *P. huttoni* was extracted from the winding burrows of a piece of hard, undecayed cherry tree.

Both the adults and larvae have been observed feeding in rotten wood that was slightly wet (Warner 1952).

Phyllobius oblongus (Linnaeus)
(European snout beetle)
charançon radicicole européen (m.)

Distribution: British Columbia, Ontario, New Brunswick, and Prince Edward Island.

Origin: This European insect has been reported from Aikenville and Galt, Ont., in 1950 and 1952, respectively (MacNay 1954*a*). *Phyllobius oblongus* has been observed in New Brunswick and New York State in recent years.

Economic injury: This leaf-eating weevil attacks fruit and shade trees (MacNay 1954*a*). It has been found on white elm and walnut in Ontario. The larvae feed on the roots of strawberry and other plants.

Phyllobius sp.

Distribution: Ontario.

Economic injury: CAIPR (1976) reported that the insect feeds on the petals of blueberries and strawberries in Ontario. No adverse effects were noted from the small holes that the insects made.

Pissodes approximatus Hopkins
northern pine weevil
charançon du tronc des pins (m.)

Distribution: Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: The economic injury of the northern pine weevil was described by Finnegan (1958). This species has recently been increasingly important in southern Ontario, especially in areas where pine trees, particularly Scots pine, are grown in pure stands to be sold as Christmas trees. In several such locations the stumps of the previous year's cutting have provided breeding sites that allow populations to build up to epidemic proportions. Damage caused by adults feeding on the twigs and small branches of the remaining trees has been serious; the quality and value of these trees have been reduced, and in some cases, the trees have been killed. In 1956, over 5% of the trees in a Scots pine plantation near Paris, Ont., were killed in the second-year attack. The northern pine weevil usually breeds in the inner bark of dead or dying pines. One- and two-year-old seedlings to mature trees may be attacked, with injury occurring from the roots up to branches as small as 1.3 cm in diameter. Recent transplants are especially susceptible to attack. The larval population in five 9-year-old, heavily infested, Scots pines averaged

224 larvae per 0.1 m^2 of bark in the bottom 0.6 m of the trunk. *Pissodes approximatus* has been reported on many varieties of pine—Austrian, eastern white, jack, pitch, red, scrub, shortleaf, and table-mountain.

The overwintered adults feed on the inner bark of pine branches and on the stems of seedlings and small trees. They show a preference for the underside of low-lying branches in contact with the litter. The adults chew out large portions of the inner bark from small punctures made through the outer bark. These fresh wounds differ from those made by *Hylobius pales* (Hbst.) and *H. radicis* Buch., two other weevils that are often associated with the northern pine weevil on young pines, in that the *Hylobius* species chew irregular pits in both the outer and inner bark. The injuries, however, become similar as the bark of the twigs injured by the northern pine weevil becomes weathered and the outer bark flakes off.

Newly hatched larvae begin feeding immediately in the cambial layer and usually mine in either direction along the grain of the wood. The length of larval mines averaged 0.8 cm in the first instar, 2.2 cm in the second instar, 3.6 cm in the third instar, and 25.3 cm in the fourth instar. If the bark is too thin for pupal chambers, larvae may bore into the centre of the stems of seedlings to pupate.

Biology: The biology of this species was described by Finnegan (1958). In southern Ontario the northern pine weevil overwinters mainly in the adult stage in the duff and top soil overlying the roots and under scales and crevices of the rough outer bark; it also overwinters in the larval and pupal stages in pine trees. The overwintered adults appear in early May and feed for about 3 weeks; the overwintered larvae and pupae emerge in the adult stage in late June and July. During the second half of May, the adults fly off in masses to find suitable oviposition sites. The availability of these sites is the main factor controlling the population density of the weevil. The adults mate at this time, and egg-laying starts around the end of May.

The eggs are usually laid singly in cavities eaten into the inner bark by the female, although groups of four or five eggs may be found together. Although the preferred oviposition sites are on the rougher bark at the branch nodes, eggs may also be deposited anywhere on the trunk and large branches. The average number of eggs laid by nine females in the insectary was 47, and one female laid 62. Egg-laying is usually completed before the end of the first week of July, after which the adult population declines rapidly. However, a few females were observed ovipositing as late as early September. The eggs required an average incubation period of 8.6 $\pm$ 1.6 days.

The larvae, which begin feeding immediately after hatching, pass through four instars and complete development in approximately 36 days. When the larvae become full grown, they construct "chip cocoons" in the outer surface of the wood in which pupal development takes place after 3 or 4 days. The pupal period averaged 14.8 $\pm$ 0.7

days. An average of 59.8 ± 10.2 days was required by 42 weevils to develop from egg to adult. Approximately 5 days are spent in the pupal chamber by the newly transformed adults before they chew their way to the outside.

The new adults began to appear on 26 July, emerging in large numbers between about 15 August to 10 September. The number of males and females emerging was approximately equal. The adults continue feeding until cold weather forces them to hibernate, but the females do not mate or lay eggs until the following summer. The percentage of each overwintering stage is largely dependent on when the breeding material becomes available to the weevils during the year. A complicated seasonal history, with generations of both one and two years' duration, results from the fact that the insect may overwinter in the larval, pupal, or adult stage and that there is a long oviposition period.

A vipionid ectoparasite of the genus *Coeloides* killed up to 35% of the larval population. Sap suckers and woodpeckers may devour large numbers of larvae, pupae, and adults from under the bark. The downy woodpecker, *Dendrocopus pubescens medianus* (Swainson), reduced the weevil population by up to 90% in individual trees.

Pissodes strobi (Peck)
white pine weevil, Engelmann spruce weevil, Sitka spruce weevil
charançon du pin blanc (m.)

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: The white pine weevil was reported by Swaine and Hutchings (1926) to be the most serious pest of white pine in eastern Canada. Severe damage has been inflicted to a large percentage of the young growth of white pines in several localities in Ontario and Quebec (Swaine 1917). Although eastern white pine is the principal host of *P. strobi*, the insect also occurs on jack, Scots, and dwarf Scots pine; fir; and Norway and red spruce (Swaine and Hutchings 1926, Metcalf et al. 1951, MacNay 1960, Philip 1977). Damage is most severe to young trees—trees less than 25 years old (Philip 1977) or trees 5–22 cm in diameter and 1.6–8 m high (Washington State University 1978)—and to those growing in open (Agriculture Canada 1957*b*) or in pure or almost pure stands (Swaine 1917).

The chief damage results from the larvae, which feed on the terminals or leaders of the host trees (Philip 1977). The larvae tunnel into and feed downward, destroying the inner bark (Swaine 1917, Goble 1969*a*, Philip 1977). Metcalf et al. (1951) noted small drops of resin exuding from the many "shot holes" made in the bark by the larvae. When infestations are heavy, the leaders are thoroughly riddled and the tree dies around midsummer (Swaine and Hutchings 1926). The bud, the year-old growth, and occasionally the 2- and

3-year-old growth are killed (Agriculture Canada 1957*b*). The death of the terminal results in an upward bending of the more vigorous of the uppermost whorl of lateral shoots (Swaine 1917). These new terminals are often attacked, and the timber and aesthetic value of the tree are destroyed. The trees are rarely killed, but continued yearly attacks result in their developing bunch tops and forked or bent trunks (Agriculture Canada 1957*b*).

The adults chew holes in the bark, and these holes as well as those made by the larvae provide favorable entry sites for wood-rotting fungi (Philip 1977).

Biology: The species overwinters in the ground litter under the host tree (Goble 1969*a*, Philip 1977). Some larvae or pupae may overwinter in the terminal and transform to adults the following spring (Washington State University 1978). The adults emerge in April and crawl or fly to the tree terminals where they feed, mate, and lay eggs (Swaine 1917, Agriculture Canada 1957*b*, Goble 1969*a*). According to Swaine (1917), the period of mating and oviposition extends from April through June. The eggs are deposited in cavities gnawed in the bark (which may exude a small drop of resin), usually just below the terminal buds (Swaine 1917, Agriculture Canada 1957*b*). The incubation period is approximately 10 days (Washington State University 1978).

The larvae may be found feeding on the inner bark and wood during the summer (Swaine 1917, Philip 1977). The feeding period may vary from 5 to 8 weeks (Agriculture Canada 1957*b*, Philip 1977). The larvae reach maturity by about midsummer and then tunnel into the wood, passing through to the pith on the younger wood (Swaine 1917). "Chip cocoons" are constructed either partly or entirely below the wood surface in the enlarged ends of tunnels (Agriculture Canada 1957*b*, Philip 1977). They remain in these chambers for nearly 14 days before transforming to adults (Agriculture Canada 1957*b*).

The new adults emerge from the shoots in late summer (Swaine and Hutchings 1926) or early fall (Philip 1977). They feed for a short time before seeking winter quarters (Agriculture Canada 1957*b*, Philip 1977). Only one generation occurs each year.

Plinthodes taeniatus (LeConte)

Distribution: British Columbia.

Economic injury: MacNay (1951) reported that *P. taeniatus* caused extensive damage to the foliage of strawberry at Sooke, on Vancouver Island.

Polydrusus impressifrons Gyllenhall
(leaf-weevil)

Distribution: Manitoba and Ontario.

Origin: According to Sheppard (1955), the leaf weevil is native to Europe and was accidentally introduced into New York State early in the present century.

Economic injury: *Polydrusus impressifrons* caused noticeable injury to the foliage of ornamental weeping willow in Niagara Falls, Ont. (CIPR 1941). Sheppard (1955) stated that the insect has become firmly established and increasingly common in the eastern end of the Niagara Peninsula over the past few decades. In the United States the species has been reported to be a pest of shade and fruit trees (Parrott and Glasgow 1916). The beetles feed on the foliage of a large number of plants but prefer birch, willow, poplar, apple, and pear. Scattered individuals have on occasion been taken on elm, rose, linden, and black locust.

The adults feed on the unfolding buds and then attack the foliage, especially the margins of the leaves (Parrott and Glasgow 1916). Serious injury may result when a large number of beetles are confined to a relatively small feeding area. In a nursery plantation of willow, the weevils killed a high percentage of the opening buds or damaged the buds, causing imperfect clusters of leaves. Feeding on the edges of the leaves caused the leaves to have an uneven or ragged appearance. No injury to the buds of poplar, birch, apple, or pear has been observed. The larvae feed on the roots and can live exclusively on willow, poplar, and birch.

Biology: According to Parrott and Glasgow (1916), in New York *P. impressifrons* overwinters in the larval stage; the larvae pupate in late April and early May in pupal cells in the soil at an average depth of about 5 cm. The adults emerge during the latter part of May and early June, mate freely on the foliage, and begin to lay eggs by the end of May. The eggs may be deposited singly or in masses but most often in clusters of 20–25 eggs. They are laid in cracks or crevices in the bark, as high as 3 m from the ground, and among loosened bud scales on twigs or wood on the ground. They choose almost any dry cavity exposed to sunlight. Egg laying is most active during early June. The average incubation period under normal conditions is between 12 and 13 days. The newly hatched larvae fall to the ground and enter the soil to feed on the tender roots.

Pseudanthonomus validus Dietz
currant fruit weevil

Distribution: Ontario and Nova Scotia.

Economic injury: The main injury is caused by larvae, which feed on the pulp of blueberry fruit (Maxwell and Wood 1961). Most of the infested berries drop to the ground after larval development. The adults cause little damage to the berries unless they are present in large numbers.

Biology: Maxwell and Wood (1961) have described the biology of the currant fruit weevil. The eggs are deposited in the calyx lobes of the berries while they are small and green. Hatching occurs in late June or early July in Nova Scotia. The larval feeding period lasts for about a month, after which the larvae change to pupae in the berries. Pupation takes 9 or 10 days. Both the larval and pupal stages may be found in the berries as they begin to ripen. In about a week to 10 days, most of the larvae pupate, and about a week later most of the infested berries drop. The new adults begin to appear in early August.

Rhynchaenus pallicornis (Say)
apple flea weevil
orcheste du pommier (m.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Economic injury: The apple flea weevil has been reported to be a pest of apple in Ontario (MacNay and Creelman 1958) where it caused, for the first time on record in Canada, noticeable foliage injury in an apple orchard (MacNay 1951). The species has been especially injurious in Ohio and Illinois (Hatch 1971). Hawthorn, crab apple, wild crab apple, elm, hazelnut, chokecherry, quince, and blackberry may also be attacked (Goble 1963, Davidson and Lyon 1979).

Damage is caused by adults, which feed on the opening buds and leaves, and by larvae, which mine the leaves (Davidson and Lyon 1979). According to Metcalf et al. (1951), the opening leaves and buds are punctured by adults in the spring; they chew small holes into the underside of leaves during the summer. Injury to the leaves, when severe, resembles that made by fine birdshot. The yellowish brown larval mines begin near the middle of the leaf and extend to small blisterlike cells at the leaf margin.

Biology: The insect overwinters in the adult stage under various debris, usually beneath apple trees (Metcalf et al. 1951). The adults emerge in the spring, when they either crawl or fly to the newly opening buds and leaves. They feed for 1–2 weeks and begin to lay their eggs along the midribs when the leaves are about two-thirds grown. The larvae mine the leaves and hollow out cells at the leaf margin (about 6 to 7 mm across) in which to pupate. According to Davidson and Lyon (1979), the larvae reach maturity in 2 weeks or longer. In late May or early June, the new adults appear and feed for about a month. Only one generation is produced each year.

Rhynchaenus rufipes (LeConte)
willow flea weevil
orcheste du saule (m.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, Nova Scotia, Newfoundland, and Yukon Territory.

Economic injury: The willow flea weevil was recorded for the first time in Alberta, when it was observed attacking *Salix pentandra* L. in Edmonton (MacNay 1955). In Canada, it had previously been collected in Manitoba and eastward (MacNay 1961).

Rhynchaenus uniformis (Brown)

Distribution: Alberta, Saskatchewan, and Manitoba.

Economic injury: The species was reported to mine the leaves of cotoneaster in Alberta, constituting a new record for the province (CAIPR 1972).

Rhynchites aeneus (Boheman)

Distribution: Saskatchewan and Manitoba.

Economic injury: Beirne (1971) reported the species to be an insignificant pest of sunflower in Manitoba, where it first caused damage in 1957. Previous injury has not been serious and has been limited to field margins (Turnock 1977). In one instance, 9% of the heads of sunflower were cut off along the margin of a field northwest of Altona, Man. (MacNay 1957*b*). The insect attacks chiefly volunteer sunflowers (Beirne 1971) and also occurs on wild rose (Turnock 1977).

Rhynchites aeneus is a stem feeder that can decapitate sunflowers in the prebloom stage (Beirne 1971, Turnock 1977).

Biology: Little is known about the life history of this species. Turnock (1977) suggested that because the attacks on sunflower are restricted to field margins, the species has not become fully adapted to the sunflower plant as a host and that it cannot cope with winter conditions in the open field. The availability of mature hosts along the field margins may dictate the abundance and presence of the insect in the sunflower fields.

Sciaphilus asperatus (Bonsdorff) (= *muricatus* Fabricius)

Distribution: Nova Scotia.

Economic injury: Twinn (1933) reported this species in great numbers on a market garden farm near Yarmouth, N.S. Damage was most evident to young cabbage seedlings.

Sciopithes obscurus Horn
obscure root weevil (obscure strawberry root weevil)

Distribution: British Columbia.

Economic injury: This root weevil has been reported to be a sporadic pest of commercial strawberry (Cram and Neilson 1978). The species has apparently become less important since the advent of insecticide-treated soil. *Sciopithes obscurus*, which normally feeds in the forest under shrubs in the Pacific coast area, is known to attack ornamentals (rhododendron in particular), seedling conifers, raspberries, and other small fruits (Cram 1965, Gerber et al. 1974, Cram and Neilson 1978).

The larvae feed on the roots and the adults chew on the margins of the leaves (Gerber et al. 1974). The main damage is caused by the larvae, which may weaken or kill some plants. The adults are especially injurious to the foliage of rhododendron (Cram and Neilson 1978).

Biology: Gerber et al. (1974) noted that the life history of the obscure root weevil is similar to that of *Otiorhynchus* spp. It overwinters both in the larval stage in the soil and in the adult stage (Cram 1965, Cram and Neilson 1978). Only a few adults normally survive the winter and resume egg-laying the following spring (early May) and summer. The overwintered larvae begin feeding again in the early spring and pupate around the middle of May (Cram and Neilson 1978). Cram (1965) reported that teneral adults emerge from the soil in June and oviposit from July to September. Oviposition occurs within a fold in the leaf margin (Cram and Neilson 1978). *Sciopithes obscurus* is parthenogenetic and flightless and usually occurs on new land or near wooded areas (Cram 1962, 1965). The adults are nocturnal and are found in areas where the humidity is always near saturation (i.e., on damp soil under plant litter during the day and on relatively dense foliage during the night) (Cram 1965). The species appears to be able to withstand drying diurnal conditions. The larvae feed on the roots in the fall before hibernating in the soil. Only one generation is produced annually.

Sitona cylindricollis (Fåhraeus)
sweet-clover weevil
charançon du mélilot (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Origin: This European species was first reported in North America in 1924 from Hemmingford, Que. (Bird 1947, 1949). Beirne (1971) stated that *S. cylindricollis* invaded Quebec in 1924 from the south, but no record before 1932 (Middlebury, Vt.) has been reported from the United States (Caesar 1935). In 1928 the sweet-clover weevil was abundant in the area of Ottawa, Ont., and in 1939 it was collected at Shediac, N.B. (Bird 1947). Goble (1936) pointed out that because of the large populations of the insect in Ontario in 1936, *S. cylindricollis* must have been present in Canada for at least 20 years or more if it is of European origin. The species was first reported from Manitoba in 1939, when it occurred in large numbers (Bird 1947). A sweet-clover field near Waldeck, Sask., was the site of a severe attack in 1940. First records for the pest in Alberta and British Columbia were made in 1941 (MacNay 1949) and 1953 (Hatch 1971), respectively.

Economic injury: According to Craig (1978), the insect is a major pest of sweet-clover (*Melilotus* spp.) wherever the crop is grown. Attacks are most damaging to young plants and may result in almost complete crop loss (Beirne 1971). First-year sweet-clover crops planted near or in succession to older crops are most likely to suffer serious injury, especially after the second-year crop is harvested. During dry years, new seedlings can be completely destroyed and second-year stands thinned and stunted (Craig 1973). Sweet-clover is by far the preferred host of this weevil, and all varieties are attacked (Bird 1947, Bird et al. 1956). Beirne (1971) noted that the insect attacks sweet-clover when it is growing in grain stubble but does not appear to injure the plant when it is growing in corn or corn stubble. Alfalfa, alsike clover, and black medick are also attacked but usually only when sweet clover is not available (Goble 1936, Herron 1953, Beirne 1971). Only one instance of some minor feeding on red clover (in southwestern Ontario) has been reported (MacNay 1948). Loan (1961) pointed out that the development of *S. cylindricollis* is more successful on sweet-clover than on any other species of legume and that it develops significantly more rapidly on *Melilotus officinalis* (L.) Lam. than on *M. dentata* Pers. In the Soviet Union, the sweetclover weevil is a major pest of alfalfa (Loan 1961), having destroyed up to 87.5% of the nodules (Bird 1947).

The adults are nocturnal and feed on the foliage of sweet-clover in the spring and fall and occasionally attack the green seeds; the larvae feed on the roots during the summer and are suspected of carrying root rot (Beirne 1971). Leaf injury is very characteristic and is more readily observed than the adults, which have a habit of dropping to the ground and feigning death when disturbed (Bird 1947). Crescent-shaped notches are made in the margins of sweet-clover leaves (Mitchener 1956), and when damage is most severe, the whole leaf surface except for the midrib is eaten and the outer bark of the stems may be seriously damaged (Bird 1947). Second-year fields may be severely defoliated in the spring but normally outgrow the damage, provided there is sufficient moisture (Bird et al. 1956). Bird (1947) stated that fall damage is often the most severe and also noted that associated with the defoliation may be a severe infestation of root rot, *Rhizoctonia* sp., resulting in almost complete winter killing. The adults do not injure ripe seed but do feed on green seed if no leaves are available (Craig 1973). Kelleher (1954) reported large reductions in sweet-clover seed yield which resulted because the weevil ate the seed or caused it to fall. An estimated 15–40% loss of seed was reported in Saskatchewan (MacNay 1949).

Most larvae develop on the roots of second-year sweet-clover (Allen 1959), with only a few developing on first-year roots (Bird 1947). The root hairs and nodules are attacked but not the taproot. Herron (1953) noted that larvae were recovered only from sweet-clover. The larvae are suspected of spreading root rot disease either by acting as vectors or by producing portals of entry for the fungus *Phytophthora cactorum* (Leb. and Cohn) Schroet., which is in part responsible for failures of second-year stands of sweet-clover in southwestern Ontario (Davey 1955).

The relative abundance of this insect is subject to periodic fluctuations (Bird 1947, Beirne 1971). For example, in 1939 and 1940 the species caused severe injury in Manitoba, but in 1941 and 1942 the damage was less, becoming severe again in 1943, 1944, and 1945 (Bird 1947). Beirne (1971) reported a large population of 252 larvae and 96 adults per 0.09 m^2 in one infestation.

Because of this pest and other contributing factors, the use of sweet-clover as a forage and soil improvement crop has diminished in Canada and the United States (Craig 1978). This has caused some concern to agronomists, who consider the legume an important forage crop, and to apiarists, who believe the crop to be one of the main sources of honey (Bird 1947).

Biology: The species overwinters in the sexually immature adult stage in the upper 2.5 cm of soil or under almost any kind of shelter in and around sweet-clover fields (Caesar 1935, Bird 1947, Beirne 1971). Emergence begins around the latter part of April in Manitoba – about the time the second-year sweet-clover begins to show green (Mitchener 1956) – and peaks by the middle of May (Bird 1947). Some individuals continue to appear until as late as the end of July. Adults become active in second-year fields when the temperatures reach about 4.4°C (Craig 1973). Mean daily temperatures of near 15.6°C preceded by rainfall favored the greatest emergence (Bird 1947). In the spring the overwintered adults begin to disperse from second-year stands, with some moving into new seedling fields to feed (Allen 1959, Craig 1973). Migration at this time is by flying and running, and the weevils may fly some distance from their overwintering sites to feed (Bird 1947, Allen 1959). The adults begin to mate soon after emergence and immediately begin feeding. Mating becomes more frequent as the temperature rises, and it continues for as long as the adults live (Herron 1953). In Manitoba, mating was observed from the middle of May until well into July (Bird 1947). Herron (1953) reported the spring preoviposition period to be as short as 1 week.

In Manitoba, oviposition begins in May and continues well into August, when the overwintered generation dies (Bird 1947). The eggs are indiscriminately dropped on the ground or may be hidden in soil crevices or under litter around the sweet-clover plants (Bird 1947, Herron 1953). Bird (1947) recorded 40–60 eggs per day for several days in a row, with an average oviposition of 400 eggs for 73 females and a maximum of 1665 eggs for one individual. According to Herron (1953), in Ohio a female may deposit a maximum of 1600–1800 eggs, with an average daily production of 40–70 eggs; most of the eggs (85%) were laid by the end of April. After laying for a number of days or weeks, heavily producing females (more than 1000 eggs) rest for as long as a month before again beginning oviposition (Bird 1947). Few eggs deposited after the end of June produced larvae that reached maturity (probably less than 25% in 1945). This may be caused by hot, dry weather desiccating the eggs and the newly hatched larvae before they can become established on the roots. Herron (1953) observed that if moisture was removed from around the eggs after the first few days, the eggs hatched, but the mortality of emerging larvae was high. The incubation period required from 7 days at 26.7°C to 30 days at 12.2°C, but the eggs failed to hatch after 50 days at 5°C until they returned to higher temperatures, at which they hatched in normal time.

The species has four larval instars (Bird 1947) and takes 5–9 weeks to mature (Mitchener 1956). According to Herron (1953), in Ohio the larval instars require 29–45 days. The larvae burrow to a depth of 18 cm and feed on the sweet-clover root hairs and nodules until full grown (Bird 1947, Mitchener 1956, Craig 1973). For the most part, the larvae live in the top 15 cm but can be found as deep as 25 cm in more sandy soils (Beirne 1971). There is a vertical migration of the larvae within the soil, with the younger larvae usually occurring below 8 cm and the older larvae occupying the upper 8 cm (Herron 1953). In about 80% of the findings, Bird (1947) and Philip (1977) observed that the fourth instar moves to the upper 2.5 cm of soil to pupate. Larval development is somewhat retarded around plants growing in heavy soils and in protected areas as opposed to those in open areas and lighter soils (Herron 1953).

Pupation takes place mainly in the upper 2.5 cm of soil and requires 8–10 days in Manitoba (Bird 1947) and from 7 to 12 days in Ohio (Herron 1953). At least 24 hours and often 48 hours are spent by the new adults within the pupal cell (Herron 1953). In Manitoba, first-generation emergence begins in late July and peaks in early August (Bird 1947). In Ontario the new adults appear as early as 25 June and continue to emerge well into August (Goble 1936). The new generation feeds voraciously and disperses, by running only, to new seedlings; there is no mating (Bird 1947, Herron 1953). The weevils seek hibernation quarters with the onset of cool weather and the first frost in late August but may be active during warm days in September and October (Bird 1947). Loan (1961) showed that a period of diapause at low temperatures is not required for summer-emerged adults to mate and oviposit. Sexually immature adults collected in September mated and laid eggs at a constant temperature of 23.3°C in early October. Herron (1953) found that weevils taken from hibernation did not mate before February and failed to lay eggs before March in the laboratory. The life cycle is completed in 45–70 days; only one generation per year occurs in North America and two occur in Asia.

Weather is considered to be the most important natural control regulating the size of the population of the sweetclover weevil (Bird 1949). Hot, dry weather adversely affects both the establishment of the larvae and the survival of newly emerged adults.

Disease, of which the pathogen *Beauveria bassiana* (Balsamo) Vuillemin is the most important, is second to weather in the control of the species (Bird 1949). Also isolated were *Fusarium acuminatum* Ellis & Everhart as *F. scirpi* Lamb, *F. equiseti* (Corda) Saccardo, *F. avenaceum* (Fries) Saccardo, and *F. solani* (Martius) Saccardo, but it is not known whether these diseases were responsible for the deaths of the weevils. A species of *Hirsutella* was also reported to be pathogenetic (Bird 1947). Herron (1953) reported the isolation of a fungus, probably near *Sporotrichum* sp., from the overwintering stage of *S. cylindricollis*. Graham (1965) reported the braconids (Hymenoptera) *Microctonus aethiops* (Nees), *Pygostolus falcatus* (Nees), and *Perilitus rutilus* (Nees) and the tachinid (Diptera) *Syntomogaster exigua* (Meigen) to be parasites of the sweet-clover weevil. *Mycetosporidium jacksonae* Tate is parasitic on *Sitona* weevils (Herron 1953).

Sitona hispidula (Fabricius)
clover root curculio
charançon des racines du trèfle (m.)

Distribution: British Columbia, Saskatchewan, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Origin: This native European species was first recorded in North America in 1875 in New Jersey (Hatch 1971).

Economic injury: The clover root curculio has been of economic importance to various forage legumes in the Maritime Provinces (Thompson 1967, Thompson and Willis 1967*b*) and has caused moderate damage to red clover in southwestern Ontario (MacNay 1948). According to King et al. (1953), the species rarely becomes a nuisance in British Columbia. Beirne (1971) reported the insect on red, ladino, and alsike clover and alfalfa in the Atlantic Provinces, Ontario, Saskatchewan, and British Columbia but noted no significant injury except in one instance, where plants suffered the additional effects of drought. The clover root curculio has been described by Bigger (1930) as a potentially serious pest of clover and alfalfa in central Illinois. In Virginia the insect was reported to be one of the most common and destructive pests of alfalfa (Underhill et al. 1955), and in Kansas it was described as particularly dangerous to alfalfa and sweet-clover (Marshall and Wilbur 1934). Loan (1963) noted that the species feeds and breeds on vetch and yellow sweet-clover in the Belleville area of Ontario. Other known hosts include white, mammoth, and crimson clover as well as blue grass (Wildermuth 1910, Hudson 1925*a*, Herron 1953).

Most damage is caused by the larvae (Underhill et al. 1955), which may completely remove the secondary rootlets, chew into and destroy the nodules, and score and furrow the taproots, frequently girdling them from the surface to a depth of several centimetres (Marshall and Wilbur 1934, Thompson and Willis 1967*a*). Injury to the roots ranges from moderate to severe and generally occurs within the upper 10 cm of soil, although damage has been observed as deep as 25 cm or more (Underhill et al. 1955). In Virginia the insect is most injurious to alfalfa from early March through June and has caused severe damage to first-year alfalfa. According to Bigger (1930), the larvae first attack the nodules, then the smaller roots, and finally the main root system. As the larvae develop, they proceed to the larger roots and finally to the taproot, where they may be found in large concentrations as they mature (Marshall and Wilbur 1934). Injured plants become less vigorous and may wilt and die during dry weather, resulting in loss in yield and stand (Underhill et al. 1955, Arrand and Neilson 1958). Damaged plants are also subject to such diseases as root rot, crown rot, and bacterial wilt (Marshall and Wilbur 1934, Thompson and Willis 1967*a*). Underhill et al. (1955) reported that winter heaving in alfalfa stands is apparently increased by weakening of the plant and its root system.

Throughout the summer and fall, the adults feed on the leaves, making characteristic, crescent-shaped notches on the margins (Marshall and Wilbur 1934). Little damage results from this feeding (Underhill et al. 1955) unless the adults develop in excessively large numbers (Wildermuth 1910). Bigger (1930) reported one instance where 0.20 ha of newly sown alfalfa was destroyed in a few days by beetles that migrated from a recently plowed red clover field. The beetles feed nocturnally in the upper parts of the plant during hot summer days (Marshall and Wilbur 1934) and descend to the lower regions to avoid extreme heat during the day.

Biology: The clover root curculio resembles the sweet-clover weevil in habits, size, and life cycle (Davidson and Lyon 1979). The species overwinters in the adult and egg stages (Bigger 1930, Davidson and Lyon 1979) and may also overwinter in the larval stage (Arrand and Neilson 1958, Beirne 1971). The adults spend the winter under clover and alfalfa debris (Hudson 1925*a*, Marshall and Wilbur 1934), and in central Illinois they become active during the latter part of March, reaching their peak of activity when temperatures range between 10 and 24°C (Bigger 1930). Egg laying usually occurs at these temperatures but may occur at temperatures as low as 4°C. Fertile eggs were produced in autumn, winter, and spring (Herron 1953). In Kansas, Marshall and Wilbur (1934) observed oviposition from April to July and September to November, apparently whenever the weather was not too cool or too hot. Bigger (1930) noted that overwintered adults deposited 72.4% of their eggs in the spring, having deposited 27.5% of them the previous fall. The female deposits her eggs, both at night and during the day, mostly on the ground at the base of the plants, but also under debris or on the stems, leaves, and stipules of the plants (Wildermuth 1910, Bigger 1930). There is a great variety in the number of eggs deposited by different individuals (Marshall and Wilbur 1934). Underhill et al. (1955) reported an average oviposition of 218 eggs, with a maximum of 498 eggs (for eggs deposited in insectories between April and June). Bigger (1930) recorded an average fecundity of 167 eggs (or two eggs per female per day) over a total laying period of about 84 days during the fall and spring. The incubation period for eggs laid in the spring or summer ranges from 6 days in mild weather (Marshall and Wilbur 1934) to about 3 weeks (Underhill et al. 1955). Eggs laid in the fall hatch the following spring (Davidson and Lyon 1979). Bigger (1930) reported that in central Illinois, fall-laid eggs hatched as early as 1 May.

Newly hatched larvae crawl rapidly and seek cracks in the soil to hide from the sun and find food (Marshall and Wilbur 1934). First-instar larvae apparently do not tunnel in the soil but crawl down the cracks to a root or nodule. The insects may start feeding within 20 min of their entry into the soil. Extensive burrowing is done by second-instar and older larvae, the larvae moving from the smaller roots to the larger ones and finally to the taproots. The length of the larval stage has been reported to vary from 17 to 21 days (Wildermuth 1910) and from 45 to 49 days (Marshall and Wilbur 1934). Larvae were not found during the fall by either Wildermuth (1910) in the Washington, D.C., area or by Bigger (1930) in central Illinois. Pupation takes place in an oval, earthen cell which is constructed in 2 or 3 days, usually within 8 cm of the surface (Marshall and Wilbur 1934). The pupae are scattered in the soil from near the base of the host plant to as far away as 15 cm (Bigger 1930). Pupae were most numerous in the soil between 7 June and 25 June, with only a few observed after 15 July (Marshall and Wilbur 1934). The length of the pupal period averaged about 10 days (range, 8–16). In central Illinois, pupation takes place mostly in June and required 17–22 days (Bigger 1930).

Adults emerge in late June and early July in Virginia (Underhill et al. 1955). Their life span is about a year (Bigger 1930, Davidson and Lyon 1979). According to Marshall and Wilbur (1934), most of the new adults in Kansas appear by 25 June and begin feeding after a few days. The clover root curculio is a weak flyer, and most of its dispersal is done by crawling, although some insects may fly considerable distances (Underhill et al. 1955). When disturbed, the beetle falls to the ground and feigns death (Wildermuth 1910). The adults become inactive when continuous hot weather sets in (Bigger 1930) but do not appear to aestivate even during the hottest days (Marshall and Wilbur 1934). Activity begins again in the early fall. Adults become sexually mature and mate during the fall (Underhill et al. 1955), and oviposition begins within 12 hours (Marshall and Wilbur 1934). Many eggs may be deposited when the weather is warm in September and October. Only one generation per year occurs (Underhill et al. 1955).

Loan and Thompson (1972) reported the braconids *Pygostolus falcatus* (Nees) and *Microctonus aethiops* (Nees) to be parasitic on weevil larvae. The tachinid *Hyalomyodes triangulifera* (Loew) emerged from *S. hispidula* (Loan 1963). The braconid *Microctonus sitonae* Mason also parasitizes the clover root curculio but prefers to lay its eggs in *S. scissifrons* held for rearing at 23.3°C. Nematodes of the genus *Diplogaster* killed larvae (Marshall and Wilbur 1934), and Herron (1953) noted that a fungus, probably near *Sporotrichum* sp., attacked adults during hibernation. A specimen of *Stenus* sp. (Staphylinidae) preyed upon the eggs, and *Mycetosporidium jacksonae* Tate parasitized *Sitona* adults. Wildermuth (1910) reported a fungus (Entomophthorae) that attacked the larvae.

Sitona lepidus Gyllenhal (*flavescens* Marsham)
(clover root curculio)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: Regarded as introduced, this species was apparently first recorded in North America in Crotch's 1873 checklist (Hatch 1971).

Economic injury: Thompson (1964) reported the occurrence of this insect on forage crops in Prince Edward Island, and Loan (1963) noted the species on white and alsike clover in the Belleville area of Ontario. *Sitona lepidus* is not a serious pest in British Columbia according to Arrand and Neilson (1958). The common clovers, alfalfa, and other leguminous plants are attacked (Arrand and Neilson 1958, Davidson and Lyon 1979).

The adults feed on the edges of the leaves; the larvae feed within or on the nodules and roots and may often girdle the taproot (Arrand and Neilson 1958, Davidson and Lyon 1979). When the weather is dry, injured plants may wilt and die (Arrand and Neilson 1958). Young stands of alfalfa are more sensitive to injury than established stands. Root injury is thought to favor the development of bacterial wilt in alfalfa (Davidson and Lyon 1979).

Biology: The species overwinters in both the adult and egg stages (Davidson and Lyon 1979) and possibly in the larval stage (Arrand and Neilson 1958). The incubation period for eggs deposited in the spring is 1 week (Davidson and Lyon 1979). The new adults emerge in June and July and have a life span of nearly a year. Both *S. lepidus* and *S. hispidula* are similar to the sweet-clover weevil in habits, size, and life cycle.

The tachinid, *Hyalomyodes triangulifera* (Loew), emerged from *S. lepidus* (Loan 1963).

Sitona lineata (Linnaeus)
pea leaf weevil
charançon rayé du pois

Distribution: British Columbia.

Origin: This European species was first recorded in North America in 1936 from southern Vancouver Island, B.C. (Downes 1938, Hatch 1971). By 1942 the insect had spread to the interior of the province (Beirne 1971).

Economic injury: The pea leaf weevil may cause serious injury to seedling peas, beans, sweet peas, alfalfa, and clover (King et al. 1953, Neilson 1954, Hatch 1971). It also attacks broad beans, red clover, bird's-foot trefoil, wild and cultivated vetch, and has been found in threshed oats (MacNay 1947, 1957*b*; Beirne 1971; Hatch 1971).

The adults chew crescent-shaped notches in the leaves and may kill seedling plants when infestations are severe (Neilson 1954, Banham and Arrand 1978). Downes (1938) described the notches as about 0.3 cm in diameter and more or less evenly and closely spaced around the leaf margin. According to Neilson (1954), larger plants do not usually suffer significant damage to the foliage. Later in the season the larvae feed on the roots, especially the root nodules. The larvae have caused severe injury to the roots of clover (MacNay 1959) and have destroyed a large percentage of the root nodules in pea fields (Hatch 1971).

Biology: The adults overwinter in field debris and become active early in the spring, feeding on emerging seedlings (Banham and Arrand 1978). The females lay their eggs in the soil. Downes (1938) stated that in Germany, a female may deposit from a few hundred to nearly 2000 eggs. After about 6 weeks of feeding on the roots, the larvae pupate (Banham and Arrand 1978). The new adults appear in midsummer – late in June according to Beirne (1971) – and feed until hibernation in the fall. Only one generation is produced each year.

Sitona scissifrons Say
(alfalfa curculio)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Northwest Territories.

Economic injury: This potentially destructive insect has been harmful only rarely in North America (Loan 1963, Beirne 1971). The species occurs mainly on alfalfa, although according to Loan (1960), it has been found on *Vicia cracca* L. in the area of Belleville, Ont. (Loan 1963). *Sitona scissifrons* (as *S. tibialis* Herbst.) caused severe damage to alfalfa seedlings in Saskatchewan (MacNay 1948) and in the Peace River district of Alberta (MacNay 1951). Serious damage was inflicted on seedlings of pea tree in 1925 at Indian Head, Sask., constituting the first record of injury by this insect (Loan 1963). Additional hosts include clover (red, ladino, and alsike), alfalfa, peas, sweet-clover, pea flower, and many garden plants such as tulip and delphinium (CIPR 1931, Loan 1963, Beirne 1971, Hatch 1971).

The adults feed on the foliage (Beirne 1971), and the larvae attack the roots (Loan 1963). The adults may completely defoliate a plant and are most injurious to seedling alfalfa in the spring (Arrand and Neilson 1958). Second-year or older stands of alfalfa do not suffer severe damage (Craig 1973). First- and second-instar larvae develop inside the root nodules (of *V. cracca*), and third- and fourth-instar larvae are thought to feed externally on the nodules and other parts of the root system (Loan 1963).

Biology: The life history of *S. scissifrons* is probably similar to that of the sweet-clover weevil (Arrand and Neilson 1958, Craig 1973). The adults spend the winter under debris in or near fields (Arrand and Neilson 1958). Loan (1963) noted that the adults prefer to hibernate under thick layers of vetch leaves rather than in areas of sparse cover. Overwintered adults became active as early as 14 April and began feeding immediately (Arrand and Neilson 1958). Large numbers of adults were reported from sweepings on 9 May, when the vetch attained a height of 5–10 cm (Loan 1963). A maximum of 450 weevils per 100 sweeps were obtained on 10 June. As adults of *S. scissifrons* are flightless, the activities of the overwintered generation are confined mostly to mating and feeding rather than large-scale dispersal. These weevils are quite active, running up and down the blades of grass and vetch foliage. Mating occurs in the field as early as late April and continues during May and June. The male apparently continues to mate until it dies. When disturbed, the adults drop to the ground and feign death (Arrand and Neilson 1958).

Oviposition begins in late April at Belleville, Ont., and the majority of eggs are deposited during May and early June (Loan 1963). Egg-laying is most active during May, and no females were without eggs and numerous young oocytes at this time. The eggs are deposited at random on the ground. The average fecundity was 105.5 eggs for 111 females reared in an insectory and 173.3 eggs for 22 females reared in the laboratory. Females laid an average of 1.9–4.9 eggs per day in the insectary and 8.8–12.5 eggs per day in the laboratory. The incubation period was 21 days for eggs placed in the field under 6 mm of soil on 30 April. The overwintered adults live an average of 10 or 11 months (including about 5 months in hibernation). There is a sharp decrease in their numbers toward the end of June and the beginning of July, although they may be observed as late as early August.

There are four larval instars, the first two feeding within the nodules (of *V. cracca*) and the last two moving about freely in the soil, feeding externally on the nodules and roots (Loan 1963). Pupae were detected as early as 27 June.

The first teneral adults were collected on 4 July and 6 July, making the period between oviposition (April or early May) and the appearance of the new generation of adults about 9 or 10 weeks (Loan 1963). Dispersal from the old vetch in early August occurs partly because most of the vetch has set seed and withered. Prolonged feeding may not be necessary before hibernation. Loan (1963) noted that weevil feeding stops at some point during the summer or autumn. Although some or all the male weevils become sexually mature before hibernation and many of the females are fertilized, little oviposition occurs before winter. Most of the mating and egg laying by this univoltine species takes place after hibernation.

The braconids (Hymenoptera) *Microctonus sitonae* Mason, *Centistes lituratus* (Haliday), and *Pygostolus falcatus* (Nees), are reported to be parasites of *S. scissifrons* (Loan 1963).

Comments: This species was formerly confused with the European *S. tibialis* Herbst. (Loan 1963).

Sitophilus granarius (Linnaeus) (*remotopunctatus* Gyllenhal)
granary weevil
calandre des grains (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Origin: According to Metcalf et al. (1951), the granary weevil is probably not indigenous to North America, and like the rice weevil it has been distributed all over the world in shipments of grain. Hatch (1971) stated that the three Pacific Northwest representatives of this genus (*S. granarius*, *S. oryzae* and *S. zeamais*) are likely native to the Orient and have probably been in the area since the earliest days of wheat, maize, and rice importation. The granary weevil was first recorded from the region in British Columbia in 1889 (as *S. remotepunctata* Gyll.).

Economic injury: *Sitophilus granarius* is one of the world's most destructive pests of stored grain (Metcalf et al. 1951, Watters 1967). Unlike the closely allied rice weevil, this species does not breed in the field but only occurs in places where grain is stored (Cotton 1956). Grains on farms, in transit, or in elevators often suffer near-complete destruction when conditions such as those of warm climates favor the growth of the insect and when grain is left undisturbed for a length of time (Gibson and Twinn 1931, 1939; Gray 1934*a*; Metcalf et al. 1951). Under heavy infestations, the kernels may be reduced to mere shells (Gray 1934*a*). Infested grain is often damp (as moisture is added to the grain by the insect's metabolic processes) and frequently heats on the surface, resulting in further damage (Gray 1934*a*, Metcalf et al. 1951). The granary weevil is infrequently found in the Prairie Provinces (Northwest Line Elevators Association 1959). Ross and Caesar (1931) reported a widespread infestation in Ontario (from Essex County to the Niagara district), where *S. granarius* was injurious to stored grain and frequently occurred in sufficient numbers to contribute to grain heating. The pest has been reported in mills and warehouses in British Columbia (MacNay 1959). In Newfoundland it infested birdseed (CAIPR 1976) and occurred in foodstuffs in a house (CAIPR 1977). Wheat, corn, rye, oats, barley, sorghum, kaffir seed, buckwheat and other grain and grain products are attacked (Metcalf et al. 1951, Neilson and Arrand 1958). According to Gibson and Twinn (1939), the granary weevil is occasionally found in pasta, flour, meal, and other cereals but is unable to breed therein unless the products have become caked. Grains with a high moisture content are preferred (Davidson and Lyon 1979).

The adults feed on whole seeds or flour; the larvae develop in seeds or pieces of seeds or cereal products large enough to afford them living quarters but not in flour unless it has become hardened into a mass (Metcalf et al. 1951). The larvae feed on the endosperm and complete their development in the kernel (Northwest Line Elevators Association 1959, Watters 1967). Only a single larva develops in a grain of wheat and other small cereals, but several larvae may develop in a kernel of corn (Gibson and Twinn 1931, 1939). About 56% of the weight of wheat kernels is consumed by the larvae, more than half of which appear to be eaten by the fourth instar (Kirkpatrick and Wilbur 1965).

The adults may be observed feeding on and in the grain, eating out the shells of kernels (Metcalf et al. 1951). Serious damage may result from the feeding of the weevils where grain is left undisturbed in warm places for some length of time, as the life span of the adult is relatively long (Gibson and Twinn 1931, 1939). High temperature and high moisture levels afford the optimum environment for development (Neilson and Arrand 1958).

The granary weevil and the rice weevil are frequently found feeding together (Metcalf et al. 1951). Unlike the rice weevil, the granary weevil prefers north- and south-temperate climates (the northern United States, Canada, and southern Australia) (Monro 1969).

Biology: The life history and habits of *S. granarius* differ but little from that of the rice weevil (Metcalf et al. 1951, Cotton 1956, Davidson and Lyon 1979). The adults or larvae may overwinter in unheated storage, the former being able to withstand –17.8°C for several hours (Metcalf et al. 1951). In contrast to the rice weevil, adults of the granary weevil are flightless (Monro 1969). The species does not occur outdoors and depends upon humans for its dispersal (Cotton 1956).

Before oviposition the female chews a slender hole through the seed coat into the endosperm, inserts her ovipositor, and lays a single egg (Kirkpatrick and Wilbur 1965). The hole is then sealed with a gelatinous secretion that protects the egg and conceals the site of oviposition. A few eggs are laid outside the kernels when the females are unable to find suitable oviposition sites or when the process of egg laying is suddenly disturbed. Davidson and Lyon (1979) reported a fecundity of 200–400 eggs for each female over a period of several months. Kirkpatrick and Wilbur (1965) presented a detailed analysis of oviposition activities on field-collected specimens in Kansas. These authors reported an incubation period ranging from 4 to 14 days, with the peak number hatching in 7 days.

The species has four larval instars (Kirkpatrick and Wilbur 1965). The first instar varied from 2 to 10 days in duration, but usually lasted only 3 days. Second-instar larvae required an average of 4.8 days. Third-instar larvae averaged 6 days in duration. Fourth-instar larvae required from 4 to 12 days, with most larvae changing to prepupae after only 6 days of feeding. Soderstrom (1960) reported that the instars of the Kansas strain of granary weevil extended over 11, 15, 19, and 16 or more days, respectively. A pupal chamber is constructed by each larva before it becomes a prepupa (Kirkpatrick and Wilbur 1965). A fluid is then secreted, giving the endosperm walls a smooth, firm texture. The prepupal period averaged 1 day and ranged from less than 1 day to 4 days.

The adult cuts a hole through the thinnest part of the kernel wall to escape (Kirkpatrick and Wilbur 1965). The emergence hole is characteristically large and roughly oblong, with somewhat ragged edges, unlike that of the rice weevil, which is usually smaller, rounder, and neater. Development to the adult stage inside the kernels was completed in 39–50 days from oviposition under an optimum environment of approximately 26.7°C and 70% RH. The life cycle may take 4–7 weeks under favorable conditions but is greatly prolonged during cool weather (Metcalf et al. 1951, Davidson and Lyon 1979). Adults can survive without food for 2 or 3 weeks – for 1–2 months according to Neilson and Arrand (1958); they frequently live for 7 or 8 months and may survive for more than 2 years (Metcalf et al. 1951). According to Cotton (1956), the adult life-span averages 7–8 months. Several generations are produced each year (Neilson and Arrand 1958), with four or five occurring in Kansas (Metcalf et al. 1951).

Sitophilus granarius thrives at moderate temperatures and needs a high relative humidity. According to Howe (1965), 15°C and 50% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 26–30°C, and the maximum rate of increase every 4 weeks is 15-fold.

Cotton and Good (1937) listed the following parasites and predators: *Aplastomorpha calandrae* How., *Cephalonomia formiciformis* Westw., *Chaetospila elegans* Westw., *Chremylus rubiginosus* Nees, *Dibrachys* (*acutus* Thoms.?), *D. cavus* Walk., *Lariophagus distinguendus* Först., *Pteromalus tritici* Gour., and *Pediculoides ventricosus* Newp.

Comments: The insect probably occurs in Alberta, as it has been reported from the Prairie Provinces, and is known to occur in both British Columbia and Saskatchewan.

Sitophilus oryzae (Linnaeus)
rice weevil (corn weevil, black weevil, lesser rice weevil)
charançon du riz (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Ontario, Quebec, New Brunswick, and Newfoundland.

Origin: The rice weevil is believed to be a native of India, and like the granary weevil, it has become distributed over all the world in shipments of grain (Metcalf et al. 1951). According to Hatch (1971), the three Pacific Northwest representatives of this genus (*S. oryzae*, *S. granarius*, and *S. zeamais*) are likely native to the Orient and have probably been in North America since the earliest days of wheat, maize, or rice importation.

Economic injury: The rice weevil and the granary weevil are the most destructive insect pests of stored grain (Cotton 1956, Canada Department of National Defence 1981). Grains in elevators, in farm bins, or on ships frequently suffer near complete destruction when conditions favor the growth of the insect and when grain is left undisturbed for a length of time (Metcalf et al. 1951). Infested grain is often damp and frequently heats on the surface, resulting in further damage. Unlike the granary weevil, the rice weevil may fly to grain (i.e., corn, wheat, and rice) in the fields and begin the infestations that are so severe after the grain is harvested (Cotton 1956, Monro 1969). In the southern United States, the weevil may literally reduce an ear of corn to powder. The pest feeds on rice, wheat, corn, rye, oats, barley, sorghum, kaffir seed, buckwheat and other grain and grain products (Gibson and Twinn 1931, 1939, Metcalf et al. 1951, Neilson and Arrand 1958). Apart from seed, the rice weevil may also breed in solidified farinaceous material, such as pasta and caked, compressed meal and flour (Cotton 1956, Monro 1969).

The adults feed on whole seeds or flour; the larvae develop in seeds or pieces of seeds or cereal products large enough to afford them living quarters but not in flour unless it has become caked (Metcalf et al. 1951). The larvae feed on the inside of the grain, hollowing it out. High temperature and high moisture are the most favorable conditions for the beetles (Neilson and Arrand 1958).

The rice weevil and the granary weevil are often found feeding together (Metcalf et al. 1951). *Sitophilus oryzae*, in contrast to the granary weevil, favors a tropical or subtropical climate but can survive in a temperate climate in protected situations (Cotton 1956).

Biology: The rice weevil and the granary weevil have similar life histories and habits (Metcalf et al. 1951, Cotton 1956, Davidson and Lyon 1979). The adults or larvae may spend the winter in unheated storage, the former being able to withstand temperatures of –17.8°C for several hours (Metcalf et al. 1951). Before oviposition, the female gnaws a slender hole through the seed coat into the endosperm, inserts her ovipositor, and lays an egg (Kirkpatrick and Wilbur 1965). The cavity is then plugged with a gelatinous secretion, which serves to protect and conceal the site of oviposition. The process of egg-laying is described in detail by Lathrop (1914). Some individuals may lay as many as 417 eggs during a period of 110 days. Davidson and Lyon (1979) reported a fecundity of 200–400 eggs for each female over a life span of several months. Cotton (1956) stated that each female lays between 300 and 400 eggs during an average life span of 4–5 months. The eggs hatch in a few days (Metcalf et al. 1951, Neilson and Arrand 1958).

The larvae pass through four instars, each of which extended over 10, 7, 9, and 11 or more days, respectively (Soderstrom 1960). Monro (1969) noted that the development of the rice weevil within a kernel of grain is very similar to that of the granary weevil but is somewhat faster. The rice weevil larvae do not exhibit the cannibalism of the granary weevil, and as a result, two rice weevil adults often emerge from the same kernel of wheat (Kirkpatrick and Wilbur 1965). When mature, the larvae transform into pupae and then to adults, which bore a hole in the grain and emerge (Cotton 1956). The egg, larval, and pupal stages may be completed in as little as 26 days during warm summer weather (Cotton 1956). The life cycle may take 4–7 weeks under favorable conditions but is greatly extended in cool weather (Metcalf et al. 1951, Davidson and Lyon 1979). Adults can go without food for 2 or 3 weeks – for 1–2 months depending on temperature according to Neilson and Arrand (1958) – and they often live for 7 or 8 months, with some persistence for over 2 years (Metcalf et al. 1951). According to Cotton (1956), the average adult life span is 4–5 months. Several generations occur each year (Neilson and Arrand 1958), with four or five occurring in Kansas (Metcalf et al. 1951).

According to Howe (1965), *S. oryzae* thrives at moderate temperatures and needs a high relative humidity. The minimum temperature and humidity at which the species can multiply sufficiently to become a pest is 17°C and 60% RH. The optimum temperature range is 27–31°C, and the maximum rate of increase every 4 weeks is 25-fold.

Cotton and Good (1937) reported the following parasites and predators: *Aplastomorpha calandrae* How., *Cephalonomia formiciformis* Westw., *C. tarsalis* Ashm., *C. waterstoni* Gahan, *Cerocephala cornigera* Westw., *Chaetospila elegans* Westw., *Chremylus rubiginosus* Nees, *Lariophagus distinguendus* Först., *Meraporus requisitus* Tucker, *Pteromalus tritici* Gour. (?), *Zatropis incertus* Ashm., and the mite *Pediculoides ventricosus* Newp.

Sitophilus zeamais Motschulsky
maize weevil (rice weevil)

Distribution: Ontario and Quebec.

Origin: According to Hatch (1971), the three Pacific Northwest representatives of this genus (*S. zeamais*, *S. granarius*, and *S. oryzae*) are cosmopolitan species and likely are native to the Orient. It is thought that the species may have been present in the Pacific Northwest from the earliest days of wheat, maize, or rice importation.

Economic injury: CAIPR (1971) reported the maize weevil in bins used to store corn from the United States. Sinha (1965*b*) stated that the insect occurred only in imported corn in Quebec.

Biology: The species breeds in whole grain or in secondarily compacted meal (Hatch 1971).

Smicronyx fulvus LeConte

Distribution: Saskatchewan and Ontario.

Economic injury: According to CIPR (1962), *S. fulvus* attacks the heads of sunflower early in their development and feeds on the immature seeds, causing serious losses.

Smicronyx sordidus LeConte

Distribution: Manitoba.

Economic injury: In Manitoba this species, as *Desmoris constrictus* (Say), has been reported to be abundant on the blossoms of sunflower (Criddle 1922) and on ornamental sunflower, but it has not been observed in commercial fields (CIPR 1952). Known hosts in the United States include sunflower, alfalfa, senna, and cotton (Anderson 1962).

Biology: *Smicronyx sordidus* breeds in the seeds of various sunflowers and pupates in the ground (Anderson 1962).

Comments: *Desmoris constrictus* (Say) is reported as a synonym of *S. sordidus* by Anderson (1962).

Sphenophorus spp.
billbugs (snout beetles)
calandres (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: According to Beirne (1971), billbugs are infrequent and usually minor pests of corn in Ontario and wheat in Manitoba, in situations where these crops have been planted after old pasture. One of the several species that attack corn is the maize billbug (*S. maidis* Chittenden). Injury resulted in the destruction of young plants and, in one instance, necessitated replanting. Injured plants usually recover but may be stunted. Billbugs have seriously injured wheat at field margins next to sloughs. Barley has also been attacked in the Prairie Provinces. Other hosts include nearly all the cultivated and wild grasses, the small grains, rushes, sedges, reeds, cattails, peanuts, rice, and sugarcane (Metcalf et al. 1951, Davidson and Lyon 1979). Billbugs prefer lowland areas that are wet or subject to overflow from adjacent streams (Davidson and Lyon 1979).

Both adults and larvae cause damage. According to Metcalf et al. (1951), the larvae are most harmful as they feed upon the fibrous roots of small grains and cultivated grasses, in timothy corms, and in the stems of small grains, causing the heads to bleach and the straws to fall or lodge. The larvae of the maize billbug also cause serious damage to corn by tunneling and feeding inside the stalk down into the taproot below the surface. The smaller grasses may be so weakened by the larvae hollowing out the interior that they fall in a wind or from their own weight (Vaurie 1951). The adults cause damage by perforating the unfolding leaves and the stems of the young plants (Beirne 1971). The feeding and egg-laying punctures, made while the developing leaves are curled in the heart of the plant, appear as transverse rows of punctures or holes across the leaves after they expand (Metcalf et al. 1951). The injured leaves frequently fall or twist into a curl, interfering with later growth. Punctures made low down on the stalk cause the plant to produce excessive suckers or sprouts. According to Vaurie (1951), punctures made by a large species such as *S. maidis* on a corn plant no thicker than a lead pencil and but 7–10 cm high usually kill the plant. Thicker plants outgrow their injury when their inner tissues cannot be reached by the billbug's beak. Smaller grasses may be dwarfed but are not usually killed by the adults feeding at the base, as they do not pierce the central tissues. Beirne (1971) reported that the adults eat through the sheath above the upper node, severing the stems and turning the heads of wheat white. The developing kernels are also attacked, the adult inserting its head downward through the chaff. Poultry may be killed by the sharp, tibial claws of billbugs when they unwarily pick them up and are unable to either swallow or eject them (Vaurie 1951).

Biology: The species usually overwinters in the adult stage, but in the warmer regions of the United States, it may overwinter in various stages (Metcalf et al. 1951). In the case of *S. maidis*, adults that have transformed early overwinter in coarse grasses or other litter in the fields, whereas those that have transformed later hibernate in the base of the stubble. Billbugs seldom fly but are capable of crawling very quickly (Vaurie 1951). When alarmed, the beetles feign death and are difficult to see on the soil, as they are often covered with mud (Metcalf et al. 1951). After emergence, billbugs feed, mate, and deposit eggs in feeding punctures in the stems of the host plants over a period of about 2 months. The incubation period ranges from 4 to 15 days (Metcalf et al. 1951). Vaurie (1951) noted that oviposition frequently occurs in the rootstalks or in bulbous roots. The overwintered generation feeds for a considerable period in the spring and may still be observed when the larvae are well-grown and even after the appearance of the new generation of adults (Davidson and Lyon 1979). The larvae of the maize billbug feed for a period or 40–50 days (from early June to September) in the pith of corn and always pupate in the larval tunnel in the upper part of the taproot in August and early September (Metcalf et al. 1951). For billbugs in general, pupation is said to occur either in the stems of plants or in the soil among the roots. Vaurie (1951) found the larval stage of *S. maidis* to require about 49 days (range, 33–70). The larvae molt 5 or 6 times; they pupate in 5–18 days either in their cells or nearby in the soil.

Davidson and Lyon (1979) reported that pupation occurs in midsummer in the soil or in feeding cavities near the base of plants. Billbugs produce one generation per year.

Additional notes on the biology of the various species and their parasites and predators are given in Metcalf et al. (1951) and Vaurie (1951). Davidson and Lyon (1979) pointed out that natural enemies do not play a significant role in the control of billbugs.

Strophosoma melanogrammus Förster (*S. coryli* (Fabricius))

Distribution: British Columbia, Ontario, Quebec, Nova Scotia, and Newfoundland.

Origin: This European species was first reported in North America from New Jersey and Massachusetts in 1888 (Hatch 1971). The earliest record of *S. melanogrammus* in British Columbia was made at Agassiz in 1923. In Ontario the insect was detected for the first time in 1958, at Barrie (CIPR 1959).

Economic injury: The species attacks the foliage of broad-leaved trees and shrubs (MacNay 1961). Hatch (1971) reported occasional injury to rhododendron. According to CIPR (1924), this species (as *S. coryli*) defoliated strawberries on the Experimental Farm at Agassiz, B.C.

Tachypterellus quadrigibbus (Say)
apple curculio
charançon de la pomme (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: According to Metcalf et al. (1951), the apple curculio can cause serious injury to crops. Like the plum curculio, this species thrives best in uncultivated orchards, which provide suitable hibernating quarters. The species has not been important in well-cultivated orchards with clean surroundings (Ross 1930). In earlier years, *T. quadrigibbus* was one of the most destructive insect pests of apple in Ontario and Quebec, causing damage to 50% of the apples in certain orchards (Caesar 1914; Petch 1926*b*, 1928*b*). The apple curculio has, however, steadily declined in numbers and has become a much less important pest in these provinces, with only occasional outbreaks (Twinn 1942; MacNay 1949, 1952, 1953). In the Salmon Arm district of British Columbia, the species caused 80% of the small pears of some trees to fall and deformed most of the remaining pears, thus rendering them unmarketable at harvest time (Buckell 1930). It was observed that only pears in a mixed orchard of apple, cherry, and pear suffered injury, suggesting the possible existence of a different form of apple curculio from that which attacks apple in the east. *Tachypterellus quadrigibbus* has infested *Amelanchier alnifolia* Nutt. in Saskatchewan (CIPR 1965) and has been suggested as a main cause of variable berry production in the province (Steeves et al. 1979). Damage by the apple curculio may go unnoticed in orchards infested by the plum curculio, as both species cause similar injuries (except those resulting from egg punctures) (Davidson and Lyon 1979). The insect commonly attacks apple, pear, crab apple, and hawthorn (Davidson and Lyon 1979); it has been described by others as a pest of plum, peach, cherry, quince, serviceberry, haw, shadblow, saskatoon, and wild crab apple and has been collected on cotton in Florida (Petch 1926*b*, Metcalf et al. 1951, CIPR 1965, Steeves et al. 1979). Haw, hawthorn, and wild crab apple have been cited as the insect's natural hosts and as causes of its prevalence (Bethune 1870, Petch 1912, 1926*b*).

The chief injury of the apple curculio is caused by the adults, which puncture the fruit for the purpose of oviposition and feeding (Petch 1926*b*). Injured fruits are malformed, knotty, and undersized (Metcalf et al. 1951, Davidson and Lyon 1979). Attack on the fruit begins when the petals are falling and the young fruit is just forming (Ross 1930). Before this the adults often feed on the foliage, buds, fruit spurs, and terminal twigs, blighting the terminal shoots (Petch 1926*b*, Metcalf et al. 1951). Young peach trees in Connecticut suffer serious injury when adults puncture the twigs (Buckell 1930). In feeding on apple the weevil pierces the skin and hollows out a cylindrical cavity in the pulp as deep as the length of the snout. The oviposition cavity is similar but is considerably enlarged at the bottom. Cavity excavation causes normal growth around the puncture to stop, the surrounding tissue to harden, and a knotty deformity to develop. The hard, green core-formations that result from the cessation of growth usually extend to the centre of the apple, taste bitter, and when the fruit is badly punctured, spoil it for eating and cooking (Petch 1926*b*). According to Petch (1912), the adults hold on to the fruit tenaciously and are not interrupted from feeding by heavy rains. Steeves et al. (1979) pointed out that a single adult is capable of inflicting numerous wounds in a limited time, suggesting that a large population is not necessary for the occurrence of extensive damage. Injury on mature fruits differs from that inflicted by the plum curculio in the larger number of punctures close together through the skin, the larger deadened areas on the fruit surface, and the absence of crescents (Metcalf et al. 1951).

The larvae eat large, irregular tunnels into the flesh of the apple at a rate of about 2 mm per day, making their way to the core, which is eventually consumed, and feeding on the centre until they are mature (Petch 1912, 1926*b*). Most of the apples infested with larvae drop prematurely, although some have been found on trees with adults ready to emerge (Caesar 1915, Petch 1926*b*, Ross 1930). If the larvae do not hatch, the apples remain on the tree but become deformed.

Steeves et al. (1979) reported development occurring in saskatoons that do not drop to the ground.

Biology: The adults overwinter in debris on the ground in and around orchards, but especially under the host trees (Ross 1930, Metcalf et al. 1951, Davidson and Lyon 1979). Petch (1912) reported that the beetles overwintered in the soil. The overwintered generation appears on the trees shortly before the blossoming period (Petch and Armstrong 1925, Petch 1926*b*). Steeves et al. (1979) noted that although adults seem capable of strong flight, they usually do not migrate very far in any one season, and one part of a field may be severely infested while another part remains unharmed. Over a period of several years, the species may spread to only several rows of trees. When disturbed, adults become motionless and often drop to the ground (Petch 1912, 1926*b*). Oviposition begins soon after the adults begin to feed on the newly formed apples (Buckell 1930).

Eggs are laid during May and June in cavities excavated in the fruits by the long snouts of the females (Davidson and Lyon 1979). Metcalf et al. (1951) reported an average oviposition of several dozen eggs (one in a place) and a maximum fecundity of up to 125 eggs during an egg-laying period extending from May to mid July. The small external opening of the cavity is plugged with a drop of excrement after the egg is laid at the bottom of the cavity (Buckell 1930). The eggs hatch in 4–7 days (Petch 1926*b*, Buckell 1930, Davidson and Lyon 1979). Most of the eggs, however, do not produce adults, as only an average of 38 beetles were reared per 100 eggs (Petch 1926*b*). Petch (1912) reported that only a little over 28% of the eggs hatched.

The larvae bore into the flesh of the apple at a rate of approximately 2 mm per day for approximately 3 weeks and feed on the centre of the apple until full grown (Petch 1926*b*). Metcalf et al. (1951) pointed out that many larvae mature in June drops and in mummied apples on the trees. Unlike the plum curculio, the larvae pupate within the fruit (Petch 1926*b*, Davidson and Lyon 1979). The larvae transform to pupae after about 20 days (Buckell 1930, Davidson and Lyon 1979), and the pupal stage requires between 5 and 6 days (Petch 1912). Davidson and Lyon (1979) reported the appearance of new adults in about 7 days after transformation to pupae. According to Metcalf et al. (1951), the insect spends a total of 5–6 weeks in the fruit as egg, larva, and pupa.

The first generation begins to emerge about 20 July and feeds on maturing fruits before hibernating well into September (Petch 1926*b*, Davidson and Lyon 1979). According to Petch (1912), these beetles begin feeding the first week in August and are most commonly found on the fruit during the second and third week. Buckell (1930) noted that the insects fed very little during the summer in British Columbia before seeking winter quarters, usually in August. Only one generation of the apple curculio is produced annually (Petch 1926*b*, Davidson and Lyon 1979).

Comments: Notes from Metcalf et al. (1951) are a generalization of four different forms of apple curculios: the apple curculio (*Tachypterellus quadrigibbus* (Say); its variety, the western or larger apple curculio (*T. q. magnus* List.); a distinct species (*T. consors* Dietz.); and a variety of the latter, the cherry curculio (*T. c. cerasi* List.).

Trachyphloeus bifoveolatus (Beck)

Distribution: British Columbia, Ontario, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: The insect was introduced from Europe (Gibson and Twinn 1939) and was first recognized in North America in 1876 from a single specimen (originally determined as *T. asperatus*) from the "Middle States" (Hatch 1971). The species was first collected in the Pacific Northwest from southeastern British Columbia (Hatch 1971). Gibson and Twinn (1939) reported *T. bifoveolatus* at several locations in New Brunswick and Nova Scotia and stated that it invaded a house in Nova Scotia in 1936. The eastern and western populations of the species appear to have developed from separate European introductions (Brown 1965).

Economic injury: *Trachyphloeus bifoveolatus* caused serious damage to cucumber and beans in Prince Edward Island (MacNay 1953). In this province, it injured many vegetables (CIPR 1961) and occurred on forage crops (Thompson 1964). The species was reported for the first time as a pest of strawberry in June 1964, in British Columbia, where it severely injured the foliage of a newly set 10-ha planting near Abbotsford in the Fraser Valley (Cram 1964). The insect attacked the lower leaves of tobacco seedlings in Nova Scotia (CIPR 1961) and, along with *Barynotus obscurus* (F.) and *Tropiphorus terricola* (Newm.), caused considerable crown and leaf stem injury to newly set small fruit plants (CIPR 1958). The pest also invades houses but causes no real damage (Gibson and Twinn 1939, Cram 1964, Hatch 1971).

The adults attack the foliage and crowns, and the larvae feed on the roots (CIPR 1958, 1961; Cram 1964). Cram (1964) reported the adults in groups of up to 50, feeding generally beneath strawberry leaves but occasionally completely unprotected from the sun and drying winds. The insect appears to primarily attack strawberry plantings in fields that were recently used for pasture (Hatch 1971).

Biology: The adults may be found under cover on dry soil (CIPR 1961), and they apparently breed in pastures or similar areas (Hatch 1971).

Trichobaris trinotata (Say)
potato stalk borer
charançon de la pomme de terre (m.)

Distribution: Ontario and Atlantic Provinces (?).

Economic injury: The insect is of little importance throughout much of its distribution, but it may occur in sufficient numbers in some areas to completely destroy potato fields (Metcalf et al. 1951). In 1901 the potato stalk borer caused serious injury to potatoes on Pelee Island, Ont., constituting the first record of the species as a pest of potato in the province (Lochhead 1901). *Trichobaris trinotata* is most destructive to early potatoes, but it also occasionally injures eggplant and attacks several other solanaceous plants such as jimsonweed, horse-nettle, and ground-cherry (Metcalf et al. 1951, Davidson and Lyon 1979).

The principal damage is caused by the larvae, which burrow up and down the stalks eating the interior for several centimetres and causing the plant to wilt and die. Overwintered adults feed on the foliage and make slender, deep punctures in the stems (Metcalf et al. 1951, Davidson and Lyon 1979). Lochhead (1901) reported larval burrows extending from the base to near the tip of the stalks. The presence of the pest may be indicated by stems that blacken prematurely, leaves that turn yellow, and wilting (Lochhead 1901, Lochhead and Jarvis 1906).

Biology: The adults normally overwinter inside the stalks but may also be found among old vines (Metcalf et al. 1951, Davidson and Lyon 1979). These adults emerge in the spring and feed on the foliage and stems. According to Lochhead (1901), egg laying occurs in late May or early June in Ontario. The eggs are deposited singly in deep punctures made in the stems or leaf petioles (Metcalf et al. 1951). Davidson and Lyon (1979) noted that the eggs are laid on the stems of potatoes and other plants. The incubation period is a week or 10 days (Metcalf et al. 1951).

The newly hatched larvae begin to hollow out the centre of the stems (Lochhead 1901, Metcalf et al. 1951). When it is mature, the larva chews an escape hole almost through the stem for the adult (Metcalf et al. 1951) and constructs a cocoon within the burrow (Beirne 1971). Pupation takes 1 or 2 weeks and the new adults may be found in the stalks from late July through the winter in the northern states (Metcalf et al. 1951). The adults remain in this retreat until the following spring, unless the stalks are broken open.

Comments: Beirne (1971) considered the record of the species from the Atlantic Provinces to be doubtful.

Tropiphorus terricola (Newman)

Distribution: Quebec, Nova Scotia, Prince Edward Island, and Newfoundland.

Economic injury: This insect caused injury to the crown and leaf stem of newly set, small fruit plants in Nova Scotia (CIPR 1958). MacNay (1957*b*) reported that the species damages strawberry plants in this province.

Tychius picirostris (Fabricius)
clover seed weevil
charançon de la graine du trèfle (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, Prince Edward Island, Newfoundland, and Yukon Territory.

Origin: The presence of this introduced European species in the Pacific Northwest has been known since 1920, when the insect was collected from Vancouver, B.C. (Hatch 1971). It was found in Ontario in 1946 (Arnott 1947), in Saskatchewan and Manitoba in 1949 (MacNay 1949), in Nova Scotia in 1950 (CIPR 1954), and in Quebec in 1962 (Beirne 1971). Beirne (1971) pointed out that records of the species in Quebec before 1962 may have referred to *T. stephensi* Schönherr (the red clover seed weevil).

Economic injury: The clover seed weevil has caused severe reductions in the seed yield of alsike, white, and ladino clovers in southwestern Ontario and has been described as the most important insect known to attack these seed crops in the province (MacNay 1950, Beirne 1971). The species has reduced the yield of seed by up to 50% in Ontario and by 12–15% in British Columbia (Beirne 1971). Heavily infested fields of alsike clover in southwestern Ontario have yielded as little as three-quarters to two bushels of seed per hectare (MacNay 1949). Red clover has also suffered serious injury (MacNay 1948). In Washington, Idaho, and Oregon, where *T. picirostris* is considered the most destructive pest of alsike and white clover seed, up to 70% of the crop may be destroyed (Hatch 1971). The insect has also been reported on white Dutch clover varieties, apple trees, dandelion, strawberry, evergreen blackberry, salmonberry, *Spiraea douglasi* Hook., plantain, a species of sedge, alfalfa, willow, lodgepole pine, white pine, and spruce (Baker 1934, Venables 1943, Arnott 1947, MacNay 1954*b*, Davidson and Lyon 1979).

Both the larvae and adults injure the seed. The larvae feed on and destroy the developing seeds inside the pod (Craig 1973, Davidson and Lyon 1979). The adults, which are the smallest weevils found on clover, puncture the calyx and petals to feed on the reproductive parts (pods, developing seeds, ovules) and to lay eggs in the green seedpods (Arnott 1947, Craig 1973). Damage results in the failure of the seed to set. Beirne (1971) also noted first-generation adults feeding on foliage.

Biology: The adults spend the winter in debris or at shallow depths in the soil in and around infested fields but especially in the heavier cover afforded in weedy or grassy headlands and fencerows (Arnott 1947). Emergence in southwestern Ontario began near the middle of May, did not become general until early June, and peaked by the end of the month. Another report from Ontario stated that emergence occurs throughout the month of May and is nearly completed by the end of the month (CIPR 1950). On first emerging, the adults have a tendency to remain in or near their hibernating quarters (Arnott 1947). Adults were observed feeding on the blossoms of wild strawberry and dandelion (23 May and 4 June) before the alsike clover bloomed. When the clover starts to bloom, around the latter part of May (CIPR 1950), the overwintered generation migrates into the clover and begins feeding on the blossom heads (Arnott 1947). In southwestern Ontario, the infestation in alsike clover became general by the latter part of June, with the number of adults rapidly increasing and peaking between 4 and 10 July. A gradual decrease in the number of weevils was noted as the crop matured.

Mating was first noted around 20 June and continued throughout the alsike blossoming period (Arnott 1947). The females puncture the petals and the base of the flower and deposit their eggs in the green seedpods (Craig 1973). Infested pods generally contain only one egg, but two eggs are occasionally found (Arnott 1947). Oviposition was first observed on 19 June in southwestern Ontario. Davidson and Lyon (1979) reported the incubation period to be about 7 days.

The larvae, which eat the developing seed, were found from 23 June until the crop matured around 20 July (Arnott 1947). Arrand and Neilson (1958) stated that the larval feeding period is about 2 weeks. At maturity, the larvae drop to the ground to pupate in the soil (Davidson and Lyon 1979). Arnott (1947) first observed larvae and pupae in the soil on 18 July and noted that they were quite numerous by 24 July in one field. According to Davidson and Lyon (1979), the new adults emerge approximately 14 days after dropping to the ground to pupate. The life cycle of the clover seed weevil requires about 40 days. Beirne (1971) reported that the new adults appear in late July and August and feed on the foliage and developing seedpods. Emergence of the new generation in southwestern Ontario occurred from 1 to 15 August and peaked between 4 and 7 August (Arnott 1947). During this time, over 2300 weevils were recovered in cages covering a total area of 1.1 m^2. These adults moved from the field into adjacent vegetation and then into hibernation quarters by late summer. Only one generation is produced each year.

Davidson and Lyon (1979) reported that the pteromalid parasite *Trimeromicrus maculatus* Gahan has been reared from infested pods.

Comments: Early reports of this species on red clover may well be misidentifications of *T. stephensi* Schönherr (= *T. griseus* Schaeffer). For example, Detwiler (1923) gave a detailed discussion of *T. picirostris*, but it is thought that he was actually referring to *T. stephensi*, as he reported the species to be apparently confined to red clover and stated that it was redescribed by Schaeffer under the name of *T. griseus*. According to Moreland (1953), the two species are easily confused.

Tychius stephensi Schönherr (*griseus* Schaeffer)
red clover seed weevil (clover head weevil)
charançon de la graine du trèfle rouge (m.)

Distribution: British Columbia, Alberta, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Origin: The first North American record of this European species was made on 8 July 1907, in Ithaca, N.Y. (Hatch 1971). The red clover seed weevil was found as early as 1912 in Quebec and 1934 in New Brunswick (Arnott 1947).

Economic injury: *Tychius stephensi* has been reported to be an important pest in the areas where red clover seed is produced in the United States and Canada (Muka 1955). Beirne (1971) stated that production of red clover seed frequently suffers some losses in eastern Canada and that damage was extensive in Ontario, especially in 1947 and 1948. Considerable seed injury to red clover in southwestern Ontario was also noted by MacNay (1948–1950). Reports of minor damage in Ontario were made in MacNay (1951–1953, 1954*b*), CIPR (1955), and Guppy (1958). Thompson (1964) pointed out that although the red clover seed weevil is abundant in most fields on forage crops in Prince Edward Island, its injury is only of minor importance because little clover is grown for seed. In New York the insect was shown to rapidly build up a heavy population in a crop that is allowed to go to seed and to cause seed losses as high as 65% (Muka 1955). Although *T. stephensi* may be taken from numerous species of plants, it appears to confine its feeding to red clover. In Europe the adults also occur on sweet-clover, strawberry, hawthorn, and vetch. The species reportedly attacks alsike clover, but there is an indication that it only injures volunteer red clover growing among the alsike clover (Beirne 1971). The adults are said to be active on the blossoms of dandelion and strawberry.

The larvae feed on the developing seeds, one larva to each floret, and the adults feed on the reproductive portions of the flower (Muka 1955). As the larva reaches maturity, it completely hollows out the seed. Populations have run as high as 1344 larvae per 100 heads or 13 larvae per head in New York. Beirne (1971) reported the adults feeding on the leaves and later on the flowering heads, where they puncture the unopened florets and feed on the pollen grains.

Biology: Muka (1955) described the life history of the red clover seed weevil in New York. The weevil spends the winter in the adult stage in red clover sod, both in established fields and in volunteer roadside patches. Adults emerge during May and begin flying as the air and soil temperatures rise during the latter part of the month. The beetles are thought to fly considerable distances during their flight period. Mating is believed to start soon after the adults settle on the heads of red clover in the spring and begin feeding. Egg laying begins in the florets of red clover as soon as heads of clover appear. The female chews a small hole through the calyx and corolla tubes near the distal end of the calyx tube and deposits her egg on the ovary. Only one egg or rarely two eggs are deposited per floret. Eggs may be laid in florets that are at the proper stage of development throughout the summer; however, oviposition ceases with the onset of cool weather in late August and early September. The eggs hatched in an average of 7.7 days (range, 7–10).

Newly hatched larvae were first recorded in the field on the first clover heads that came into bloom during the first or second week of June. The larvae pass through three instars and required an average of 11.5 days (range, 7–17) to become full grown. Larval development takes less time early in the season than in late July and August. Two larvae were only rarely observed in the same floret and then only in the first instar. Larvae may be found in the heads of red clover in September, but these insects are apparently the last phases of the second generation. At maturity, the larva usually crawls from the head and drops to the ground, where it pupates in the top 1.3 cm of soil; it occasionally pupates in the head when there is no other suitable site. The cocoon is spun in 2 or 3 days, after which the larva becomes quiescent. The prepupal period averaged 8.9 days (range, 6–12) at 21.7°C and 72% RH and 14 days (range, 12–16) at 17.8°C and 93% RH. The pupal period required an average of 10.3 days (range, 8–14). The callow adult spends several days in the cocoon before emerging from the soil. In New York, two generations occur each year on red clover, the first beginning in early June and the second by early to mid July.

A predacious mite destroyed a high percentage of the species in the pupal stage in the laboratory.

Comments: The red clover seed weevil has frequently been confused with the clover seed weevil (Muka 1955). See section entitled "Comments," under *T. picirostris*.

Tyloderma nigra Casey
(godetia weevil)
charançon de la godétie (m.)

Distribution: Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: The adults attack the foliage of *Clarkia* and evening-primrose (Gibson 1934). However, most of the injury is caused by the larvae, which seriously damage the roots and often kill the plants. The species has been recorded as injurious only from Manitoba.

Biology: The species overwinters in the adult stage (Gibson 1934). During the fall and early spring the insects are common on and around the foliage of wild evening-primrose.

DERMESTIDAE dermestid beetles or skin beetles

This family is commonly associated with stored products, and many species are major household and museum pests. Adults as well as larvae feed on a wide variety of products of both plant and animal origin. Species of this family occur in all faunal regions. The family contains about 850 species of which 42 are estimated to occur in Canada.

Anthrenus flavipes LeConte (*vorax* Waterhouse)

furniture carpet beetle

Distribution: Alberta.

Origin: Nearly cosmopolitan, *A. flavipes* is believed to be indigenous to the Orient (Hinton 1945). This beetle was first recorded from North America when specimens were taken from upholstered furniture at Augusta, Ga., in 1911 (Griswold 1941). MacNay (1952) reported a serious infestation in a house at Edmonton, Alta., which is believed to have originated in furniture imported from Missouri (MacNay 1954a). This represents the first record of this species in Canada.

Economic injury: The larvae of *A. flavipes* feed on a variety of animal products including wool, hair, bristles, fur, feathers, horn, and tortoise shell. They also damage any substance that is stained or impregnated with animal material (Hinton 1945).

Biology: Hinton (1945) summarized the biology of this species. The adults, like those of other species of *Anthrenus*, normally feed on pollen and nectar, though they do not require food to mate or lay eggs. Oviposition begins 1–3 days after emergence from the puparium. Eggs are deposited in the vicinity of suitable larval food. Unfed females laid an average of 62 eggs in batches of 1–57 eggs. The higher number of batches laid by a single female was three. Depending on food, temperature, relative humidity, and light, the larval stage varied from 50 to 600 days, and the number of instars varied from 6 to 29. The duration of the larval period and number of molts are slightly greater in the female than in the male. Pupation occurs within the last larval skin. The pupal period is also temperature- and humidity-dependent and ranges from 6 to 19 days. The newly formed adult remains quiescent for a time in the last larval skin. The duration of this resting period has also been shown to be controlled by sex, temperature, and humidity.

Burkholder et al. (1974) have shown that females of *A. flavipes* emit a sex pheromone to attract males. This behavior begins after the onset of light and reaches a maximum 1–2 h later, ceasing after 4 h of light.

A bethylinid wasp, *Laelius voracis* Muesebeck, has been reared from this species. A single beetle larva may contain from one to four parasite larvae.

Comments: According to Bostanian (1974), this beetle is expanding its range northward in parts of the United States but is still rare in Canada.

Anthrenus fuscus Olivier

Distribution: Ontario.

Origin: According to Hinton (1945), the distribution of this species is Holarctic, occurring in Europe, Asia, and North America.

Economic injury: In Europe, the larvae of *A. fuscus* usually maintain themselves on insect remains in spider webs in the vicinity of sheds, barns, and houses and have also been reported in bird, wasp, and bee nests. The species has been reported in houses, but there are few records of damage to stored products. They have been found in stored blankets, damaging insect collections, and in cacao and spice warehouses (Hinton 1945). In CIPR (1962), this dermestid is listed as only an occasional pest in Ontario. Becker (1977) reported additional Ontario records of this species.

Biology: A synopsis of the biology of this species was given by Hinton (1945). In Britain, the adults are found on flowers from the beginning of May to the middle of August. Although found on a variety of flowers, they show a marked preference for those of parsley. The adults apparently eat nectar and pollen. Mating occurs during the day, and eggs are deposited in the pubescence of dead insects. At 30°C the eggs hatch in 10–11 days. Larvae that hatch in spring or early summer do not pupate until April or May of the following year. The pupal stage lasts 5–6 days at approximately 25°C, and the newly formed adult remains within the puparium for 4–5 days before it becomes active.

Anthrenus museorum (Linnaeus)
(museum beetle)

Distribution: Ontario, Quebec, New Brunswick, and Newfoundland.

Origin: This is a cosmopolitan species, occurring abundantly in temperate regions (Hinton 1945).

Economic injury: *Anthrenus museorum* occurs in houses and museums where the larvae feed on wool, fur, feathers, dried insects, and other animal matter (Cotton and Good 1937). Spencer (1928*a*) reported that the larvae fed on dead cluster flies, *Pollenia rudis* (Fabricius), in a house in Ontario. Hinton (1945) cited records of this species in granaries, herbariums, and libraries.

Biology: Hinton (1945) summarized the literature on the life history of *A. museorum*. Under natural conditions, the species overwinters in the larval stage and pupates from May to July. The pupal stage lasts 9–10 days at 20–22°C, and the adults remain quiescent for 4–7 more days before emerging. After emergence, the females are positively phototropic, copulating in sunlight; after mating and before oviposition, they become negatively phototropic. It is at this time that the females may enter houses in search of oviposition sites. The active sexual life of males and females lasts for 10–14 days and 12–18 days, respectively. Females lay an average of 22 eggs, with a maximum of 35 eggs having been recorded. Ten larval instars have been recorded, but the number is variable. A generation requires 7–14 months. Like other *Anthrenus* species, the adults are nectar and pollen feeders.

Anthrenus pimpinellae Fabricius (*occidens* Casey, *lepidus* LeConte)

Distribution: British Columbia.

Origin: According to Mroczkowski (1968), *A. pimpinellae* is widely distributed and nearly cosmopolitan.

Economic injury: Under the name *A. occidens* Casey, Sinha (1965*b*) listed this species as a stored-product pest in Canada, but Hatch (1962) reported the species as being of little or no economic importance. In Eurasia this species has been reported to attack insect collections, woolens, saddles, horsehair upholstery, and dried fish (Hinton 1945). It has also been recorded as a household pest in the Old World.

Biology: According to Hinton (1945), the life cycle of *A. pimpinellae* requires 1–2 years. In May, adults are found on flowers, feeding on pollen and nectar. Oviposition occurs in the spring or early summer. Eggs hatch in 15 days at 20–22°C and 8 days at 26°C. Larvae require 3–4 months to develop, molting about nine times. Pupation usually occurs in June to October. Although a small number of larvae overwinter, the majority of individuals overwinter as adults in the pupal skin.

The species occurs naturally in birds' nests, feeding on feathers, hair, dead nestlings, and insect remains. Spencer (1957*a*) reared this beetle from larvae collected in the nests of cliff swallows, tree swallows, and mountain bluebirds in British Columbia. He also reported pupal cases with evidence of a high incidence of parasitism by a bethylinid wasp, *Laelius* sp.

Anthrenus scrophulariae (Linnaeus)
carpet beetle (common carpet beetle, old-fashioned carpet beetle, buffalo carpet beetle)
anthrène des tapis (m.) [anthrène de la scrophulaire (m.)]

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, and Northwest Territories.

Origin: This beetle is described as indigenous to Eurasia and has been reported from Asia, Australia, Europe, and North America (Hinton 1945). Saunders (1878) reported damage by this species to rugs in Schenectady, N.Y., as early as 1872. Fletcher (1905*b*) reported the species as expanding its range in Canada, indicating that it was well established by that time.

Economic injury: Hinton (1945) summarized the damage done by the larvae of this species, an important pest of carpets, woolens, and furs. It has also been reported to feed on products made from hair, bristles, horn, feathers, and silk. This beetle is a well-known pest of museum specimens and is especially destructive to insect collections. In Canada it has been reported in stored wheat, where the larvae feed on the sloughed off seedcoats, rather than the whole grain (CAIPR 1970).

Biology: Greenwald (1941) investigated the life history and habits of this dermestid. Eggs were laid on the surface of a cloth provided as larval food. At room temperature, the incubation period of the eggs averaged 15.2 days (range, 13–20) at which temperature the larvae began feeding immediately after hatching. Most larvae passed through five or six instars, but up to 12 molts were recorded under some conditions. Pupation occurred in the last larval skin; the pupal periods at room temperature and at 27°C averaged 13.5 and 9.6 days, respectively. The entire development period, from egg to adult, ranged from 78 to 439 days. After transformation, the adults remained dormant in the old larval skin until they emerged 56–84 days later.

Under natural conditions, adults feeding on pollen and nectar were collected on blossoms in late May and early June. When disturbed, the adults feigned death and dropped to the ground or moved to the underside of the flowers. According to Hinton (1945), larvae have been found, under natural conditions, living on dead animals and in the nests of birds and bees.

Anthrenus verbasci (Linnaeus) (*varius* Fabricius)
varied carpet beetle (small cabinet beetle, buffalo carpet beetle)
anthrène bigarré des tapis (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, and Newfoundland.

Origin: This cosmopolitan species is believed to be of European origin (Gibson and Twinn 1939). It was first reported in North America in 1853 (Hinton 1945). Twinn (1932*b*) reported the species in Toronto, Ont., in 1928, and it was first recorded in British Columbia in 1936 (Spencer 1948).

Economic injury: Hatch (1962) considered this species to be the most important pest of houses and insect collections in the Pacific Northwest. In Canada, according to Bostanian (1974), the species is abundant only in coastal areas in British Columbia and occurs as an occasional pest in Ontario and infrequently in the other provinces. In British Columbia, *A. verbasci* has been reported in large numbers in flour mills and cereal warehouses (MacNay 1954*b*). However, Cotton and Good (1937) considered this dermestid of little economic importance to cereal products. The larvae have been recorded feeding on various products of animal origin including wool, fur, horn, leather, feathers, silk, bone, hide, and skin (Hinton 1945). The same author stated that unlike other species of *Anthrenus*, *A. verbasci* can develop normally when fed only plant materials.

Biology: Hinton (1945) reviewed the literature on the biology and ecology of this species. The adults of *A. verbasci* are found outdoors in spring and summer on flowers, where they feed on pollen and nectar. Copulation usually occurs on the flowers, and copulation and oviposition may occur before feeding begins. The females copulate about 10 days after emergence, ovipositing 4–7 days after mating. The females lay 14–100 eggs during the oviposition period, which lasts for 3–14 days. In temperate climates the eggs are laid singly in the spring and early summer on or near the larval food. The duration of the egg stage is 7–18 days, depending on temperature.

The larvae of *A. verbasci* begin feeding immediately after hatching. They molt 5–16 times (usually 6–8). The duration of the larval stage and number of molts vary with temperature, relative humidity, food supply, and sex. Under natural conditions, the larvae live as scavengers in the nests of birds and bees. The species overwinters in the larval stage.

Pupation takes place in the last larval skin, in or near the larval food supply. The length of the pupal period varies from 7 to 30 days, depending on temperature. After transformation, the newly emerged adults remain quiescent within the last larval skin for 1–8 days. In temperate climates, one generation occurs per year, with an occasional partial second generation.

Attagenus brunneus Falderman (= *elongatulus* Casey)

Distribution: Ontario (?) and Quebec.

Origin: Beal (1970) suggested that the irregular distribution of this species (as *A. elongatulus*) indicates that it may be introduced. Halstead (1981) confirmed that *A. elongatulus* is a synonym of the Palaearctic species *A. brunneus* and is not native to North America.

Economic injury: This species has been reported to infest dried milk in New York and Nebraska, woolens in Illinois, and peanuts in Georgia (Beal 1970). The same author stated that adults and larvae have frequently been brought into houses, although records of materials infested are not available. According to Barak and Burkholder (1977*b*), the economic status of *A. brunneus* is uncertain because it is often confused with *A. unicolor*. Damage attributed to *A. unicolor* may have been caused by *A. brunneus*.

Biology: Barak and Burkholder (1977*b*) studied the biology of *A. brunneus* under controlled conditions of temperature (25.5° ± 1°C) and humidity (60 ± 10% RH). Males began to mate successfully after 2 days, with a 90% peak of sexual activity reached at 4–6 days. After this time, the number of successful copulations declined. The majority of females did not oviposit until 1–2 days after mating. Eighty percent of the eggs were produced after 2 days, and all the eggs were laid 1–4 days after mating.

Under these conditions, the average life cycle lasted 90–95 days, with the egg, larval, and pupal stages requiring 9, 75–80, and 6–8 days, respectively. The rate of pupation was found to be inversely proportional to the degree of crowding, which is an advantage for a stored-product pest, as it allows a large, overcrowded population to cease development when food sources become depleted.

Virgin females of *A. brunneus* have been shown to exhibit a calling behavior which is associated with pheromone release (Barak and Burkholder 1977*a*). Calling behavior started 1 h after the onset of the light period, peaked after 2 h, and declined after 5 h of calling. The calling behavior began when the females were 3–4 days old. Males also exhibited an age-dependent and photoperiod-dependent responsiveness. This served to coordinate male attraction with the time that females were most receptive.

Comments: The Canadian distribution of *A. brunneus* is based on the map provided by Beal (1970). This map does not clearly indicate whether or not points along the Ontario–New York border at Niagara Falls represent specimens from Ontario. Halstead (1981) placed *elongatulus* in synonymy with *brunneus*.

Attagenus unicolor (Braham) (*piceus* Olivier, *megatoma* (Fabricius))
black carpet beetle (pitchy carpet beetle)
attagène des tapis (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: Beal (1970) stated that *A. unicolor* was probably originally Holarctic in distribution but is now cosmopolitan as a result of dispersion by commerce. He discussed two subspecies that occur in North America, *A. unicolor unicolor* and the northern *A. unicolor japonicus* Reitter (Halstead 1981), which occurs in Canada.

Economic injury: Bostanian (1974) considered this species to be the most widespread and injurious carpet beetle in Canada. According to Beal (1970), the species is commonly found in human habitations, but probably not as frequently as in the past because of the advent of synthetic rugs and furniture stuffing. MacNay (1965) reported the species as the most common household pest in Ontario. The larvae of this species feed extensively on wool, wool and synthetic fabric combinations, silk, and to a lesser extent on nylon, but they rarely feed on other synthetic fabrics (Beal 1970). MacNay (1952) reported that this species damaged nylon hosiery in a factory in Ontario. MacNay (1950) also considered the species to be a major fabric pest throughout Canada, apparently more prevalent than clothes moths. Beal said that *A. unicolor* is best known as an inhabitant of granaries, usually occurring in grain dust and debris and less often in the grain bulk. Chao (1954) found *A. unicolor japonicus* to be abundant in grain elevators in Washington. The black carpet beetle was also the most common insect found in a recent survey of grain elevators, warehouses, and flour mills in British Columbia (CAIPR 1977). In addition, Beal reported that the species infested cereal products such as bran, barley, ground Indian corn, peanuts, cake mix, and alfalfa meal.

Biology: Baker (1977) investigated the growth and development of *A. unicolor* under controlled conditions of 30° ± 0.5°C, 45–55% RH, and continuous darkness. The mean duration of the larval stage was 253.9 days for males and 260.5 days for females. Males and females completed 6.2 (range, 4–11) and 6.8 (range, 5–9) larval molts, respectively. The development of the larvae exhibited an unusual growth curve. Pupation began after 31 weeks and continued for 10 weeks. The pupal period did not exceed 7 days.

In Alberta, according to Philip (1977), mating and oviposition take place 5–11 days after adult emergence. Larvae emerge 1–2 weeks later. Depending on temperature and food availability, the larval period lasts 1–3 years. The larvae pupate from April through June, the adults emerging 1–1.5 months later. In Ottawa, Ont., Gibson and Twinn (1939) suggested that the species overwinters in the larval stage and that a generation requires 1 year. Under laboratory conditions, adults regularly mate and lay fertile eggs without food, water, or the opportunity to fly (Beal 1970).

Beal (1970) described the ecology of *A. unicolor*. The black carpet beetle is commonly found in various birds' nests and has also been recorded in the nests of the alfalfa leafcutting bee, *Megachile rotundata* (Fabricius); a mud dauber, *Sceliphron* sp.; and a pocket gopher, *Geomys* sp. Adults of *A. unicolor unicolor* have been taken on the flowers of *Spiraea*, *Achillea*, and *Castanea*, and adults of *A. unicolor japonicus* have been recorded from the flowers of alsike clover and sweet-clover. It is unknown whether the adults feed on the pollen or nectar of these plants or use the flowers as attraction sites for mating.

Comments: Griswold (1941) carried out extensive studies on the biology of this species, and Hinton (1945) summarized the existing literature on the subject. However, according to Beal (1970), it is not clear whether the work of these authors pertains to *A. unicolor* or to the related species *A. brunneus*.

According to Mroczckowski (1968), the valid name for this species is *A. unicolor* (Brahm). The species is better known in North America by the name *A. megatoma*.

Attagenus pellio (Linnaeus)

Distribution: British Columbia, Ontario, Quebec, and Nova Scotia.

Origin: *Attagenus pellio* is widely distributed throughout the Palaearctic region (Beal 1970). Hatch (1962) believed it was introduced into the New World. The first Canadian record appears to be Kirby's (1837) report of specimens collected from Nova Scotia.

Economic injury: According to Hatch (1962), the species is of no economic importance in North America. Fletcher (1902), however, reported that *A. pellio* damaged carpets in Nova Scotia. In Europe, Hinton (1945) reported the species to be a pest of the following products: furs, skins, woolens, carpets, upholstered furniture, house-insulating material, museum specimens, smoked meat and fish, silk, grain, cereal products, flour, maize, meal, cattle feed, rye bran, and sugar. Whether it can develop successfully on cereal products alone is unknown (Beal 1970).

Biology: Larvae of *A. pellio*, like those of other species of *Attagenus*, occur naturally as scavengers on dried material of high protein content (Beal 1970). Hinton (1945) gave a summary of literature outlining the biology of this beetle. In the wild, the larvae occur in birds' nests. Pupation in the last larval exuviae generally occurs in the fall. Adults occur on flowers in the spring and early summer and feed on nectar and pollen. The female becomes negatively phototropic at the onset of oviposition, depositing up to 50 eggs on or near the larval food supply. A generation usually requires 1 year but may take up to 3 years.

Like the larvae of *Anthrenus verbasci*, those of *A. pellio* are parasitized by the gregarine *Pyxinia mobuszi* Leger and Duboscq (Beal 1970).

Attagenus schaefferi hypar Beal
Distribution: British Columbia.

Origin: According to Hatch (1962), it is probably an introduced species. However, based on its North American distribution in areas away from centres of commerce and human activity, the paucity of records of this species, which infests stored products, and the existence of geographic segregates suggest that the Nearctic forms are probably indigenous (Beal 1970).

Economic injury: Beal (1970) first mentioned that this dermestid occurred in stored products, recording it from bran and barley in Arizona. Whether the species was feeding on the grain or on other insects is uncertain. This beetle has the potential to be a stored-product pest because it completes its development in the laboratory on a diet of oatmeal.

Biology: According to Beal (1970), *A. schaefferi* is a general scavenger, feeding on a variety of protein materials. He also reported it from various habitations of mammals and birds.

Dermestes ater De Geer
black larder beetle
dermeste noir (m.)

Distribution: British Columbia (?), Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and the Maritime Provinces.

Economic injury: In Ontario and Quebec *D. ater* has been recorded from a restaurant and from dwellings (MacNay 1954*a*, CIPR 1964). The species has been reported to feed on hides, leather goods, and other materials of animal origin (MacNay 1954*a*). Hinton (1945) cited examples of *D. ater* in dried fish, woolens, silk, cheese, copra, henbane leaves, poonac, custard powder, flour, rotten nuts, and dried mushrooms; it was also found in granaries and warehouses. In products of low protein content, the species probably occurs as a secondary pest, feeding on the dead bodies of other insects.

Biology: In Hawaii, according to Illingworth (1916), larvae of *D. ater* passed through seven instars and completed development in 28–41 days. Pupation of these larvae, unlike most dermestids, did not take place in the last larval skin. The pupal period lasted 9 days.

Comments: Hatch (1962) recorded *D. ater* in imported stored products in the Pacific Northwest, but whether or not this indicates that the species is established in British Columbia is unknown. Sinha (1965*b*) listed the species from the Maritime Provinces but did not specify which provinces.

Dermestes caninus Germar

Distribution: British Columbia, Alberta, and Ontario.

Economic injury: This species is listed by Sinha (1965*b*) as a pest of stored products.

Dermestes fasciatus LeConte

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, and Quebec.

Economic injury: Sinha (1965*b*) listed this species as a pest of stored products in Canada.

Dermestes frischii Kugelann

Distribution: British Columbia, Ontario, and Nova Scotia.

Origin: Hatch (1962) suggested that this species may be introduced. According to Mroczkowski (1968), *D. frischii* occurs in the Ethiopian, Neotropical, and Holarctic regions.

Economic injury: Hinton (1945) described the larvae and adults of this dermestid as carrion feeders. In the Old World, they have been recorded to feed on dried fish, dead locusts, silkworm cocoons, bath sponges, dog biscuits, corpses, dried rabbit, and skins. This species has been recorded in warehouses, houses, shops, and granaries. In granaries it probably fed on dead insects. In Canada *D. frischii* was reported in a feed plant in British Columbia (CIPR 1964) and in a fish meal plant in Nova Scotia (MacNay 1958).

Biology: Amos (1968) studied the development rate, mortality, and oviposition of *D. frischii* in the laboratory. These data are supplemented with information summarized by Hinton (1945), where indicated.

At 30°C and 60% RH the shortest preoviposition period for *D. frischii* was 2 days and the maximum duration was 6 days. Females exhibited a considerable variation in fecundity (Hinton 1945). The mean number of eggs laid per female (from 10 pairs of adults) was 65.9 (range, 6–107). According to Hinton (1945), eggs are laid in batches of two to four. Each female reached the approximate maximum laying rate of 8–25 eggs every 2 days during the first 6–8 days of oviposition. After 8 days, the rate of oviposition declined rapidly for the next 16 days. Under variable conditions, the oviposition rate was highest at 30°C.

Approximately 90% of the eggs hatched under most conditions; but they failed to hatch at 10° and 45°C at all levels of humidity and at 40°C and 30% RH. Humidity did not affect the duration of the egg stage, but a decrease in temperature increased the duration of this stage. Temperatures of 30–40°C resulted in a minimum egg period of 2 days, and a temperature of 15°C resulted in a maximum egg period of 15 days. The shortest mean duration for the larval period was 20 days at both 35 and 30°C and 90% RH. At constant temperatures, reducing the humidity or reducing the temperature decreased the rate of larval development. Larvae failed to develop at 40 and 15°C, these temperatures being near the upper and lower levels for development. The larvae passed through five to nine instars, depending on temperature and available food, and ceased feeding 4 days before pupation (Hinton 1945).

Larvae may leave their food supply and bore into a suitable substrate to pupate (Hinton 1945). The pupal period increased with falling temperature from under 5 days at 35°C to over 18 days at 20°C. The duration of this stage is not affected by humidity. In the USSR, *D. frischii* produces three generations a year and overwinters in the larval stage (Hinton 1945).

Dermestes frischii prefers both high temperature and high relative humidity. According to Howe (1965), 22°C and 50% (?) RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest (the figure for RH is not reliable). The optimum temperature range is 31–34°C, and the maximum rate of increase in 4 weeks is 30-fold.

Coleopteran predators of this beetle include the histerids *Saprinus semistriatus* Scriba and *S. semipunctatus* Fabricius and the clerids *Necrobia violacea* (Linnaeus) and *Korynetes coerulus* De Geer (Hinton 1945).

Dermestes lardarius Linnaeus
larder beetle (bacon beetle)
dermeste du lard (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This introduced species is now cosmopolitan in distribution (Hatch 1962). According to Saunders (1873*b*), *D. lardarius* is native to Europe.

Economic injury: *Dermestes lardarius* is a fairly common household pest in Canada (Gibson and Twinn 1938, MacNay 1967*a*). Both the adult and larva feed on a variety of materials of animal origin including feathers, skins, hair, ham, bacon, dried and processed meats, decayed meat, cheese, and wool. The larvae also damage wood products by burrowing into them to pupate (Philip 1977). Wong (1979) reported finding dead adults, larvae, and pupae in the oak beams of an old fort, the infestation probably dating before 1846. The species is also known to attack dried insects and stuffed birds (Saunders 1873*b*, Fyles 1886). MacNay (1959) reported *D. lardarius* from mills and warehouses in British Columbia, and Smith (1975) reported that the species infested hog feed residues in Manitoba. The species is occasionally reported to feed on materials of vegetable origin, though the insects may tunnel into these products before pupation. In CIPR (1965) and CAIPR (1977), this beetle is reported from stored wheat. However, according to Hinton (1945), when *D. lardarius* is reported from granaries and warehouses containing cacao, dried fruits, and other vegetable products, it is probably feeding on the remains of other insects.

Biology: In Alberta, Philip (1977) reported that the adults of *D. lardarius* overwinter in crevices in bark and enter houses in May and June. Coombs (1978) observed that the main oviposition period started 100 days after emergence and lasted about 90 days, but in some cases, there was an earlier oviposition period, which started a few days after emergence and lasted for about a month. The number of eggs laid ranged from 3 to 38 and from 26 to 131 in the early and main oviposition periods, respectively. Hinton (1945) stated that the eggs are usually laid in batches of 6–8 with extremes of 4–12. However, Hilali et al. (1972) found that the eggs are laid singly on the larval food during the day or night. These authors also noted that the egg period, at 22°C and 80% RH, varies from 4 to 6 days, with a mean of 4.4 days. Recently, Jacob and Fleming (1980) studied the development period and fertility of eggs of *D. lardarius* over a range of temperatures and levels of humidity. They found that the mean duration of the egg stage was 3 days at 30 and 32.5°C. The percentage of hatched eggs rarely reached 50% and was as low as 12.5% at 32.5°C and 60% RH.

The number of larval molts for males and females at 22°C and 80% RH, was nine and eight, respectively (Hilali et al. 1972). The same authors found that under the same conditions, the mean duration of the larval periods was 41.1 days for males and 47.3 days for females. Before pupation, the mature larva searches for compact material in which to excavate the pupal cell. Pupation occurs in the last larval skin (Philip 1977). The pupal period at 22°C and 80% RH lasted 20–22 days.

Coombs (1978) found that successful development could take place at temperatures ranging from a little above 15°C to at least 32.5°C at 65% RH. This period (egg to adult) ranged from 145 days at 15°C to over 300 days at higher levels of humidity and 25°C. Above the latter temperature, adult longevity was reduced. In Alberta, *D. lardarius* produces two generations per year indoors (Philip 1977).

Adults possess functional wings but rarely fly. They are most frequently observed walking in houses and occasionally feeding on pollen on flowers in gardens (Evans 1963).

Dermestes maculatus De Geer (*vulpinus* Fabricius)
hide beetle (leather beetle, skin beetle)
dermeste des peaux (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and the Maritime Provinces.

Origin: This cosmopolitan species was probably introduced into North America from Eurasia (Fauvel 1889).

Economic injury: Both adults and larvae of *D. maculatus* feed on dead animal matter such as stored hides, skins, carcasses, dried fish, meat, and dead silkworm cocoons (Bellemare and Brunelle 1950, Paul et al. 1963). MacNay (1952, 1953) reported that *D. maculatus* fed on meat scraps in a feed warehouse in Ontario and in a tannery in Manitoba. The damage done by the species is intensified by the habit of the mature larva of boring into any substance close at hand to form a pupal chamber (Hinton 1945).

Biology: Paul et al. (1963) studied the life history of this species (as *D. vulpinus*) under controlled conditions of temperature and humidity. Unless otherwise specified, the biology discussed here was taken from the work of these authors.

Adults of *D. maculatus* mate several hours after emergence (Azab et al. 1973*c*). Following a mean minimum oviposition period of 3.6 days at 30°C and 90% RH, eggs are laid in batches of one to three. The female deposits her eggs mostly in darkness in crevices and sheltered places. Females exhibited a considerable variation in the number of eggs laid, averaging 213 eggs per female (Azab et al. 1973*c*). In a later paper, the same authors (Azab et al. 1973*b*) observed even higher oviposition rates. The duration of the egg stage is inversely proportional to temperature, with a minimum incubation period of 1.1 days at 37.5°C and a maximum period of 3.6 days at 25°C. The incubation period was not affected by levels of humidity between 30 and 90%.

Larvae of *D. maculatus* are negatively phototropic. Larvae developed only at the higher levels of relative humidity of 70 and 90%, the optimum temperature being 30°C. This is consistent with the findings of Bellemare and Brunelle (1950), who observed complete larval development only at 70–100% RH. Azab et al. (1973*a*) found that the larval development period varied from 18 to 64 days at 75% RH and temperatures of 35 and 21°C, respectively. Depending on temperature, the larvae molted from 6 to 17 times. However, Bellemare and Brunelle (1950) found that humidity, and not temperature, affected the number of molts. At all temperatures, they found that 70% RH resulted in seven larval molts and 100% RH resulted in only five molts.

Before pupation the larvae bore into any convenient compact material to form the pupal cell (Hinton 1945). The mature larvae pupate in the last larval skin. Temperature, rather than humidity, influenced the duration of the pupal period, which was shorter at 35 and 37.5°C than at 25 and 30°C. In experiments conducted by Azab et al. (1973*a*), this period varied from 4 days at 35°C to 13 days at 21°C.

Adult longevity is influenced by both temperature and humidity. An increase in humidity generally increased longevity, but the latter varied inversely with temperature. Depending on temperature, humidity, and food supply, adults lived from a mean minimum of 4.7 days to a mean maximum of 42.8 days. However, Azab et al. (1973*a*) recorded adult longevity values as high as 125 days. The number of annual generations under the conditions outlined varies from three to six. In Egypt, Azab et al. (1973*c*) reported five or six overlapping generations for *D. maculatus*.

Comments: Sinha (1965*b*) listed *D. maculatus* from the Maritime Provinces but did not specify which provinces.

Dermestes marmoratus Say
(common carrion dermestid)

Distribution: British Columbia, Alberta, and Manitoba.

Economic injury: *Dermestes marmoratus* was listed as a stored product pest by Sinha (1965*b*). It has been reported from cereal warehouses and a powdered-milk plant in British Columbia (CIPR 1962).

Biology: In California *D. marmoratus* feeds on carrion and dry animal products (Essig 1926).

Dermestes signatus LeConte

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario.

Economic injury: Sinha (1965*b*) listed *D. signatus* as a stored-product pest in Canada. It has been collected in cereal warehouses and a powdered-milk plant in British Columbia (CIPR 1962) and in a broiler barn in Saskatchewan (CAIPR 1978).

Dermestes talpinus Mannerheim

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and the Maritime Provinces.

Economic injury: According to Gregson (1900), *D. talpinus* was well known to the fur trappers of the Northwest. The larvae are known to feed on fur, hide, skin, bacon, wool, and dead insects.

Biology: Gregson (1900) observed pupation on 7 June and adult emergence on 9 August in Alberta.

Comments: Sinha (1965*b*) reported *D. talpinus* from the Maritime Provinces but did not specify which provinces.

Dermestes tristis Fall

Distribution: British Columbia and Alberta.

Economic injury: Sinha (1965*b*) listed *D. tristis* as a stored-product pest in Canada.

Megatoma cylindrica (Kirby)

Distribution: British Columbia, western Alberta, and Northwest Territories.

Economic injury: According to Beal (1967), this species is of negligible economic importance. It has been recorded on corn in Colorado and as a minor household pest in British Columbia.

Biology: Beal (1967) considered the larvae of this species to be general scavengers in the nests of spiders, insects, birds, and mammals, occurring generally in arboreal habitats. Adults are commonly found under the bark of trees.

Megatoma variegata (Horn) (*nevadica* Casey)

Distribution: British Columbia and Alberta.

Economic injury: This species has been reported as a pest of insect collections (Beal 1967). Neilson and Arrand (1958) listed *M. variegata* as an important species of carpet beetle in British Columbia. It has also been found in stored wheat in Oregon, where it was probably feeding on other insect remains (Beal 1967).

Biology: This species is a general scavenger and has been reared on dead house flies, feathers, dry dog food, and pollen (Beal 1967). It has been found in a variety of habitats including an owl's nest, wasp nests, and under a bat roost.

Orphilus niger (Rossi)

Comments: Sinha (1965*b*) listed this species as a stored-product pest in British Columbia, Ontario, and Quebec. Hatch (1962) recorded *O. niger* from the Pacific Northwest, with *O. subnitidus* LeConte and *O. chalybeus* Casey as synonyms. However, according to Mroczkowski (1968), the distribution of *O. niger* is restricted to the Old World, and *O. subnitidus* and *O. chalybeus* are valid North American species. In addition, two other species of *Orphilus* are known from North America (*O. aequalis* Casey and *O. ater* Erichson). Therefore, the true identity of Hatch's and Sinha's *O. niger* is unknown.

Reesa vespulae (Milliron)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: Beal (1967) described this species as a pest of minor economic importance. He suggested that specimens found in wheat in the United States might have been feeding on other insect pests and not on the grain. In British Columbia, Spencer (1957*b*) reported that this species attacked specimens in an insect collection and a herbarium. In the herbarium the larvae fed on petals, buds, and leaves of many plants except conifers. *Reesa vespulae* has also been reported to attack insect specimens in Saskatchewan (MacNay 1958) and Quebec (Robert 1956). Adams (1978) described the pest status of *R. vespulae* in Europe, where it was introduced from North America around 1958. The species has become established in Europe as a pest of museum specimens, but it has also gained prominence as a seed trade and domestic pest.

Biology: Milliron (1939) stated that this species reproduced parthenogenetically, which was confirmed by Beal (1967). The eggs are laid in crevices of dried insects, where they hatch in about 2 weeks (Milliron 1939). According to Robert (1956), the larvae pass through at least six instars, and a generation requires a minimum of 1 year.

Under natural conditions, the dermestid probably lives as a scavenger on dead insects and spiders in wasps' nests (Beal 1967).

Thylodrias contractus Motschulsky
odd beetle (tissue paper beetle)
thylodrias (m.)

Distribution: Alberta, Manitoba, Ontario, Quebec, and Yukon Territory.

Origin: Hinton (1945) reported this species to be native to the USSR and introduced into North America. According to Twinn (1932*b*), it was first discovered in North America in 1902 and in Canada in Ottawa, Ont., in 1930.

Economic injury: This rare insect is found to infest mainly insect collections, but it is also known to feed on fabrics such as wool and silk (Bostanian 1974). It has been reported to damage valuable paintings in the National Gallery of Canada, where it apparently fed on color pigments (MacNay 1954*a*). There are several records of household infestations by this species (Hinton 1945). It is the most frequently found dermestid known to damage insect collections at the Biosystematics Research Centre, Ottawa.

Biology: Although the larvae of this species can live for 3 or 4 years without food, the life cycle of the beetle usually takes about a year. Unlike the males, the females are larviform and wingless (Hinton 1945). Adults emerge early in the spring, even in heated museums, suggesting a temperate origin (Barber 1947).

Trogoderma glabrum (Herbst) (*boron* Beal)

Distribution: Alberta, Ontario, and Quebec.

Origin: Mroczkowski (1968) gave the distribution of *T. glabrum* as the Holarctic region. Vick et al. (1973) stated that the species is native to continental Europe.

Economic injury: White and McGregor (1957) reported that *T. glabrum* is able to develop and maintain large populations in stored wheat and shelled corn, where it tends to infest the upper portions of the grain bulk. In literature summarized by Kantack and Staples (1969), *T. glabrum* has also been reported in cottonseed meal, bromegrass seed, barley, sorghum, soybean meal, and wheat bran. These same authors also described the nature of the injury caused by this species. Damage by the larvae is confined mainly to the germ portion of the wheat, corn, and sorghum kernels. The endosperm and bran are attacked only after the germ has been consumed. Infestations are indicated by the presence of exuviae and metabolic waste products on the surface of the grain, which produce a dead animal odor. In Canada, CIPR (1958) reported *T. glabrum* from flour mills in Alberta, and MacNay (1957*b*) reported the species as infrequent in flour mills in the Prairie Provinces.

Biology: Archer and Strong (1975) investigated the biology of *T. glabrum* under various conditions of temperature and humidity. The results reported here refer to their work, unless otherwise specified.

In *T. glabrum*, mating took place immediately after the adults emerged from the last larval skin (Kantack and Staples 1969). A decrease in temperature resulted in an increase in the length of the preoviposition and oviposition periods. At constant and programmed fluctuating temperatures of 32.2 and 26.7°C, these periods lasted 2 and 4–7 days, respectively. The number of eggs laid per female was variable under all conditions and ranged from 76 to 89 eggs under the most favorable temperatures. Eggs were laid singly in crevices or under loose particles near the surface of the food.

An increase in temperature decreased the egg-hatching period, the effect being most pronounced at 21.1°C. At 32.2 and 26.7°C, eggs hatched in 6–9 days. Humidity had little effect on the duration of the egg stage, but it influenced egg viability. In general, the hatchability of eggs of *T. glabrum* was adversely affected by combinations of high humidity and low temperature or low humidity and high temperature.

A temperature of 37.8°C resulted in high larval mortality, the effect being more pronounced as the RH decreased from 70 to 30%. The rate of larval development was greatest at 32.2°C and 70% RH. Males and females normally required five or six and six or seven larval molts, respectively, before pupation. However, under adverse conditions, larvae may molt 11 or 12 times (Kantack and Staples 1969). Beck (1971) found that mature larvae of *T. glabrum*, when deprived of food, failed to pupate and entered a period of retrogressive development. In this state, they periodically underwent "retromolts" to a progressively smaller size. This phenomenon was arrested when food was reintroduced.

Pupae took longer to develop at 21.1°C and at temperatures fluctuating around daily means of 21.1 and 15.6°C than at higher temperatures. The pupal stage lasted 3–6 days at constant and programmed fluctuating temperatures of 32.2 and 26°C. After transformation, adults remain quiescent in the last larval skin for a period of 2 days at 38°C to 7 days at 21°C (Kantack and Staples 1969). At 32.2 and 26.7°C with 70% RH, the average period from egg hatch to adult emergence was 30–49 days.

Adult longevity increased as temperature decreased. Unmated females lived longer than mated females and much longer than males. Kantack and Staples (1969) reported that adults of *T. glabrum* did not feed. In Nebraska the species overwinters in the larval stage.

Vick et al. (1973) found that males of *T. glabrum* subjected to a photoperiod of 14 h of light and 10 h of darkness were more responsive to the female pheromone between the 5th and 11th h of the photophase. This corresponded to the period of optimum mating receptivity, even though the amount of extractable female sex pheromone remained fairly constant during the first 9 h of the photophase.

Trogoderma granarium Everts
khapra beetle
dermeste des grains (m.)

Comments: The khapra beetle is among the world's most feared pests of stored grain (Banks 1977). It has been intercepted at most major Canadian ports (CIPR 1957, 1958, 1962 to 1965). However, according to Monro (1969), *T. granarium* is not known to be established in Canada. Howe and Lindgren (1957) predicted that this species is not likely to multiply in sufficient numbers to become a problem unless the average temperature exceeds 20°C for at least 4 months, but it would become a very serious pest if an average of 20°C is exceeded for 6 months or longer. Of the 106 locations in the Prairie Provinces and eastern Canada where the temperatures were calculated for small grain bulks, Sinha (1963) found that a small area in the vicinity of Chatham, Ont., was the only locality that had a mean monthly temperature of at least 20°C for 6 months or longer. However, the high humidity in this area would not allow the species to compete successfully with other stored-product pests.

The report of *T. granarium* from a house in Mt. Pearl, Nfld. (CAIPR 1978), refers to *Stegobium paniceum* and not to the khapra beetle (D.E. Bright, personal communication).

Trogoderma inclusum LeConte (*versicolor*, of authors not Creutzer)
(warehouse beetle)
trogoderme des denrées (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Prince Edward Island, and Newfoundland.

Origin: *Trogoderma inclusum* is known from the British Isles and North America; whether the species is indigenous to Great Britain or North America will probably never be known (Beal 1956). Twinn (1934*b*) reported that the beetle was first recorded in Canada from a dried-milk plant at Napanee, Ont., in 1930.

Economic injury: Under the name *T. versicolor*, Beal (1954) described this species as a very common pest in dried-milk factories. Marzke (1963) gave the relative preferences of adults and larvae of this species to various dried-milk products. Both larvae and adults showed a marked preference for caseins, with the highest average numbers being attracted to sweetened casein. According to Strong (1975), larvae of *T. inclusum* are found on a wide variety of products, but are most likely to infest processed dry foods and animal feeds in processing plants and storage facilities. They are less likely to infest stored grains. In Canada this dermestid has been recorded in drug (CIPR 1958) and cereal warehouses (MacNay 1948, CIPR 1962), flour mills (MacNay 1957*b*), powdered-milk plants (Twinn 1934*b*, MacNay 1950), empty granaries (Liscombe and Watters 1962), and a dwelling (CIPR 1960). It has infested stored seed (MacNay 1956), grain (CAIPR 1978), wheat (CAIPR 1977), and botanical specimens (CIPR 1960). Strong (1975) believed that *T. inclusum*'s pest status is limited by climate rather than suitable food. Because of the cold winters and short summers in grain-growing areas of Canada, van Whervin and Pengelly (1973) do not think that this species can adapt physiologically or behaviorally to become a serious pest of stored grain in this country.

Biology: Strong (1975) studied the biology of *T. inclusum* under various controlled and programmed fluctuating conditions of temperature and humidity. Unless otherwise indicated, the summary given here is based on Strong's work.

Vick et al. (1972) have shown that males of *T. inclusum* are most responsive to the female pheromone between the 3rd and 8th h of the photophase in a photoperiod of 14 h of light and 10 h of darkness. Optimum female mating receptiveness also corresponded to this period, even though the amount of extractable sex pheromone remained fairly constant for the first 9 h of the photophase. Multiple matings are common in this species, but females do not require frequent copulations to lay a full complement of eggs. Vick et al. (1973) found that females of *T. inclusum* have a refractory period that ranges from 2 days to the remaining life of the female following mating, in which they do not mate again. However, approximately 75% of the eggs are produced before the second mating, and the sperm from the first mating fertilizes some eggs after the second mating.

The duration of the preoviposition and oviposition periods was inversely related to temperature. The period of preoviposition ranged from less than 1 day to 2 days at 32.2°C and from 4 to 25 days at a programmed fluctuating daily temperature around a mean of 15.6°C. The oviposition period lasted 1–6 days at 37.8°C and up to 30 days at the same programmed temperature. Females deposited eggs singly in crevices near the surface of the larval food. The duration of the egg stage at temperatures between 37.8 and 21.1°C was 3–8 and 10–18 days, respectively. Humidity had no effect on the duration of this stage, but low humidity adversely affected egg hatch at 37.8°C.

An average of 84.8 larvae were produced by each female at 32.2°C and 50% RH. Van Whervin and Pengelly (1973) found that the mean duration of the larval stage at 29°C and 44–72% RH was 35.3 days, and at 17–28°C and 10–82% RH it was 251.5 days. Most males and females pupated after five (range, four to seven) and six molts (range, five to nine), respectively. Larval mortality was 100% at all temperatures above 40.6°C and approached 100% at 37.8°C and 30% RH. Larval development was retarded at a constant temperature of 21.1°C and a programmed temperature of 15.6°C, and larvae pupated under these conditions. Some larvae failed to pupate after reaching full growth and were considered to be in diapause.

The optimum combinations of temperature and RH for pupation and adult maturation were 32.2°C and 70% RH. Sex had little effect on the duration of the pupal period and on subsequent adult maturation, which required an average of 4.8 days for males and 4.7 days for females at the optimum temperature. Pupae took longer to develop as the temperature fell below 32.2°C. Adult longevity also increased with decreases in temperature. Unmated adults lived longer than mated adults and males had a greater life span than mated females. At the optimum temperature for development, mated males and females lived an average of 42.5 and 8.6 days, respectively. Quite high average temperatures are necessary for the development of *T. inclusum*.

Trogoderma ornatum (Say)

Distribution: Ontario.

Economic injury: Beal (1954) described *T. ornatum* as having some economic importance in North America. Occasionally found in Ontario, Gibson and Twinn (1939) did not consider it important in that province. Although able to subsist on cereals alone, it is apparently never a serious granary pest in Ontario. In California, it has been found infesting beans, barley, cottonseed pellets, broom corn, beet seed, fish meal, canarygrass seed, and oats (Beal 1956). Hinton (1945) summarized other economic records of this beetle. It has been found infesting stuffed mammals and birds, insect collections, and botanical specimens in museums. The larvae have been reported to feed on stored seeds of a wide variety of cultivated plants and on various animal products.

Biology: The larvae of this dermestid have been found under bark in Ohio feeding on the eggs of the spiders *Nuctenea cornuta* (Clerck) (as *Aranea frondosa* Walckenaer) and *N. sclopetaria* (Clerck) (as *Epeira sclopetaria*) (Auten 1925). Cotton and Good (1937) listed the bethylid wasp, *Laelius trogodermatis* Ashmead, as a parasite of this species.

Trogoderma simplex Jayne

Distribution: British Columbia.

Economic injury: According to Beal (1954), this species is a pest of only minor economic importance. Although widely distributed in western North America and occurring on a wide variety of stored products, *T. simplex* rarely becomes a serious pest, possibly because of natural control by diseases at high population densities (Strong and Mead 1975). MacNay (1957*b*) reported *T. simplex* from a cereal warehouse in British Columbia. However, according to Zuk (1958), this species is only of local importance. It has been recorded in oatmeal in Montana, in a farm granary in Utah (Beal 1954), and in grain elevators in Washington (Chao 1954). Strong et al. (1959) provided a list of stored products or possible host materials with which *T. simplex* was associated in California. Emsley (1978) described infestations by this beetle in gelatin pharmaceutical capsules in Minnesota and Colorado.

Trogoderma simplex appears to occur naturally in the nests of bees and wasps, but it has also been collected in a forest tent caterpillar nest and a bostrychid burrow (Beal 1954). The adults have been recorded on the flowers of cotton, citrus, *Pluchea* sp., *Acacia* sp., and *Heliotropium* sp. (Beal 1956).

Biology: Strong and Mead (1975) investigated the biology of *T. simplex* under various combinations of controlled constant and programmed fluctuating temperatures and humidity. The preoviposition period of the species increased as the temperature decreased. The oviposition period exhibited a similar trend except at 21.1°C (one of the lower temperature conditions), at which the females laid all the eggs within a short period following a long preoviposition period. Females laid eggs singly near the surface of the food supply in or between food particles. At the optimum conditions of 32.2°C and 50% RH, the eggs hatched in an average of 7.1 days and produced an average of 79.3 larvae per fecund female. As the temperature decreased, the incubation period increased. Male and female larvae required 39.6 and 42.3 days to develop, completing a minimum of five and six molts, respectively. All larvae died at temperatures of 40.6°C and above, and at 37.8°C and 50% RH, larvae failed to pupate. At the same temperature and 30% RH, all larvae died. A temperature of 18.3°C was close to the lower tolerance limit of young larvae.

At 32.2° and 50% RH, pupation and adult maturation averaged approximately 6 days. Unmated females generally lived longer than mated males and females and unmated males. Decreased temperature increased adult longevity. Males pupated significantly earlier than females. The rate of pupation was high at both 32.2 and 26.7°C, but at 32.2°C, reducing the RH to 20–30% increased the length of time to pupation.

Feeding studies with 32 food types indicated that the greatest population increases occur on pollen, poultry-laying mash, cat food, and dog food. Foods such as recleaned barley, lima beans, and kidney beans, all of which have hard seedcoats, were resisted by the feeding insects and therefore did not cause population increases.

Trogoderma sinistrum Fall

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Northwest Territories, and Yukon Territory.

Economic injury: This species has been recorded in wheat in a granary in the Prairie Provinces (MacNay 1957*b*) as well as in an empty granary (Liscombe and Watters 1962). Liscombe and Watters (1962) stated that the species had uncertain significance as a stored-product pest.

Trogoderma sternale Jayne

Distribution: British Columbia.

Economic injury: According to Beal (1956), this species is best known as a pest of insect collections, but it is also known to occur in granaries, usually in association with other insects. Beal also gave an extensive list of stored products that this species has been reported to infest in California. These included a wide variety of stored seeds, nuts, cereals, dehydrated vegetable materials, and miscellaneous proteinaceous animal and vegetable products. He suggested that *T. sternale* may exist only as a secondary pest, following infestation by other insects.

Biology: Beal (1954) discussed various aspects of the life history and behavior of this species. In cultures, males generally emerge 3 days to a week before the females. Males attempt to copulate with females of several other species of *Trogoderma*. Females, however, are receptive to males of the *T. sternale* species only.

As with all species of the genus, this species pupates in the last larval skin. After transformation, the adults remain quiescent in the larval skin for a period of time that is dependent on the temperature.

This species has been reported, under natural conditions, to feed on the eggs and web contents of the black widow spider. This behavior is typical of members of the genus, which are scavengers in the nests of birds, bees, and spiders.

Trogoderma teukton Beal

Distribution: Quebec.

Origin: Beal (1956) suggested that *T. teukton* is probably an introduced species to North America, as indicated by its unnaturally limited distribution.

Economic injury: This species has been recorded from a display of silk in Minnesota, as a pest of whole wheat from North Dakota (Beal 1956), and in a grain elevator in Washington (Hatch 1962). Two specimens of this species in the Canadian National Collection from Montreal, Que., are labeled "flour mill". These specimens represent the only record of this species in Canada.

Trogoderma variabile Ballion (*parabile* Beal)
warehouse beetle (grain dermestid)
trogoderme des grains (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and New Brunswick.

Origin: When Beal (1954) described *T. parabile* from North America, he assumed that its distribution and association with humans suggested that it was an introduced species. At that time, he stated that eventually it would be made synonymous with a species indigenous to another faunal region. Subsequently, Mroczkowski (1968) recognized *T. parabile* as a synonym of the central Asian species *T. variabile*. The first record of this species in Canada is based on specimens collected in feed warehouses and flour mills in southern Alberta in 1957 (Loschiavo 1960).

Economic injury: According to Cross et al. (1977), *T. variabile* is a major pest of stored products. Beal (1956) reported that the species can be reared successfully on cereal products alone and that it feeds on a wide variety of stored seeds, legumes, and nuts and products with a high protein content. Partida and Strong (1975) reared *T. variabile* on a variety of stored products, but stated that animal feeds (mixed feeds and processed grains), barley, wheat, several grocery commodities and pollen were the preferred foods. Beal (1954) described the species as a granary pest in California.

Loschiavo (1960) stated that since *T. variabile* can adapt itself to cold conditions and overwinter in unheated buildings, it may become an economically important pest in Canada. This, in conjunction with its high reproductive potential, makes the species a potentially serious pest. However, in the Prairie Provinces, the short summer season would not allow optimum development and reproduction of *T. variabile* in unheated grain storages because suitable temperatures are not sustained for the long life cycle of this species (Loschiavo 1967). In Canada *T. variabile* has been found in stored samples of seed wheat, feed mills (MacNay 1958), a cereal warehouse, a powdered-milk plant (CIPR 1962), warehouses, flour mills (CIPR 1960) and stored grain (CIPR 1964). The larvae eat all the grain kernel except the shell and can chew holes in hard plastic at least 1.5 mm thick (CIPR 1960).

Biology: Partida and Strong (1975) studied the biology of *T. variabile* over a range of combinations of constant temperature and humidity. They also evaluated the effects of programmed fluctuating daily temperatures and levels of humidity on the biology of this species. The information provided here pertains to the work of these authors, unless otherwise indicated.

The length of the preoviposition and oviposition periods of *T. variabile* increased as the temperature decreased. At 32.2°C and 50% RH, the optimal climatic condition, the mean preoviposition and oviposition periods were 1.0 and 3.2 days, respectively. Loschiavo (1968) found that adults fed but did not require food to lay eggs. Eggs were usually laid singly or in short chains, the females preferring to deposit eggs in crevices and under the surface of loose food. Egg production was extremely variable among individuals. Females did not require frequent copulations to lay a full complement of eggs. Most larvae were produced by eggs laid soon after oviposition began. At 37.8°C the percentage hatch of eggs was greatly reduced, especially at 30% RH. At temperatures of 32.2°, 26.7°, and 21.1°C, a high percentage of eggs were hatched, the duration of the egg stage increasing as the temperature decreased. At 32.2°C and 50% RH, the eggs hatched in 6 days.

Under optimum conditions of temperature and humidity, a mean of 82.3 eggs were produced per fecund female, although egg production was extremely variable under all conditions. Temperatures of 35 and 21.1°C approached the upper and lower limits for larval development. Loschiavo (1960) found that the greatest increase in size occurred between the third and fourth larval instars and that the duration of each instar was progressively longer. Before pupation, males and females usually completed five and six molts, respectively. Some larvae went into diapause during unfavorable conditions of temperature or moisture. Mature larvae are able to survive 6-day exposures to temperatures as low as -1°C (Loschiavo 1960).

Of the nondiapausing larvae, the majority pupated within a 10- to 15-day period. Decreases of temperature prolonged the pupal period but had little effect on adult maturation. At 32.2°C and 50% RH, pupation and adult maturation lasted approximately 5 days. Adult longevity varied inversely with temperature, and unmated adults generally lived longer than mated adults. At 32°C and 70% RH, females that were older than 7 days laid few eggs and lived only a few days after oviposition ceased (Loschiavo 1960).

Programmed fluctuating temperatures, conditions approximating those that insects would normally experience, indicated that *T. variabile* required quite high average temperatures to develop. However, high peak temperatures are detrimental to development.

Cross et al. (1977) have shown that females of *T. variabile* exhibit a diel calling behavior characterized by abdominal elevation and pheromone release. The maximum calling activity occurred 2–4 h after the onset of the light period. This is approximately 7 h earlier than the peak calling activity of *T. glabrum* and may function as a reproductive isolating mechanism between the two species.

Loschiavo (1969) discussed the biology and parthenogenicity of a protozoan species of *Adelina*, which parasitized larvae, pupae, and adults of *T. variabile*.

ELATERIDAE click beetle or wireworm
taupin (m.) or ver fil-de-fer (m.)

Larvae of this family are known as wireworms, and the majority are predaceous on mites and insects. However, many are phytophagous root feeders and are major pests of crops, and other species are saprophagous. Little is known about the feeding habits of adults; they may feed on pollen or tender plant tissue, but they seldom cause any significant damage. Species of this family are well represented in all parts of the world. There are about 9000 species known, of which 380 are estimated to occur in Canada.

Aeolus mellillus (Say) (*dorsalis* (Say))
(flat wireworm)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, and Northwest Territories (?).

Economic injury: Stirrett (1936) listed tobacco, corn, and sugar beet as important crops damaged by this species in Ontario. Additional crops attacked include soybeans, commercial mint, potato, strawberry, and wheat. This species severely injures crops during the first year that they are planted on new sod land (Stirrett 1936), although crops on land under cultivation for a number of years may also be damaged. In western Canada, Glen et al. (1943) considered *A. mellillus* to be a minor pest of cereals and compared the damage it caused to the work of cutworms. The point of attack is usually near the soil surface, and in the case of young grain plants, the stems are completely cut off. The larvae bore into seed corn, eat out the germ, and enter the underground stem, causing wilting and death of the young plants (Wressell and Hudon 1968).

Biology: Jewett (1942) made observations on the life history of this species in captivity. He observed that in central Kentucky, this beetle is parthenogenetic as described by Glen et al. (1943) in Canada.

In Kentucky, overwintered adults lived throughout spring and summer and laid eggs from early May to late September. The average incubation period for 2 years lasted 9.7 and 12.5 days (range, 7–18).

Two distinct broods of larvae were observed each year, one that developed from eggs laid in the spring and early summer and produced adults the same season; and another that developed from eggs laid in midsummer and later and overwintered. Newly hatched larvae actively sought shelter and food by boring into tender rootlets or germinating seeds. The larvae are also predacious (Glen et al. 1943) and cannibalistic (Jewett 1942).

Seventy-five percent of the overwintered larvae pupated before the end of June. The pupal period ranged from 8 to 23 days.

This species prefers drier situations in native grasslands and is usually found under stones, sticks, or dry manure (Brooks 1960). Infestations, however, also occur in irrigated land and in soils of a wide range of textures (Glen et al. 1943).

In Saskatchewan adult activity began in late May, reached a peak from about mid June to mid July, and ended about the end of August. Adults were far more abundant in fields than in border areas (Doane 1977*b*).

Comments: Two specimens in the Canadian National Collection, of doubtful origin, are labeled "N.W.T."

Agriotes criddlei Van Dyke

Distribution: British Columbia, Alberta, Saskatchewan, and southwestern Manitoba.

Economic injury: On one occasion in British Columbia, larvae were reported to feed on wheat seedlings, but the damage was negligible (Wilkinson 1963). Glen (1944) described *A. criddlei* as an important grain-crop pest in Alberta and Saskatchewan.

Biology: Wilkinson (1963) reported this species in upper parkland loam in British Columbia. The larvae of this typical prairie species prefer loam soil with considerable clay in the subsoil. They have also been taken in soils ranging from fine, sandy loam to clay (Glen 1944). Brooks (1960) stated that *A. criddlei* is moderately abundant on the prairies of southern Alberta but more abundant in meadows than on mixed prairie of the Cypress Hills. Laboratory-reared larvae pupated in early August, and the adults appeared 7–10 days later (Glen 1944).

Agriotes ferrugineipennis (LeConte)

Distribution: British Columbia and southwestern Alberta.

Economic injury: This species is often found in gardens, but it has not been found in large numbers, nor has it been reported damaging crops (Wilkinson 1963).

Biology: *Agriotes ferrugineipennis* is usually found in wet areas and irrigated land and seems to have no preference for soil type (Wilkinson 1963).

Agriotes limosus LeConte
(little brown click beetle)
petit taupin brun (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland, and Northwest Territories.

Economic injury: This species may be of minor economic importance where aspen poplar is cultivated in damp sand (Glen et al. 1943, Beirne 1971).

Biology: Mature larvae pupated in July, and emergence occurred about 2 weeks later. Other than this rearing record, no details are known regarding the life history of this species (Becker 1956).

This species inhabits the aspen poplar successional stages of the northern coniferous forest. The larvae prefer moist, well-drained situations such as damp leaf litter overlying sand or gray podzolized soil in field depressions (Becker 1956).

Agriotes lineatus (Linnaeus)
lined click beetle
taupin rayé (m.)

Distribution: British Columbia, Nova Scotia, and Newfoundland.

Origin: This European species was first recorded in Canada on Vancouver Island in 1949 and was subsequently found in Nova Scotia and Newfoundland (Beirne 1971). In the Maritime Provinces, according to Eidt (1953), it was probably introduced in ship ballast and is now restricted by forests to small areas in the vicinity of old ports.

Economic injury: This species is among the most important agricultural pests in Europe (Eidt 1953). In Canada it has been reported to damage beet, cabbage, corn, lettuce, onion, potato, pumpkin, rhubarb, rutabaga, and turnip, as well as flowers and lawns.

Biology: In British Columbia, *A. lineatus* is found in conjunction with *A. obscurus*, the former being the more dominant of the two species. In the limited areas of British Columbia where the two species occur, the soils are silty loam and clay. Both species, however, may occur in light sandy, gravelly, and muck soils as long as the moisture content remains high all year (Wilkinson 1963).

Adults may be found under boards, stones, and debris at the margins of fields. Larvae are usually collected in the top 10 cm of soil during every month, but they may be found as deep as 20 cm. The life history of the lined click beetle is similar to that of *A. mancus* (Becker 1956).

Agriotes mancus (Say)
wheat wireworm
taupin du blé (m.)

Distribution: southeastern Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: The wheat wireworm is the most important economic species of click beetle in eastern Canada. Crops planted in fields recently ploughed from sod are especially liable to damage (Beirne 1971). Injury to corn, cucumber, oats, potato, soybeans, strawberry, tobacco, turnip, and wheat has been reported. Sound, ripe tomatoes resting on ground have also been attacked (CIPR 1955).

Biology: The life history of *A. mancus*, in the organic soils of southwestern Quebec, was studied by Lafrance (1967). Adults overwintered in the pupal cell at a depth of 2.5 to 17 cm. Emergence started in early May, when the soil temperatures ranged from 2 to 10°C, and was followed by peak levels of copulation when air temperatures ranged from 14 to 27°C. Oviposition began around the second week in June and peaked around the last week in June. Eggs were deposited in the top few centimetres of soil. For 23 mated pairs, the number of eggs laid ranged from zero to 194, and the oviposition period lasted an average of 44 days.

During early spring until early June, the larvae remained in the top 15 cm of soil. As the soil dried out, the larvae migrated deeper, where they remained until mid September. At this time the larvae moved back toward the surface, only to descend again before the soil froze. After 3 years of larval development, the larvae pupated in earthen cells during the second week of July. They remained in the cells until the adults emerged the following spring.

The distribution of this species appears to be governed by soil moisture. The species occurs in a variety of soil types but is mainly restricted to poorly drained land and muck soils (Glen et al. 1943).

The spider *Xysticus ferox* (Hentz) and the beetles *Staphylinus badipes* LeConte and *Pterostichus lucublandus* Say have been reported to feed on the adults; *Pterostichus lucublandus* also feeds on the larvae (Hawkins 1936).

Agriotes obscurus (Linnaeus)
(dusky wireworm)
taupin obscur (m.)

Distribution: British Columbia, Nova Scotia, and Newfoundland.

Origin: This is one of the most common species of *Agriotes* in Europe (Becker 1956). Brown (1940*b*) reported specimens of this species collected in Nova Scotia circa 1859. It is believed to have been introduced into British Columbia between 1895 and 1900 in soil around hop plants and into eastern Canada in ballast from sailing ships (MacNay 1954*a*). In the Maritime Provinces, this species is generally restricted to areas around old ports (Eidt 1953).

Economic injury: The larvae of this species have been reported to damage alfalfa, corn, potato, rye, and grassland.

Biology: In Nova Scotia, Fox (1973*a*) found that grasses and clovers are the preferred habitats and food of larvae of this species. Wilkinson (1963) observed *A. obscurus* usually in clay and silty loam but stated that it may also occur in light sandy, gravelly, and muck soils that have a high annual moisture content. Larvae are usually found in the top 10 cm of soil, seldom occuring below 20 cm (Becker 1956).

Agriotes obscurus exhibits a life history similar to that of *A. mancus* (Becker 1956).

In Nova Scotia, Fox (1961*b*) investigated the incidence of a fungus known as green muscardine, *Metarrhizium anisopliae*, in this wireworm species. The fungus caused the highest mortality immediately before, during, and after the pupal period. Few overwintered larvae and adults were killed by this pathogen. A neoplectanid nematode has been observed infesting a few of these wireworms in Nova Scotia (CIPR 1965).

Agriotes opaculus (LeConte)

Distribution: British Columbia.

Economic injury: This species, with *Ctenicera aeripennis aeripennis*, has been reported to feed on potato seed pieces in silty loam soil (Wilkinson 1963).

Agriotes sparsus LeConte
(western wireworm)
taupin occidental (m.)

Distribution: British Columbia.

Economic injury: According to Wilkinson (1963), this is one of the main pests known to attack potatoes, especially late potatoes in the delta of the Fraser Valley. Damage to potatoes is more severe in the second year following the breaking of sod. This species is also known to attack a wide range of plants including vegetables (Banham and Arrand 1978), and there is one record of attack by this species on gladiolus corms (Wilkinson 1963).

Biology: In the Fraser River delta, the larvae are found mostly in low, moist, silty-loam soils (Wilkinson 1963). In summer, the larvae are found at depths of 30 cm or more in the soil (Becker 1956).

Agriotes sputator (Linnaeus)

Distribution: New Brunswick and Nova Scotia.

Origin: This common European and Mediterranean species (Becker 1956) was first recorded in North America from a single specimen collected in beach drift at Tabusintac, N.B., in 1939 (Brown 1940*b*).

Economic injury: Fox and MacLellan (1956) referred to this wireworm as a prolific and destructive pest in Nova Scotia. The species develops high populations in grassland, causing the vegetation to deteriorate. Only hawkweeds (*Hieracium* spp.) are spared, plants that are apparently unattractive to this species. *Agriotes sputator* has been known to ruin hay and greatly reduce yields in cereal and row crops (MacNay 1954*a*). Beirne (1971) listed potato, onion, parsnip, cabbage, turnip, mangel, carrot, and beans as crops damaged by this wireworm.

Biology: The life history of this species is similar to that of *A. mancus*, but the larvae apparently prefer drier and lighter soils

(Becker 1956). They are usually numerous in high, dry grassland but do not spread into forested areas (Fox 1961*a*).

Laboratory feeding tests indicated that larvae of *A. sputator* preferred to feed on grasses than on other plants found in grasslands; however, a plantain species, ribgrass, was preferred to timothy (Fox 1973*b*).

Using the precipitin test, Fox and MacLellan (1956) showed that species of the carabid genera *Agonum, Amara, Clivina, Harpalus,* and *Pterostichus* and the staphylinid genera *Philonthus, Staphylinus,* and *Tachyporus* prey on larvae of this species in the field.

Cardiophorus fenestratus LeConte

Distribution: British Columbia.

Economic injury: There is one old record in the literature (Brittain 1914) of a major infestation of this species, which fed on the buds and tender foliage of apple.

Ctenicera aeripennis aeripennis (Kirby) (*aeripennis tincta* LeConte)
Puget Sound wireworm
taupin des graminées (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Northwest Territories, and Yukon Territory.

Economic injury: Wilkinson (1963) considered this species to be the most widespread wireworm pest in British Columbia. He stated that larvae have been found in every agricultural area in the province, although they do not occur in large numbers in irrigated land. *Ctenicera aeripennis aeripennis* is a pest of cereals and truck crops (Glen et al. 1943). MacNay (1946) listed lima beans, tobacco, corn, and gladiolus as cultivated plants attacked. It has also been reported to add slightly to grain injury in the northern areas of Saskatchewan (MacNay 1953), and it commonly causes damage to strawberry (Andison 1956) and raspberry (Chamberlain and Putnam 1964) in British Columbia. Other plants attacked include alfalfa, barley, carrot, flax, sugar beet, rye, and wheat.

Biology: The Puget Sound wireworm occurs in areas of grey soil with a natural vegetation of mixed aspens and conifers. It has been taken in soils that range in texture from sand to clay. Highest population densities occur in light loams with loose structure (Zacharuk 1962).

Comments: Beirne (1971) recorded that this subspecies damaged tobacco in Ontario. This finding is inconsistent with the known distribution of the subspecies. Fox and Stirrett (1952), who list

British Columbia as the area of distribution, provide the only reference to the species attacking tobacco. Since Beirne cited "Rep. Ent. Soc. Ont. 82", the publication in which Fox and Stirrett's paper is found, his record is probably a misinterpretation.

Ctenicera aeripennis destructor (Brown)
prairie grain wireworm
taupin des prairies (m.)

Distribution: Peace River District of British Columbia, Alberta, Saskatchewan, Manitoba, and Northwest Territories.

Economic injury: Eidt (1959) considered *C. aeripennis destructor* to be the most important wireworm in western Canada. This subspecies, along with *Hypolithus bicolor* Escholtz, is one of the two most widespread wireworms known to cause economic damage in the Prairie Provinces (Doane 1977*a*). Grain fields and other grasses are severely infested (Glen et al. 1943). Extensive records in the literature described damage by this species to grain crops. Wheat seeded on summerfallow is most severely damaged, but crops seeded on stubble are also seriously thinned. The larvae attack underground stems of cereals, shredding them without cutting them off. The larvae squeeze the stems with their mandibles, ingest the fluids, and leave the fibres intact (Eidt 1959). Damage to potato and other vegetables is also common. Other crops attacked include barley, carrot, corn, flax, lettuce, oats, onion, canola, strawberry, sugar beet, sunflower, and tomato.

This dryland species is abundant and injurious on the well-drained, light and medium soils of the open prairies, but it is also a pest in irrigated sandy soil (Glen et al. 1943). Crops grown in newly broken sod are damaged for the first few years; the injury then decreases rapidly only to increase gradually in succeeding years (Philip 1977).

Biology: Zacharuk (1962) gave detailed information on the ecology, life history, and habits of *C. aeripennis destructor*. This subspecies appears to be confined to Black and Brown soil zones in the prairie and parkland regions of the grassland formation. In the Gray–Black transition zone, *C. aeripennis destructor* occurs in islands of Black soil with a natural vegetation of grasses and aspen groves. Larvae are taken in all but very saline or very sandy soils. Maximum population densities occur in poorly leached sites such as knolls and slopes.

Under laboratory conditions, the average incubation period at 20 and 28°C was 20 (range, 19–23) and 11.5 days (range, 11–15), respectively. The larvae passed through 9–11 instars, with males averaging fewer instars than females, but under favorable conditions of soil and food, the larvae passed through more instars. The larval period lasted from 1 year to more than 2 years. Larvae of the first five instars fed on root hairs and fungal mycelia; those of the third to fifth instars also fed on moist seeds, coleoptiles, and stems; and later instars attacked the germ end of the seed and often destroyed all but the bran. In the field, the majority of larvae hibernated at a depth of 5–10 cm, but depths ranged from 1.5 to 46 cm. When soil temperatures reached 7°C in late April and early May, the larvae resumed activity. As observed with other wireworms, vertical distribution in the soil was controlled by soil moisture content. Under field conditions, the larval period probably requires a minimum of 2 years, with an average of about 3 years.

Prepupae are formed during the last week of the final instar. Earthen cells for pupation are formed by continuous rotation of the prepupa in firm, moist soil. In the field, pupation started in late July and was completed in August. The pupal period at 20°C lasted 2–3 weeks.

Adults hibernated in the pupal cell to emergence the following spring. In the Saskatoon area, emergence occurs around the beginning of May. Females emerged 1–2 days later than males. Copulation occurred soon after the females emerged. Males died 1–3 weeks after mating. Neither males nor females could be induced to mate more than once. In the laboratory, the preoviposition period ranged from 7 to 16 days, and the oviposition period lasted 1 to 22 days. In the field, females were collected in decreasing numbers until the end of July. Females were occasionally observed feeding on grass blades, wheat seeds, mushroom, strawberry, and roots of radish.

Zacharuk (1962) reported carabid, therevid, and other elaterid larvae preying on this species. Pathogenic fungi of the genera *Beauveria* and *Metarrhizium* were observed infesting the larvae and nematodes, and mites were reported to parasitize the adults of *C. aeripennis destructor*.

Ctenicera cylindriformis (Herbst)
(meadow wireworm)
taupin des prés (m.)

Distribution: southwestern Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: This species has been reported on forage crops in Prince Edward Island (Thompson 1964), in gardens in New Brunswick (Glen et al. 1943) and in permanent pastures and old fields in the Atlantic Provinces and Ontario (Beirne 1971). In the Annapolis Valley, N.S., Fox (1961*a*) stated that this species is not as numerous in cultivated fields as it is in dike land.

Biology: Fox (1961*a*) suggested that this species shows a preference for low, wet land and that the larvae may be partly carnivorous.

Ctenicera glauca (Germar)
dryland wireworm

Distribution: British Columbia, Alberta, and Saskatchewan.

Economic injury: Larvae of this species have been reported to injure grain crops (Glen et al. 1943). Wilkinson (1963) reported attacks on wheat in parkland soil and on cabbage transplants in muck soils in British Columbia.

Ctenicera hieroglyphica (Say)
taupin hiéroglyphe (m.)

Comments: Brittain (1912) reported that *C. hieroglyphica* adults fed on the buds and young leaves of apple in British Columbia. However, Brown (1936) gave the distribution of this species as eastern North America, occurring as far west as Manitoba, with no records of damage. Brittain's record undoubtedly represents a misidentification and may refer to *C. pucida* (Brown) (E.C. Becker, personal communication).

Ctenicera inflata (Say)

Comments: In British Columbia, Brittain (1912, 1914) and Ruhman (1915) reported economic damage by *C. inflata* in apple orchards. Glen et al. (1943), however, stated that *C. inflata* inhabits only eastern North America and is of no economic importance. These western records may be attributable to *C. glauca* as are other records discussed by Glen et al. (1943).

Ctenicera kendalli (Kirby) (*virens* Schrank)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Newfoundland, Northwest Territories, and Yukon Territory.

Economic injury: Although this is a widely distributed species, localized records of damage are limited to northern Saskatchewan, where it is a serious pest for 3 or 4 years following the breaking of willow scrubland (Glen et al. 1943).

Ctenicera limoniiformis (Horn)

Distribution: Alberta, Saskatchewan, Manitoba, and western Ontario.

Economic injury: Larvae believed to belong to this species were collected in cultivated fields in the parklands of Saskatchewan (Glen et al. 1943).

Biology: This species occurs in grassy margins of fields and groves (Brooks 1960).

Ctenicera lobata caricina (Germar)

Distribution: British Columbia.

Economic injury: There are several records of damage by this subspecies to potato (MacNay 1957*b*–1959). Neilson (1957*a*) also reported that this subspecies fed on strawberry.

Biology: According to Wilkinson (1956), this subspecies inhabits low-lying silt and clay soils, especially when fields are left in sod for several years.

Ctenicera lobata lobata (Eschscholtz)
(gladiolus wireworm)
taupin de glaïeul (m.)

Distribution: British Columbia.

Economic injury: Chamberlain et al. (1964) reported that this subspecies occasionally attacked new raspberry plantings. The larvae fed on the roots, weakening the plants.

Ctenicera lobata tarsalis (Melsheimer)

Distribution: Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: The literature contains many records of adults reported to feed on the flowers and buds of apple throughout the range of this species (Fletcher 1900, MacNay 1954*b*, CIPR 1955, Lafrance and Cartier 1964, Paradis et al. 1979). In CIPR (1961), it was also reported to damage pear.

Ctenicera morula (LeConte)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Labrador, Northwest Territories, and Yukon Territory.

Economic injury: Wilkinson (1963) stated that there is no record of crop damage by this species in British Columbia. Mitchener (1956) reported that *C. morula* destroyed vegetation in widely separated prairie areas but did not give specific details.

Biology: Larvae of *C. morula* are usually found with *C. aeripennis aeripennis* in well-drained soils but never as the predominant species (Wilkinson 1963). The habits of this species are much the same as those of *C. aeripennis* (Brooks 1960).

Ctenicera pruinina (Horn)
Great Basin wireworm

Distribution: British Columbia.

Economic injury: In the northwestern United States, this species is a serious pest of grain crops in dry farming areas, but there is no record of it as a pest in British Columbia (Wilkinson 1963).

Biology: In the United States, this dryland species occurs in an area that normally receives less than 38 cm of rainfall annually (Glen et al. 1943).

Dalopius asellus Brown

Distribution: British Columbia, Alberta, and Saskatchewan.

Economic injury: This species has damaged potato seed pieces in British Columbia (Wilkinson 1963).

Biology: This species occurs in grassy pastures and forest margins (Brooks 1960).

Dalopius lateralis Eschscholtz

Comments: King and Arnason (1931) reported scattered damage by this species in Saskatchewan. When Brown (1934) revised the genus, he considered the species unrecognizable.

Dalopius mirabilis Brown

Distribution: Alberta, Saskatchewan, Manitoba, and Quebec (?).

Economic injury: Larvae of this species have been collected in cultivated fields in Saskatchewan and Manitoba (Glen et al. 1943).

Beirne (1971) noted that cereals have been reported to be damaged by this species in the Prairie Provinces.

Biology: Brooks (1960) reported that this species occurs in prairies and parklands throughout the Prairie Provinces. Glen et al. (1943) reported that *D. mirabilis* occurred under horse and cow dung in a native grass pasture in an alkaline situation.

Comments: One of Brown's (1934) paratypes is labeled "Montreal, Quebec." As the specimen represents the only record of *D. mirabilis* from outside of the Prairie Provinces, it may be mislabeled.

Dalopius pallidus Brown

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Economic injury: This species has been reported to feed on turnip and potato in Nova Scotia (Fox 1961*a*). It is also known as a crop pest in Alberta and Ontario (Glen et al. 1943). In Quebec, it is known to damage potato and truck crops (Beirne 1971).

Biology: Adults of this species hibernate at the base of roots in the top 8 cm of soil. Second- and third-year larvae hibernate deeper (Lafrance and Cartier 1964).

This species occurs in damp situations throughout its range. It occurs in muck soils in Ontario and Quebec, in leaf litter on a riverbank in Saskatchewan (Glen et al. 1943), and in dike land in Nova Scotia (Fox 1961*a*). Fox (1961*a*) reported it to be rare in well-drained soils. Beirne (1971) stated that this species requires an exceptionally rich and moist habitat and can probably tolerate considerable variations in pH.

Dalopius parvulus Brown

Distribution: Saskatchewan and Manitoba.

Economic injury: This species appears to be associated with grassy situations in open parkland areas and causes injury to grain crops when such land is put under cultivation (Glen et al. 1943).

Biology: According to Beirne (1971), this species occurs in medium-textured soils. Brooks (1960) listed the habitat of *D. parvulus* as mixed prairie and parkland in the Prairie Provinces, but according to Glen et al. (1943), the species prefers watered gardens, muck soils, and low-lying land.

Hemicrepidius memnonius (Herbst)

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, and Prince Edward Island.

Economic injury: The larvae were reported to be abundant in garden soil (Brooks 1960). Damage by the larvae to vegetables and strawberry has been recorded (CIPR 1957).

Hypolithus abbreviatus (Say)
abbreviated wireworm
taupin trapu (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Economic injury: This species is a minor pest in muck soils (Glen et al. 1943). MacNay (1956) reported injury to turnip and potato in muck soil areas of Quebec. Beirne (1971) pointed out that *H. abbreviatus* does not noticeably injure potato because it does not tunnel deeply, but it causes serious problems when it attacks seed pieces. Stibick (1978) also recorded *H. abbreviatus* in onion fields and on chives and cabbage.

Biology: The abbreviated wireworm inhabits soils of various textures but appears to be more abundant in poorly drained land (Glen et al. 1943). Brooks (1960) gave the habitat as sandy parklands, parklands, and forest margins. The adults feed on various grasses, and the larvae are partly predacious (Stibick 1978).

Under normal conditions in Maine, pupation occurs during the month of August, and adults normally lay eggs the following spring (Hawkins 1936).

Comments: Stibick (1978) proposed the use of the genus *Hypnoidus* to replace *Hypolithus* for all but the nominate species *H. littoralis*. E.C. Becker (personal communication) believes that *H. littoralis* is not a distinct enough taxon to warrant generic status. Therefore the name *Hypolithus* is retained for the economic species discussed here.

Hypolithus bicolor Eschscholtz
(lesser grain and grass wireworm)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Labrador, Northwest Territories, and Yukon Territory.

Economic injury: With *Ctenicera aeripennis destructor*, this is one of the most widespread species of wireworm known to cause economic damage in the Prairie Provinces (Doane 1977*a*). The larvae feed on planted seed and on the underground parts of plants of most field and garden crops (Burrage 1963). Doane (1977*a*) reported this species on spring wheat, and the CAIPR (1971) reported that it damaged potato.

Biology: In Saskatchewan, Zacharuk (1958) described two forms of this species, parthenogenetic and bisexual. The parthenogenetic form is associated with *C. aeripennis aeripennis* in the north and west and the bisexual form with *C. aeripennis destructor* in the grassland formation. The bisexual form occurs in the zone of intergradation.

This species exhibits the same general life history as does *C. aeripennis destructor* but with several exceptions (Doane 1977*a*). The adults of both sexes of the bisexual form become active at the same time but later in the season; they also lay fewer eggs per batch and in total, live longer, and fly readily. Like *C. aeripennis destructor*, the eggs of this species are highly aggregated. In Saskatchewan, males were active on the soil surface from the end of April until the first week of August. Females were active about a week later in the season (Doane 1961).

Hypolithus impressicollis (Mannerheim)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, Newfoundland, Labrador, Northwest Territories, and Yukon Territory.

Economic injury: Wilkinson (1963) reported that this species caused damage to potato seed pieces in spring but not to the mature crop.

Biology: In British Columbia, the species is found in the delta of the Fraser River in low, poorly drained fields. Its distribution suggests that it may be confined to river clearings in largely coniferous areas (Stibick 1978).

Hypolithus nocturnus Eschscholtz

Comments: Many records in the literature discuss damage by this species across Canada. According to Stibick (1978), *H. nocturnus* is endemic in British Columbia, with a doubtful record from Alberta. The records of the species outside British Columbia probably refer to *H. bicolor*, a species often referred to as a variety of *H. nocturnus*.

Limonius aeger LeConte

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Labrador.

Economic injury: Larvae believed to belong to this species have been reported to be injurious to truck crops in southern Quebec. The species has never been reported in cultivated land in the Prairie Provinces (Glen et al. 1943).

Biology: Brooks (1960) gave the habitat of this species as parkland and forests, occurring abundantly in mixed shrubs and poplar groves and in the surrounding long grass.

Limonius agonus (Say)
eastern field wireworm
taupin bosselé (m.)

Distribution: Ontario and Quebec.

Economic injury: Begg (1956) described this species as the principal wireworm pest in southwestern Ontario, known to attack most garden and field crops. He pointed out that damage to row crops is more noticeable than to grains because of the smaller number of plants per unit area. This wireworm has been reported to attack cabbage, corn, grain, potato, soybeans, squash, sugar beet, tobacco, and tomato.

Biology: Begg (1961) summarized the biology of this species in Ontario. Overwintering adults emerge from the pupal cell in late April to early May. Males emerge first, with females following 1–3 days later. Virgin females are usually found in crevices in the soil with their abdomens protruding, and males are found circling on the ground waving their antennae. Mating takes place in direct sunshine at optimum temperatures of 21 to 27°C. The maximum dispersal of this species occurs in late May and early June, at which time the females are still laying eggs. The female makes a tunnel, 2.5–7.5 cm deep in the soil, in which eggs are deposited. In the laboratory the incubation period varied from 24 days at 23°C to 48 days at 18°C.

The larvae require a single animal protein feeding for survival. Cannibalism in the oviposition tunnel may provide this meal. The larval stage lasts 3–5 years, although a 1-year larval period has been observed under laboratory conditions. Larvae overwinter 8–23 cm deep in the soil. In April, when the temperature reaches 10°C at the hibernation depth, the larvae move toward the soil surface. In late May and early June, the larvae descend to the summer depth of about 13 cm. The larvae often return to the surface in September before descending to the overwintering depth. Soil moisture may induce these vertical migrations, since soils with a water content of less than 12% are avoided by the larvae.

Pupation occurs in late July and early August at a depth of about 15 cm. The mean pupal period is 15–16 days at an average temperature of 25°C.

The bethylid *Pristocera armifera* (Say) is known to parasitize the larvae of this species (Thomas 1940).

Limonius californicus (Mannerheim)
sugarbeet wireworm

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: Banham and Arrand (1978) considered this insect to be one of the most economically important species of wireworm in British Columbia. They reported that it attacked a wide variety of plants including vegetables. *Limonius californicus*, an important pest of sugar beet, has caused economic damage to this crop in Alberta (Lilly 1954). Potato (Wilkinson 1963), wheat (MacNay 1957*a*), and corn (Beirne 1971) are also attacked.

Biology: Lilly and McGinnis (1968) discussed the responses of males of the species to the female sex pheromone. Highest concentrations of this attractant are found in virgin females and in females that have been mated for not more than 4 hours.

In the Prairie Provinces, this species occurs in saline habitats in mixed and adjacent parkland (Brooks 1960).

Limonius canus LeConte (*discoideus* LeConte)
Pacific Coast wireworm
taupin du Pacifique (m.)

Distribution: British Columbia and Alberta.

Economic injury: According to Wilkinson (1963), *L. canus* has been a major pest of vegetables for many years in British Columbia and is well adapted to conditions in irrigated areas. Larvae damage seedlings in the spring and root crops in the late summer and fall. The larvae attack the following crops: onion, potato (MacNay 1947), carrot (MacNay 1953), grain (Glen et al. 1943), strawberry (Neilson 1957*a*), and raspberry (Chamberlain and Putman 1964).

Biology: The Pacific Coast wireworm is generally found in light, moist, sandy loam and loam soils. The larvae overwinter at depths of 60 cm or more (Wilkinson 1963).

Limonius dubitans LeConte

Comments: MacNay (1956) reported that this species attacked wheat in Manitoba. However, we have not seen specimens or other published records of the species from anywhere in Canada.

Limonius ectypus (Say)

Comments: Beirne's (1971) accounts showing that this species caused harm in Saskatchewan and destroyed wheat on summerfallow are erroneous. The reference he cited (CIPR 1942) refers to a species "near *ectypus*" and not to this one. Glen et al. (1943) described *L. ectypus* as an eastern species occurring in Ontario and probably Quebec. Many other records show that the species damaged corn, tobacco, potato, tomato, and other crops in Ontario. However, according to E.C. Becker (personal communication), the only Canadian record is based on a single specimen in the Canadian National Collection from Manitoba. In CIPR (1944), this species is referred to as the eastern field wireworm, the common name usually associated with *L. agonus*. This finding might suggest that the eastern records are attributable to *L. agonus*, a well-known pest species in Ontario and Quebec.

Limonius infuscatus Motschulsky
western field wireworm
taupin de l'ouest (m.)

Distribution: British Columbia and Alberta.

Economic injury: Wilkinson (1956) considered this species to be a major pest in the interior of British Columbia. It is well adapted to conditions found in irrigated fields of the Okanagan, Boundary, Kootenay, and Fraser Valley areas. Banham and Arrand (1978) considered the western field wireworm to be one of the most economically important species known to attack a wide variety of plants, including vegetables, in British Columbia. The larvae have been reported occasionally to injure the roots of new raspberry plantings and to weaken the plants (Chamberlain and Putman 1964). This wireworm has also been known to damage barley, potato, strawberry, and tobacco.

Biology: This species is similar in habits to *L. canus*, with which it generally occurs; *L. infuscatus*, however, is the predominant species that causes damage (Wilkinson 1963).

Comments: Beirne (1971) recorded that this western species damaged tobacco in Ontario, but the record probably represents a misinterpretation.

Limonius pectoralis LeConte

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Northwest Territories, and Yukon Territory.

Economic injury: This wireworm has been found damaging wheat in British Columbia (Wilkinson 1963), Alberta (CIPR 1961) and Manitoba (CIPR 1950). It has also been reported in potato fields in Prince Edward Island (CIPR 1961). According to Glen et al. (1943), this species is known to be an important crop pest in the park belt area of the Prairie Provinces and in the Peace River section of British Columbia. King (1928) mentioned economic infestations of *L. pectoralis* in Saskatchewan, stating that it is able to thrive in a grassland rotation and may become of greater importance should truck farming become common in the district.

Biology: Under natural conditions, this species is associated with the thin-leaved snowberry, *Symphoricarpos albus* (L.) Blake, growing in dark, rich, loam soils in drained, low-lying locations (King 1928).

Melanotus communis (Gyllenhal)
(corn wireworm)

Distribution: Ontario and Quebec.

Economic injury: Caesar (1927) referred to *M. communis* as a common Ontario species known to attack many kinds of plants. In Quebec, DuPorte (1914) reported that this species damaged seed corn sown in a field that followed sod.

Biology: The duration of the larval period is at least 3 years (Hawkins 1936).

Melanotus depressus (Melsheimer) (*divarcarinus* Blatchley)

Distribution: southern Ontario.

Economic injury: This species is known to injure tobacco (Fox and Stirrett 1952). In Missouri, *M. depressus* has been reported to infest corn and is believed to be one of several species of *Melanotus* that damages this crop (Keaster et al. 1975).

Biology: In Missouri, Pill et al. (1976) studied some aspects of the development of *M. depressus* larvae in the laboratory. Larvae that were held on soil and germinating wheat for 21 months underwent two or three molts. Even though the larvae were held at constant temperature and photoperiod, all pupation occurred in the spring, and the larvae remained dormant during the winter months. Under adverse nutritional conditions, the larvae underwent regressive ecdyses. Larvae maintained on an inadequate food supply survived for several months.

Melanotus longulus oregonensis (LeConte)
Oregon wireworm

Distribution: British Columbia.

Economic injury: Wilkinson (1963) did not consider this species to be a serious pest. It was once reported that it damaged newly planted grape cuttings in light sandy soil in the Okanagan Valley.

Oestodes puncticollis Horn

Distribution: Alberta and Saskatchewan.

Economic injury: This species has been known to damage spring wheat and oats in alkaline parts of fields (Glen et al. 1943).

Biology: The distribution of *Oestodes puncticollis* is found in long grass around the margins of saline ponds (Brooks 1960).

Oestodes tenuicollis (Randall)

Distribution: Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: Oats were thinned by this species in Ontario (CIPR 1961), and a survey in Prince Edward Island revealed that this species feeds on forage crops (Thompson 1964).

Biology: In Nova Scotia, this wireworm was recorded from low-lying sandy land (MacNay 1951).

ITHYCERIDAE

This family contains only one species, the New York weevil, which is restricted in distribution to the northeastern United States and southeastern Canada.

Ithycerus noveboracensis (Förster)
New York weevil
charançon de New-York (m.)

Distribution: Ontario and Quebec.

Economic injury: This insect was reported in large numbers in Quebec for the first time in 1931, causing serious damage to the leaf spurs of apple trees at Saint-Hilaire (CIPR 1932). *Ithycerus noveboracensis* has also been reported on peach, apple, plum, oak, and beech (Sanborne 1981).

Biology: According to the study by Sanborne (1981), adults emerge and begin feeding from May to July. The adults feed mainly on the bark of shoots, leaf petioles, leaf buds, and acorn buds of their hosts, which include a wide variety of species in three closely related families of woody plants: Betulaceae, Juglandaceae, and Fagaceae. Females oviposit throughout June and July, depositing their eggs singly in small depressions in the soil around the base of the host plants. The eggs hatch in approximately 6 weeks, and an average of 157 eggs were laid per female. After hatching, the larvae begin feeding on the roots of the host plants by removing the external bark and exposing the inner xylem layer. A minimum of seven instars were observed. The species apparently has a 2-year life cycle in Canada.

LANGURIIDAE languriid beetles or lizard beetles

Larvae of most species of this family are stem borers that feed on a variety of plants, but especially on members of the Compositae and Leguminosae. The adults often feed on pollen or leaves of the host plant. The family is cosmopolitan, but most species are tropical. Of the 900 species in the family, only 6 occur in Canada.

Languria mozardi Latreille
clover stem borer
perce-tige du trèfle (m.)

Distribution: Manitoba and Ontario.

Economic injury: According to Hatch (1962), *L. mozardi* breeds in yellow sweet-clover and alfalfa in the southwestern United States. The larvae eat the centre of the clover stem, causing the plant to weaken or die (Saunders 1881). Larval tunnels usually begin high up in the stem and extend 15–20 cm downward. The insect is usually not abundant enough to be economically important.

Biology: The species overwinters in the adult stage (Saunders 1881). The eggs are generally imbedded in the pith high up in the stem. Upon hatching, the larvae burrow downward and pupate in the lower part of their burrow. The length of the pupal period varies considerably. Emergence of new adults occurs from August until late October. There is probably only one generation per year.

Saunders (1881) reported two species of parasites within the burrows of the clover stem borer: a small, black chalcid wasp and a yellowish ichneumon wasp.

LATHRIDIIDAE minute brown scavenger beetles

Many species of this family are almost cosmopolitan in distribution because of their association with stored products. All species are apparently spore feeders and are usually associated with molds. Species found in stored products do not often cause damage but generally indicate other problems associated with storage, such as excessively high moisture. The family is well represented in all areas of the world. About 500 species are known, and 60 are estimated to occur in Canada.

Adistemia watsoni (Wollaston)

Distribution: Ontario.

Origin: The first Canadian record of this species was made in Ottawa, Ont., in February 1974 (Becker 1977).

Economic injury: This cosmopolitan insect was taken from the wall of an office building in Ottawa (Becker 1977). Like other lathridiids, *A. watsoni* is associated with fungi in damp situations.

Aridius nodifer (Westwood)

Distribution: British Columbia, Manitoba, Ontario, Quebec, and Nova Scotia.

Origin: This species is cosmopolitan in distribution.

Economic injury: *Aridius nodifer* has been reported in buildings in Ontario and Nova Scotia (MacNay 1955). Hinton (1945) listed several European records of this species found in and around the following: moldy wood, moldy pine bark, vegetable refuse, moss, woodstacks, nests of *Bombus lapidarius* and *Vespa vulgaris*, haystack refuse, the cellar of a house, mold under linoleum, walls of a warehouse, fresh nuts, moldy cheese, and a flour depot. When reared on fungi growing on bread and cheese, both the adults and larvae fed exclusively on the spores, conidia, and hyphae of the molds.

Biology: The biology of this species is described from specimens reared on cultures of *Penicillium glaucum* Link and *Mucor mucedo* L. growing on bread and cheese in petri dishes (Hinton 1945). The female deposits her eggs singly on the surface of the bread or cheese. The incubation period varied from 5 to 7 days at an average temperature of 15.6°C. At this temperature, the first- and second-larval instars lasted 6 days each. The third-instar fed for 5 or 6 days at 20°C and then rested for 2 or 3 days before pupating. From 3 to 4 days were spent in the pupal stage. Development from egg to adult required 27–32 days.

Cartodera constricta (Gyllenhal)
plaster beetle

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick.

Origin: This species is cosmopolitan in distribution.

Economic injury: The plaster beetle feeds on fungi (Sinha 1961). It has been taken in a dwelling in British Columbia (CIPR 1963), Ontario (MacNay 1954*b*), and Quebec (Gibson and Twinn 1931, 1939). Hinton (1945) recorded the species in and around the following: bark, dead leaves, a nest of *Acanthomyops fuliginosa*, a warehouse, cheese (Britain), moldy hay and straw refuse (Germany), and cellars (Finland). The species may be abundant in stored grain, but according to Loschiavo (1975), it is not a primary pest but indicates the presence of microorganisms that can cause grain spoilage.

Corticaria fenestralis (Linnaeus)

Distribution: British Columbia, Ontario, and Quebec.

Origin: According to Hatch (1962), *C. fenestralis* was probably introduced. It is known from Europe, Asia, and North America (Hinton 1945).

Economic injury: *Corticaria fenestralis* has been reported in houses and museums and on grain and other plant materials (Hatch 1962). The species has also been bred from *Pinus ponderosa* Lams. in southeastern British Columbia. The species has also been reported in and around the following: grain, vegetable products, flour (United States), cut grass, hay refuse, dead jackdaw, pine bark, manure heaps, vegetable refuse, and moss (Hinton 1945).

Corticaria pubescens (Gyllenhal)

Distribution: British Columbia and Ontario.

Origin: This species is nearly cosmopolitan in distribution. Hatch (1962) reported that it was probably introduced from Europe.

Economic injury: *Corticaria pubescens* occurs in houses, cellars, granaries, and stored tobacco in various parts of the world (Hatch 1962). Some European records include haystack and flood refuse, decaying seaweed, moss, hay, straw, an old bird's nest, bark of trees, and vegetable detritus (Hinton 1945).

Lathridius minutus (Linnaeus)
squarenosed fungus beetle

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia.

Origin: This cosmopolitan species was probably introduced into the Pacific Northwest (Hatch 1962).

Economic injury: *Lathridius minutus* normally feeds on fungi associated with grain (Sinha 1974). According to Loschiavo (1975), it is not a primary pest, but its presence indicates the presence of microorganisms that can cause grain spoilage. The squarenosed fungus beetle may be found in a large number of natural habitats and is also associated with damp and moldy houses, warehouses, and stored organic products. Adults have been reared from *Abies lasiocarpa* (Hawk.) Nutt., *Picea engelmanni* (Parry) Engellm., *Pinus muneyana* Belf., *P. monticola* Doug., and *P. ponderosa* Laws in southeastern British Columbia. Its occurrence has been noted in dwellings in Manitoba, Ontario, and Quebec (Gibson and Twinn 1931, 1939). In Europe, Hinton (1945) recorded this species in and around the following: moldy radish, moldy coffee, nests of wasps and ants, birds' nests, haystack and other refuse, moss, dung heaps, woodstacks, a herbarium, bark, granaries, warehouses, flour, wheat, oatmeal, damaged cocoa and soybeans, licorice, and flax.

Biology: *Lathridius minutus* has been reared on cultures of *Penicillium glaucum* Link growing on petri dishes at a mean temperature of 16.7–18.3°C (Hinton 1945). Both adults and larvae fed on the conidia and hyphae of *Penicillium* and *Mucor mucedo* L. The female deposited the eggs singly under or on the surface of the bread. Hatching occurred in 5 or 6 days, and three larval instars were produced. The first instar required 4 or 5 days and the second instar about the same time. The third instar fed for 3 or 4 days and stopped feeding for 2 or 3 days before attaching itself to the substratum, where it pupated. The length of the pupal period was 6–7 days. Development from egg to adult was completed in 24–30 days.

Melanophthalma cavicollis (Mannerheim)

Distribution: British Columbia, Manitoba, Ontario, and Quebec.

Economic injury: CIPR (1963) reported *M. cavicollis* from a dwelling in British Columbia.

Melanophthalma distinguenda Comolli

Distribution: British Columbia, Manitoba, and Ontario.

Origin: According to Hatch (1962), this species was possibly introduced.

Economic injury: *Melanophthalma distinguenda* has been reported in herbage, feed mill debris, and stored grain (Hatch 1962).

Microgramme costulata (Reitter)

Distribution: Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: CIPR (1964) reported *M. costulata* on fungal growth on the barrel heads of whiskey kegs in the maturing warehouse of a distillery in Ontario. The insect also occurred in a basement storage cupboard in Quebec (CIPR 1961).

Microgramme filum Aubé

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: *Microgramme filum* has been found in dwellings in Saskatchewan, Manitoba, and Ontario (Gibson and Twinn 1931, 1939). Both the larvae and adults feed on fungi and have been recorded in and around the following: warehouse; soup powder (Britain); herbaria on moldy plants; damp houses; stored wheat, maize, and rye; and stored drugs (Germany) (Hinton 1945).

Biology: *Microgramme filum* has been reared on cultures of the fungi *Mucor mucedo* L. and *Penicillium glaucum* (Hinton 1945). The eggs are deposited singly on the surface of the fungi. The incubation period was 6 or 7 days at a mean temperature of 23.9°C. The larvae pass through three instars and spent 5, 7, and 12 days in the first, second, and third instars, respectively (at the same temperature). The last 3 days of the third instar were spent attached to the substratum in a more or less motionless state. The pupal period took 7–8 days. The shortest period for development of egg to adult was 36 days at 23.9°C. At 18.3°C, approximately 54 days were required for a complete life cycle.

Thes bergrothi (Reitter)
ridgewinged fungus beetle

Distribution: Saskatchewan, Manitoba, New Brunswick, and Nova Scotia.

Origin: The first Canadian record of the ridgewinged fungus beetle was made in 1926, at Saskatoon, Sask. (MacNay 1954*a*). Hinton (1945) noted that it was distributed in Europe and Greenland.

Economic injury: *Thes bergrothi* feeds on fungi and is often found in stored products (Sinha 1961, 1965*b*). MacNay (1954*a*) reported the species from hay packing in boxes of china imported into Saskatchewan from England in 1938. In Europe, the species has been reported in and around cheese, dates, granaries, houses, cellars, and warehouses (Hinton 1945).

Biology: Adults placed in a jar containing moldy bread on 25 July produced larvae by 20 August (Hinton 1945). The larvae lived under the bread because they were negatively phototropic. Pupation took place in early September and new adults emerged by 20 September, though some of the original adults were still alive at that time.

LYCTIDAE lyctid powder-post beetles

Both larvae and adults of this family are wood borers and are of considerable economic importance, especially to the forest product industry. Recent classifications (Lawrence 1982) have combined this family with the Bostrichidae. About 65 species are known from all areas of the world, 8 of which are estimated to occur in Canada.

Lyctus brunneus (Stephens)
(powder-post beetle)

Distribution: British Columbia and Ontario.

Origin: This species is now almost cosmopolitan in distribution, but it possibly originated in the Neotropical region (Gerberg 1957). The first Canadian record of the species was made in Ottawa, Ont., from a mahogany table imported from Scotland (MacNay 1951).

Economic injury: The true powder-post beetles in the family Lyctidae can cause serious damage to recently seasoned hardwood lumber and semimanufactured products (La Fage and Williams 1979). According to Spencer (1958), *L. brunneus* is a sporadic pest in Vancouver, B.C., emerging from oak floors usually within 1 year of their being laid. It has also been taken from bamboo mats in Vancouver (Hatch 1962) and from a mahogany table in Ontario (MacNay 1951). Several additional records of this species in the United States are listed by Gerberg (1957).

Damage by *L. brunneus* is caused mostly by the larvae, which tunnel in the sapwood of hardwoods (La Fage and Williams 1979). The higher starch level of the sapwood favors larval development. As the female oviposits in wood pores (vessels), ring-porous hardwoods such as ash, oak, and walnut, which have many large-diameter pores, are more easily infested. Diffuse-porous hardwoods, such as basswood and maple, are usually unsuitable for oviposition. Softwoods are not attacked, partly because of their low starch content and absence of large vessels for oviposition sites. New wood in storage, manufacture, or transport is most likely to be infested because starch content decreases as wood gets older. Injury generally occurs after milling. Infestations may be indicated by the presence of small, circular "flight holes" (1.5–3.0 mm in diameter) when at least one generation has been completed, by the accumulation of borer dust on or beneath the infested wood, or by the presence of frass-filled larval tunnels if the wood is sawed.

Biology: Unless otherwise stated, the biology given here applies to lyctids in general and is taken from La Fage and Williams (1979).

One or two eggs are inserted into a wood pore by the female. Hatching occurs within 1–3 weeks. According to Rosel (1969) in Australia, the eggs of *L. brunneus* required 7.5–8 days to hatch at 26°C and 75% RH and 14.5–15 days at 20°C and 50% RH. From a few months to several years may be required to complete larval development, depending on environmental conditions. Pupation takes place in an enlarged part of the tunnel near the surface of the wood. From 2 to 4 weeks are spent in this stage. The new adults chew their way out through small, circular holes. Development from egg to adult may require from a year to several years, depending on the temperature and on the starch and moisture content of the wood.

Lyctus planicollis LeConte
southern lyctus beetle (southern powder-post beetle)
lycte à cou plat (m.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, and Nova Scotia.

Economic injury: This species was found in imported oak flooring in Alberta, constituting the first record in the province (MacNay 1954*b*). According to La Fage and Williams (1979), the true powder-post beetles can severely damage recently seasoned hardwood lumber and semimanufactured products. In British Columbia, the southern lyctus beetle occurred in ash, oak flooring, oak woodwork, pickax handles (Hatch 1962), and occasionally in imported furniture (Spencer 1958). In Ontario, *L. planicollis* was found in hickory furniture and even in the wooden heel of a shoe (MacNay 1946, 1954*b*). Gibson and Twinn (1931, 1939) stated that this insect is a widely distributed household pest. Damage by *L. planicollis* was described by La Fage and Williams (1979) and is similar to that of *L. brunneus* (for details refer to the description under the latter species).

Biology: The general life history of lyctids was described by La Fage and Williams (1979). For details refer to the description following *L. brunneus*. According to Rosel (1969) in Australia, the eggs of *L. planicollis* hatched in 7.5–8 days at 26°C and 75% RH and in 11.5–12 days at 20°C and 50% RH.

Lyctus linearis (Goeze) (*unipunctatus* Herbert)
(cosmopolitan powder-post beetle, European powder-post beetle)
lycte strié (m.)

Distribution: British Columbia and Ontario.

Origin: According to Hatch (1962), *L. linearis* was formerly a western European species but is now cosmopolitan.

Economic injury: The economic injury of lyctids in general was described for *L. brunneus*. This insect occurred in furniture, oak flooring, and dead apple twigs in British Columbia (Hatch 1962). Several records of the species in the United States are listed in Gerberg (1957).

Biology: See *Lyctus brunneus* for a description of the general life history of lyctids. Graham (1965) reported that the species (under the name *L. unipunctatus* Herbert) was parasitized by the braconid wasps *Monolexis fuscicornis* Förster and *Miocolus utilis* (Cresson).

Lyctoxylon japonum Reitter

Distribution: Manitoba.

Origin: According to Gerberg (1957), this insect appears to be distributed throughout the Orient and may have become established in Panama. The species is not known to be established in Canada.

Economic injury: In Manitoba, *L. japonum* was found in bamboo venetian blinds imported from Japan (MacNay 1958). Several records of this species are given by Gerberg (1957) from the United States.

Trogoxylon parallelopipedum (Melsheimer)

Distribution: British Columbia and Ontario.

Origin: Gerberg (1957) stated that the species is Nearctic in distribution and listed several records from the United States.

Economic injury: CIPR (1963) reported *T. parallelopipedum* as a wood borer in a home in British Columbia.

Trogoxylon prostomoides (Gorham)

Distribution: British Columbia, Alberta, Ontario, and Yukon Territory.

Origin: This species was found in bamboo shades in Ontario, constituting the first Canadian record of this insect (CIPR 1963). *Trogoxylon prostomoides* commonly occurs in Mexico and Central America but rarely in the United States.

Economic injury: The species has been found to infest bamboo shades in Ontario (CIPR 1963). A few records of this species in the United States are mentioned in Gerberg (1957).

MELOIDAE blister beetles
méloés (m.)

Larvae of this family feed on eggs of grasshoppers or eggs, larvae, and food stores of wild bees. Adults are frequently phytophagous and many are important pests of agricultural crops. Blister beetles are known from most regions of the world, but they are most abundant in warmer, drier habitats. About 3000 species are known, of which 60 are estimated to occur in Canada.

Epicauta cinerea (Förster) (*marginata* auct., nec Fabricius, in part; *fissilabris* LeConte)
clematis blister beetle (gray blister beetle)
méloé gris (m.)

Distribution: British Columbia (?), Alberta (?), Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: According to Werner (1945), adults of this species appear to feed only on plants of the genus *Clematis*. However, in New Brunswick, Walker (1923) described injury by this species to Windsor beans and to potato. In Ontario and Quebec, *E. cinerea* has been destructive to potato, beans, vetch, alfalfa, honey-locust, and the foliage and fruit of apple trees (Gibson 1911). In CIPR (1941), the species was reported on *Delphinium* sp. in Ontario. Beirne (1971) reported the species on beet in Alberta and, under the synonym *E. fissilabris*, CIPR (1926) reported that the species attacked potato, alfalfa, and wheat in British Columbia.

Biology: According to Gibson (1911), the adults are active in July and August.

Comments: Werner (1949) considered the record of *E. fissilabris* from Aweme, Man., to be near the western limit of the distribution of *E. cinerea*. This statement casts doubt on Beirne's (1971) report of *E. cinerea* from Alberta and CIPR's (1926) record of *E. fissilabris* from British Columbia. In addition, Werner's (1945) comment that the adults feed only on *Clematis* spp. suggests that the economic damage attributed to this species may be caused by some other, misidentified species.

Epicauta fabricii (LeConte) (*cinerea* Fabricius; *debilis* LeConte; *unicolor* auct., in part)
ashgray blister beetle
méloé gris cendré (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Prince Edward Island.

Economic injury: The adults of *E. fabricii* generally feed on the succulent growth and flowers of leguminous herbs, especially alfalfa, clover, and *Baptisia* (Werner 1945). The species has been reported, in large numbers, to feed on alfalfa in Saskatchewan (MacNay 1948). MacNay (1950, 1951) reported that the species fed on caragana and, associated with other meloids, on potato and broad beans (MacNay 1957*b*) in Manitoba. MacNay and Creelman (1958) listed the species as a pest of plum in the same province.

Biology: The larvae of *E. fabricii* feed on grasshopper's eggs (MacNay 1953, 1954*b*). The adults occur in early summer (Werner 1945).

Comments: According to Brown (1940*c*), most of the references to *E. unicolor* in the literature on economic entomology refer to this species. He also listed the distribution of *E. fabricii* as Alberta, Saskatchewan, Manitoba, and the Lake Erie district of Ontario. However, the majority of records of *E. unicolor* (Fletcher 1893, 1899*a*; Harrington 1893; Bethune 1896; Gibson 1911, 1916, 1917, 1921, 1934; Chapais 1913; Spittall 1924; Twinn 1933; CIPR 1941) are from eastern Canada and are probably not referable to *E. fabricii*. Thompson (1964) reported *E. fabricii* from Prince Edward Island. This record is also outside the range suggested by Brown.

Epicauta ferruginea (Say)

Distribution: Alberta, Saskatchewan, and Manitoba.

Economic injury: Burgess (1983) reported that the adults of this species fed on the flowers of canola, which they quickly damaged or destroyed. Based on a literature search by Burgess, *E. ferruginea* has also been reported to feed on the flowers of the following plants: thistle, another unidentified composite, commercially grown sunflower, and commercially grown Indian mustard.

Epicauta maculata (Say)
spotted blister beetle
méloé maculé (m.)

Distribution: Saskatchewan, Manitoba, northwestern Ontario, and Prince Edward Island (?).

Economic injury: Pinto (1980) reported *E. maculata* from alfalfa, sugar beet, and potato. According to Gibson (1911), adults of this species are particularly injurious to potato, but they have also done considerable damage to beet, cabbage, spinach, beans, and clover. Twinn (1938) suggested that the feeding of this species interfered with the establishment of caragana shelter belts. In addition to the above crops, Beirne (1971) listed turnip, lettuce, squash, celery, and onion as cultivated plants attacked by the species.

Biology: Pinto (1980) described the bionomics of *E. maculata*. The average number of eggs in four egg masses was 125.5 (range, 115–146). Larvae have been reported to feed on the egg pods of the grasshopper, *Melanoplus sanguinipes* (Fabricius), and adults have been reported on plants of the genera *Tribulus*, *Beta*, *Datura*, *Solanum*, and *Medicago*. According to Gibson (1911), the adults are present from the middle of May until the middle of August.

Comments: Beirne (1971) reported that *E. maculata* attacked beans in Prince Edward Island. This report appears to be well outside the range of the species as reported by Pinto (1980). MacNay (1950) reported a severe attack by *E. maculata* on sugar beet in Alberta. According to Pinto (1980), *E. maculata* does not occur in that province, and the many records of *E. maculata* in the economic literature refer either to *E. normalis* Werner or to *E. ventralis* Werner, or both, which do occur in Alberta.

Epicauta murina (LeConte) (*unicolor*, auct., in part)
(dark blister beetle)
méloé cendré (m.)

Distribution: Manitoba (?), Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: MacNay (1950) described *E. murina* as conspicuous on ornamentals and potato in Ontario. He also reported damage to potato, beans, and alfalfa in Quebec and Ontario (MacNay 1949) and to potato in New Brunswick (MacNay 1948).

Biology: According to Werner (1945), adults occur in early summer.

Comments: Criddle (1912) reported *E. unicolor* var. *murina* from Manitoba. Whether or not he was referring to this species is unknown.

Epicauta normalis Werner

Distribution: Alberta and Saskatchewan.

Economic injury: CIPR (1951) reported that adults of *E. normalis* severely attacked a beet field in Alberta, and Pinto (1980) reported that they attacked alfalfa and sugar beet.

Biology: Pinto (1980) gave details of the biology of this species and documented the sexual behavior. The number of eggs laid in two masses averaged 48.5 (range, 35–62), and the duration of the stage was 24 days (range, 23–25). A single male of *E. normalis* has been reared from the egg pod of the grasshopper, *Aulocara elliotti* (Thomas). The asilid *Ospriocerus abdominalis* (Say) has been reported to be a predator of *E. normalis* in Colorado. Host plants of the adults include the genera *Althaea*, *Bassia*, *Beta*, *Cucurbita*, *Medicago*, *Salsola*, and *Sarcobatus*.

Comments: Hatch (1965) described this species as occasionally injurious to garden crops in British Columbia. According to Pinto (1980), *E. normalis* does not occur in that province.

Epicauta oregona Horn

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: According to Hatch (1965), adults of *E. oregona* have frequently been reported to damage potato, tomato, and other garden crops in British Columbia. In addition, the species has been reported to attack alfalfa (MacNay 1951, 1958), vetch (MacNay 1950), and beet (MacNay 1951).

Biology: According to Werner (1945), the adults occur in June and July. Among weeds, lamb's-quarters are a preferred food plant (King et al. 1953).

Comments: Females of *E. oregona* are frequently confused with members of the Maculata Group (Pinto 1980). Hatch (1965) stated that some of the records of damage by this species may refer to *E. normalis*. However, according to Pinto (1980), *E. normalis* does not occur in British Columbia.

Epicauta pensylvanica (De Geer)
black blister beetle
méloé noir (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: According to Horsfall (1941), adults of this species are strictly pollen feeders, occurring almost exclusively on goldenrod and wild aster. However, the Canadian literature contains many records of damage by the species to a wide variety of cultivated plants. Gibson (1911) stated that the species has a wide range of food plants, occurring most frequently in destructive numbers on potato, but also attacking mangel, beet, carrot, cabbage, tomato, corn, faba beans, mustard, aster, clematis, zinnia, and other garden plants. In addition, the species has caused moderate damage to Swiss chard (MacNay 1954*b*) and light damage to caragana and honeysuckle (MacNay 1950).

Biology: Horsfall (1941) described the biology of *E. pensylvanica* from field and laboratory observations in Arkansas, where one generation a year occurs. The preoviposition period lasted for 2–3 weeks after the females emerged. Eggs were deposited in a compact mass in the soil in a vertical burrow about 2.5 cm deep. The females used their mandibles to dig the cavity and their front legs to remove the soil, then backed into the hole, oviposited within a 15-min interval and immediately refilled the hole. The mean number of eggs in 11 cavities was 165 (range, 96–220). At 24°C, the incubation period for 504 eggs averaged 15 days (range, 14–18).

After hatching, the triungulins or first-instar larvae remained in the egg tunnels for 1 day or more and then burrowed to the surface and dispersed. These larvae either entered grasshopper egg pods, the larval hosts, or continued to search for pods until they died. The larvae punctured the grasshopper eggs and ate the liquid contents; one egg usually filled one triungulin. The gorged triungulins then molted in a day or two to the first grub phase, which included four feeding instars. Each larva in this phase required 21–27 grasshopper eggs to complete development, with only one larva surviving in one place in an egg pod. The larvae macerated the eggs but ingested only the soft contents. The fifth-instar larvae, having fed to repletion, burrowed down into the soil and excavated a resting chamber, where they became quiescent and molted. The fifth-instar stage was usually followed by the coarctate phase (or sixth-instar larva) or the larvae pupated directly after the fifth instar. Larvae in the coarctate phase were nonfeeding, immobile, relatively resistant to desiccation and temperature variation, and variable in duration. The duration of this phase ranged from 6 weeks to several months. The species usually overwinters in the coarctate stage. The seventh-instar larva or second grub phase was also nonfeeding, but it was mobile and burrowed upward within 2.5–5 cm of the soil surface to form the pupal chamber. The larval feeding period required a mean of 28 days, and all seven larval instars required a mean of 43 days in the absence of diapause.

The pupal stage lasted 11–20 days. In Arkansas the adults emerged from the pupal chambers in late August and were observed until mid November. In Ontario, the beetles may be found from late June until the end of September (Gibson 1911).

Epicauta pestifera Werner (*marginata* auct., nec Fabricius, in part; *cinerea* auct., nec Förster, in part; *solani* Werner)
margined blister beetle
méloé marginé (m.)

Distribution: eastern Canada–Ontario (?).

Economic injury: Under the name *E. solani*, Werner (1945) described this species as the well-known margined blister beetle, adults of which often do considerable damage to potato and occasionally to other soft garden plants. Beirne (1971) reported the species on potatoes in eastern Canada. Gibson (1911) reported damage by *E. marginata* to beet, beans, potato, tomato, aster, and *Clematis*, which is probably referable to this species.

Biology: According to Gibson (1911), adults of *E. pestifera* (as *E. marginata*) appear in July and August.

Comments: Beirne (1971) reported *E. pestifera* from eastern Canada but did not specify the province. Gibson (1911) reported *E. marginata* from Ontario, but whether or not he was referring to this species is uncertain.

Epicauta pruinosa LeConte

Distribution: British Columbia, Alberta, and Manitoba.

Economic injury: King et al. (1953) noted that *E. pruinosa* and other species of meloids attacked alfalfa and caragana during grasshopper outbreaks in British Columbia.

Epicauta puncticollis (Mannerheim)
(punctured blister beetle)

Distribution: British Columbia and Alberta.

Economic injury: According to Hatch (1965), adults of *E. puncticollis* occasionally damage field and garden crops. King et al. (1953) listed this species as one of the meloids sometimes seen in great numbers during grasshopper outbreaks in British Columbia. Adults have been collected from sow-thistle at Lethbridge, Alta. (G.H. Gerber, personal communication).

Biology: The adults of this species have been reported to feed on the blossoms of *Convolvulus arvensis* L. in Alberta (CIPR 1941). From observations in California and examined specimens, Ballmer (1979) listed the following plant species as food of the adults: *Chaenactis glabriuscula* DC., *Clarkia cylindrica* (Jeps.) F.H. Lewis & M.E. Lewis, *C. speciosa* F.H. Lewis & M.E. Lewis, *Eriophyllum confertiflorum* (DC.) A. Gray, *Layia glandulosa* (Hook.) H. & A., *Salvia columbariae* Benth., *Agroseris* sp., *Eriogonum* sp., *Escholtzia* sp., *Grindelia* sp., *Hemizonia* sp., *Hugelia* sp., *Lupinus* sp., *Medicago* sp., *Solanum* sp., and *Wyethia* sp. According to the same author, the larvae of *E. puncticollis* presumably prey on the eggs of the following grasshoppers: *Camnula pellucida* (Schudder), *Melanoplus femurrubrum* (De Geer), *M. sanguinipes* (Fabricius), *M. marginatus* (Scudder), and *Oedaleonatus enigma* (Scudder); the last two do not occur in Canada.

According to Church (1967), the female of *E. puncticollis* oviposited in a depression on the underside of a rough stone. Occasionally, eggs were laid in the soil under a cavity formed by the stone or in a crevice in hard soil.

Comments: In a recent revision of the Puncticollis Complex of the genus *Epicauta*, Ballmer (1979) listed British Columbia as the only Canadian province in which this species occurs. Whether or not *E. puncticollis* occurs in Alberta, as suggested in CIPR (1941), remains unknown.

Epicauta sericans LeConte

Distribution: Alberta and Saskatchewan.

Economic injury: Adults of *E. sericans* have been reported to defoliate *Syringa* sp., and *Spiraea prunifolia* Siebold and Zucc. in Alberta (CIPR 1929).

Biology: Adults occur mostly in June and July (Werner 1945).

Epicauta subglabra (Fall)

caragana blister beetle
méloé du caragan (m.)

Distribution: northeastern British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: According to Mitchener (1956), the adults of this native prairie species feed largely on the leaves of caragana, which is widely grown for windbreaks in fields near roadsides. They have also been reported to damage potato in Saskatchewan (MacNay 1948, 1949) and sweet-clover in Manitoba (MacNay 1949). In addition, Twinn (1938) reported damage by this species to beans, peas, alfalfa, mangel, and other garden crops, and Gibson (1934) reported damage to flowering plants. G.H. Gerber (personal communication) has collected adults from rapeseed fields a number of times.

Biology: According to Werner (1945), the adults of *E. subglabra* are active in June and July. In CIPR (1955) the larvae of this species are described as predators of grasshopper eggs.

Epicauta ventralis Werner

Distribution: Alberta and Saskatchewan.

Economic injury: According to a recent publication by Pinto (1980), adults of the Maculata Group, which generally confine their feeding to the inflorescence, tender leaves, and stems of their host plants, have been reported to attack sugar beet, alfalfa, potato, corn, soybeans, cabbage, spinach, beans, and clover. Since the species discussed have been confused in the past, some of these records may refer to *E. ventralis*. More specifically, Pinto listed alfalfa and sugar beet as crops attacked by the adults. In addition, he listed the genera *Bassia*, *Beta*, *Salsola*, *Sarcobatus*, *Medicago*, and *Melilotus* as food plants of the adults.

Biology: Pinto (1980) described the biology of *E. ventralis*. The average number of eggs in five masses was 79 (range, 46–132), and the duration of this stage averaged 14.3 days (range, 12–19). In Arizona the mirid *Hadronema bispinosa* Knight has been reported to attempt to suck the hemolymph from this beetle.

Epicauta vittata (Fabricius)
striped blister beetle
méloé rayé (m.)

Distribution: Ontario and Quebec.

Economic injury: Adults of *E. vittata* feed on soybeans and may become locally a serious pest of this crop (Adams and Selander 1979). Patel and Pitre (1971) demonstrated in the laboratory that this species is capable of transmitting the soybean disease caused by the bean pod mottle virus. The adults have also been recorded to injure potato, tomato, mangel, and beet in Ontario, as well as turnip, beans, peas, radish, melon, corn, clover, and alfalfa in the United States (Gibson 1911). Werner (1945) described *E. vittata* as a serious pest of potato. Adams and Selander (1979) had the impression that striped blister beetles were of more importance before the 1940s than they have been in recent years. They now consider *E. pestifera* to be more common and troublesome in Illinois than *E. vittata*. The same authors described adults of the Vittata Group primarily as leaf feeders that chew the edges of leaves and feed systematically and persistently, leaving only the larger veins intact. In addition, they attack flowers, fruit, and succulent stems.

When crushed or rubbed on the skin, adults of *E. vittata* can cause blisters in humans because of the presence of cantharidin in the hemolymph (Adams and Selander 1979). Cantharidin, or "Spanish fly," from blister beetles was administered to humans in ancient times as an aphrodisiac and vesicant, but the substance is directly toxic to the kidneys and a potent irritant to the gastrointestinal and urogenital systems (Presto and Muecke 1970). Cantharidin, from dead striped blister beetles in baled hay, has been implicated in the acute poisoning of horses in the southern United States (Schoeb and Panciera 1979).

Biology: Adams and Selander (1979) discussed the biology of the Vittata Group of the genus *Epicauta*. This summary is based on observations and literature cited by these authors, with particular reference to *E. vittata*. The species is univoltine in the northern United States. The females oviposit in burrows 1.3–2.5 cm deep, excavated with the mandibles and legs. Eggs are deposited over a period of 0.5–1 h in a compact mass in the bottom of the cavity, and the hole is then refilled. The length of time from attainment of the adult stage to first oviposition, for one female of *E. vittata*, was 22 days, and the mean period between ovipositions was 12 days. Females oviposit repeatedly throughout adult life; the maximum number of ovipositions and total number of eggs observed were 8 and 754, respectively. For the egg masses, the mean incubation period was 11.5 days at 27°C and 100% RH. There was some evidence of parthenogenesis in this species, and a small percentage of the eggs laid by virgin females developed to the adult stage, even though there was a high incidence of defects among emerging larvae.

Larvae of the Vittata Group are predators of grasshopper eggs. Grubs, presumably of *E. vittata*, have been recorded from the eggs of *Melanoplus differentialis* (Thomas), *M. femurrubrum* (De Geer), *M. sanguinipes* (Fabricius) (as *M. atlantis* Riley), *M. bivittatus* (Say), and *Arphia sulphurea* (Fabricius) (as *Oedipoda sulphurea*). The first-instar larva or triungulin and the four following instars (first-grub phase) are feeding stages. When the fifth-instar larva completes feeding, it prepares a cell in the soil outside the grasshopper egg pod, transforms to the coarctate stage, and then enters diapause before overwintering. In the next season the coarctate phase becomes the second-grub phase or seventh-instar larva. This stage is followed by pupation and adult emergence.

Adults started feeding, on the average, 2.3 days after emergence. One male was observed courting and copulating on the day of emergence and another on the day after emergence; otherwise, the minimum interval between emergence and this behavior was 6 days.

In the Vittata Group, males assume the active role in courtship, the females becoming receptive only periodically. Olfaction is involved in sexual recognition, but males are not able to locate females by olfactory clues. The mean duration of mating for *E. vittata* was 155 min, with the average first mating of males and females occurring 8.0 and 10.3 days after emergence, respectively. Mated and unmated females lived 47.5 (range, 28–72) and 64.0 days (range, 38–91), respectively. Adults in the eastern United States are active both day and night. They seldom feign death or reflex bleed when disturbed, as do other meloids. Gibson (1911) reported the adults during the last week of July and the first week of August in Ontario.

Linsleya sphaericollis (Say)

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: Adults of *L. sphaericollis* may sometimes be seen in great numbers during grasshopper outbreaks in British Columbia, feeding on thin-leaved snowberry as well as attacking alfalfa and caragana hedges (King et al. 1953). They have also been recorded defoliating honeysuckle in Saskatchewan (MacNay 1949, 1950). Selander (1955) reported specimens collected from lupine, sweet-clover, lilac, honeysuckle, potato, and snowberry. The same author reported that the adults are extremely gregarious and cause considerable damage. Even though the food plants may be relatively widespread, the adults usually congregate in areas a few meters in extent (Church and Gerber 1977*b*). They also recorded that *L. sphaericollis* defoliated trees in plantations of green ash in Manitoba.

Biology: Church and Gerber (1977*b*) studied the development and habits of *L. sphaericollis* in the laboratory. Eggs were deposited in batches in burrows excavated in the soil. Females showed a preference for ovipositing in moist soil. Egg batches contained a mean of 51 eggs (range, 25–70), and some females presumably laid several batches. Of the eggs incubated at 15, 20, 25, and 30°C, those at 25°C exhibited the optimum incubation periods of 26–33 days. At 15°C none of the eggs hatched; at 20°C the incubation period was about 50% longer than at 25°C; and at 30°C the eggs matured in 17–18 days but failed to hatch until days 38–57.

The larvae of *L. sphaericollis* have never been observed in nature. In the laboratory the triungulin or first-instar larvae actively burrow into the soil, presumably in search of food, and can live for a relatively long period without food. In addition to the triungulin, there are four first-grub instars. The typical meloid coarctate phase and second-grub phase of larval development appear to be absent in this species. At 20°C the total larval feeding period lasted about 3 weeks. The fifth-instar larvae lived 4–10 weeks after ceasing to feed and were presumed to be in diapause, the implication being that they overwinter in this stage. It is presumed that the larvae of this species prey on the eggs of grasshoppers, but the species attacked remains unknown. The adults of *L. sphaericollis* emerge in June and feed during June, July, and August.

Lytta cyanipennis (LeConte)
(green blister beetle)

Distribution: southern British Columbia and southwestern Alberta.

Economic injury: According to Selander (1960), all food plants recorded for adults of *L. cyanipennis* belong to the Leguminosae, including *Lupinus* sp. and *Vicia* sp. He also stated that the beetles feed on the leaves but prefer flower petals, and in captivity they fed continuously, day and night. Gibson (1911) reported that *L. cyanipennis* destroyed beans and peas in British Columbia. However, Church and Gerber (1977*a*) stated that the species has seldom been reported to damage cultivated crops significantly.

Biology: Females of *L. cyanipennis* excavated burrows for oviposition 2.5–6 cm deep in the soil, usually during periods of darkness or subdued light (Selander 1960). Eggs were laid in batches containing an average of 390 eggs (range, 260—570), with each female having the potential to lay three to four batches (Church and Gerber 1977*a*). Selander (1960), however, observed a lower number of eggs per batch and assumed that females oviposit only once, dying within a few days of egg-laying. In Canada, Church and Gerber (1977*a*) assumed that the hatching of eggs is completed by the end of July.

Selander (1960) described the larval development of *L. cyanipennis*. The triungulin stage or first-instar larva is positively phototactic and can survive for at least 15 days without food. Although the hosts of the larvae are unknown, they fed readily on provisioned pollen and immature stages of the alkali bee in the laboratory. It was assumed that the first grub phase or feeding phase consisted of the second, third, fourth, and fifth instars. The fifth instar, having fed sufficiently, excavated a resting chamber, the entire grub phase having lasted approximately 36 days in the laboratory. The coarctate phase, or sixth-instar larva, is attained in late summer and lasts throughout the winter. The second-grub phase, or seventh-instar larva, occurs in the spring and is followed by pupation.

In southwestern Alberta the flight period of the adults extends from mid June to early July, and in areas with shorter winters, such as British Columbia, adults have been recorded from late March to mid August (Church and Gerber 1977*a*). The same authors stated that the species is most commonly encountered on hilltops near lakes, streams, and sloughs, congregating on a few plants, even though acceptable plants may be widespread. They also stated that the sex ratio of adults is near unity, and both sexes mate more than once. According to Selander (1960), copulation lasted for 11.5 h, and the adults continued to feed while in copula.

Comments: MacNay (1951) reported appreciable damage to flax caused by this species in the Peace River District of Alberta. According to Selander (1960) and Church and Gerber (1977*a*), this species does not occur in that area and does not feed on the plant family Linaceae. The damage was probably caused by *L. nuttali* or *L. viridana* (G.H. Gerber, personal communication).

Lytta nuttalli Say
Nuttall blister beetle (western blister beetle, caragana blister beetle)
méloé de Nuttall (m.)

Distribution: British Columbia (?), Alberta, Saskatchewan, Manitoba, and northwestern Ontario.

Economic injury: Church and Gerber (1977*a*) summarized the damage caused by the adults of this species. They considered the species to be of little economic importance to agricultural crops since the 1930s because of the relatively small populations in the Prairie Provinces. However, they do consider the species capable of defoliating young caragana plantations, devastating gardens, and seriously damaging seed plots. Plants of the family Leguminosae are the favored hosts, the adults feeding readily on the leaves and flowers of faba beans, the young growth of caragana, alsike clover, and coumarin-free strains of sweet-clover. *Lytta nuttalli* has also been reported to attack nonleguminous plants such as larkspur, iris, canola, sugar beet, oats, barley, and wheat. The damage in some instances is greater than the amount consumed, since the adults may feed on just the flowers of faba beans, chew through the stems of sweet-clover 15–25 cm below the tip, or destroy the flowers and young seed pods of canola. According to these authors, the species does not feed on alfalfa and generally does not eat beans and peas if other food is available. However, there are several records in the literature of damage to alfalfa (Seamans 1931, CIPR 1932, Twinn 1938, Mitchener 1956). In addition to the host plants listed above, the beetles have been reported to attack the flowers of sainfoin (CIPR 1941) and to infest spring vetch (CIPR 1930), potato (Dustan 1932), honeysuckle (CIPR 1961), gladiolus (CIPR 1932), and licorice (Dustan 1932). Burgess (1983) reported damage to canola grown adjacent to caragana hedges.

Biology: Church (1967) described the egg-laying behavior of *L. nuttalli*. The female excavates a burrow 3.5–5 cm deep, usually on an angle under a stone, digging with her mandibles and clearing the soil with her front legs. Upon completing the burrow, the beetle emerges from the hole, turns around, and backs into the cavity to deposit the egg mass at the bottom. Without emerging from the hole, the female begins filling the burrow by dislodging the soil from the sides. At 30–35°C, excavating, ovipositing, and refilling the burrow requires approximately 1.5–2, 0.5, and 1 h, respectively.

Gerber and Church (1976) studied the reproductive biology of *L. nuttalli*. In two different years, 25 and 35 females laid an average of 1.2 and 1.6 batches of eggs; the maximum number of batches was 5. The average period between successive ovipositions for the two groups was 6.7 and 6.6 days, respectively. The average number of matings for the two groups of females was 1.5 and 3.2, respectively, and the maximum was 7. However, females were capable of developing additional batches of eggs without further copulation. The mean number of matings for two groups of 25 males was 1.5 and 2.5. The maximum number for an individual male was nine, and males are capable of mating once every 24 h, although the most frequent interval was 2–3 days. Each of several dozen egg masses contained between 180 and 490 eggs. According to Church and Gerber (1977*a*), hatching is probably completed by the end of August.

Church and Gerber (1977*a*) summarized other aspects of the biology of the species. The flight period of *L. nuttalli* in Canada's Prairie Provinces extends from early June to early July, but in some areas where the winters are shorter, the adults are present from late May to late September. The beetles are gregarious and are known to congregate on a few plants when suitable host plants are widespread. Noncultivated plants attacked by the adults include the following: *Astragalus bisulcatus* (Hook.) A. Gray, *A. drummondi* Dougl., *A. pectinatus* (Hook.) Dougl., *A. tenellus* Pursh, *Lupinus argenteus* Pursh, *Oxytropis gracilis* (A. Nels.) K. Schum., *O. macounii* (Greene) Rydb., *Thermopsis rhombifolia* (Nutt.) Richardson, *Vicia americana* Muhl., and *V. sparsifolia* Nutt. Males and females kept in a greenhouse, where the temperature was 20°C at night and 30–35°C during the day, lived an average of 32 (range, 17–41) and 25 days (range, 13–33), respectively. The species is known to hybridize occasionally with *Lytta viridana*. The adults are attacked by the mirid *Hadronema militaris* Uhler, which feeds on the beetles' hemolymph, but its effects are unknown.

Comments: Beirne (1971) and Twinn (1938) reported *L. nuttalli* from British Columbia. However, Selander (1960), in his revision of the genus *Lytta*, did not record the species from that province. This record probably represents *L. cyanipennis* (G.H. Gerber, personal communication).

Lytta sayi LeConte
Say blister beetle
méloé de Say (m.)

Distribution: Ontario, Quebec, and New Brunswick.

Economic injury: The adults of this species are generally arboreal, feeding on the blossoms of certain trees, causing damage to cherry, plum, elder, and nannyberry (Gibson 1911). In Quebec, the adults have been reported to destroy apple blossoms (MacNay 1948–1950). In addition, Selander (1960) cited records of *L. sayi* from peach, pear, rose, beans, wheat, butternut, black locust, pussy willow, dogwood, and *Kolkwitzia* sp.

Lytta viridana LeConte

Distribution: Northeastern British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: Church and Gerber (1977*a*) summarized the economic damage caused by the adults of this species. The natural food of adults of *L. viridana* is a variety of wild legumes, but the species seems to prefer cultivated legumes when available. The adults eat both the leaves and flowers of faba beans, the young growth of caragana, alsike clover, and coumarin-free strains of sweet-clover. The species generally ignores pea and bean and does not feed on alfalfa or on sweet-clover strains containing coumarin. Of nonleguminous cultivated plants, *L. viridana* has been reported to feed on *Iris* sp. and *Delphinium* sp. The adults are gregarious and congregate on a few host plants, even though suitable food plants may be widespread. Additional host plants of the adults include the following: *Astragalus bisulcatus* (Hook.) A. Gray, *A. drummondii* Dougl., *A. pectinatus* (Hook.) Dougl., *Vicia sparsifolia* Nutt., and *Thermopsis rhombifolia* (Nutt.) Richards. The relatively small populations of this species in the Prairie Provinces since the 1930s are of little economic concern. However, the damage caused by the species may exceed the actual amount of plant tissue consumed, since the beetles may merely chew through the stem of sweet-clover or eat the flowers of faba beans.

Biology: Church and Gerber (1977*a*) studied the development and habits of the eggs and adults of this species. Females in captivity may lay only one batch of eggs, but others lay up to three. They deposit their eggs in the bottoms of burrows 4–5 cm deep excavated in the soil, usually in moist soil and angled in under a stone or clod of earth. The average number of eggs in 20–25 randomly selected batches was 340 (range, 220–490). Hatching of eggs is completed by mid July.

In Alberta, the flight period of adults of *L. viridana* extends throughout the last 3 weeks of June, with the earliest and latest records being 25 May and 27 June, respectively. Under greenhouse conditions, the life span of adults was about 3 weeks, and some individuals lived for 4 weeks. In areas where winters are shorter, the species is present from late May to mid August. Hybrids between *L. viridana* and *L. nuttalli* have been observed in the field. Adults are attacked by the mirid *Hadronema militaris* Uhler, which feeds on the beetles' hemolymph, but whether or not this insect has a detrimental effect is unknown.

Meloe americanus Leach
(buttercup oil beetle)
méloé d'Amérique (m.)

Distribution: Ontario.

Economic injury: The adults of this species have been reported to damage the foliage of potato in Ontario (Fletcher 1899*a*).

Biology: Pinto and Selander (1970) made observations and summarized the biology of this species. Eggs were deposited in cavities excavated by the females. The larvae were reported as predators in the nests of the halictid bees *Augochloropsis metallica metallica* (Fabricius) and *Halictus ligatus* Say. The adults are plant feeders and have been reported to feed on *Ranunculus septentrionalis* Poir. and *Iva* sp. The beetles, unlike other species in the genus, are active only in dim light or darkness and spend the day beneath leaf litter, rocks, or logs. In winter the adults have been found in cold torpor in the same microhabitats. The adults are fed upon by the anthicid beetle *Pedilus terminalis* (Say).

Meloe angusticollis Say (*montanus* LeConte)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia.

Economic injury: According to MacNay (1951), adults commonly damage *Clematis* and have been reported to occur on potato in Alberta. As *M. montanus*, Banham and Arrand (1978) described this species as an economic pest of most vegetables in British Columbia, the adults feeding on the foliage.

Adults of *M. angusticollis* have been observed feeding on the following plants: *Ranunculus hispidus* Michx., *R. septentrionalis* Poir., *Claytonia virginica* L., *Ulmus rubra* Muhlenb., *Chaerophyllum procumbens* (L.) Crantz, *Galium aparine* L., *G. triflorum* Michx., *Taraxacum officinale* Weber, *Arisaema triphyllum* (L.) Schott, *Carex pensylvanica* Lam., and *Elymus villosus* Muhl.

Biology: Pinto and Selander (1970) reported the biology of *M. angusticollis*. The adults of this species are active primarily in the spring. Males and females are capable of repeated copulations and females are capable of several ovipositions.

The larvae of *M. angusticollis* are predators in the nests of bees and have been observed, attached in phoretic association, on the following species: *Andrena carlini* Cockerell, *A. cressoni* Robertson, *Anthophora furcata terminalis* Cresson, *Colletes inaequalis* Say, *Agapostemon radiatus* (Say), *Evylaeus cinctipes* (Provancher), *E. macoupinensis* (Robertson), *Nomada* sp., and *Ceratina calcarata* Robertson. The larvae attached themselves to the bees by their claws.

The anthicids beetles *Pedilus impressus* (Say) and *P. terminalis* (Say) feed on the adults of this species (Pinto and Selander 1970).

Meloe impressus Kirby

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Northwest Territories, and Yukon Territory.

Economic injury: Adults of *M. impressus* have been reported to feed on rutabaga, potato, *Ranunculus acris* L., *R. septentrionalis* Poir., *Clematis* spp., *Anemone hupehensis* Hort. Lemoine, (as *japonica* (Thunb.) Siebold & Zucc.), *Hepatica* sp., *Brassica campestris* L., and *Iva capensis* Meerb. (as *biflora* Walt.) (Pinto and Selander 1970).

Biology: Pinto and Selander (1970) described the biology of *M. impressus*. This is an autumnal species, with adults active in summer and fall. Adults do not enter diapause and probably live for 1.5–2 months. The females oviposit several times during their lives. The average number of eggs in six egg masses was 1278 (range, 701–1652). The eggs undergo a prolonged embryonic diapause in which they overwinter.

The larvae are predators in the nests of bees, having been found in phoretic association with the following species: *Andrena carlini* Cockerell, *A. mandibular* Robertson, *Apis mellifera* Linnaeus, and *Colletes inaequalis* Say.

Meloe niger Kirby

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Northwest Territories.

Economic injury: Adults of *M. niger* have been reported to feed on asparagus, onion, red clover, and Japanese anemone (Pinto and Selander 1970). According to Mayer and Johansen (1978), adults exhibit some degree of host plant specificity but will feed on any plant rather than starve. The same authors reported that the adults feed on the leaves and stems of alfilaria, wild oats, perennial rye grass, wheat, and iris, as well as on other noncultivated plants. They fed at ground level early in the spring and on the plant tips later in the season.

Mayer and Johansen (1977) have shown that the blood of *M. niger* contains the drug cantharidin, or "Spanish fly." This chemical has been implicated in the poisoning of horses (Schoeb and Panciera 1979) and humans (Presto and Muecke 1970). However, Mayer and Johansen (1977) did not observe blistering symptoms typical of topical application of the chemical in any of 10 humans who came in contact with the blood of *M. niger*.

The larvae of *M. niger* are predators in the nests of the alkali bee, *Nomia melanderi* Cockerell, a principal pollinator of alfalfa grown for seed in the Pacific Northwest. According to Mayer and Johansen (1978), this is the only time that a *Meloe* was known to cause economic injury to a beneficial bee species to the extent that control was required.

Biology: In the Pacific Northwest, Mayer and Johansen (1978) made observations on the biology of *M. niger* in the laboratory and the field. The majority of eggs were laid in April in alfalfa fields or in ecotones containing suitable host plants. Females, using their mandibles and legs, excavated burrows 3.8–5.8 cm deep in damp soil and deposited the eggs in a compact mass in the bottom of the cavity. The female remained in the hole for 6–8 h until oviposition was completed and then refilled the hole. Eight females laid an average of 3179 eggs (range, 2730–3623). In the laboratory, females died soon after ovipositing and, in the field, marked females were never observed ovipositing a second time. The mean incubation period for the eggs ranged from 21.6 days at 28°C to 50.8 days at 18°C.

The usual hypermetamorphic sequence of postembryonic development in *M. niger* consists of five anatomically and behaviorally discrete phases consisting of the triungulin phase (first instar), the first-grub phase (second to fifth instar), the coarctate phase (sixth instar), the second-grub phase (seventh instar), and the pupal phase (eighth instar). Unusual or uncommon sequences that either shorten or lengthen development time, depending on temperature and humidity, also occurred, resulting in 6–10 instars.

In the laboratory, newly hatched triungulins remained clumped together for 6–10 days before dispersing. Triungulins at this stage are highly mobile and climb flowers that are being visited by insects. Although found on other flowers, triungulins of *M. niger* occurred primarily on the flowers of alfalfa from about mid June to mid July. The triungulins are phoretic – when a bee approached the flower, the triungulins reared up on their hind legs and attached themselves to the hairs of the bee with their claws and mandibles. Triungulins were found attached to the bees *Nomia melanderi* Cockerell, *Apis mellifera* Linnaeus, *Megachile pacifica* (Panzer), *M. brevis* Say, and *Chloralictus* sp. and the wasp *Philanthus ventilabris* Fabricius. However, no triungulins were found in the hives and cells of *A. mellifera* and *M. pacifica*, suggesting that they detach themselves from nonhost bees before reaching the bee's nests. In Washington, *M. niger* has been recorded only from the cells of *N. melanderi* and

Anthophora urbana urbana Cresson. Hosts of *M. niger* must be solitary, ground nesting, and gregarious; they must also overwinter as prepupae and not use foreign material for nest construction. Upon reaching the bee cell, the triungulin gorges itself on pollen and occasionally the host egg, with only one triungulin surviving per bee cell.

Following the engorging subphase, the triungulins molt to the second instar. This constitutes the beginning of the first-grub phase, or primary feeding phase. The second instar feeds on pollen and the egg, if the latter has not already been consumed by the triungulin. The third instar consumes about one-third of the pollen supplied by the bee, and the fourth instar consumes the remainder. The fourth instar may leave the original bee cell in search of a new cell, or it may molt to the fifth instar in the original cell. The fifth or final first-grub instar burrows into any bee cell it encounters and finally burrows down into the soil to a depth of 22–30 cm to construct a resting chamber. All subsequent instars occur within this pupal chamber. The sixth instar is the coarctate phase, a nonfeeding, resting stage characterized by reduced mouth parts, legs, and antennae. This phase usually lasts about a month, transforming in the first week in September, but approximately 20% of the coarctates enter diapause and overwinter in this state, resulting in a 2-year life cycle. The second-grub phase follows the coarctate phase and usually consists of the seventh instar, which is usually followed by the pupal stage.

Adults develop in the pupal cells in the fall; they overwinter and emerge from the cells from mid February to mid April. Males emerge slightly ahead of the females, although their emergence overlaps. Newly emerged adults were active and began feeding at a ground surface temperature of 4°C. Below this temperature, they were inactive and hid under weeds and dirt clumps. There is evidence that females produce a sex pheromone, but they are not sexually receptive until they have fed for 2–3 weeks. In the field, copulation was first observed about mid March. In the laboratory, males and females mated a maximum of five and three times, respectively. The adults are diurnal and were not observed in the field after the beginning of June.

When disturbed, adults of *M. niger* responded by reflex bleeding, a behavior consisting of blood emission from the leg joints while feigning death. This is believed to be a defence mechanism, with the cantharidin in the blood acting as a feeding deterrent.

Predators and parasites of *M. niger* are rare, although a pedilid beetle, *Pedilus monticola* (Horn), has been reported to attack the species and a humpbacked fly, *Megaselia* sp., was found feeding on egg masses. In the field, dead coarctates have been found infected with a fungus, *Aspergillus* sp., but this may not have been the causal organism.

MICROMALTHIDAE telephone-pole beetles

Larvae of this family are wood borers, and the adults are not known to feed. The family is unusual in that the larvae go through a complicated life cycle having a variety of larval growth forms, and under certain conditions, the larvae give birth (paedogenesis). The only species in this family is probably native to eastern North America, but it has been introduced into a number of other areas.

Micromalthus debilis LeConte
(telephone-pole beetle)

Distribution: British Columbia.

Origin: This species is native to eastern North America. Its first record from Canada and the western Nearctic region was made in Vancouver, B.C. (Becker 1977). It has also been reported from South Africa.

Economic injury: Larvae have been found in a crosstie (Douglas fir) treated with creosote in Vancouver, B.C. (Becker 1977). The species has also been imported in mine timbers into South Africa, where it caused serious injury. The larvae damage buildings, poles, and other wooden structures by boring into moist, decaying oak or chestnut logs in the red-rotten or yellowish-brown stage of decay (Arnett 1960).

Biology: The complicated life cycle of *M. debilis* was described in detail by Barber (1913). Arnett (1960) noted that the larvae exhibit such forms as caraboid, cerambycoid, and curculionoid larval types. The larvae often reproduce by paedogenesis, giving birth to living young of the caraboid type. Adults are produced only under adverse conditions.

MORDELLIDAE tumbling flower beetles

Larvae of this family usually feed in the stems of herbaceous plants or in rotten wood; a few bore into the fruiting bodies of fungi. Adults are commonly found on flowers. The family contains about 1200 species and is common in all areas of the world. About 70 species are estimated to occur in Canada.

Mordellistina pustulata (Melsheimer)
(sunflower-pith beetle)

Distribution: Manitoba and Ontario.

Economic injury: Larvae of this species may severely damage sunflowers by tunneling into the stems (Criddle 1922). The larvae usually occupy the pith of the stem but also damage the more woody parts; they are most often found near the base of the plant, although any part of the stem may be infested. Damaged plants appear stunted and occasionally die. The larvae have also been taken in the stems of *Amaranthus retroflexus*. The adults occur on flowers.

Biology: *Mordellistina pustulata* hibernates in the larval stage in the stems of host plants (Criddle 1922). A single stem may contain several larvae. Pupation takes place in the spring, and the new adults appear in June (in Manitoba). When disturbed, the beetles jump like fleas.

MYCETOPHAGIDAE **hairy fungus beetles**

Most species of this family feed on various types of fungi either on spores of Ascomycetes or in rotting fruiting bodies of mushrooms. Some species are often associated with stored products and are indicative of poor storage conditions, such as high moisture with excessive fungus growth. The family is well represented in temperate and tropical areas, with about 200 species known. Sixty species are estimated to occur in Canada.

Mycetophagus quadriguttatus Mueller
spotted hairy fungus beetle

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Origin: According to Hatch (1962), *M. quadriguttatus* is probably an introduced species. Its known distribution includes Europe, the Caucasus, and eastern and central United States (Hinton 1945).

Economic injury: The spotted hairy fungus beetle has been reported in waste feed, sacked grain, grain elevators, cereal warehouses, and flour mills in British Columbia (Zuk 1958, Hatch 1962). Hinton (1945) noted several records of the species in and around the following: old flour barrels (United States), basements of flour mills, waste grain (North America), fungal growth at the bottom of old hay and clover stacks, granary refuse, fungus on trees, a vegetable store, a corn shop (Britain), stored grain, and warehouses where mold is growing (Germany).

Biology: Hinton (1945) stated that other species of this genus have an irregular number of molts – (i.e., more than three and up to five for *M. quadripustulatus* (Linnaeus) and *M. multipunctatus* (Fabricius).

Typhaea stercorea (Linnaeus) (*fumata* Linnaeus)
hairy fungus beetle
mycétophage des céréales (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This species is cosmopolitan in distribution. Hatch (1962) assumed that it was introduced into North America.

Economic injury: The hairy fungus beetle occurs in moldy food products and other organic materials (Hatch 1962). It is not infrequently found both outdoors and in houses and barns. The species was reported in Nova Scotia in large numbers from dairy barns, where it was contaminating milk (B. Wright, personal communication). Monro (1969) noted that this species is not considered to be a primary pest because it does not attack sound grain. In ships' holds, *T. stercorea* is occasionally numerous and it is regularly intercepted at Canadian ports. According to Cotton and Good (1937) and Cotton (1956), the insect is known to occur in warehouses, stores, flour mills, dwellings, and granaries and to infest stored grain and seeds, tobacco, peanuts, and cacao. *Typhaea stercorea* often occurs in corn fields and is apparently attracted to decaying kernels of exposed ears (Cotton 1956). The species was reported to be numerous in grain during threshing and in feed mangers in Ontario (CIPR 1961). Heavy infestations are often found after the corn is harvested and shelled, although there is little feeding on undamaged grain. Hinton (1945) reported the species in and around the following: heads of wheat in the field, railway boxcars that carried wheat (North America), moldy grape skins (France), stored wheat (Britain, Germany), nests of swans and moorhens, a large number of various commodities (Britain), moldy wood, warehouses but only when mold is present (Germany), dried apricots imported into Germany from North America, a heap of weevily millet (Egypt), heads of durra (Sudan), and stored maize (Australia).

NITIDULIDAE sap beetles

Species of this large family feed on a wide variety of food materials, but most are saprophagous or mycetophagous, feeding on decaying fruits and fermenting materials, carrion, and decaying fungi. A few species are predaceous or even phytophagous. This family is well represented in all faunal regions and contains approximately 3000 species of which 120 are estimated to occur in Canada.

Carpophilus dimidiatus (Fabricius)
corn sap beetle
nitidule du maïs (m.)

Distribution: British Columbia, Saskatchewan, Quebec, and New Brunswick.

Origin: According to Hatch (1962), *C. dimidiatus* is probably an introduced species.

Economic injury: Hatch (1962) reported that the corn sap beetle occasionally infested such stored products as dates and copra in southeastern British Columbia. The species is found in all tropical and temperate parts of the world (Lindgren and Vincent 1953). In the southern United States, the insect is frequently observed in cornfields and rice mills (Cotton and Good 1937, Cotton 1956). In the field, it normally feeds on decaying fruit and vegetation and in the sap exuding from injured plants (Hinton 1945). The insect attacks a wide variety of stored foods (corn, shelled nuts, cacao, nutmeg, grain, flour), with *C. dimidiatus* being especially common on dried fruit and cereals (Cotton and Good 1937, Hinton 1945). Cotton (1956) stated that cereal products in good condition are seldom damaged.

According to Lindgren and Vincent (1953) and Cotton (1956), damage from adult and larval feeding is insignificant in comparison with the loss caused by the presence of larvae, adults, excreta, and the molting skins in and on dates. Frequently, there is no visible indication that the insects or their remains may be in the seed cavity of dates (Lindgren and Vincent 1953). Nitidulid beetles may also carry mold and souring organisms that cause further fruit spoilage.

Biology: *Carpophilus dimidiatus* has a similar appearance and life cycle to that of the dried fruit beetle (Davidson and Lyon 1979). The beetles are strong, active flyers and may live as long as 6 months to a year (Lindgren and Vincent 1953). During this time, the female may deposit 500–1000 eggs. At temperatures of 18.3–32.2°C, the egg period required is 1.6–4.1 days, the larval period 5.1–15.6 days, the prepupal period 3.1–11.6 days, the pupal period 4.9–17.9 days, and the egg-to-adult period 14.7–49.2 days, respectively.

Carpophilus hemipterus (Linnaeus)
driedfruit beetle (fig-beetle, two-spotted beetle)

Distribution: British Columbia, Manitoba, Ontario, and Quebec.

Origin: The species is almost cosmopolitan in distribution and was introduced into North America (Hatch 1962).

Economic injury: According to Hinton (1945), the insect is found throughout the temperate and warm regions of the world and feeds on a wide variety of ripe and decomposing fruit in the field. The species is a serious pest of dried fruit of all kinds and also occurs in stored maize, cornmeal, wheat, oats, rice, beans, nuts, peanuts, cotton seed, copra, spices, drugs, bread, sugar, and honey. Hinton gave a list of host records from various parts of the world. Hatch (1962) reported that *C. hemipterus* infested dried fruit in southern British Columbia. Metcalf et al. (1951) stated that the driedfruit beetle is chiefly a pest of the fig and date industries in California and that it feeds on fermenting tree fruits, raisins, and watermelons.

The beetles feed on the flesh of the fruit and are capable of transmitting bacteria, yeasts, and fungal spores, which cause smut and souring of fruit (Hinton 1945, Metcalf et al. 1951). Adults are most attracted to fruits contaminated with such fungi as yeast, *Rhizopus*, *Aspergillus niger*, *Fusarium*, *Cladosporium*, and *Botrytis* (Hinton 1945). Fruit is usually penetrated only when the surface has been broken, but beetles have eaten through the skin of sound nectarines on trees where two fruits touched or where a leaf was in contact with a fruit. The insect enters sound figs through the open eye of the fruit. According to Lindgren and Vincent (1953), adult and larval feeding is insignificant in comparison with loss caused by the presence of excreta, larvae, adults, and the cast skins in and on dates. There is often no visible indication that the insects or their remains may be in the seed cavity of dates.

Biology: The species overwinters in the pupal stage in the soil and in the adult stage in all kinds of cull and fermenting fruits, fruit debris, and stored fruits (Metcalf et al. 1951). Adults are very active and are strong flyers. According to Hinton (1945), they are active at all hours of the day and night in warm places. Eggs are deposited singly on or in ripe or fermenting fruit in the field or in stored products. Lindgren and Vincent (1953) stated that the females prefer to lay their eggs in sour or decaying dates, especially those lying on the ground beneath the trees. The preoviposition period, oviposition period, and postoviposition period averaged 3.2 days (range, 1–8), 61.3 days (range, 18–122), and 38.9 days (range, 2–103), respectively, for 21 mated pairs that emerged from early May to late September (Hinton 1945). The average fecundity was 1071 eggs (range, 461–2134). Adult longevity is occasionally longer than 1 year. In the laboratory the females lived for an average of 103.3 days (range, 24–166) and the males for an average of 145.6 days (range, 82–196).

The eggs hatched in an average of 2.2 days (range, 1–7) (Hinton 1945). There are probably four larval instars. The larvae are quite active in all stages of development and move quickly when disturbed (Lindgren and Vincent 1953). Larval development was completed in an average of 9.9 days (range, 6–14); the pupal period averaged 6.8 days (range, 5–11); and the period from egg to adult averaged 18.6 days (range, 14–23) at an average temperature of 28.2°C (range, 20.3–36.5°) (Hinton 1945). At temperatures ranging from 18.3 to 32.2°C, Lindgren and Vincent (1953) reported the egg stage to require from 1.1 to 4.1 days, the larval stage from 4.2 to 13.7 days, the prepupal stage from 2.8 to 8.0 days, the pupal stage from 4.3 to 16.4 days, and the egg-to-adult period from 12.4 to 42.2 days, respectively. Metcalf et al. (1951) noted that one generation may be produced every 3 weeks in warm weather.

Carpophilus hemipterus requires a high temperature and relative humidity for development. According to Howe (1965), 19°C and approximately 50% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 31–34°C, and the maximum rate of increase every 4 weeks is approximately 50-fold.

Cotton and Good (1937) reported *Pseudisobrachium flavinervis* Fouts. to be a parasite of the species.

Carpophilus mutilatus Erichson

Distribution: Not in Canada.

Economic injury: This sap beetle is a major pest of ripening and partly dried figs in the San Joaquin Valley of California (Hall et al. 1978). A wide range of fruit, vegetables, and stored products are attacked by this nitidulid (e.g., fig, orange, plum, grapefruit, peach, cantaloupe, persimmon, nectarine, grape, and prune). Ripening and partly dried figs infested with adults and larvae are rendered unsuitable for marketing. The species is also capable of transmitting the brown-rot pathogen, *Monilinia fructicola* (Wint.) Honey, to late maturing stone fruit. This insect has been confused with the corn sap beetle.

Biology: The life history of *C. mutilatus* was described by Hall et al. (1978). Viable larvae and adults were taken through most of the year. Although there is apparently no adult hibernal diapause in the San Joaquin Valley, adults were shown to overwinter successfully in sticktight figs (those remaining on the tree after harvest). Mating began soon after emergence in the laboratory and continued throughout the adult's life span. The females deposited an average of 7.7 ± 4.9 eggs per female per day. The daily oviposition was quite variable, with individuals laying from zero to 25 eggs in 1 day. The beetles are apparently long-lived, and the egg-laying period may extend for 4 months or longer. The larvae pass through three instars and pupate in a cell in the soil. Mean developmental times under laboratory conditions (26°C) were as follows: egg, 2.2 days (range, 1.8–2.6); egg to wandering-stage larva (late third instar), 10.4 days (range, 8–16); wandering-stage larva to adult, 15.5 days (range, 12–19); and preoviposition period, 3.0 days (range, 1–4).

A neogregarine protozoan, *Ophryocystis* sp., is a pathogen of the adult stage of *C. mutilatus*.

Glischrochilus fasciatus (Olivier)
(red-spotted sap beetle)
nitidule fascié (m.)

Distribution: British Columbia, Manitoba, Ontario, Quebec, and Nova Scotia.

Economic injury: This insect occurs occasionally on some crop plants in Ontario, but apparently as a saprophyte rather than as a primary pest (Beirne 1971). Because it feeds in injuries inflicted by other insects or disease, *G. fasciatus* is generally considered to be a secondary problem (CIPR 1957). In 1956 an outbreak of this sap-feeding beetle occurred in central and southwestern Ontario on raspberry before and after picking, on corn where there was any injury or loose husk, and on tomato or any other fruit or vegetable with cracks in the skin. According to CIPR (1940), *G. fasciatus* is usually found in decaying fruit and fermenting sap from newly cut tree-stumps. Hinton (1945) reported that the species attacked growing ears of sweet corn in North America and the calyx of pear in the United States. It also damaged bread, cake, and other sweets kept in cupboards and pantries in Ohio and lived in stored dates in Chicago.

Biology: This insect was observed hibernating beneath logs and wood chips in Indiana and occasionally congregating in large numbers at sap flows of oak or maple (Hinton 1945).

Glischrochilus quadrisignatus (Say)
(four-spotted sap beetle, picnic beetle, sap beetle, scavenger beetle, four-spotted fungus beetle, fungus beetle, *Ips* beetle)
nitidule à quatre points (m.)

Distribution: British Columbia, Manitoba, Ontario, Quebec, and Nova Scotia.

Economic injury: *Glischrochilus quadrisignatus* is a serious pest of several fruit and vegetable crops and is annoying at roadside fruit and vegetable stands and in picnic areas (Foott and Timmins 1979). It is generally regarded as a secondary pest, entering such crops as corn, tomato, and raspberry through wounds caused by splitting, primary insects, aging, or disease and through yeast-induced fermentation (Wilde 1970). Many reports of injury to these crops have been made in Ontario (MacNay 1957*b*–1959; Goble 1965–1967, 1970; Wressell 1970; CAIPR 1971, 1974) and Quebec (CAIPR 1970, 1973, 1975, 1978; Paradis et al. 1974, 1979). The insect was found to be most numerous in fields near corn, since it breeds in corn fields (CAIPR 1973, Paradis et al. 1974). Other hosts include peach, pear, apple, melon, cabbage, onion, spilled grain, rotting corms of gladiolus and iris, potato seed pieces, strawberry, berries, tree wounds (oak), and fruit of osage orange (Luckmann 1963, Rivard et al. 1973, Foott and Timmins 1977*a*).

The adults cause damage when they bore into many types of ripe or overripe fruit and vegetables, and kernels of sweet corn initially injured by other insects or birds. The adults also cause injury by burying themselves deep into the flesh of damaged processing tomatoes between picking and delivery to the factory. In addition the beetles are attracted to bait and to exposed food in homes, backyards, public picnic areas, roadside fruit and vegetable stands, and food-processing plants (Luckmann 1963, Beirne 1971, Foott 1975, Foott and Timmins 1977*a*). According to Foott and Timmins (1977*a*) the beetles may be found in or under almost all types of overripe and rotting fruit and vegetables throughout the summer and fall. Their habit of playing dead within the berry makes them very difficult to extract before sale (CAIPR 1972). Luckmann (1963) noted that they may be so numerous as to prevent the natural healing of minor wounds or cracks and may so enlarge a wound that partial or total loss of the fruit or vegetable results. Wilde (1970) reported as many as 28 sap beetles in one sample of four apples, with feeding penetration to the core. Damage was indicated by frass and a brownish viscous ooze at the entrance sites and along the sides of the affected apples. Rotting peach, pear, apple, and melon had up to 72 beetles per fruit according to Foott and Timmins (1977*a*). A total of 158 beetles were recovered from a quart basket of raspberries. In corn, the beetles usually feed on ripening ears that have been injured by birds or other insects (Wressell and Hudon 1968). Sound ears are occasionally attacked when the insect is numerous, especially varieties that have a short or loose husk. Luckmann (1963) found beetles invading the silk channels of undamaged ears of silking sweet corn and noted that such attacks make conditions favorable to invasion by smut, mold, and the dusky sap beetle. Although the adults may appear to be primary invaders in the case of undamaged silking corn and ripe raspberry, attraction may be provided by the moist, fermenting pollen on the corn silk and by the first elements of decomposition following ripening of the berry. Luckmann (1963) also reported the beetle as a secondary pest of germinating corn seed. Tiller ears of corn, which are usually smutted, often contain from 200 to more than 400 adults; from 30 to 50 adults were reported in smut balls on the stalks (Foott and Timmins 1977*a*). Infestations of cracked and squashed tomatoes on the ground and in hampers occasionally exceed 100 individuals per fruit (as many as 304 beetles were reported in one tomato). It was pointed out that the longer that injured tomatoes are left in the field the more attractive is their odor to the beetles (Foott 1973). The beetles may escape detection in processing and inadvertently appear in the packaged product (Wressell 1970). The adults do not eat foliage or undamaged tomatoes on the vine (Foott and Hybsky 1976).

According to Luckmann (1963), larval development takes place in various types of decomposing plant materials such as spilled grain, feed, corn ears, cob piles, waste onion piles, and soil saturated with the juice or ooze of decomposing plant material. The larva's food must be moist and either buried in the soil or in contact with it. They do not occur in the ears of marketable sweet corn or in any corn ears still on the standing plant. Wilde (1970) reported larvae in Spy apple and noted that all infested apples occurred on the inner or shaded portions of the apple tree canopy up to a height of 1.8 m.

Biology: In southwestern Ontario, the species overwinters in the adult stage in grassy and weedy waste areas along the edges of woods, fields, and creeks, mostly in the top 2.5 cm of soil (Foott and Timmins 1977*a*). Preference is given to areas with grass sod and tall weeds over those with sod and short weeds; overwintering beetles rarely occur in forested areas or in soil with sparse vegetative growth (Foott and Timmins 1977*a*). In the United States, the insect reportedly overwinters in and around the following: bark of logs, tree wounds, soil, clumps of grass, decomposing vegetables, fruit, or grain, heavy leaf mold in forested areas, gladiolus corms. Very few beetles are found overwintering under bark, under objects on the ground, or in leaf mold in southwestern Ontario; accumulations of decomposing fruit and vegetables are usually not large enough to offer sufficient protection over the winter. Overwintering adults are not found in soil cultivated in the fall. Activity begins about mid April, when the temperature first begins to rise. At this time the adults may be observed in low-level flight over the previous year's corn fields. Most of the females are fertilized in the fall (Foott and Timmins 1979). Ears of corn left in the field are the main and often the only source of decomposing vegetative matter available for oviposition (Foott and Timmins 1977*a*), and the adults are capable of locating ears buried under 7.5 and 15 cm of soil. Foott (1975) reported the beetles to be more reproductive on fall-buried ears than on spring-buried ears because the kernels of the former are more decomposed and emit a stronger odor at egg-laying time. Eggs may be found on the husks of ears, between the kernels, and in the soil. Such decaying vegetative matter as rotting cabbage, piled onions, spilled grain, soil saturated with juices or ooze of decomposing plant material, decaying fruit, rotting corms of gladiolus and iris, and potato seed pieces are other suitable oviposition sites (Foott and Timmins 1977*a*). Eggs were found as early as 27 April on ears of corn in southwestern Ontario. Most of the eggs are deposited during May, but the egg-laying period may be extended considerably if suitable oviposition sites are available. Overwintered females brought into the laboratory deposited an average of 132.9 eggs from 24 June to 25 July, with substantial numbers deposited afterward. Luckmann (1963) pointed out that the eggs are deposited singly or in clusters of 2–20. Foott and Timmins (1979) reported that one female laid a total of 838 viable eggs, and several oviposited over 600. Adults may live a long time without food, provided they have sufficient moisture (Foott and Timmins 1979). The incubation period averaged 4.1 days at 21°C. Mussen and Chiang (1974) reported that at 15, 25, and 30°C the respective development periods for the eggs were 8.3, 3.6, and 3.0 days. The threshold temperature for egg development was 6.5°C, and eggs did not complete development at 5 or 35°C.

In southwestern Ontario, larvae were reported as early as 4 May (Foott and Timmins 1977*a*). Most of the larvae completed development before mid June, when the endosperm of the kernels had been eaten or was no longer suitable for food. The larvae began to pupate in early June and continued until early August, mostly in earthen cells beside or below buried ears but occasionally above the ear. Luckmann (1963) reported that the larvae moved away from the food at maturity, becoming inactive for several days and then pupating in the soil. At 23.9 and 29.4°C, the respective duration of the following stages was as follows: first instar, 3 and 3.5 days; second instar, 3 and 4 days; third instar and pre-pupal period, 13.2 and 13.5 days; and pupal period, 8.7 days. Larvae completed development to the adult stage in the laboratory at temperatures between 15.6 and 29.4°C. At 21.1–29.4°C, the life cycle (egg to adult) averaged 31–36 days. Mussen and Chiang (1974) reported threshold temperatures of 5.5 and 10.5°C for development of larval and pupal stages, respectively. At temperatures between 15 and 30°C, the larvae developed in 17.3–53.1 days and the pupae in 7.3–18.0 days, respectively. Larvae did not complete development at 5, 10, or 35°C nor did pupae at 5°C (the pupae were not tested at 35°C). The new adults remained in the soil for an average of 11.2 days before emerging (Foott and Timmins 1979). During the last few days, a gradual movement toward the surface was observed instead of a sudden change from inactivity to emergence from the soil. Emergence began on 15 June in southwestern Ontario and peaked from mid July to early August (Foott and Timmins 1977*a*). According to the same authors, only one generation occurs each year in southwestern Ontario, but two were produced in outdoor cages when moist soil and a sufficient supply of suitable food were provided. Two generations of this species occur each year in the United States (Davidson and Lyon 1979).

Foott and Timmins (1979) reported a species of *Beauveria* as a fungal parasite of *G. quadrisignatus*. Pree (1968) noted that many dead insects were infested with the fungus *B. bassiana* (Bals.) Vuill. According to Foott (1973), predators are of minor importance in controlling the beetle.

Meligethes nigrescens Stephens

Distribution: British Columbia, Alberta, Manitoba, Ontario, and Quebec.

Economic injury: CIPR (1960) reported this species to be numerous on clover in Quebec. In Oregon it is a pest of Dutch clover and hairy vetch, and in Pennsylvania it has been injurious to muskmelon.

Nitidula bipunctata (Linnaeus)

Distribution: British Columbia, Manitoba, Ontario, Quebec, and Northwest Territories.

Economic injury: *Nitidula bipunctata* occurred in some numbers in a dwelling in Montreal, Que. (MacNay 1953). Hinton (1945) has recorded this species in and around the following: bread, cakes, and other sweets in cupboards and pantries in Ohio; dead birds, dead animals, and old bones in Britain; carrion and bones in Germany, and ham, sausage, and bacon in houses in Germany.

Nitidula rufipes (Linnaeus)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Economic injury: CIPR (1963) noted that adults of this carrion feeder invaded a household near Ottawa, Ont. Hinton (1945) reported the insect in and around the following: chestnuts and ginger imported from China into Hawaii; dead birds, dead animals, and old bones in Britain; and carrion, bones, and frequently smoked bacon in houses in Germany.

Stelidota geminata (Say)
strawberry sap beetle

Distribution: in Canada.

Economic injury: The strawberry sap beetle attacks ripe, overripe, and injured fruit of a great many plants, but only when the fruit is on or near the ground (Connell 1980). The fruit of low-growing species such as strawberry and mayapple is damaged as it ripens while still on the plant, whereas apple, peach, and citrus fruit is infested only after having fallen to the ground. Weber and Connell (1975) reported injury to harvested fruit and vegetables by feeding and physical contamination. *Stelidota geminata* reportedly caused the loss of an entire season's strawberry crop in one area. In 1976 the species damaged as much as 10% of the strawberry crop in Summit County, Ohio; in 1977 a survey revealed that injury ranged from zero to 5% across the state (Weiss and Williams 1978). Records of infestations in strawberry date from the 1950s, because before this time the fruit was harvested before reaching an attractive stage of maturity (Connell 1980). Additional hosts include the fruit of pineapple, melon, common persimmon, common fig, kumquat, tomato, ceriman, red or American mulberry, pear, and immature ears of corn (Weber and Connell 1975). The insect has also been associated with sap flows of oak and has been collected from *Polyporus* sp. and the flowers of maple, rose mallow, and *Vaccinium* sp.

Damage is caused by the adults, which enter the fruit from the underside where it is in contact with the ground (Connell 1980). Small perforations in the fruit are characteristic of adult injury (Weiss and Williams 1978). According to Connell (1980), any disturbance causes these beetles to drop off and hide, and so they are only rarely seen by buyers. The strawberry sap beetle also serves as a vector for organisms that cause rot (Weber and Connell 1975).

Biology: Unless otherwise stated, the life history of the strawberry sap beetle is taken from Weber and Connell (1975). In Delaware the winter is passed in the adult stage only. Adults were collected in leaf litter from a woodland near an abandoned orchard during December and January and were observed feeding as early as 14 April. Connell (1980) stated that these beetles are essentially ground dwelling, with almost cryptic behavior. Observations made by the same author suggest that adults have only limited flight. Under laboratory conditions (23°C), mating began in an average of 3.7 days (range, 1–8) after eclosion. The females mate frequently. Egg-laying started in an average of 4.8 days (range, 2–9) after mating. The females laid an average of 5.6 eggs (range, 2.7–10.3) per day (in moist crevices near larval food) over an average oviposition period of 69.6 days (range, 20–153) for an average total fecundity of 346 eggs (range, 118–737). In nature the eggs are probably deposited near the female's food in crevices such as are present in herbaceous litter and in the soil. Suitable oviposition sites may also include crevices present among bracts at the base of such fruits as strawberry. The postoviposition period averaged 5.5 days (range, 0–30). The adults lived for an average of 58.4 days.

The eggs hatched in an average of 2.5 days if kept moist. Of the 10 047 eggs laid, only 10% failed to hatch. The larvae pass through three instars. The first and second instars were each completed in 1 day, and the third instar averaged 6 days. In the latter instar, 3 days were spent feeding, 1 day wandering and making shallow burrows, and 2 days constructing a pupal cell 1–2 cm below the substrate's surface. Soon after construction of the cell, the larva becomes scarabaeiform and quiescent; it molts within a few days. The period from pupation to eclosion averaged 5 days. Newly eclosed adults darkened from cream to castaneous within 12 h while remaining in the pupal cells. Females emerged from the cells 12–18 h after eclosion and males about a day longer. The complete life cycle averaged 20 days.

OEDEMERIDAE false blister beetles

Little is known about the habits of this family. Most known larvae breed in moist, decaying wood. The adults are usually found feeding on the pollen of flowers; they are frequently attracted to lights. The family is of little economic importance, although one cosmopolitan species is a pest of wood pilings and timbers. Species are known from all faunal regions but are most abundant in tropical areas. About 1000 species are known, of which 20 are estimated to occur in Canada.

Nacerdes melanura (Linnaeus)
wharf borer
nacerde (f.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Origin: This cosmopolitan species is considered by most to be of European origin, although Balsbaugh et al. (1979) believed the insect is native to the Great Lakes region of North America and was introduced into Europe. In Canada *N. melanura* was first recorded in Ontario in 1897, Nova Scotia in 1898, Quebec in 1917, British Columbia in 1928, Manitoba in 1931, and New Brunswick in 1935 (Balch 1937).

Economic injury: According to Goble (1971*b*), *N. melanura* is chiefly a pest of wood used in wharves and piling. Damage is done only to wood that has been kept moist and is often starting to rot. Balch (1937) reported that injury to a wharf in Saint John, N.B., was so severe that it required reconstruction. Although the wharf borer appears to be most abundant near the coast, it has also been taken in a variety of inland habitats. Bridge timbers and wood such as beams, studs, window frames, and floor planking in poorly ventilated areas or in moist basements in buildings may also be infested (Goble 1971*b*). The insect is occasionally a pest of telegraph poles and fences, especially where dogs have urinated (Balch 1937, Balsbaugh et al. 1979). Infestations are known to occur in buried or partly buried wood and, in one instance, in wood completely surrounded by concrete. *Nacerdes melanura* has been a nuisance in dwellings, garages, service stations, and public buildings (Gibson and Twinn 1939). Records of this species in buildings of various sorts (in Manitoba, Ontario, Quebec, Nova Scotia, and Newfoundland) are given in Balch (1937), MacNay (1951, 1953, 1956, 1958, 1959), and CAIPR (1978). Spencer (1958) reported that the insect appears to be spreading widely in Vancouver, B.C.

The larvae tunnel in moist or decaying wood in much the same manner as do the larvae of long-horned beetles (Gibson and Twinn 1939, Goble 1971*b*). Balch (1937) described the tunnels as oval in cross section, filled with fine frass, and extending mostly lengthwise with the grain. Some of the wood from a wharf in Saint John was almost completely honeycombed with tunnels and could be pulled apart by hand, even though there was little evidence of external damage. It was noted that although most of the tunnels were found in rotten wood, many larvae bored in sound wood but only within a few centimetres of at least partly rotted wood. Damage may be detected by the presence of adult exit holes (Goble 1971*b*). Newly emerged adults may become a nuisance by entering adjacent buildings or by their attraction to lights.

The association of *N. melanura* with fungi appears to be accidental because of the preference of both for a similar environment (Balch 1937). The wharf borer, however, hastens the penetration of fungi and the subsequent decomposition of wood.

Biology: According to Goble (1971*b*), the life history of this species is similar to that of many long-horned beetles. Balch (1937) indicated that at Saint John, the larvae appear to overwinter in many different stages. The larger larvae pupate early in the season, and the smaller ones may not pupate until the following year. Pupation occurs in a cell made up of coarse shreds of wood in the last few centimetres of the tunnel. The adult chews a more or less circular hole to the surface to escape. Adult emergence usually occurs from June to August (Goble 1971*b*). Balch (1937) observed large numbers of the beetles during July and August but found only dead specimens by 23 September. The adults of both sexes are erratic in movement and apparently require no food (Spencer 1957*c*). Balsbaugh et al. (1979) reported that adults can mate and oviposit within the cavities made in the wood by the larvae. According to Goble (1971*b*), the female may lay up to 300 eggs in cracks of damp or wet wood. The eggs are inserted singly or in small groups as deep as possible into the crevices (Spencer 1957*c*). The incubation period varies from 5 to 7 days, and the larvae wander for days on the sodden wood before tunneling in (Spencer 1957*c*). Balch (1937) found larvae of a variety of sizes (10–30 mm long) on 23 September, but no eggs or pupae. The larvae may require 2 years or longer in the wood before pupation (Goble 1971*b*). Balch (1937) noted considerable overlap in generations and that two or more seasons may be required to complete development in New Brunswick.

PTINIDAE spider beetles
ptines (m.)

Species of this family are found in all faunal regions but are best represented in arid regions. Most species occur on a variety of materials of both plant and animal origin. Many are major pests of stored products. The family contains approximately 450 species of which 20 are estimated to occur in Canada.

Epauloecus unicolor Piller & Mitterpacher

Distribution: New Brunswick and Nova Scotia.

Origin: Cotton and Good (1937) gave the distribution of this species as Europe and Transcaucasia. It was first recorded in North America in 1938 when three specimens were collected in warehouses at Truro, N.S., and at St. John and Fredericton, N.B. (Brown 1940*a*).

Economic injury: Throughout its range, this spider beetle has been recorded in houses, bakeries, corn shops, flour mills, warehouses, stables, old wood, and birds' nests. It feeds on stored grain and moist animal skins (Hinton 1941).

Gibbium psylloides (Czempinski)
(hump beetle)

Distribution: Quebec.

Origin: According to Cotton and Good (1937), this species is cosmopolitan in distribution, although it is found more frequently in warm climates (Howe and Burges 1953).

Economic injury: Sinha (1965*b*) listed this species as a stored-product pest in Quebec. In other parts of its range, *G. psylloides* occurs commonly in houses, hotels, warehouses, mills, granaries, and latrines (Hinton 1941), where it has been reported to feed on stored wheat, cereal, cakes of opium, paste, cayenne pepper, hay, bread, and animal material (Cotton and Good 1937).

Biology: Howe and Burges (1953) studied the life history of *G. psylloides* under controlled conditions. For two experiments, the mean period of male longevity was 25.5 and 10.6 weeks and for female longevity it was 49.2 and 41.6 weeks at 25°C and 70% RH on a wheat feed diet. Eggs were laid throughout the life of the female, with an average of 283.1 (range, 45–524) eggs laid. Females required food and free water to achieve maximum oviposition. The mean incubation period was 14.6 days at 23°C and 70% RH. Most larvae had three instars, but some occasionally have more. The mean development periods of the three instars was 17.4, 18.5, and 29.2 days, respectively, under the same conditions as above. At maturity, the larvae of *G. psylloides* spin strong dense cocoons in which to pupate, the duration of the pupal stage averaging 13.4 days.

The total mean development time from oviposition to adult emergence from the cocoon, at temperatures ranging from 35 to 20°C, was 61.0–122.9 days, respectively. A temperature of 35°C was the maximum for complete development, and the optimum temperature was near 33°C. The optimum temperature for adult longevity and maximum egg output was, however, near 25°C. According to Howe (1965), 20°C and 30% RH constitute the minimum temperature and RH at which the species can multiply in sufficient numbers to become a pest. The optimum temperature range is 31–34°C, and the maximum rate of increase every 4 weeks is fourfold. The species developed on a variety of foodstuffs of animal and plant origin, but development was better on the latter. All life-history stages were found at any given time of year.

The pyemotid mite *Pyemotes ventricosus* (Newport) (as *Pediculoides ventricosus*) has been reported to be a parasitoid of this ptinid species.

Mezium affine Boieldieu
(shiny spider beetle)
ptine luisant (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick.

Origin: This introduced species (Hatch 1962) is said to be almost cosmopolitan in distribution (Brown 1940*a*). The species has been known in the United States since 1904 (Brown 1944).

Economic injury: This insect is known to occur in basements and cereal warehouses, and at times it may become very abundant (Gibson and Twinn 1939). It has been reported in grain debris in Quebec (MacNay 1948), in a clothing store in Saskatchewan, and in fish meal in Manitoba (CIPR 1956). According to Hinton (1941), *M. affine* has been found in seeds and in various kinds of decaying animal and vegetable refuse.

Biology: *Mezium affine* requires high temperature and moderate relative humidity. According to Howe (1965), 22°C and 30% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 29–33°C, and the maximum rate of increase every 4 weeks is 2.5-fold.

Mezium americanum (Laporte)
American spider beetle

Comments: Several records have reported *M. americanum* to occur in Canada. However, according to Brown (1944), all specimens of *M. americanum* recorded from Canada should be referred to *M. affine*. The distribution of *M. americanum* is more southern in North America.

Niptus hololeucus (Falderman)
golden spider beetle
niptus doré (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Origin: Schwartz (1896) described this species as a native of Asia Minor. Although absent in the tropics, *N. hololeucus* is said to be nearly cosmopolitan in distribution (Brown 1959). The first North American record of this species appears to be a specimen reported by Gibson (1924) from Halifax, N.S., in 1899.

Economic injury: Follwell (1952) found the golden spider beetle in several warehouses in Vancouver, B.C. Brown (1940*a*) described the species as an occasional pest of households and warehouses in Canada and pointed out that it breeds in a variety of stored products. MacNay (1955) reported a heavy infestation of the beetle in a church in Prince Edward Island, where it was apparently breeding in dry pigeon manure. In Europe this species is said to be a general feeder known to attack household provisions, spices, woolens, and artificial silk (Gibson and Twinn 1939).

Biology: Howe and Burges (1953) studied the biology of *N. hololeucus* under controlled conditions of temperature, humidity, and diet. Adults required food and free water to lay a maximum number of eggs over a period of several months. At 25°C and 70% RH, the mean period of longevity of males and females was 11.4 and 16.3 weeks, respectively. Egg production reached a peak a few days after the onset of oviposition, and frequent matings are probably necessary for maximum egg production. At 25°C the number of eggs laid by individual females ranged from 2 to 151. A single female maintained at 20°C deposited 223 eggs, suggesting that this may be a more favorable temperature for oviposition. The adults were active in dim light and normally laid eggs in the food material. The mean incubation period at 20°C and 70% RH was 15.3 days.

The larvae normally had three instars, but additional instars may occur under unfavorable conditions of humidity or diet. The mean duration of the normal three instars was 22.9, 24.9, and 63.2 days, respectively, at 20°C and 70% RH. Mature larvae spin a weak silken cocoon in which they pupate. The mean duration of the pupal stage under the same conditions was 14.9 days. The preemergence-adult stage was the time that the teneral adults required for cuticular hardening and attainment of sexual maturity.

According to Howe (1965), *N. hololeucus* thrives at moderate temperature and needs a high relative humidity. The minimum temperature and RH at which the species can multiply in numbers sufficient to become a pest is 10°C and 50% RH. The optimum temperature range is 19–23°C, and the maximum rate of increase every 4 weeks is twofold. A temperature of 25°C was near the maximum for development of *N. hololeucus*, the optimum probably being slightly above 20°C. Development was more rapid at 25°C, but mortality of all stages was significantly higher than at 20°C. The golden spider beetle developed on a wide variety of foodstuffs of both animal and plant origin. The species may have one or two annual generations, and all life-history stages may be found at any time of year in storage places.

Parasites of *N. hololeucus* include the bethylids *Cephalonomia nigricornis* Sarra and *C. gallicola* (Ashmead) (as *quadridentata* Duchaussoy) and the gregarine *Gregarina latifolia* Braune.

Pseudeurostus hilleri (Reitter) (*alienus* Brown)

Distribution: British Columbia, Alberta, Ontario, Quebec, and New Brunswick.

Origin: According to Brown (1959), this species was originally described from Japan. It was first taken in Canada in 1936, and by 1940 it had been collected in warehouses in four provinces.

Economic injury: This species is found in granaries and warehouses (Hinton 1941). All specimens reported by Brown (1940*a*) were collected in warehouses where cereals were stored.

Biology: The life history of *P. hilleri* was studied by Howe and Burges (1953) under controlled conditions. Adult males and females lived an average of 16.0 and 18.7 weeks, respectively. Eggs were laid throughout the life of the female, with frequent copulations, available food, and free water required for maximum egg output. The mean number of eggs laid per female was 15.3 (range, 1–33). The incubation period at 25°C and 70% RH was 8.3 days. At 20°C and RH between 90 and 30%, the mean incubation period ranged from 9.9 to 16.4 days, respectively. At the lowest humidity, only 30% of the eggs hatched. The duration of the three larval instars was 8.0, 7.7, and 17.8 days, respectively, at 25°C and 70% RH. At maturity the larvae spin cocoons in which they pupate. The mean pupal period at 25°C and 70% RH was 6.8 days.

The maximum temperature for development of *P. hilleri* was between 25 and 30°C, but the maximum rate of development occurred between 23 and 25°C. The shortest mean development from egg deposition to adult emergence from the cocoon was 53 days at 25°C. The rate of development and adult weight were significantly greater at 70% RH than at 50% RH. All life history stages of this species occurred throughout the year in storage places.

According to Howe (1965), 15°C and 50% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 19–21°C, and the maximum rate of increase every 4 weeks is 2.5-fold.

Ptinus bicinctus Sturm

Distribution: British Columbia, Alberta, Ontario, Quebec, New Brunswick, and Nova Scotia.

Origin: Although widely distributed in Europe and northern Africa, this introduced species is rarely reported in North America (Brown 1940*a*).

Economic injury: *Ptinus bicinctus* has been taken in old wooden barns, granaries, warehouses, and dwellings (Hinton 1941). In Canada this spider beetle was found infesting poultry food in Quebec (CIPR 1965) and was taken, with *P. fur*, when infesting flour in a warehouse in British Columbia (Follwell 1952).

Ptinus clavipes Panzer (*brunneus* Duftschmid, *hirtellus* Sturm)
brown spider beetle
ptine brun (m.)

Distribution: British Columbia, Ontario, Quebec, and Nova Scotia.

Origin: This cosmopolitan species is rarely taken in Canada (Brown 1940*a*).

Economic injury: The brown spider beetle is mainly a scavenger. It has been reported to damage books, feathers, skins, dried mushrooms, drugs, and roots. It has been found in stored cacao, sugar, and dried fruit and in granaries throughout its range (Hinton 1941). In Canada it has been recorded in warehouses (Brown 1940*a*), but not as a household pest (Gibson and Twinn 1939).

Biology: According to Moore (1957), *P. clavipes* has a parthenogenetic form, which he named *P. mobilis*. Hatch (1962), citing Follwell (1952), gave evidence that this form may be present in British Columbia. The morphologically distinct form possesses 27 chromosomes in contrast to the 18 chromosomes of the bisexual *P. clavipes*. The triploid females must, however, mate with the diploid males to produce viable eggs. The sperm of *P. clavipes* serves to activate the eggs of *P. mobilis* but does not contribute any chromosomes.

Ptinus clavipes thrives at moderate temperature and needs a high relative humidity. According to Howe (1965), 18°C and 50% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 20–27°C, and the maximum rate of increase every 4 weeks is slightly more than 50%.

Ptinus fur (Linnaeus) (*latro* Fabricius)
whitemarked spider beetle
ptine bigarré (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Origin: This species is widely distributed in the Palaearctic region (Brown 1940*a*). It was first reported in the United States in 1869, and losses were recorded in flour in Canada as early as 1893 (Gray 1942).

Economic injury: The whitemarked spider beetle occurs in dwellings and warehouses from coast to coast in Canada but appears to be most abundant in British Columbia (Brown 1940*a*). According to Follwell (1952), this species feeds on a variety of dried and decaying animal and vegetable material. It attacks foods such as flour, cornmeal, and bran (Gibson and Twinn 1939). In addition, Cotton and Good (1937) listed seeds, grain, pepper, cocoa, and sugar as foods consumed by this species. Spencer (1928*b*) reported it to be a serious pest of zoological collections. It has also been reported to feed on accumulations of grain dust in terminal elevators in British Columbia (MacNay 1958).

Biology: Howe and Burges (1952) studied the biology of *P. fur* at various temperatures, at 70% RH and on diets of fish meal and wheat feed. Females laid their eggs over a period of several months, requiring both food and water to lay the maximum number. The average number of eggs laid by individual females was 38.6 at 25°C. At 23 and 20°C the incubation periods were 16.5 and 19.7 days, respectively.

Larvae normally have three instars at 23°C, but occasionally some have an additional instar. At 23°C the mean duration of each of the three instars was 13.7, 16.4, and 32.1 days, respectively.

Mature larvae spin strong cocoons in which they pupate. At 20 and 23°C some individuals entered diapause as mature larvae in the cocoons. Diapausing third-instar larvae had a mean development time of 235.2 days. Diapause did not occur at 30°C. At 23°C and when the insects were on various diets, the mean duration of the pupal periods ranged from 16.0 to 17.1 days. Adults remained within their cocoons for a mean period of up to 47.8 days at 23°C, to allow the cuticle to harden and to attain sexual maturity. The duration of this period varied with diet and temperature. Adults lived for several months, and females lived longer than males.

The optimum temperature for development of *P. fur* was probably slightly above 23°C, and the maximum temperature for development was less than 30°C. Larvae developed faster on a wheat feed diet than on a fish meal diet, although fish meal produced heavier beetles.

Ptinus fur thrives at moderate temperature and requires a high RH. According to Howe (1965), 10°C and 50% RH constitute the minimum temperature at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 21–25°C. The maximum rate of increase every 4 weeks is twofold.

Hymenopterous parasites of *P. fur* include the bethylid *Cephalonomia gallicola* (Ashmead) (as *C. xambeui* Girard), the braconids *Hecabolus sulcatus* Curtis and *Spathius exarator* (Linnaeus), the pteromalid *Lariophagus distinguendus* (Förster), and *Cryptus ptinivorus* Rondani, possibly an ichneumonid of uncertain status.

Ptinus ocellus Brown (*tectus* Boieldieu)
Australian spider beetle
ptine ocellé (m.)

Distribution: British Columbia, Saskatchewan, Ontario, New Brunswick, Nova Scotia, and Newfoundland.

Origin: Known in Europe as *P. tectus*, this cosmopolitan pest is believed to be of Tasmanian origin (Brown 1940*a*). It has been known in Great Britain since 1901 and in continental Europe since 1916 (Hatch 1962). It was first collected in North America from fish meal at Victoria, B.C., in 1927 (Brown 1940*a*).

Economic injury: *Ptinus ocellus* is a serious and widespread pest in humid and temperate zones (Howe and Burges 1954). It is found in houses, warehouses, and stores, breeding in a variety of dried animal and vegetable material (Cotton and Good 1937). Follwell (1952) considered this species to be the most widespread and abundant ptinid in British Columbia. MacNay (1958) reported it to be fairly common in terminal grain elevators, mills, and warehouses in that province. The risk of infestation is highest in poultry-laying meal, fish meal, warehouse sweepings, and bran; moderate in whole wheat flour, ground oats, and ground barley; low in cornmeal and middlings; and lowest in patent flour (CIPR 1963). Monro (1969) also considered it to be common on cargo ships.

Biology: Howe and Burges (1954) made observations on the life history of *P. ocellus* (as *P. tectus*) under controlled conditions. Adult females oviposited throughout their lives. At 25 and 23°C and 70% RH the males lived 91 and 137 days and females 100 days and 140 days, respectively. The maximum female life span was 387 days at 13°C, and the shortest was 69 days at 30°C.

Egg laying started 2 days or more after adults emerged from the cocoon. The adults deposited eggs in the food supply when it was available, and if the commodities were bagged, eggs were laid through the meshes of the sacking into the food material. The maximum temperature for oviposition was probably a little above 30°C and the minimum, from warehouse observations, was probably below 5°C. At a relative humidity of 70% and temperatures ranging from 25 to 15°C, the mean production of eggs after 10 weeks ranged from 296 to 103, respectively. Available free water and food were required for maximum egg production. At temperatures ranging from 11 to 25°C and 70% RH the incubation period averaged from 24.5 to 7.9 days, respectively. Below a relative humidity of 50%, the incubation period lengthened.

The larvae usually underwent three instars, but a few had additional molts. At temperatures ranging from 11 to 25°C, the mean duration of the three instars was 35.7, 35.5, and 164.9 days at 11°C to 8.2, 9.7, and 26.0 days at 25°C, respectively. Mature larvae spin strong silken cocoons in which to pupate. The cocoons are usually located in cracks or crevices in the storage area. The duration of the pupal stage at the temperatures given above ranged from 34.0 to 9.8 days.

After transformation to the adult stage, the tenerals spent a preemergence period within the cocoons, the duration of which varied from 13.0 days at 15°C to 6.4 days at 25°C. The adults were negatively phototropic and mainly nocturnal.

The development rate was greatest between 23 and 27°C, with the maximum temperature for complete development at 28°C and the minimum between 5 and 10°C. The most rapid rate of development occurred between 70 and 90% RH, and the minimum RH necessary for complete development was 40%. According to Howe (1965), 10°C and

50% RH constitute the minimum temperature and RH at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is from 23 to 25°C, and the maximum rate of increase every 4 weeks is fourfold. The species can complete development in organic dust and in rodent fecal pellets. Both larvae and adults can overwinter in warehouses, and all stages are present throughout the year.

Ewer and Ewer (1942) have shown that *P. ocellus* is well adapted to a temperate climate with a high humidity. According to Follwell (1952), adults and larvae can survive for long periods of time if the humidity and moisture content of the food are high. Larval development can be completed on relatively small amounts of food.

Parasites of *P. ocellus* include the bethylid *Cephalonomia gallicola* (Ashmead) (as *quadridentata* Duchaussoy) and the pteromalid *Dimachus discolor* (Walker). Predatory laelaptid mites, *Hypoaspis* sp., have been reported from cultures of this ptinid.

Ptinus raptor Sturm
(eastern spider beetle)
ptine oriental (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Origin: Gibson and Twinn (1939) considered this species to be introduced into Canada, apparently from Europe. It was first taken in Canada at St. Peters, N.S., in 1930 (Brown 1940*a*).

Economic injury: Brown (1940*a*) described *P. raptor* as the most abundant spider beetle in the warehouses of New Brunswick and Nova Scotia. It has been reported to infest flour in warehouses in British Columbia (Follwell 1952), Manitoba (CIPR 1961), Nova Scotia, and Saskatchewan (MacNay 1960). It has spoiled wheat meal (MacNay 1955) and has occurred in Quebec (MacNay 1953). This species is said to be responsible for most of the spider beetle infestations in Ontario (MacNay 1949). The first provincial record of *P. raptor* in Saskatchewan was found infesting a rolled oats mill (CIPR 1957).

Biology: In appearance and habits, this species closely resembles the hairy spider beetle, *P. villiger* (Gibson and Twinn 1939). Like other ptinids, the species can exhibit activity at lower temperatures than can most other insects. It has been reported to crawl on the ground when the soil surface temperature was near 0°C (Gray 1942).

Ptinus villiger (Reitter)
hairy spider beetle
ptine velu (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Origin: This introduced species is known from eastern Europe and Asia in the Palaearctic region (Brown 1940*a*). *Ptinus villiger* was first noted in Canada at Rosebank, Man., in 1915 (Gray 1933) and was first reported in British Columbia in 1933 (Follwell 1952).

Economic injury: According to Brown (1940*a*), the hairy spider beetle occurs commonly in warehouses from coast to coast in Canada. It is also found in dwellings and granaries (Cotton and Good 1937). The losses to cereal products far exceed those caused by any other spider beetle (Gray 1942). It infests mill products such as flour (patent, whole wheat, graham, and rye), cornmeal, rolled oats, oatmeal, and farina, as well as feeds such as bran, shorts, and various meal preparations. In flour the damage results from the accumulation of silk and granular material during heavy infestation, although this can be removed by sifting without any noticeable reduction in flour quality. However, salvaging by rebolting increases production costs and is only practical with patent flours. The particle size of the other mill products makes removal of insect material impossible by mechanical means. The infested stock must then be sold as feed at greatly reduced prices (Gray 1933). *Ptinus villiger* is also known to feed on stored grain near the surface. The adults and larvae chew irregular holes in the endosperm of the kernel. Three or four larvae often cement several kernels together to form a cluster, where they feed and develop (Watters 1976). This beetle feeds on wheat and to a lesser extent on rye, but it causes little damage to barley and oats (Gray 1933).

Biology: Gray (1933) outlined the life history of *P. villiger* in flour sheds in the Prairie Provinces. The adults were observed in flour sheds during the first warm days in late April. All mating occurred in the spring at temperatures ranging from 16 to 22°C. Oviposition occurred in flour debris in cracks and corners, on the outside of bags, and through the mesh of sacks. Females deposited as many as 7 eggs in a 24-h period for a total of 40 eggs. In the laboratory, at temperatures varying from 22 to 28°C, the minimum incubation period for the eggs ranged from 10 to 5 days, respectively. Fifty percent of the eggs had hatched in 9–13 days, respectively.

At 30°C larval development required approximately 3 months. At maturity the larvae ate their way through the bags and pupated in debris on the floor or burrowed into the wood of the shed. The larvae secreted a silky substance to form the pupal cell, the outside of which was covered with particles. When pupation occurred in the wood, only a small silky cap was apparent on the surface. Many of the mature larvae overwintered in the pupal cell and pupated the following spring.

Adult longevity was quite variable. A few of the adults that emerged in the fall survived the winter under outside conditions, but the life span of adults at higher temperatures was not particularly long.

A hymenopteran, *Pteromalus* sp., parasitizes *P. villiger*. However, the presence of the parasite is usually an indication of a long-standing infestation by this pest rather than a significant degree of control (Gray 1934*b*).

Sphaericus gibboides (Boieldieu)

Distribution: British Columbia.

Origin: This introduced species (Hatch 1962) is distributed in the Old World in southern Europe and northern Africa (Hinton 1941).

Economic injury: Hatch (1962) reported that this species infested saffron, cayenne pepper, curry powder, and fish meal in Vancouver in 1938. It has also been reported as a herbarium pest outside of Canada (Hinton 1941).

Trigonogenius globulus Solier (*farctus* LeConte)
globular spider beetle
ptine globuleux (m.)

Distribution: British Columbia and Alberta.

Origin: In North America, *T. globulus* is largely confined to the Pacific region (Brown 1940*a*); however, it is also known from Chile, Colombia, Great Britain, West Germany, and Australia (Tasmania) (Cotton and Good 1937). Hatch (1962) suggested that this may be a South American species dispersed by commerce. Schwartz (1896) reported an infestation of the species under the name *T. farctus* in Victoria, B.C., which appears to be the earliest record of it in Canada.

Economic injury: This species has been reported in warehouses and dwellings in British Columbia (Follwell 1952) and may occur in large numbers in the former (Brown 1940*a*). This relatively rare species has been found to infest pepper, hellebore, and cereal products (Gibson and Twinn 1939). In addition, Hinton (1941) listed the globular spider beetle in granaries and in cotton, flour, and corn mills. He also found it feeding on argol, vegetable ivory, caraway seed, and dried pear.

Biology: Howe and Burges (1953) made observations on the biology of *T. globulus* under controlled conditions. Adults are active in dim light and normally lay eggs in the food supply. The mean longevity of males and females was 33.7 and 36.7 weeks, respectively, at 25°C and 70% RH. Oviposition occurred throughout adult life, and the mean number of eggs deposited was 161 (range, 22–417). The incubation period at 25 and 20°C was 13.0 and 17.1 days, respectively, at 70% RH.

The larvae normally had three instars, but occasionally there were one to four additional instars. Such additional instars are generally considered a function of unfavorable conditions of food and humidity. At 23°C, the mean duration of the three instar stages was 20.6, 21.3, and 39.3 days at 50% RH and 16.9, 25.3, and 40.3 days at 70% RH, respectively. Mature larvae spin weak silken cocoons in which to pupate. At 23°C and 50 and 70% RH the mean pupal period was 12.9 and 11.6 days, respectively. Teneral adults remained within the cocoons for a period of cuticular hardening and sexual maturation. At 50 and 70% RH, the mean duration of these periods was 4.0 and 2.7 days at 23°C, respectively.

The shortest mean development period in the cocoon, from egg deposition to adult emergence, was 74 days at 25°C. The maximum temperature for complete development was between 25 and 30°C, with the optimum near 25°C. Development was significantly faster at 25°C than at 20°C. According to Howe (1965), 18°C and 50% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 22–24°C. The maximum rate of increase every 4 weeks is 2.5-fold. It was also faster and adult weights were greater at 70% RH than at 50% RH. The species developed on a wide range of foodstuffs, and all development stages were found throughout the year.

SCARABAEIDAE scarabs
hannetons (m.)
scarabées (m.)

Species of this large family are found in a wide variety of habitats in all faunal areas of the world. Many species feed on dung and carrion, and adults often provide the larvae with food. Many economically important species are phytophagous, with the larvae living in the soil and feeding on roots and the adults feeding on leaves, flowers, and fruit. Larvae of other species live in dead logs. This family contains about 26 000 species of which 220 are estimated to occur in Canada. The family is frequently divided into a number of smaller families by many modern authors (Lawrence 1982).

Aphodius granarius (Linnaeus)

Distribution: British Columbia, Alberta, Ontario, Quebec, New Brunswick, and Nova Scotia.

Origin: According to Ritcher (1966), this is an introduced species that is now widespread in Canada and the United States. Hatch (1971) described *A. granarius* as originating in the Palaearctic region.

Economic injury: The larvae occur in soil where they feed on the roots of grasses (Ritcher 1966). Sears (1978) reported that larvae damaged annual and Kentucky blue grass on golf course fairways in Toronto, Ont. According to Ritcher (1966), the larvae were reported to feed on sprouting corn in Minnesota.

Biology: The adults of *A. granarius* occur abundantly on cow dung (Ritcher 1966). The species has two generations per year and is presumed to have a life cycle similar to *Ataenius spretulus* (Haldeman) (Sears 1978).

Aphodius hamatus Say

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, and Quebec.

Economic injury: The larvae of this species have been reported to injure grass roots in Nevada (Ritcher 1966).

Biology: The adults are found in cow dung and are sometimes attracted to oily spots on highways. The species often occurs at high altitudes in the west (Ritcher 1966).

Aphodius pardalis LeConte

Distribution: British Columbia.

Economic injury: The grubs of this species have been reported to damage bowling greens, golf greens (Downes 1927, 1928), and tennis lawns (CIPR 1931) in British Columbia. The larvae cut the sod evenly below the surface, causing it to turn brown in patches (Downes 1927, 1928).

Biology: According to Downes (1927), *A. pardalis* is a common species on the West Coast. The same author observed pupation in June, adult emergence in July, and a major adult flight in September and October.

Ataenius spretulus (Haldeman) (*cognatus* LeConte)
black turfgrass ataenius

Distribution: southern Ontario.

Economic injury: *Ataenius spretulus* has been reported to damage turf on golf greens and fairways in Minnesota (as *A. cognatus* LeConte) (Hoffmann 1935), New York (Kawanishi et al. 1974), Ohio, Connecticut (Niemczyk and Dunbar 1976), and Ontario (Sears 1978). The larvae feed on turf roots, a practice which causes the turf to wilt and die in characteristic small irregular patches (Niemczyk and Dunbar 1976).

Biology: Niemczyk and Dunbar (1976) made observations on the biology of the species in Ohio and Connecticut. In both locations, the beetle completed two generations per year and overwintered as an adult. In Ohio, eggs were laid in clusters of 8–10, 2.5–5.0 cm beneath the turf. Eggs and early-instar larvae were observed in early June and again in early August. Adults were observed flying in early May; they were collected at lights and under turf in July and under turf in early September. These insects probably represented overwintered adults, first-generation adults, and second-generation adults, respectively. Pupation was observed in October. Larvae that had not completed their development by November did not survive the winter. According to observations made by Hoffmann (1935), apparently only one generation a year occurs in Minnesota. Hoffmann also observed the mature larvae excavating soil cells in which the quiescent prepupal and pupal stages occurred. He found that the duration of the pupal period was 8.7 days (range, 7–11).

Bothynus gibbosus (De Geer)
carrot beetle
scarabée de la carotte (m.)

Distribution: southern Ontario.

Economic injury: Hayes (1917) described and summarized the economic damage caused by this species in the United States. The adults of *B. gibbosus* are known to feed on ambrosia, carrot, celery, corn, cotton, dahlia, elm, oak, parsnip, potato, sugar beet, sunflower, and wheat. The adults have been reported to feed on the roots of celery and sunflower, burrowing into and destroying stalks of corn and feeding on the foliage of oak and elm. The larvae were observed feeding on the roots of corn, oats, and wheat. We have not seen any records of damage by this species in Canada.

Biology: Hayes (1917) described the life history of *B. gibbosus* in Kansas. Oviposition began at the end of May and continued until the end of June. The eggs were laid at the base of plants, in loose soil containing decaying organic material, to a depth of 12–15 cm. The average egg period was 10.9 days (range, 7–22).

The larval period averaged 52.1 days (range, 40–70). In soil cages, the incidence of larval cannibalism was high, accounting for the majority of the larval mortality. Before pupation, the mature larvae enlarged their soil burrows and entered a quiescent prepupal stage. The duration of the prepupal and pupal stage was 7.2 (range, 4–11) and 19.1 days (range, 11–29), respectively. Pupae were observed from the end of July to the end of October.

The adults appear above ground in the fall but return to the soil to hibernate at depths of 18–120 cm; they emerge during the first warm days of spring. During the day, the adults burrow into the soil or crawl under shelter. Mating takes place underground.

Three species of flesh flies, *Helicobia rapax* (Walker) (as *Sarcophaga helicis* Townsend), *Boettcheria cimbicis* (Townsend) (as *Sarcophaga ambicis*), and *Boettcheria rudis* (Aldrich) (as *Sarcophaga rudis*) were observed emerging from dead adults of *B. gibbosus*.

Cotalpa lanigera (Linnaeus)
(goldsmith beetle)
hanneton lanigère (m.)

Distribution: southern Ontario.

Economic injury: According to Saunders (1879*a*), the adults of this species feed on the foliage of pear, oak, hickory, poplar, sweet gum, and silver poplar. He also reported root destruction to strawberry patches caused by larval feeding. In addition, Davis (1916) described severe larval damage to raspberry bushes, corn, and grasses.

Biology: Saunders (1879*a*) briefly described the life history of *C. lanigera*. Eggs were laid singly during the latter part of June at various depths in the soil. The eggs hatched in less than a month, and the larvae required several years to reach maturity. Transformation to the adult occurred in the spring. Adults were short-lived, the female dying after oviposition. Adults remained inactive during the day and were found on the underside of the leaves of trees. At dusk the adults were observed flying among the leaves of the host plants.

Cyclocephala longula LeConte (*abrupta* Casey)

Distribution: British Columbia.

Economic injury: Larvae of this species have been reported to damage seriously alfalfa and grain in Oregon (Ritcher 1966).

Dichelonyx backi (Kirby)
green rose chafer (pine chafer beetle)
scarabée vert du rosier (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: In the Prairie Provinces, the green rose chafer is sufficiently abundant in some years to cause important injury to cultivated roses (Gibson 1934). It has also been reported to damage the foliage of raspberry and juneberry in British Columbia (CIPR 1941). MacNay (1951) noted that the species severely damaged raspberry buds in Saskatchewan. The species is apparently uncommon in eastern Canada (Gibson 1934).

Biology: According to reports cited by Hatch (1971), adults of *D. backi* have also been recorded from pine, Douglas fir, trembling aspen, and thimbleberry.

Diplotaxis brevicollis LeConte

Distribution: southern British Columbia.

Economic injury: The adults and larvae of this species have been reported to damage lawns on southern Vancouver Island, B.C. (CIPR 1941). They were also reported to be numerous in a cherry orchard where wheat and vetch were grown as a cover crop.

Diplotaxis tenebrosa Fall

Distribution: British Columbia.

Economic injury: Treherne (1921) reported that *D. tenebrosa* injured young apricot seedlings in British Columbia. MacNay and Creelman (1958) listed the species as a pest of apple in the same province.

Euphoria inda (Linnaeus)
bumble flower beetle
euphore (m.)

Distribution: British Columbia, Alberta, Manitoba, Ontario, and Quebec.

Economic injury: This beetle is abundant in June and September in some years and causes injury to roses and other flowering plants. The beetle eats the pollen and sucks the juices from buds and succulent stems (Gibson 1934). Lochhead (1900) reported considerable damage by this beetle, which ate holes in pear and tomato. In southern Ontario, *E. inda* has been reported to feed on ears of sweet corn and on ripe fruit, especially peach and pear (Ross and Caesar 1921). *Euphoria inda* has also been reported to injure apple (CIPR 1938) and corn in Manitoba (CIPR 1942) and Alberta (CIPR 1959). Only the adults are injurious; the larvae feed on manure and humus (Lochhead 1900).

Biology: This species has a 1-year life cycle and overwinters in the adult stage (Ritcher 1966). Eggs are laid in early May and the larvae mature in about 2 months (Lochhead 1900). In Wisconsin, Ritcher (1966) found that pupation occurred in early July at a depth of 5–12 cm in soil cells. The duration of the pupal stage is about 16 days (Lochhead 1900). Adults emerge and are in flight from late August to September (Ritcher 1966).

Geotrupes stercorarius (Linnaeus)
geotrupes des fumiers (m.)

Distribution: Quebec, New Brunswick, Prince Edward Island, and Newfoundland.

Origin: According to Howden (1955), *G. stercorarius* is an introduced species.

Economic injury: In Newfoundland, MacNay (1961) reported that this species caused damage by tunneling in hay and pasture fields. The species has also been recorded in potato soil in that province (CAIPR 1978).

Biology: Howden (1955) summarized the life history of *G. stercorarius*. The species has a 2-year life cycle. Oviposition occurs in spring and early summer, the incubation period lasting 14–16 days. The larvae grow rapidly until fall, when they overwinter as third-instar larvae. They resume feeding in the spring, pupate in July, and the adults emerge from the pupal cells in September. The adults overwinter and start ovipositing the following spring. The adults and larvae are dung feeders. The adults construct burrows, provisioning them with dung to form larval cells.

Hoplia callipyge LeConte

Distribution: British Columbia.

Economic injury: Hardy (1977) stated that the adults of this species do not have a preferred host. The list of plants that the adults have been collected on include the following cultivated species: *Alyssum maritimum* (= *Lobularia maritima*), azalea blossom, Australian holly, barley, blackberry, yellow mariposa, carrot, *Clarkia* sp., clover, grape, alfalfa, sweet-clover, rose, buckthorn, Spanish broom, strawberry, and sunflower. The same author also reported the larvae in lawns.

Hoplia sackenii LeConte

Distribution: British Columbia.

Economic injury: Like *H. callipyge*, this species does not seem to have a preferred host; it has been recorded in *Azalea* sp., barley, grassbrush, pear, pine, and *Ribes* sp. (Hardy 1977).

Hoplia trifasciata Say
scarabée trifascié (m.)

Distribution: Alberta, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: Hardy (1977) reported the species from honeysuckle, cherry blossoms, pear blossoms, willow flowers, apple blossoms, shadbush flowers, *Amelanchier* sp., arrowwood, white pine, and oak. The species has been reported to feed in large numbers on apple blossoms in Nova Scotia (CIPR 1931) and on the blossoms of tulip and daffodil in a nursery in Ontario (CIPR 1958).

Macrodactylus subspinosus (Fabricius)
rose chafer (rose beetle)
scarabée du rosier (m.)

Distribution: southern Ontario and southwestern Quebec.

Economic injury: The rose chafer is a minor pest of apple and pear orchards, where the adults feed on the leaves and gouge the small fruit (Goble 1963). The species is also occasionally injurious to stone fruit, especially peach, where it feeds on the blossoms, makes holes in the fruit, and skeletonizes the leaves (Dustan and Davidson 1973). Chamberlain and Putnam (1964) stated that the adults may severely damage raspberry plants in June and early July. This beetle also feeds on the blossoms and newly set fruit of grape, and when abundant may completely destroy the crop (Ross and Hall 1939). According to Fox and Stirrett (1952), *M. subspinosus* is occasionally injurious to tobacco in years of high population. Fletcher (1905*a*) described an infestation of these beetles in a corn field, where they devoured the leaves of young plants. The species also attacks blossoms of rose, peony, and other ornamentals (Ross and Hall 1939). MacNay (1955, 1956) and the CIPR (1934, 1956) provided extensive lists of additional plants attacked by this beetle including the following: African marigold, asparagus, basswood, cherry, Chinese chestnut, Chinese elm, *Coreopsis* sp., *Deutzia* sp., elderberry, German iris, honeysuckle, *Hydrangea* sp., Iceland poppy, Lombardy poplar, maple, mountain ash, ninebark, pansy, Siberian dogwood, *Spiraea* sp., sycamore, walnut, *Weigela* sp., willow, and *Zinnia* sp. The bodies of rose chafers are toxic to small animals such as young fowl and have been reported, occasionally, to kill large numbers of chickens (Ross and Hall 1939). The same authors stated that the larvae of *M. subspinosus* feed on the roots of grasses, grains, and weeds.

Biology: Ross and Hall (1939) described the life history and ecology of this species. The rose chafer breeds only in light sandy soil in neglected or poorly cultivated grasslands, orchards, vineyards, and small-fruit plantations.

The species overwinters in the form of nearly mature larvae in the soil at depths of 15–45 cm. In spring the larvae resume feeding near the soil surface. Pupation starts in late May and requires approximately 3 weeks for adult transformation. Adults begin to emerge from the soil in June. Although emergence may continue for 1 month, the majority emerge within the first 2 weeks.

Mating occurs soon after adult emergence, and oviposition starts 5 or 6 days later. The female burrows 7–15 cm into sandy soil to deposit her eggs. Adults are abundant for only 3 weeks and die off shortly thereafter. The eggs hatch in about 2.5 weeks, and the newly hatched larvae begin feeding on roots of grasses and weeds.

Onthophagus hecate (Panzer)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: According to MacNay (1951), potatoes were apparently damaged by this species in Manitoba.

Biology: Adults of *O. hecate* have been found in carrion and under many types of dung, rotting fungi, and fruit (Howden and Cartwright 1963). In Kentucky, according to Ritcher (1966), adults dig tunnels under dung to a depth of 5–22 cm, the lower end of which is packed with a wad of dung. The egg is laid in the dung pellet, and the larva, when mature, pupates in an elliptical cell within the pellet.

Osmoderma eremicola (Knoch)
(smooth osmoderma, hermit flower beetle)
osmoderme ermite (m.)

Distribution: Alberta, Manitoba, Ontario, and Quebec.

Economic injury: According to Hoffmann (1939), the larvae of this species occur in the decaying wood of fruit and forest trees, where they consume the wood and induce more rapid decay. They have been recorded from the decaying wood of beech, hickory, elm, apple, cherry, oak, maple, and cottonwood. The adults feed on the sap exuded from the bark of apple and cherry trees and have been observed feeding on ripe apples.

Biology: Hoffmann (1939) summarized the literature and made observations on the biology of *O. eremicola*. Eggs were laid in the wetter portions of decaying wood and hatched in 7–16 days. Based on five females, the average preoviposition period was 26 days (range, 21–33), the average oviposition period was 24.6 days (range, 5–53), and the number of eggs laid was 38.8 (range, 31–74). Female and male longevity was 58 (range, 31–74) and 38.4 days (range, 25–48), respectively. The prepupal and pupal stages occurred in oblong cocoons constructed from decaying wood particles. In the laboratory, the prepupal stage for nine individuals and the pupal stage for four individuals averaged 8.1 (range, 6–12) and 18.3 days (range, 16–23), respectively. It is assumed that the life cycle in Minnesota would require 3 years to complete. Ritcher (1966) stated that the winter is spent in the mature larval stage and that pupation occurs in the spring.

The tachinid fly *Zelia vertebrata* (Say) has been reported to be a parasite of this species (Stevenson 1902).

Osmoderma scabra (Beauvois)
(rough osmoderma, rough flower beetle)
osmoderme rugueux (m.)

Distribution: Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: According to Hoffmann (1939), like *O. eremicola*, the larvae of *O. scabra* occur in fruit and forest trees, where they eat decaying wood and escalate decay. The species has been recorded in the decaying wood of apple, cherry, beech, sweet gum, hickory, poplar, willow, sycamore, sassafras, maple, oak, chestnut, and birch. The adults feed on the juices of injured apple and cherry trees and have been observed feeding on ripe apples. Adults have also been found on the foliage of apple, oak, and other fruit and forest trees.

Biology: Hoffmann (1939) summarized the literature and made observations on the biology of *O. scabra*. He stated that the species probably has a 3-year life cycle in Minnesota. The prepupal stage lasted approximately 7 days, and the pupal stage of five individuals lasted 16 days (range, 15–18). Both stages occur within an oblong or egg-shaped cocoon constructed from bits of decaying wood cemented together. From prepupae collected in early May, adults were obtained in late May. The nocturnal adults are active in the months of June, July, and August.

Pelidnota punctata (Linnaeus)
(spotted pelidnota, grape vine beetle, spotted grape beetle)

Distribution: Manitoba, Ontario, and Quebec.

Economic injury: The adults of *P. punctata* attack the foliage of grape vines, chewing numerous holes in the leaves. However, the beetles are seldom abundant, and extensive damage is rare (Saunders 1874). In CIPR (1958), the adults were reported to be abundant on Virginia creeper. The larvae feed on rotten wood in decaying stumps and logs and are not injurious (Bethune 1911).

Biology: Eggs are laid in decaying stumps and on exposed roots of various trees (Saunders 1874). Larvae have been recorded from the decaying wood of maple, oak, hackberry, apple, elm, sycamore, and walnut. The larvae were found to feed occasionally in the centre of old stumps, but most were found in tunnels in the large lateral roots 15–20 cm beneath the soil surface (Ritcher 1966).

Pupation occurs in a cocoon fabricated from excrement and decaying wood; this stage lasted 8–10 days (Saunders 1874). The same author noted that in Ontario, adults occur on grape vines in July, August, and September and that the life cycle may require 3 years. In Kentucky the species overwinters in the larval stage and has a 2-year life cycle (Ritcher 1966).

Phobetus comatus LeConte
(hairy June beetle)

Distribution: British Columbia.

Economic injury: Hatch (1971) cited a report stating that the larvae of this species damaged alfalfa in Oregon.

Biology: Cazier (1937) reported the larvae from the roots of *Artemisia californica* in California.

Phyllophaga anxia (LeConte) (*dubia* Smith)
(common June beetle)
hanneton commun (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Labrador, and Northwest Territories.

Economic injury: Hammond (1948*b*) considered *P. anxia* to be the most common and injurious species of *Phyllophaga* in Canada and described the feeding habits and food plants of both adults and larvae. The adults prefer the tender developing foliage of a variety of plants, but they may also consume fully developed leaves. Adults typically feed on the edges of leaves, biting through the lateral ribs and midribs and occasionally biting through the petioles, causing the leaves to drop. During a major flight, the adults completely defoliate hundreds of large trees and partly defoliate thousands of smaller trees and shrubs. Preferred host plants of the adults include: apple, aspen, butternut, elm, large-toothed poplar, lilac, oak, raspberry, rose, and white ash. Secondary hosts include alder, basswood, birch, cherry, chokecherry, dogwood, elderberry, hawthorne, juneberry, mountain ash, pear, snowball, walnut, and willow. Plants seldom fed upon include: balsam poplar, beech, evergreens, horse chestnut, maple, rock elm, slippery elm, and sumac.

The larvae feed underground on a wider variety of plants than do the adults. Damage by the nearly omnivorous grubs is limited only by the size and toughness of the roots. Little damage is done either by the first-year larvae, because of their small size, or by third-year larvae, because of their relatively lower numbers and reduced feeding activity. However, second-year larvae cause serious damage from May to late September or early October to roots, underground stems, and tubers. These larvae cause excessive damage to fibrous-rooted plants by feeding gregariously on a horizontal plane about 5 cm below the soil surface. They shear off the roots at this depth, killing the plant but not consuming the entire underground parts. On fleshy roots and tubers, they do not kill the plant but produce surface lesions or deep excavations in the root tissue. The larvae cause damage to young evergreens and fruit trees by feeding on the fibrous roots and removing the bark from the larger roots. In eastern Ontario, Twinn (1933) reported that timothy, corn, and potato were the principal crops attacked. In Quebec, Maheux (1929) noted that the following plants were damaged: oats, potato, strawberry, grasses, garden seedlings, coniferous and deciduous seedlings, and ornamentals. In British Columbia, Alberta, and Saskatchewan, MacNay (1949, 1950) reported severe larval damage to potato and strawberry.

Biology: Hammond (1948*b*) outlined the biology of *P. anxia* in Ontario and Quebec, where the species has a 3-year life cycle. The adults begin emerging from their overwintering sites in the soil during the second week in May and reach their maximum abundance in early June. Oviposition begins in late May and eggs are laid in grassy situations. The incubation period lasts about 30 days. The newly emerged first-instar larvae feed on the roots of the surrounding vegetation and in 6–8 weeks molt into second-instar larvae. These larvae feed for a short period and then burrow down into the soil to overwinter.

The following spring they return to within 5–7.5 cm of the soil surface, where they actively feed until late July. At this time, the second molt occurs, producing the third-instar larva. Grubs in this stage feed for a short time and then burrow to depths of up to 90 cm to spend the second winter.

The grubs are relatively inactive during the third spring. They do little feeding and begin pupating about the middle of July. The beetles transform in late summer but remain inactive in the soil until the following spring. Lim et al. (1979) found that the adults required approximately 176 degree-days accumulated above a base of 5°C for flying to begin.

The development rhythm of *P. anxia* in any one area is partly synchronized, with the same stage occurring in the same season. The year adults emerge from the soil is known as the flight year. At this time the adults emerge in large numbers and cause severe damage by defoliating trees and shrubs. The following year is known as the outbreak year; second-instar larvae are abundant at this time, causing severe losses to cultivated crops and pastures. This development sequence for all *Phyllophaga* in one area is constant and is referred to as a brood. Three broods of *P. anxia* occur in different areas of eastern Canada, with each brood having a different outbreak year.

Light soils that are well drained, such as those that occur in rolling topography, are particularly suited to this species. Populations in middle or upper slopes are greater than those in lowlands, which have poorly drained heavier soils.

Graham (1965) listed the parasites, predators, and pathogens recorded for this species. Rivers et al. (1979) reported the tiphiid wasp *Tiphia berbereti* Allen to be an additional parasite of *P. anxia*.

Phyllophaga balia (Say)

Distribution: southwestern Ontario.

Economic injury: Luginbill and Painter (1953) listed beech, birch, elm, laurel, maple, rose, walnut, willow, and witch hazel as host plant families of the adults of *P. balia*.

Phyllophaga crenulata (Froelich)

Distribution: Ontario.

Economic injury: Host plant families of adults of *P. crenulata* include: barberry, basswood, beech, birch, bignonia, buckeye, cyrilla, dogwood, ebony, elm, grasses, honeysuckle, laurel, lily, loosestrife, mallow, maple, mulberry, pine, planetree, pulses, rose, saxifrage, sumac, tupelo, vines, walnut, willow, and witch hazel (Luginbill and Painter 1953). The same authors consider the larvae injurious to sod land and crop plants.

Phyllophaga drakii (Kirby)
hanneton de Drake (m.)

Distribution: Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: Although widely distributed in eastern Canada, the species is seldom abundant enough to be of economic importance (Hammond 1940). Luginbill and Painter (1953) described *P. drakii* as a common species in some areas of its range, with the grubs being destructive to crops. They also listed the host plant families of the adults, which include basswood, beech, birch, calycanthus, dogwood, elm, honeysuckle, maple, pulses, rose, tupelo, willow, and witch hazel.

Biology: According to Criddle (1918), *P. drakii* has a 4-year life cycle in Manitoba. On 15 July, pupae were abundant and were observed in the field as late as 15 September. Adults were first observed in early August, although the majority did not develop until late in the month. Adults of this species overwinter in the pupal chamber and rarely burrow down deeper in the soil. Adults reached their flight peak the following spring, when oak trees were leafing out. Newly laid eggs were discovered on 23 June, and larvae hatched from 11 July to 5 September. Larvae overwintered in the soil at an average depth of about 1 m.

The species inhabits sandy soils in the vicinity of open woods, where larvae are found among the roots of low bushes in low valleys.

Phyllophaga ephilida (Say)

Distribution: Unknown.

Economic injury: Luginbill and Painter (1953) listed the host plant families of the adult as basswood, beech, bignonia, birch, dogwood, ebony, elm, grasses, honeysuckle, mallow, mulberry, olive, pine, planetree, pulses, rose, saxifrage, sumac, tupelo, vines, walnut, and willow.

Comments: Luginbill and Painter (1953) reported *P. ephilida* from Canada, but stated that the exact location was unknown. We have not seen any specimens of this species from Canada.

Phyllophaga errans (LeConte)

Distribution: southwestern British Columbia.

Economic injury: Banham and Arrand (1978) considered the larvae of this species to be of economic importance in vegetable-growing areas of British Columbia. Luginbill and Painter (1953) described *P. errans* as uncommon in Washington, Oregon, and California.

Phyllophaga fervida (Fabricius) (*quercina* Knoch) (common cockchafer)

Distribution: southern Ontario.

Economic injury: Saunders (1872) considered this species to be very destructive in both the adult and larval stages. Adults caused serious damage to leaves of cherry, oak, Lombardy poplar, and many other trees; and larvae fed on the roots of strawberry, potato, corn, other vegetables, and grasses. Gott (1877) described larval damage to the roots of young spruce, hemlock, and fir trees in a nursery. The larvae gnawed off the fibrous roots and removed the bark from the woody roots. According to Luginbill and Painter (1953), the grubs damage cereal and forage crops. Host plant families of the adults listed by the same authors include beech, dogwood, ebony, elm, grasses, honeysuckle, logania, maple, olive, pine, pulses, rose, tupelo, vines, walnut, willow, and witch hazel.

Biology: Saunders (1872) described the life history of the species. Males die soon after copulation, and females burrow 15 cm or more into the soil, deposit 50–100 eggs, and die soon thereafter. The larvae feed on roots near the soil surface until the fall, when they burrow down into the soil to overwinter. After three summers, the larvae cease feeding and pupate in oval cells up to 60 cm deep in the soil. Transformation to the adult stage may occur in the fall but usually takes place the following spring. The nocturnal adult is sluggish during the day and seeks shelter under boards and logs (Geddes 1874).

Phyllophaga fraterna Harris

Distribution: Ontario.

Economic injury: The species is common in some localities in its range, the adults feeding on the following plant families: beech, birch, ebony, elm, grasses, heath, honeysuckle, logania, mallow, maple, olive, pine, planetree, pulses, rose, tupelo, walnut, willow, and witch hazel (Luginbill and Painter 1953).

Phyllophaga fusca (Froelich)
(northern June beetle)
hanneton du nord (m.)

Distribution: British Columbia, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Economic injury: In southwestern Ontario, *P. fusca* is sufficiently abundant to be a serious agricultural pest (Hammond 1940). In eastern Ontario, MacNay (1957*b*) considered it to be the most abundant species of *Phyllophaga* and reported larval damage to sod and turf. MacNay (1951) also reported damage to pasture land, lawns, golf courses, potato, turnip, wheat, spring grain, strawberry, and garden crops in Ontario. The adults have been reported to defoliate forest, shade, and fruit trees (MacNay 1946). In British Columbia, Banham and Arrand (1978) listed *P. fusca* as one of the pest species occurring in the vegetable growing areas of the province. In Quebec, the species has been reported to damage red pine seedlings (CIPR 1964). Luginbill and Painter (1953) listed the host plant families of the adults, which include basswood, beech, birch, buckeye, calycanthus, composite, dogwood, elm, heath, honeysuckle, laurel, logania, maple, oleaster, olive, pulses, rose, tupelo, walnut, willow, and witch hazel.

Biology: As with *P. anxia*, the larvae of this species occur abundantly on well-drained slopes composed of lighter soil types with a pH between 5.25 and 6.25. Poorly drained bottom lands seldom contain large populations of white grubs (Hammond 1948*a*). The same author stated that this species has a 3-year life cycle in Ontario.

Parasites of this species include the tiphiid wasp *Tiphia inornata* Say (Brittain 1912) and the pyrogotid fly, *Sphecomyiella valida* (Harris) (CIPR 1942).

Phyllophaga futilis (LeConte) (*gibbosa* Burmeister)
(lesser June beetle)
petit hanneton (m.)

Distribution: Ontario, Quebec, and New Brunswick.

Economic injury: According to Hammond (1940), *P. futilis* is sufficiently abundant in southwestern Ontario to be a serious agricultural problem. The larvae have been responsible for turf and sod damage (MacNay 1957*b*) and the adults have defoliated forest, shade, and fruit trees (MacNay 1946). This was one of the five species of *Phyllophaga* in an infestation in the Guelph area, which caused severe damage to pasture, grain crops, and corn; it also caused significant losses to root crops, garden vegetables, flowering plants, and lawns (Hammond 1945). Luginbill and Painter (1953) listed the host plant families of adults, which included basswood, beech, birch, buckeye, buttercup, composite, dogwood, ebony, elm, grasses, honeysuckle, laurel, lily, logania, mallow, maple, mulberry, nettle, oleaster, olive, planetree, pulses, rose, St. John's-wort, saxifrage, walnut, willow, and witch hazel.

Biology: According to Hudson (1919*b*), this is about the earliest species to appear in large numbers, and it is very abundant until the middle of June. The species has a 3- or 4-year life cycle.

Phyllophaga gracilis (Burmeister)

Distribution: Ontario.

Economic injury: This is a fairly common species in some localities, the adults having been taken on the following host plant families: beech, bignonia, ebony, elm, grasses, honeysuckle, laurel, planetree, pulses, rose, tupelo, vines, walnut, willow, and witch hazel (Luginbill and Painter 1953).

Phyllophaga hirsuta (Knoch)

Distribution: Ontario.

Economic injury: Taken mostly in the southern United States, the adults of this species have been recorded from the following plant families: beech, calycanthus, dogwood, elm, grasses, heath, honeysuckle, maple, olive, pulses, rose, tupelo, vines, and walnut (Luginbill and Painter 1953).

Phyllophaga hirticula (Knoch)

Distribution: Ontario and Quebec.

Economic injury: Although common in some sections of the United States, where the grubs destroy sod land and farm crops, the species occurs sparingly in Ontario and Quebec (Luginbill and Painter 1953). The same authors listed the adult host families, which include basswood, beech, birch, ebony, elm, grasses, honeysuckle, laurel, logania, magnolia, maple, mulberry, nightshade, olive, pokeweed, pulses, rose, sumac, tupelo, walnut, willow, and witch hazel.

Phyllophaga ilicis (Knoch)

Distribution: Ontario.

Economic injury: This species is not common in open pastures, occurring more commonly in forested areas, where the adults have been reported from the following plant families: basswood, beech, calycanthus, dogwood, ebony, elm, heath, laurel, logania, magnolia, maple, mulberry, olive, planetree, pulses, rose, vines, walnut, willow, and witch hazel (Luginbill and Painter 1953). In Ontario, according to the same authors, the species has been taken in limited numbers and the adults have been recorded from the witch hazel family.

Biology: *Phyllophaga ilicis* prefers wooded areas where the soil is neutral or alkaline and the dominant tree species is *Quercus muehlenbergii* Engelm. (Horsfall 1929). According to the same author, pupation occurred at a depth of 30–35 cm, and adults overwintered in the pupal cells; adult emergence took place as the ice started to melt in the spring.

Phyllophaga inversa (Horn)
(southern June beetle)
hanneton méridional (m.)

Distribution: Ontario.

Economic injury: The larvae of this species damaged pasture and meadow sod in Ontario (CIPR 1941). They have also been reported to cause injury to corn, strawberry, and wheat (Beirne 1971). In a mixed infestation with four other *Phyllophaga* spp. in the Guelph area, larvae severely damaged pasture, grain crops, fodder, and grain corn, causing significant losses to root crops, garden vegetables, flowering plants, and lawns (Hammond 1945). The adults were reported to defoliate forest, shade, and fruit trees along the north shore of Lake Ontario (MacNay 1946). According to Luginbill and Painter (1953), the species is not abundant in Ontario. They also listed the adult host plant families throughout its range, which include the following: basswood, beech, birch, buckeye, dogwood, elm, honeysuckle, logania, pulses, rose, walnut, willow, and witch hazel.

Phyllophaga lanceolata (Say)
(wheat white grub)

Distribution: Manitoba and Ontario.

Economic injury: According to Luginbill and Painter (1953), the grubs of this species are injurious to field and garden crops in the United States. Rogers and Morrison (1978) indicated that *P. lanceolata* is a pest of native grasslands in the plains states; wheat in Kansas and Oklahoma; corn and soybeans in Iowa; and truck crops, cotton, and commercial sunflower in Texas. Travis (1939) stated that both the adults and larvae are known to attack cultivated plants. The same author reported that the adults are general feeders in Iowa, attacking a wide variety of plants. In the same state, grub damage to pasture occurred in the higher ground.

Biology: Reinhard (1940) described the life history and ecology of *P. lanceolata* in Texas, where the species has an annual life cycle. The adults, unlike those of most *Phyllophaga*, are diurnal. Males have normally developed wings, but females lack functional wings.

Eggs were laid within individual cells in clumps of soil 5–20 cm beneath the surface. The number of eggs laid per female ranged from 36 to 85. The preoviposition and incubation periods averaged 10 and 19.3 days, respectively. Larvae passed through three instars, the species overwintering in the last instar. The total larval period lasted 327.3 days, with pupation occurring the following season. The pupal period averaged 19 days for both sexes.

Travis (1939) found that sexually receptive females, crushed females, and the chemical isoamylamine strongly attracted the males of this species.

Phyllophaga longispina (Smith)

Distribution: Ontario and Quebec.

Economic injury: Adults have been reported from the following plant families: beech, dogwood, ebony, elm, heath, lily, maple, rose, walnut, and witch hazel (Luginbill and Painter 1953).

Phyllophaga marginalis (LeConte)

Distribution: Ontario and Quebec.

Economic injury: According to Luginbill and Painter (1953), this is an uncommon, probably woodland, species, the adults of which have been reported from the following host plant families: beech, elm, laurel, olive, pine, rose, walnut, and witch hazel.

Phyllophaga nitida (LeConte)

Distribution: Alberta, Manitoba, Ontario, and Quebec.

Economic injury: The adults of this uncommon species have been recorded from the following host plant families: birch, beech, dogwood, elm, rose, rue, walnut, willow, and witch hazel (Luginbill and Painter 1953).

Biology: In Manitoba this species has a 4-year life cycle and shows a preference for woodlands and dry soil conditions (Criddle 1918). The same author described the biology of *P. nitida*. The adults of this species appear later than do those of *P. anxia* and seldom leave the vicinity of the open groves in which they breed. The adults show a preference for aspen poplar and have been observed feeding on elm. Eggs were prevalent in early July and began hatching by the end of the month. In years that pupation occurred, pupae were numerous in the middle of July and the beginning of September. Adults overwintered below the pupal cell at an average depth of 15 cm.

Phyllophaga rugosa (Melsheimer)
(rugose June beetle)
hanneton rugueux (m.)

Distribution: Alberta, Manitoba, and Ontario.

Economic injury: This species is found primarily in southwestern Ontario, where the larvae are serious agricultural pests (Hammond 1940). In CIPR (1941), they were reported to cause severe damage to pasture and meadow sod, lawns, grain crops, and strawberry; they also caused minor injury to flowering plants, nursery stock, small ornamentals, and other shrubs. They have also been reported to cause severe damage to raspberry patches (CIPR 1935). According to Beirne (1971), the larvae of this species are the most abundant *Phyllophaga* in sandy soils in Ontario and the chief outbreak species in Manitoba. Host plant families of adults include the following: barberry, basswood, beech, birch, buckeye, composite, dogwood, ebony, elm, grasses, logania, mallow, maple, olive, planetree, pulses, rose, saxifrage, walnut, willow, and witch hazel (Luginbill and Painter 1953).

Biology: The life cycle of *P. rugosa* requires 3 or 4 years (Hudson 1919*b*). In Manitoba, Criddle (1918) described the 4-year life cycle of the species. Eggs were laid at depths of 2.5–17.5 cm and were abundant in the soil from the third week in June until August. Larvae hatched from mid July until September. After larval development, pupation occurred in mid July and adults developed by the middle of August. Adults migrated from the pupal cell deep into the soil, where they overwintered at an average depth of 72.5 cm.

This species inhabits sandy soils in open situations. The adults are general feeders and have been taken on apple, plum, cherry, thorn, rose, elm, maple, oak, and aspen poplar in Manitoba (Criddle 1918).

Phyllophaga tristis (Fabricius)
petit hanneton pileux (m.)

Distribution: British Columbia and Ontario.

Economic injury: MacNay and Creelman (1958) listed *P. tristis* as a pest of apple in British Columbia. Luginbill and Painter (1953) described it as common in the northern United States and considered the grubs to be injurious to crops. Adults feed on the following plant families: beech, birch, dogwood, ebony, elm, heath, honeysuckle, maple, olive, pine, planetree, pulses, rose, saxifrage, sumac, walnut, willow, and witch hazel.

Biology: In Texas, Reinhard (1941) described the life history of the species from laboratory observations. The species has a 1-year life cycle. Eggs were deposited separately in soil cells 5–15 cm below the surface and required an average of 27 days to hatch. The larvae fed for about 4 months, underwent two molts, and reached maturity by August. Pupation occurred within a tubular, smooth-walled cell prepared by the mature larvae, 7.5–20 cm beneath the soil surface. Pupae were present throughout September. Adults transformed in 22 or 23 days, overwintered in the pupal cells, and emerged the following spring.

Phyllophaga vilifrons (LeConte)

Distribution: Ontario.

Economic injury: According to Luginbill and Painter (1953), the adults of this uncommon species have been reported from the following plant families: basswood, beech, birch, dogwood, elm, heath, laurel, rose, saxifrage, walnut, and willow.

Pleurophorus caesus (Creutzer)

Distribution: British Columbia, Ontario, and Quebec.

Origin: This species was introduced from Europe and has been known from the Atlantic Coast of North America since 1871 (Hatch 1971).

Economic injury: *Pleurophorus caesus* has been reported to damage cabbage and tomato seedlings and potato and cucumber plants in Washington (Hatch 1971).

Polyphylla crinita LeConte
(tenlined June beetle)

Distribution: south-central British Columbia.

Economic injury: According to Banham and Arrand (1978), this species of white grub occurs in all the vegetable-growing areas of British Columbia.

Polyphylla decemlineata (Say) (*perversa* Casey, *ruficollis* Casey)
tenlined June beetle (western tenlined June beetle, striped June beetle)
hanneton rayé (m.)

Distribution: British Columbia, Alberta, and Saskatchewan.

Economic injury: Downes and Andison (1941) summarized the economic damage caused by this species under the synonym *P. perversa*. The larvae are major pests of small fruits, especially strawberry, that are grown on light sandy soil. The second- and third-year larvae cause the most damage by feeding on the fibrous roots and severing the main root 5–10 cm below the soil surface. Nursery plants, including rose, apple, pear, plum, and cherry, have been completely destroyed by root damage. Loganberry and raspberry are also attacked. Larvae have been reported to damage potato by excavating large cavities in the tubers and to injure corn by cutting off the roots. When larvae are deprived of their preferred food, other crops, excluding legumes, may be attacked. Isolated reports of damage to broccoli and tulip and crocus bulbs may represent this kind of damage.

Biology: The biology of this species was studied by Downes and Andison (1941) in British Columbia. Females burrowed into light sandy or gravelly soil at depths of 20–37.5 cm to oviposit. They then burrowed horizontally, depositing eggs as they progressed. Dissection of gravid females revealed 60–70 eggs, although evidence suggested that not all were deposited in the same location. Eggs were not enclosed in earthen balls as are the eggs of other species of white grubs. The incubation period lasted about 54 days, and eggs hatched in September.

The larval period lasted for 3 or 4 years. Mature larvae occurred in the first 15–20 cm of soil, the first- and second-year larvae apparently occurring at greater depths. This phenomenon may reflect the feeding habits of the larvae, because mature grubs feed on larger, more woody roots, whereas younger ones feed on finer, more tender roots.

Pupation started in May, the pupal period lasting about 5 weeks. Pupal cells were observed at 10 cm or deeper in the soil. Adults began emerging from the soil during the first week in July, males emerging before females. Emergence holes were bored vertically from the pupal cells. The adults fed on conifers and lived for about 4 or 5 weeks. Lilly and Shorthouse (1971) demonstrated the presence of a sex pheromone in females of *P. decemlineata*. They believed that this pheromone, supplemented with visual stimuli from silhouetted trees, the female calling site, promotes the mass mating flights of the males.

Two species of muscid flies, *Muscina assimilis* (Fallén) and *M. stabulans* (Fallén), were reared from the adult stage of this beetle. Flesh flies, *Sarcophaga misera* var. *exuberans* Pandelle (?), supposedly parasitized the adults, and an unidentified tiphiid wasp, *Tiphia* sp., parasitized the larvae of this species.

Popillia japonica Newman
Japanese beetle
scarabée japonais (m.)

Distribution: southern Ontario, southwestern Quebec, and Halifax, N.S. (eradicated).

Origin: *Popillia japonica*, a native of the main islands of the Japanese archipelago, was first discovered in North America in 1916, in southern New Jersey (Fleming 1972). The first Canadian outbreak was reported from Niagara Falls, Ont., in 1940 (Baker 1943). Beetles were found in 1944 in a rose garden at Halifax, N.S., probably introduced from ships from the United States (Fleming 1972). The species was subsequently found in Quebec at Saint-Jean in 1967 (Cardinal 1972).

Economic injury: According to Fleming (1972), the Japanese beetle is a major pest, the beetles seriously damaging small fruits, tree fruits, truck and garden crops, shade trees, ornamental herbaceous garden plants, shrubs, vines, and trees. The larvae destroy lawns, golf courses, and pastures, and they damage the roots of other plants. Fleming (1970) described this damage.

Adults feed on the soft tissue of the leaves of most of their food plants, leaving only the network of veins. Large irregular portions are eaten from the leaves of thin-veined plants and flower petals. Thick, tough foliage is usually free from attack. Feeding is most extensive on warm sunny days, when the temperature ranges from 29 to 35°C. The adults eat the fruit and foliage of blackberry, blueberry, raspberry, and huckleberry; extensively skeletonize the foliage of grape; and feed on the foliage of red currant, cranberry, and strawberry. However, they generally cause little economic damage to the last three species. Of the fruit trees attacked, the foliage of apple, cherry, and plum are favored, and that of peach, nectarine, and quince are less damaged. Fruits that mature when the adults are abundant are often seriously damaged. The insects damage the foliage, the tassels, and, in particular, the silk of corn, a preferred plant of the adult. Although the adults attack many species of garden and field crops, they damage asparagus, rhubarb, lima beans, bush beans, and soybeans most extensively. The rose is perhaps the most attractive ornamental to the beetle, although it attacks many species of ornamental herbs, shrubs, vines, and shade trees. For more complete lists of plants attacked by the Japanese beetle, see Fleming (1970, 1972).

The larvae of *P. japonica* feed on the roots of a wide variety of garden crops, field crops, ornamental plants, and grasses, occurring most abundantly in well-kept lawns, pastures, and golf courses. The grubs burrow just below the soil surface, severing and consuming the roots of grasses. When the larvae are abundant, they damage seedling corn, beans, cabbage, tomato, and other crops. They injure nursery stock by girdling the roots and have caused extensive damage to strawberry beds.

Biology: According to G.S. Brown (1965), *P. japonica* appears to have a 1-year life cycle in Canada. Fleming (1970) summarized the general biology of the Japanese beetle. In most infested areas, the species has a 1-year life cycle, whereas in northern areas some individuals require 2 years to complete their development.

Females prefer to oviposit in moist, loamy soils with cropped grass cover, although they deposit some eggs in cultivated areas. They burrow to a depth of 2.5–10 cm and deposit one to four eggs, returning above ground to resume feeding between egg-laying sessions. A female lays a total of 40–60 eggs during her lifetime. The incubation period lasts about 2 weeks.

The larvae pass through three instars, the first two requiring 2–3 and 3–4 weeks to complete, respectively. The third-instar larvae are full grown by fall and reach maturity the following spring. During the summer and early fall, the grubs feed within the upper 7.5 cm of soil. In winter, the majority of larvae occur within the upper 10 cm of soil, and a few are found below 15 cm. However, soil texture affects their vertical distribution, the larvae going somewhat deeper in cultivated fields. As the soil temperature increases in the spring, the larvae ascend to their summer depths.

The larvae spend about 10 days as inactive prepupae before undergoing the final larval molt. Pupation occurs in earthern cells formed by the larvae, the stage lasting 8–20 days, depending on temperature and other conditions. After transformation, adults emerge from the ground and fly to low-growing plants, which they climb and begin to feed upon. Mating usually occurs on plants or on the ground soon after emergence and is repeated at intervals throughout the 30–45-day life span of the insects. About 2 weeks after the initial emergence, the beetles leave the low-lying plants and move to fruit and shade trees, returning to the low vegetation when the tree leaves become older and tougher. The gregarious adults feed and fly vigorously on warm summer days and tend to congregate and feed on certain plants, leaving equally attractive plants untouched. Females enter the ground to oviposit in the late afternoon and may remain there overnight or may spend 3–4 days in the ground. The adult population usually reaches its peak 4–5 weeks after the first individuals emerge. Adults, however, are present in some cases until the advent of frost.

The indigenous tiphiid wasp *Tiphia intermedia* Malloch parasitizes the larvae but only sporadically reduces the population. However, attempts at introducing exotic species of parasites have led to the establishment in North America of five insect species that to varying degrees control the population. These species include the following: the tachinid fly *Hyperecteina aldrichi* Mesnil, which parasitizes the adult; two tachinid flies, *Dexilla ventralis* (Aldrich) and *Prosena siberita* (Fabricius), which parasitize the larvae; and two tiphiid wasps, *Tiphia popilliavora* Rohwer and *T. vernalis* Rohwer, which parasitize the larvae. The fungi *Metarrhizium anisopliae* (Metchnikoff) Sorokin and *M. glutinosum* Pope infect low numbers of larvae. *Beauveria bassiana* (Bals.) Vuill. infects the adults when spore suspensions are sprayed on their food plants. Two parasitic nematodes, *Neoaplectana glaseri* Steiner and *N. chresima* Steiner, also attack the grubs of the Japanese beetle. The grubs suffer from blue disease, caused by the rickettsia *Coxiella popilliae* Dutky, and milky disease, resulting from infections by the bacteria *Bacillus popilliae* Dutky and *B. lentimorbus* Dutky.

Comments: The species has not been observed in Nova Scotia since 1953 and is believed to have been eradicated in that province (Fleming 1972).

Rhizotrogus majalis (Razoumowsky)
European chafer
hanneton européen (m.)

Distribution: southwestern Ontario.

Origin: According to Tashiro et al. (1969), *R. majalis* was first discovered in North America in 1940 at Newark, N.J. The same authors conservatively estimated that the species was probably introduced into the New World during the 1920s or 1930s. The European chafer was first recorded in Canada in 1959, when adults were discovered at Niagara Falls, Ont. (G.S. Brown 1965).

Economic injury: Tashiro et al. (1969) discussed the damage caused by this species. Its economic importance is due primarily to the feeding activity of the third-instar larvae. These grubs prune the roots of various plants, causing them to wilt, discolor, and eventually die. Lawn and pasture grasses attacked include blue grass, bent grass, brome, fescue, orchard grass, redtop, rye grass, timothy, and vernal grass. Cereal crops damaged include barley, corn, oats, rye, and winter wheat. Destruction of lawns is the most serious damage caused by the larvae. In heavily infested areas, the grubs have destroyed most of the grass in some lawns. They sever the roots, with the result that damaged lawns, although initially still green, can be rolled back like a carpet. The larvae have also been responsible for heavy damage to winter wheat. Timothy is particularly susceptible to injury, resulting in heavy losses to hay crops. Spring-planted grains, including corn, are occasionally injured but generally escape damage because they are planted within 3 or 4 weeks of pupation and are harvested before the development of the new brood of third-instar larvae. The destruction of ground cover in hilly terrain has resulted in serious erosion, and damage to lawns has allowed the invasion of noxious weeds. The grubs also attack clover, chrysanthemum, gladiolus, coreopsis, young conifers, carrot, lettuce, potato, and strawberry. Adults are not considered economically important because of their minimal feeding activity. Although large flights of beetles have been observed in and around various tree species, little damage has been reported.

Biology: Tashiro et al. (1969) summarized the biology of the European chafer in New York State. The species has a 1-year life cycle, with a few individuals requiring 2 years to complete their development. Eggs are deposited singly in moist earthen cells formed by the extrusion and evagination of the vagina to form a bulbous organ that compresses the soil. Females prefer to oviposit in light sandy loams, although they deposit eggs in all loam soils. In moist soil, the females deposit eggs 5–10 cm below the surface, but in dryer soil, they deposit them at depths of up to 20 cm. Dissected females contained up to 52 eggs, the number of eggs deposited averaging 22 (range, 2–46). In the field, eggs normally hatched in about 14 days, although laboratory rearings indicated that the incubation period is inversely influenced by temperature. Eggs are present in the soil from late June until the end of August, with the majority present in mid July.

The species has three larval instars that last for 3 weeks, 5 weeks, and 9 months, respectively; the final-instar larvae usually overwinter. Soil moisture and acidity affect larval densities. Higher populations occur where the soil moisture averages 41–65% and the pH ranges from 5.3 to 6.1. Grubs usually occupy the upper 5 cm of soil when adequate moisture is available, but during periods of drought, the larvae migrate downward to seek moisture. During winter, the grubs migrate below the frost line, the majority occurring less than

30 cm below the frozen ground. Larvae can be frozen solid and survive if thawed gradually.

Mature third-instar larvae usually form pupal cells 5–10 cm below the soil surface, but the depth is influenced by moisture and soil type. Pupation begins in late May, following a 2–4-day prepupal period, and pupae are present until mid July. In the field the pupal period lasts approximately 2 weeks.

Newly transformed adults spend 3–5 days in the pupal cell as teneral, preflight beetles. On warm sunny days in late June, the beetles leave the soil during the evening to fly to nearby trees and shrubs where they swarm and mate. After mating, they return to the soil in small numbers throughout the night. Flights are reduced at temperatures below 19°C and cease at temperatures below 11°C. During the early part of the flight season, the sex ratio of males to females is 16:1, but as the season progresses, the sex ratio declines to 1:1 and then to 1:2 by the end of the season. Mating occurs soon after the adults have come to rest and is not preceded by courtship behavior. There is no evidence of a sex pheromone in the species.

Milky disease produced by adapted strains of *Bacillus popilliae* Dutky and *B. lentimorbus* Dutky may infect up to 30% of the larvae. Attempts at introducing European insect parasites of this beetle into North America have been unsuccessful.

Serica anthracina LeConte
(manzanita serica)

Distribution: British Columbia and Alberta.

Economic injury: The adults of this common species feed on native shrubs and may invade orchards in the spring to feed on apple, plum, and other fruit trees. Larvae are common in sandy areas under grasses in California (Ritcher 1966).

Serica georgiana lecontei Dawson

Distribution: Ontario, Quebec, and Prince Edward Island.

Economic injury: Although the adults of the species are normally leaf feeders on trees, they have been reported to attack strawberry plants in Prince Edward Island (CIPR 1962).

Serica sericea (Illiger)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Northwest Territories.

Economic injury: This species has been reported to attack raspberries in Manitoba (CIPR 1951).

Serica tristis LeConte
(small leaf chafer, strawberry-leaf chafer)
scarabée des feuilles (m.)

Distribution: Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Economic injury: Adults of *S. tristis* have been reported to feed on the buds, flowers, and leaves of blueberry in Nova Scotia (CAIPR 1966). They have also stripped the leaves of strawberry in the same province (Brittain and Pickett 1933).

Strigoderma arboricola (Fabricius)
(corn chafer)
scarabée du maïs (m.)

Distribution: southwestern Ontario.

Economic injury: Although the adults have been reported from a wide variety of plants, a marked preference is shown for wild and cultivated roses (Hayes 1921). When abundant, the adults of *S. arboricola* cause considerable damage to roses by feeding on the buds and flowers (Hoffmann 1936). The same author stated that the economic status of the larvae is unknown.

Biology: According to rearing and observations made by Hayes (1921) in Kansas, the adults occurred in May, June, and July, with egg laying taking place in the latter 2 months. The eggs hatched in 10–14 days, the larvae overwintered, and the prepupal stage was reached the following spring after approximately 322 days of larval development. The prepupal and pupal stages required 4–8 and 11–14 days, respectively. According to Hoffmann's (1936) rearing results in Minnesota, eggs were laid singly following a preoviposition period of 11 days. The average incubation period was 17 days, and larvae reached maturity in 160–164 days.

SCOLYTIDAE bark and ambrosia beetles
scolytes (m.)

Most species of this family bore into trees and woody shrubs, where the larvae usually feed on the cambium layer. Other species excavate galleries in trees, and both larvae and adults feed on a fungus transmitted to the galleries. This family is one of the most economically important to the forest industry because of its feeding injury and its transmittal of plant diseases such as Dutch elm disease. The family is found in all faunal regions but is best represented in tropical areas. About 7000 species are known of which 220 are estimated to occur in Canada.

Chaetophloeus heterodoxus (Casey) (*brittaini* Swaine, *criddlei* Swaine)

Distribution: British Columbia and Manitoba.

Economic injury: According to Bright and Stark (1973), this species is generally considered to be of minor importance. Large populations of *C. heterodoxus* have, however, destroyed mountain mahogany over extensive areas. Pear, stone fruits, and mountain mahogany are known hosts (Bright 1976).

Biology: The life history of this species was described by Bright and Stark (1973). It overwinters in the adult stage. The main flight period occurs in late June in Oregon, but beetles (possibly of a second generation or from overlapping generations) have been observed later in the year. The host is attacked by both sexes at apparently the same time.

The adults construct a nuptial chamber that is roughly oval, 4×6 mm, and deeply engraved in the sapwood (Bright and Stark 1973). Extending from this chamber are from three to six short (1–3 mm) egg galleries. The larval mines extend from these egg galleries approximately 2 cm and are also deeply engraved in the sapwood. This monogamous species deposits from 6–12 eggs at the end of each of the egg galleries. The larvae construct oval pupal chambers at the ends of their galleries about three-quarters in the wood and one-quarter in the bark. There seems to be only one generation each year in the northern part of its distribution, although the possibility of a second, overlapping generation exists.

Hylastinus obscurus (Marsham)
clover root borer
perceur des racines du trèfle (m.)

Distribution: British Columbia, Ontario, Quebec, New Brunswick, and Nova Scotia.

Origin: The clover root borer was introduced into the United States from Europe sometime before 1878 (about 1870 according to Metcalf et al. 1951) and was first observed on clover in western New York

(Davidson and Lyon 1979). It has since become widely distributed in all parts of the northern United States and southern Canada, wherever red clover is an important crop.

Economic injury: Red and mammoth clovers are the preferred hosts of the clover root borer (Rockwood 1926, Metcalf et al. 1951, Davidson and Lyon 1979). The species is apparently much less troublesome than formerly, partly because of better systems of crop rotation (Metcalf et al. 1951). It rarely causes severe damage except in fields where clover has been allowed to stand more than two seasons. Rockwood (1926) described the insect as one of the main factors that limit the life of a red clover stand after the first crop-year, although there may be considerable damage even in the first crop-year when nearby infested fields of old clover are plowed in the spring. Occasionally, the clover root borer attacks red clover in the year of seeding. Gustafson and Morrison (1960*b*) reported an average infestation of 40% in the roots of the first crop-year (average of 1.5 borers per root) and an average infestation of near 100% in the second crop-year roots (average of 3.5 borers per root) based on 9 years of root sampling at Ithaca, N.Y. According to Davidson and Lyon (1979), an average of 1.5 borers per root reduces hay yields by 5.5%. In Quebec, seedling mortality is not serious, but infestations of up to 100% of all roots of red clover occur by the end of the second crop-year (Gustafson and Morrison 1960*b*). Gustafson and Morrison (1958) reported an infestation in Quebec that rose from 18% on 1 May to nearly 100% by 24 June. Leath and Byers (1973) established that the beetles prefer diseased and decayed roots of red clover. The species has been recorded on clover (alsike, crimson, and white), sweet-clover, alfalfa, peas, field beans, and vetch, but it is apparently of little importance on these crops (Metcalf et al. 1951, Davidson and Lyon 1979). White Dutch clover, volunteer clover, Scotch broom, lupine, furze, and alfalfa (in Russia) are also attacked (Hudson 1925*b*, Rockwood 1926).

Both larvae and adults cause damage. Soon after the spring migratory flight, the beetles chew into a plant selected for oviposition, usually through the crown but also through the root and stem (Hudson 1925*b*; Rockwood 1926; Metcalf et al. 1951; Gustafson and Morrison 1960*a*, 1960*b*; Beirne 1971). According to Rockwood (1926), some egg galleries are simply grooves, which may develop into completely enclosed galleries. The galleries may run either parallel or perpendicular to the longitudinal axis of the root. Occasionally, the egg galleries are spiral grooves that nearly girdle small roots. When many borers are present, the egg gallery may extend into the centre of the stem above the ground. The parent galleries have closely spaced egg pockets along the galleries and may extend up to 30 mm in length. Plants may die from the girdling of one small root.

Adults gnawing into the bases of stems rather than penetrating deeply into the crown cause the shoot to die. Larvae tunnel in the roots, frequently killing the plant (Arrand and Neilson 1958, Beirne 1971). According to Rockwood (1926), the young larva usually runs its burrow at right angles to the parent gallery for 3–5 mm and then tunnels at right angles to the first part of the burrow, usually parallel to the longitudinal axis of the root. The burrow becomes sinuous as the larva grows but generally conforms to the longitudinal axis of the root. The larval mines vary in length from 20 to 40 mm. Attacked clover plants turn brown, wilt, and die and usually appear to be suffering from some disease (Metcalf et al. 1951). The damage is most apparent when the crop is first cut for hay (Davidson and Lyon 1979). Injured plants are often pulled out by the mower during cutting, and others remain so weakened that little new growth is produced.

Climatic and soil factors, the condition of the host plant, and topography affect the development of *H. obscurus* and the damage it causes (Rockwood 1926). The insect develops more rapidly on unhealthy roots, being more injurious to clover during a dry summer; the species may carry disease-causing organisms (Rockwood 1926; Beirne 1971; Leath and Byers 1973). The beetles frequently move from one plant to another, either above or below ground, laying eggs in more than one plant (Gustafson and Morrison 1960*a*, Morrison and Gustafson 1960). Root rot and virus diseases are reportedly more prevalent where the clover root borer is numerous (Davidson and Lyon 1979).

Biology: *Hylastinus obscurus* overwinters in the clover roots, mostly in the adult stage, but occasionally as larvae (Rockwood 1926). The adults may also overwinter in soil or, rarely, under debris on the surface of the soil. The adults and the few overwintered larvae gradually resume activity when the soil temperature approaches about 7°C in the early spring. Adult emergence from the overwintering sites often occurs when the temperature of the air at the surface of the ground is between 13 and 16°C. Mating is thought to occur just before the spring flight, probably in the hibernation chamber. In Quebec the overwintered adults emerge in early May and climb up to the tops of stems and leaves before their dispersal flight (Gustafson and Morrison 1960*a*). According to these authors, females are the first to emerge. The dispersal flight takes place only once each year and appears to be triggered by the occurrence of 2 successive days, with maximum temperatures of 18°C (Rockwood 1926, Deane and Morrison 1957). According to Beirne (1971), the spring flight lasts 1 or 2 days early in May. Gustafson and Morrison (1958) noted that major distribution flights are accomplished within a 3–4-day period. After the flight the adults burrow into the host plant, usually through the crowns (Gustafson and Morrison 1960*a*). However, small numbers of adults may be observed in the field throughout the summer. According to Rockwood (1926), the females burrow to a depth of at least 6 mm before beginning oviposition.

The construction of the first egg gallery probably takes nearly a month (Rockwood 1926). In cages, a single female occasionally infested four out of five roots. These results were corroborated by Gustafson and Morrison (1960*a*) and Morrison and Gustafson (1960), who stated that adults frequently move from one plant to another, either above or below ground, and deposit eggs in more than one plant. The eggs are deposited in niches in the walls of burrows beginning in April or May in Oregon (Rockwood 1926). The egg galleries, which usually contain four to six eggs, are abandoned by the adults by the end of May or beginning of June. Hudson (1925*b*) reported that females deposit their eggs singly in pockets, which are afterwards covered with frass. From two to six eggs are usually laid in a single root. The females rarely lay more than 25 eggs and probably average considerably fewer (Rockwood 1926). Gustafson and Morrison (1960*a*) noted an average fecundity of 19.8 eggs for each of 11 females; under laboratory conditions (21.1°C), the eggs hatched in 8 days. Hudson (1925*b*) reported a maximum oviposition of 16 eggs and an average incubation period of 12.67 days (range, 9–17). Rockwood (1926) stated that the eggs hatch in 17–30 days and that larval development is slow, with pupation not beginning until about the middle of July. The larvae molt three to five times (Rockwood 1926). The larval stage was estimated by Hudson (1925*b*) to require 4–5 weeks. In Quebec the larvae are found from 15 June to 15 September and the pupae from 25 July to 5 November (Deane and Morrison 1957). The larval stage required 20–32 days under laboratory conditions (21.1°C) in Quebec (Gustafson and Morrison 1960*a*).

Pupation takes place in a smooth-sided chamber formed at the end of the mine, usually well down in the root but occasionally on or near the crown (Rockwood 1926). The pupal stage lasts 8–13 days. The pupal period lasted 8 days under laboratory conditions (21.1°C) in Quebec (Gustafson and Morrison 1960*a*). Development from egg to adult required 30–57 days in the laboratory and 62–66 days in the field. According to Davidson and Lyon (1979), pupation takes place in the roots from July to September and lasts 10 or more days. All stages of the clover root borer may be present during the late summer and fall (Metcalf et al. 1951). Gustafson and Morrison (1960*a*) pointed out that infested roots that contain adults can be detected at any time from May until November in the field (Quebec), but the highest proportion of adults occurs in May and November and the highest absolute numbers in November. Only one generation occurs each year.

According to Rockwood (1926), the clover root borer has very few natural enemies. An entomogenous fungus, *Beauveria globulifera* (Speg.) Piccard, eight species of birds, and the larvae of predaceous beetles are mentioned. Beirne (1971) reported the species to be preyed upon by larval and adult ground beetles and predatory Diptera. Deane and Morrison (1957) noted a cantharid larva, an adult staphylinid (*Gyrohypnus* sp. near *humatus* Say), and an unidentified dipterous larva feeding on borer larvae.

Hylesinus aculeatus (Say) (*cinereus* Swaine)
(eastern ash bark beetle, ash bark beetle)
scolyte du frêne (m.)

Distribution: Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: *Hylesinus aculeatus* is of little economic importance (Bright 1976). MacNay (1959) reported that this species emerged from wood stored in a basement at Ottawa, Ont. It is known to attack various species of ash (Bright 1976). The adults construct egg galleries between the bark and wood of trunks or limbs of recently felled, dying, or seriously weakened trees. Both the bark and wood are deeply scored. The egg galleries consist of two branches that extend in a transverse direction. A short tunnel or nuptial chamber below the entrance hole connects the two branches. The larvae follow the grain of the wood, which they deeply engrave.

Biology: The adults overwinter in tunnels in the bark of living or felled trees (Bright 1976). They emerge in the spring and fly to suitable host trees. The female deposits her eggs singly in niches on both sides of the egg gallery. The larvae pupate in deep pupal cells between the bark and wood. One generation and possibly a partial second is completed each year.

Hylesinus fasciatus Olivier

Distribution: Ontario.

Economic injury: Gibson (1916) reported the beetle in a few ears of corn at the Central Experimental Farm, Ottawa, Ont. The insect destroyed several kernels in one ear. This injury has apparently not been previously recorded in Canada, although similar damage has been noted in the United States. Bright (1976) reported the species to occur on various species of ash.

Hylurgopinus rufipes (Eichhoff) [*opaculus* (LeConte)]
native elm bark beetle
scolyte de l'orme (m.)

Distribution: Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Economic injury: Like the smaller European elm bark beetle, *H. rufipes* commonly attacks elm trees in Canada and the United States and is a major pest primarily because the adults are the principal vectors of the fungus *Ceratocystis ulmi* (Buism.) Moreau, which causes Dutch elm disease (Bright 1976, Davidson and Lyon 1979). Damage to Chinese elm in Ontario was also reported in the CIPR (1965). The insect feeds on various species of elm and sometimes on species of ash, stone fruit, and basswood (Bright 1976). The overwintered adults feed on the bark of living trees before moving to and breeding in recently dead limbs of at least 5 cm in diameter. Parent or egg galleries consist of two branches that diverge from the entrance holes in the bark and cut across the grain of the wood (Metcalf et al. 1951, Davidson and Lyon 1979). According to Bright (1976), these galleries may be entirely in the bark or they may slightly penetrate the wood. The larval galleries usually follow the grain of the wood.

Biology: The life cycle of the native elm bark beetle is similar to that of the smaller European elm beetle, although *H. rufipes* overwinters in both the larval and adult stages (Davidson and Lyon 1979). Emergence of the overwintered adults occurs in May, at which time they fly off in search of a suitable host (Bright 1976). The female deposits her eggs along both sides of the gallery. Typically, the larvae pass through five or six instars. Larval development may be completed in 29 days, but usually requires an average of 40–50 days. Pupation takes place in a cell at the end of the larval tunnel and lasts from 8–12 days. Only one generation or one generation and a partial second are produced each year in Canada.

Lymantor decipens LeConte

Distribution: Ontario and Quebec.

Economic injury: This species is known to attack maple and willow in Canada as well as hickory and pear in the United States (Bright 1976). The beetles feed and reproduce in the dead, dry limbs of their hosts. Galleries are constructed near the surface of the wood or occasionally deeper. Usually two or three egg galleries follow a longitudinal direction just beneath and parallel to the sapwood. Short gallery branches may run parallel to the surface or penetrate obliquely into the wood. The larvae tunnel in a more or less transverse direction through the wood. Both adults and larvae feed on certain wood fungi that grow in the galleries.

Biology: As previously mentioned, reproduction takes place in dead, dry limbs (Bright 1976). The eggs are deposited in niches in the egg galleries.

Micracis suturalis LeConte (*aculeatus* LeConte, *meridianus* Blackman)

Distribution: Ontario.

Economic injury: This scolytid has attacked white elm in Michigan (MacNay 1957*a*). Redbud, various species of walnut, hickory, and other deciduous trees are known hosts (Bright 1976). The insect prefers old wood and the beetles may emerge and reinfest the same material for several generations. Long, longitudinal, and slightly undulating galleries are characteristic of this species.

Micracis swainei Blackman (*populi* Swaine)

Distribution: Ontario.

Economic injury: *Micracis swainei* attacks various species of willow and poplar (Bright 1976). The insect has been taken from galleries in the wood just beneath the bark of a broken limb.

Phloeotribus liminaris (Harris)
peach bark beetle
scolyte du pêcher (m.)

Distribution: Manitoba, Ontario, Quebec, and New Brunswick.

Economic injury: *Phloeotribus liminaris* is occasionally a pest in peach orchards and may, at times, inflict serious injury (Bright 1976). According to Metcalf et al. (1951), attacks on vigorously growing trees are of little importance. Severe injury in peach orchards has been recorded in the Niagara district of Ontario (Fletcher 1893, 1894). MacNay and Creelman (1958) reported the insect to be a pest of peach and apricot in Ontario. Additional hosts include wild and cultivated stone fruit trees (cherry, plum), mulberry, elm, and mountain ash, but not pome fruits (Metcalf et al. 1951, Baker 1972, Bright 1976, Davidson and Lyon 1979).

The adults usually breed in weakened trees, but they also feed in the bark of healthy trees (Bright 1976). Feeding on healthy trees may result in abnormal growth of the tree. Infested trees are so weakened that they become susceptible to breeding attacks. The transverse parent gallery usually consists of two short tunnels that extend in either direction from the entrance hole and deeply engrave the wood. According to Metcalf et al. (1951), the egg gallery is excavated in the inner bark and usually runs crosswise, forking at one end to form a Y. The larval galleries extend for a distance of 5–8 cm in the inner bark, usually following the grain of the wood and terminating in small, round exit holes through the bark. Small beads of gum exude from points on the bark of infested trunks and branches. Fletcher (1894) stated that the work of the adults and larvae at Queenston, Ont., appeared to be restricted to the bark, although some observers reported penetration of the wood.

Biology: This insect is similar in appearance and habits to the shothole borer (Metcalf et al. 1951, Davidson and Lyon 1979). The adults of the peach bark beetle, however, overwinter in their pupal cells in dead or dying wood or in special hibernating cells made in the bark of healthy trees. Emergence takes place in the spring (Bright 1976) or early summer (Davidson and Lyon 1979). Fletcher (1894) reported that the beetles emerged from their burrows as early as February and March on warm days. The adults are good fliers and appear to be attracted to trees that are in poor condition or to those having dying branches (Metcalf et al. 1951). The female deposits her eggs along the sides of the egg gallery in the inner bark. The larvae pupate in enlarged cells at the end of the larval mines (Bright 1976). Two generations occur each year.

Beal and Massey (1945) reported that the predator *Neichnea laticornis* (Say) was commonly reared in association with *P. liminaris* and noted the following other associated insects: *Leptostylus tuberculatus* (Froelich), *Euderces pini* (Olivier), and *Silvanus imbellis* LeConte.

Scolytus mali (Bechstein) (*sulcatus* LeConte)
larger shothole borer

Distribution: Ontario and Quebec.

Origin: The larger shothole borer was first recorded in Canada in 1945 on apple in southern Quebec (CIPR 1952). It was discovered in 1949 on the same host in Ontario.

Economic injury: MacNay and Creelman (1958) reported the species to be a pest of apple in Ontario and Quebec. According to Goble (1963), *S. mali* is usually important only on apple and pear trees having many dead or dying limbs. Orchards near brush piles or piled firewood may be injured. The larger shothole borer breeds in apple, cherry, and elm and prefers dying and weakened limbs and freshly cut wood (Baker 1972). Healthy trees are also attacked when infestations are heavy (Goble 1963). The insect has been recorded from other species of broadleaved trees including elm and mountain ash (Bright 1976). According to Goble (1963), stone fruits are more attractive as hosts than apple and pear.

Shotlike holes are made by the adults in bark, frequently at the base of the buds or spurs (Goble 1963). Both the adults and larvae form galleries just under the bark. A limb dies when it is completely girdled by a series of galleries. The adults sometimes feed in the twig crotches of elm and can transmit the fungus of Dutch elm disease (Baker 1972).

Biology: The species overwinters in the larval stage in the bark (Baker 1972) or under it (Goble 1963). Pupation takes place in the spring, and emergence occurs in June, through shothole openings (Goble 1963). After maturing, the females chew small holes through the bark and construct channels along which the eggs are deposited. The larvae usually feed at right angles to the egg gallery. At maturity the larvae pupate, and the new adults appear in late August and September. The life cycle is repeated, and two generations are produced annually. Baker (1972), however, stated that only one generation per year occurs.

Comments: Notes from Goble (1963) are a generalization for both the larger shothole borer and the shothole borer.

Scolytus multistriatus (Marsham)
smaller European elm bark beetle
petit scolyte européen de l'orme (m.)

Distribution: Ontario and Quebec.

Origin: This European species was first reported in the United States in 1904 near Boston, Mass. (Davidson and Lyon 1979). It was first reported from Canada at Windsor, Ont., in 1948 (CIPR 1952).

Economic injury: Metcalf et al. (1951), Bright (1976), and Davidson and Lyon (1979) described the economic injury that this species causes. *Scolytus multistriatus* commonly attacks elm trees in Canada and the United States and, like the native elm bark beetle, is an important pest mainly because it is a vector of the fungus *Ceratocystis ulmi* (Buism.) Moreau, which causes Dutch elm disease. The incidence of falling twigs and elm mortality caused by Dutch elm disease in Ontario is indicative of the abundance of this insect in the province (CIPR 1965, CAIPR 1968). Elm trees are the only known hosts, and it is believed that *S. multistriatus* will spread throughout the natural range of these trees.

The adults feed in the crotches of healthy twigs but cause little damage unless they are carrying the Dutch elm disease fungus. The egg gallery is then excavated by the female in the cambium of weakened, dying, or recently dead wood. These galleries run parallel to the grain of the wood and engrave both bark and wood for 2.5–5 cm. The larvae, which feed in the cambium region, construct galleries that run across the grain of the branches. The larval mines gradually turn and continue along the grain of the wood; they frequently reach 20 cm in length.

Biology: The larvae overwinter at the ends of their tunnels and pupate in the outer bark (Metcalf et al. 1951). The adults emerge in June or July (Bright 1976). After feeding and mating, the female constructs the egg gallery and deposits 24–96 eggs (80–140 eggs according to Metcalf et al. 1951), in niches on both sides of the gallery.

The larvae complete their development in a few weeks (Metcalf et al. 1951), and adults appear in August and September (Bright 1976). Some of the larvae do not complete development during the first summer and remain to form a large part of the overwintering population (Bright 1976). Most of the adults that appear in late summer are unable to breed, oviposit, and produce overwintering larvae. In the latitude of New Jersey, development from egg to adult requires 45–60 days under favorable conditions, and two full generations and a partial third occur each year (Davidson and Lyon 1979). In Canada one generation and a partial second are produced annually (Bright 1976).

Scolytus rugulosus (Mueller)
shothole borer
scolyte des arbres fruitiers (m.)

Distribution: British Columbia, Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland.

Origin: This species was introduced from Europe in 1878 and has since spread over most of the United States and southern Canada (Davidson and Lyon 1979).

Economic injury: *Scolytus rugulosus* breeds in dead or weakened trunks and branches of all sorts of fruit trees (Armstrong and Boyce 1958). Serious outbreaks have often begun where piles of wood have been left lying all season near fruit orchards. When the insect is numerous, healthy trees may also be attacked and weakened to such an extent that they eventually become suitable for breeding purposes and may be killed outright (Ross and Putman 1933, Beal and Massey 1945, Madsen and Arrand 1971). Bright (1976) noted that an attack may be initiated in a damaged area (such as a sunscald) on a healthy tree and spread throughout the tree. While heavy infestations nearly always result in the death of the tree or the branches, the beetles are very seldom the primary cause of the death of the tree according to Metcalf et al. (1951). MacNay and Creelman (1958) reported the insect to be a pest of apple in Ontario, New Brunswick, and Nova Scotia; of apricot in Ontario; of cherry in British Columbia and Nova Scotia; and of peach and plum in Ontario and Nova Scotia. Several cases of severe attacks on peach trees in Norfolk County, Ont., were noted in MacNay (1952). The shothole borer caused serious injury to some orchards in the Rougemont area of southwestern Quebec (Paradis et al. 1977) and coastal British Columbia (Neilson 1957*b*). Apple trees were injured in Quebec (Paradis et al. 1979). CAIPR (1978) reported the infestation of a house in Newfoundland. Apple, pear, peach, plum, cherry, apricot, wild cherry, wild plum, black cherry, chickasaw plum, almond, quince, serviceberry, juneberry, chokecherry, mountain ash, hawthorn, elm, and other fruit and shade trees are attacked by this species (Caesar 1930, Beal and Massey 1945, Metcalf et al. 1951, Neilson 1957*b*, Madsen and Arrand 1971, Baker 1972, Davidson and Lyon 1979). Goble (1963) pointed out that stone fruits are more attractive as hosts than apple and pear.

Injury results from the feeding of both adults and larvae mainly on twigs and limbs (Bright 1976). On twigs the adults bore shallow feeding holes into the wood at the base of the buds. Metcalf et al. (1951) reported that small holes were chewed through the bark of twigs of healthy fruit trees, particularly above a bud or other projection. On limbs the injury is caused by adult egg galleries and larval feeding, which may girdle the branch (Bright 1976). The females bore small round holes (1.3 mm) through the bark usually in the centre of lenticels (or above any slight projection according to Metcalf et al. 1951) on injured, dying, dead or (rarely) healthy trees. The egg galleries, which lie in the cambium and slightly engrave the wood, run more or less parallel with the grain of the wood up or down from the entrance tunnel for a distance of 1–5 cm (Bright 1976, Davidson and Lyon 1979). The larvae begin tunneling at right angles to the egg gallery and then turn up or down with the grain of the wood (Bright 1976). The larval galleries extend for 2.5–10 cm and may intertwine in heavy infestations. According to Neilson (1957*b*), the young larvae feed on a fungus that grows in the gallery and not on the wood. The mature larvae usually tunnel toward the centre of the limb or trunk, entering about 16 mm into the wood (Bright 1976). Metcalf et al. (1951) described the larval galleries as packed with frass, unlike the parent galleries, which are clean. The shothole effect results from the exit and entrance holes of the adults (Davidson and Lyon 1979). These holes are about the diameter of small lead shot and are often filled with gummy exudates, particularly on peach and other stone fruits. According to Beal and Massey (1945), the adults were reported to feed in the bark of healthy trees during autumn. According to Neilson (1957*b*), they frequently attack healthy trees just below the buds, causing weakening or death of the bud. Caesar (1930) stated that the adults are capable of transmitting pear blight.

Biology: The shothole borer overwinters in the larval stage in galleries under the bark (Metcalf et al. 1951, Goble 1963, Dustan and Davidson 1973, Davidson and Lyon 1979) or as pupae (in California) (Bright and Stark 1973). Only Neilson (1957*b*) reported the species to overwinter in the adult stage. Pupation occurs in the spring in Ontario, and adults emerge through shothole openings in the bark in June (Goble 1963, Dustan and Davidson 1973). These adults can fly considerable distances (Metcalf et al. 1951), and peaks of flight are strongly correlated with maximum daily temperatures in excess of 21°C (Madsen and Arrand 1971). After mating, the females construct egg galleries in unhealthy trees (Metcalf et al. 1951). The eggs are laid singly in closely spaced niches on both sides of the gallery (Bright and Stark 1973). The female rarely deposits eggs in twigs that are less than 1.25 cm in diameter. Madsen and Arrand (1971) reported that the female laid 20 eggs or more along the gallery. Hatching occurs within a few days (Bright 1976). When mature, the larvae usually burrow about 16 mm into the wood toward the centre of the limb or trunk and pupate. Some summer-generation larvae pupate in the bark, although overwintering larvae pupate almost exclusively in rounded cells in the wood. Madsen and Arrand (1971) reported the larvae to pupate in cells at the end of their galleries in the sapwood. Second-generation adults begin to emerge from the trees around the middle of August in Ontario and lay eggs that produce the overwintering generation of larvae (Dustan and Davidson 1973). Two generations also occur in the Okanagan Valley of British Columbia, the first beginning in May and ending during the middle of August and the second overlapping the first and continuing until the end of October (Madsen and Arrand 1971).

The most important natural enemies of *S. rugulosus* are parasitic chalcid wasps (Davidson and Lyon 1979). Graham (1965) reported the following insects to be parasites of the shothole borer: the braconids (Hymenoptera) *Eubadizon* sp. and *Spathius canadensis* Ashmead; the pteromalids (Hymenoptera) *Cheiropachus colon* (Linnaeus), *Cheiropachus obscuripes* Brues, and *Pachyceras xylophagorum* Ratzeburg; and the eurytomid (Hymenoptera) *Eurytoma crassineura* Ashmead. In addition, the pythid (Coleoptera) *Salpingus virescens* LeConte was found in *S. rugulosus* galleries, but its status is unknown. The following hymenopterous parasites were reared from infested apple: *Cephalonomia hyalinipennis* Ashmead, *Sclerodermus macrogaster* Ashmead, *Cheiropachys colon* (Linnaeus), *Heterospilus* n.sp., *Eurytoma pachyneuron* Ashmead, *Eupelmus juglandis* (Ashmead), *Raphitellus maculatus* (Walker), and *Entedon leucogramma* (Ratzeburg) (Beal and Massey 1945). *Helconidea ferruginea* (Brues) and the cerambycid associate *Neoclytus acuminatus* (Fabricius) were reared from infested cherry. Other associates from small branches of apple include the following: dipterous parasites of the family Itonididinae and the Coleoptera *Euderces pini* (Olivier), *Elaphidion villosum* Fabricius, *Obrium maculatum* Olivier, *Arthrolips splendens* (Schwarz), *Tenebroides* sp., *Stephanoderes dissimilis* (Zimmerman), and *Stephanoderes* sp. (near *salicis* Hopkins).

Comments: Conflicting data (i.e., the overwintering of adults) in Neilson (1957*b*) suggest that another species was described under the name *S. rugulosus*.

Xyleborinus saxeseni (Ratzeburg) (*quercus* Hopkins, *pecanis* Hopkins, *floridensis* Hopkins, *arbuti* Hopkins, *tsugae* Swaine, *libocedri* Swaine)

Distribution: British Columbia and Ontario.

Economic injury: Downing et al. (1956) reported this species to be a sporadically injurious pest of peach in British Columbia. The same host suffered some damage in Ontario (CAIPR 1972). According to Bright (1976), *X. saxeseni* attacks various species of large, dying, deciduous trees as well as pine and hemlock. Known hosts include maple, birch, beach, oak, Douglas fir, amabilis fir, western hemlock, pecan, hickory, honey-locust, walnut, sweet gum, yellow poplar, dogwood, persimmon, holly, hemlock, cypress, and pine (shortleaf and loblolly) (Beal and Massey 1945, Prebble and Graham 1957, Baker 1972). Bright and Stark (1973) stated that possibly no species of broad-leaved and coniferous tree is exempt from attack.

The adults tunnel straight in toward the pith and then turn in a radial direction and construct a large cave (Bright 1976). Bright and Stark (1973) noted that the galleries of this ambrosia beetle penetrate deep into the sapwood, like those of *Trypodendron* spp. According to Prebble and Graham (1957), the entrance tunnel extends radially for a distance of less than 6.5 mm to more than 4 cm, and a branch tunnel, which may follow an annular ring, is formed from the side or end. Occasionally, the parents enter a *Gnathotricus* gallery and excavate their own tunnel as an offshoot (Bright and Stark 1973). The larvae and young adults feed on an ambrosial fungus that coats the wall (Bright 1976).

Biology: According to Bright (1976), the species overwinters in all stages in logs. Other workers stated that only the larvae, pupae, and adults overwinter (Prebble and Graham 1957, Bright and Stark 1973). As many as 48 eggs are laid in the radial gallery and in the chamber (Bright 1976). The adults are destructive from the latter part of May to late August in Vancouver, B.C. (Prebble and Graham 1957). According to Baker (1972), the life cycle may be completed in 2 months.

Xyleborus dispar (Fabricius) (*pyri* Peck, *swainei* Drake)
(pear blight beetle)
scolyte des feuillus (m.)

Distribution: British Columbia, Ontario, Quebec, and Nova Scotia.

Origin: This species is native to Europe and has been accidentally introduced by humans into the eastern United States and subsequently into the Pacific Northwest (French and Roeper 1975). *Xyleborus dispar* was first reported to be injurious in the West in 1901, when it attacked plum trees in Clark County, Wash. (Mathers 1940). Its presence in British Columbia has been known since about 1916.

Economic injury: This insect is a pest of all common fruit trees (Beal and Massey 1945, Baker 1972) and probably attacks all the other species of deciduous trees in its range (Bright 1976). It has become particularly troublesome in recent years in British Columbia (Mathers 1940). MacNay and Creelman (1958) reported the species as injurious to apple, cherry, peach, pear, and plum in British Columbia and to apple in Nova Scotia; they also noted that *X. dispar* has not been recorded as a pest of cherry in Ontario and Quebec. Fruit trees (apple) were severely injured and killed in Ontario (CAIPR 1975). Both the limbs and the main trunk of apple trees are commonly attacked (Brittain and Pickett 1933). According to Madsen and Arrand (1971), *X. dispar* is usually a pest of new plantings, although it often attacks older trees. Trees of low vigor (dead, dying, or weakened) are preferred, particularly those that are newly set, frost-injured, or sunscalded, and those in areas where there is a high water table or poor soil (Baker 1972, Bright and Stark 1973). Bright and Stark (1973) reported the frequent destruction of the smaller branches and tips of healthy trees and noted that perfectly healthy young trees may be attacked and killed over a period of 2–3 months. Apparently healthy fruit trees have been killed in British Columbia, especially when growing on poor soil, when recently transplanted, or when under stress (Beal and Massey 1945, Bright 1976). Other recorded hosts include yellow poplar, pine, hemlock, birch, red oak, chestnut, walnut, and other nut trees, holly, honey-locust, hackberry, prune, Japanese ornamental cherry, planetree, *Acacia*, maple, weigela, native willow, tuliptree, and possum-haw (Brittain and Pickett 1933, Mathers 1940, Beal and Massey 1945, Madsen and Arrand 1971, Baker 1972, French and Roeper 1975). Bright (1976) stated that the infrequent records from some species of conifers are probably in error.

According to Brittain and Pickett (1933), the adults usually enter the host just below a bud scar or other unevenness on the surface. Unlike the shothole borer, the entrance holes of these beetles are larger, the galleries reach into the heartwood, and there are short tunnels extending up and down from the main gallery (Madsen and Arrand 1971). Bright and Stark (1973) said that the parent or egg gallery varies according to host conditions and may, in small trees or branches, spiral around the tree upward from the point of entry. Bright (1976) reported that the beetles mined the wood a short distance and then followed a circular course parallel to the annual rings of the host. The insects form a spiral or corkscrew pattern with short longitudinal side galleries in small limbs. Young trees are frequently girdled (Madsen and Arrand 1971). An ambrosial fungus, introduced by the adults, stains the sapwood black in the vicinity of the larval galleries, which are on the same plane as the adult galleries (Brittain and Pickett 1933, Bright and Stark 1973). The larvae do not excavate tunnels or form cradles but feed in the main gallery (Madsen and Arrand 1971, Bright 1976). Both the larvae and adults feed on the spores of the fungus, which does not injure the tree (Madsen and Arrand 1971). Injury is first indicated by a sudden wilting of the leaves, which later die and fall off. Numerous small exit holes in the outer bark also indicate the insect's presence (Brittain and Pickett 1933).

Biology: The adults overwinter in the parental gallery system (Bright 1976). In British Columbia the adults emerge in early spring and attack their hosts. According to Bright (personal communication), the species is partly parthenogenetic, the unmated diploid females producing only haploid males and the mated females producing diploid females. The males mate with sisters and mothers, although outbreeding occasionally occurs. The copulation period averages 10–20 min (French and Roeper 1975). Madsen and Arrand (1971) reported that females flew to new trees in April in British Columbia while the wingless males remained behind. Although a few of the attacking population may reemerge (i.e., in May) and make a second attack, most of the adults apparently die in the tunnels after oviposition (Mathers 1940, Bright 1976). The postdiapause female must feed on its symbiotic fungus, *Ambrosiella hartigii* Batra, for oocyte development and oviposition to occur (French and Roeper 1975). From 6 to 20 eggs were laid per gallery where fungal development was full or complete. A linear relationship exists between the number of progeny and the volume of the galleries. The number of progeny per gallery system averaged 16.8. According to Brittain and Pickett (1933), the eggs are deposited loosely in the galleries during June in Nova Scotia and the developing larvae feed on the ambrosial fungus that coats the gallery walls. The adult stage is reached by about mid July in British Columbia, and the beetles apparently do not emerge until the following year (Bright 1976). French and Roeper (1975) found a female-to-male ratio that averaged 2.2:1 (range, 2:1–8:1). Mathers (1940) also reported a female-to-male ratio of about 2.2:1 but noted that a previous worker usually found a ratio of 4:1 or 5:1. *Xyleborus dispar* produces only one generation each year in British Columbia (Bright 1976).

Anoetid mites were collected from *X. dispar* galleries (French and Roeper 1975). *Ceratocystis* sp. and *Schizophyllum* sp. were discovered along with the symbiotic fungus in the galleries, and the former was isolated from postdiapause and diapause females. *Aspergillus*, *Penicillium*, and *Trichoderma* species were reported to be common contaminants in vitro and fatal to successful brood development.

SILPHIDAE carrion beetles

Most species of this small family are carrion feeders or scavengers, but a few species are phytophagous. The family is found primarily in temperate areas of the northern hemisphere, but a few species are known from Australia, South America, southeast Asia, and the region around Ethiopia. The family contains about 175 species, of which 25 are known from Canada.

Aclypea bituberosa (LeConte)
(spinach carrion beetle)
silphe de l'épinard (m.)

Distribution: British Columbia, Alberta, Saskatchewan, and Northwest Territories.

Economic injury: Both adults and larvae frequently injure beet and spinach by feeding on the leaves (Dustan 1932). Damage may occur throughout the field, but it is generally restricted to the field margins (Harper and Swailes 1956). The insects occasionally attack the following additional crops: barley, cabbage, lettuce, mangel, peas, potato, pumpkin, radish, rhubarb, squash, strawberry, turnip, and wheat.

Biology: The adults overwinter in the soil in and around the following: field margins, ditch banks, roadsides (Harper and Swailes 1956), refuse and hay (Beirne 1971), and alfalfa fields (CIPR 1950). The adults emerge in May and early June and lay eggs to a depth of 5 cm (Harper and Swailes 1956) in moist soil (Dustan 1932).

The larvae are nocturnal and remain in the soil during the day. When disturbed, they drop to the ground and crawl rapidly under clods of soil. Pupation occurs in oval cells in the soil at depths of 2.5–5 cm. Adults emerge in 2–4 weeks and start feeding (Harper and Swailes 1956).

Noneconomic host plants include lamb's-quarters (Harper and Swailes 1956), nightshade (Dustan 1932), and povertyweed (Hatch 1957).

STAPHYLINIDAE rove beetles

Species of this family are distributed in a wide variety of habitats in all faunal regions including arctic and alpine tundra. Most species are predaceous and economically important in controlling populations of destructive insects, but some are feeders of fungus, algae, or pollen. About 30 000 species are known, of which about 1900 are estimated to occur in Canada.

Creophilus maxillosus (Linnaeus)
hairy rove beetle

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Northwest Territories, and Yukon Territory.

Economic injury: This cosmopolitan species is a predator of dipterous and coleopterous larvae and pupae (several species are mentioned) and eats fresh or partly decomposed meat at least occasionally (Hinton 1945). *Creophilus maxillosus* usually occurs on old bones and dead fish, birds, and mammals. It has been found in a granary in London, England, and on wool imported from Australia into Germany.

Biology: The insect overwinters in the adult stage and produces only one generation annually in northern Europe (Hinton 1945). The length of the egg period is approximately 8 days and that of the pupal period about 15 days.

Hinton (1945) reported two hymenopterous parasites, *Exallonyx ater* Nees and *Alysia manducator* Panzer, but stated that the latter record is very doubtful because *A. manducator* is a well known parasite of *Calliphora* larvae.

Deleaster dichrous (Gravenhorst)

Distribution: Ontario and Quebec.

Origin: This species is of European origin and has been introduced into eastern Canada.

Economic injury: This species frequently occurs in dwellings in Ontario and Quebec (MacNay 1955, 1957*b*, CIPR 1963, 1965). It causes no damage, but often occurs so frequently that it is mistakenly assumed to be a household pest.

Quedius mesomelinus (Marsham)

Distribution: British Columbia, Alberta, Manitoba, Ontario, Quebec, Newfoundland, and Labrador.

Origin: According to Smetana (1971) this species is of European origin and was introduced into many parts of the world, so that it is now considered to be cosmopolitan. It was first recorded in North America at Lowell, Mass., in 1886 and was subsequently taken on the West Coast, in Oregon, in 1889 (Hatch 1957).

Economic injury: *Quedius mesomelinus* caused concern to commercial earthworm growers in Vancouver, B.C. (McLeod 1954). In the laboratory, both the larvae and adults killed and fed upon immature and mature stages of the earthworm *Eisenia foetidus* (Savigny), but not on the eggs in cocoons. Only freshly killed hosts were eaten. According to Smetana (1971), in Europe the species lives mainly near human habitation. It has been reported from cellars, stables, barns, storehouses and other farm buildings in various kinds of debris, and decaying organic matter, often also in compost piles. In nature it has been taken from mammal burrows, caves, tree holes, and other similar habitats. According to Lindroth (1957) it is common in west Greenland Inuit dwellings. Hinton (1945) also listed a number of records of this species in Europe in and around the following: exuding sap of trees, leaves, rubbish heaps, haystack refuse, bark, fungi, old bones, *Cassus* burrows, cellars, guano, and oat siftings in mills, warehouses, and silos.

TENEBRIONIDAE darkling beetles ténébrions (m.)

Most species of this large family feed on a variety of plant material. Many larvae live in the soil and are root feeders, others are found in dead wood and fruiting bodies of fungi. Species of a number of genera are among the most widespread and destructive pests of stored products. Darkling beetles are found in all faunal regions but are best represented in arid and tropical regions. About 18 000 species are known, of which 110 are estimated to occur in Canada.

Alphitobius diaperinus (Panzer)
lesser mealworm
petit ténébrion mat (m.)

Distribution: British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, and Prince Edward Island.

Economic injury: This secondary pest of stored products is cosmopolitan in distribution. It thrives in damp situations on grain and cereal products that are spoiled or out of condition. The species is not harmful to grain that is sound and dry (Cotton 1956, Monro 1969). Both the adults and larvae have been found in abundance in the feed and litter of poultry houses (CAIPR 1975, 1976, 1978), in food residues in hog barns (CAIPR 1971, Smith 1975), and in the holds of ships (Monro 1969). The lesser mealworm has also been reported in flour-mill basements, under decaying vegetation (Cotton and Good 1937), and in broiler houses (Preiss and Davidson 1971). According to Monro (1969), the insect is not of great economic importance but its presence is indicative of conditions favorable to the establishment and development of more important pests.

First-instar larvae reared on whole wheat, broken wheat, cowpeas, barley, and rice required 69, 62, 80, 150, and 143 days, respectively, to complete their development, indicating that broken wheat is probably the most suitable and preferred food (Sarin and Saxena 1975). The preferred adult food, based on the number of adults found on each food, fell into the following order: cowpeas, broken wheat, urad, corn, whole wheat, peanuts, grain, and barley.

Biology: Preiss and Davidson (1971) reared the lesser mealworm on a semisynthetic diet in the laboratory in order to study adult longevity, preoviposition period, and fecundity. The adults probably live for an average of more than 400 days. The average preoviposition period for 35 pairs of beetles was 12.7 days (range, 4–30), with 10–14 days the most frequent preoviposition period (21 of 35 observations). Females lay eggs at a slow but relatively steady rate for most of their lives. At room temperature, 58 females laid an average of 3.5 viable eggs per day over a 3-month period. One female averaged 3.8 eggs per day for a total of 2684 eggs over a life-span of more than 703 days. All stages of development (egg, larva, pupa, and adult) are affected by temperature and relative humidity (Sarin and Saxena 1973). Temperatures of 30–33°C and a relative humidity of 90% or more are apparently optimal for normal development of the insect. Development is retarded by higher temperatures (35–37°C) and does not occur at lower temperatures (15°C). A low relative humidity (50%) results in incomplete development. Under optimum conditions, the eggs hatch in 5–6 days, the larval stage is completed in about 50–54 days, and pupation takes 6–7 days. The females either die or fail to lay eggs at a low temperature or low relative humidity. Sarin (1978) mentioned three factors concerning the multiplication of this pest: temperature, relative humidity, and the cannibalistic habit of older larvae that feed on younger larvae under crowded or unfavorable ecological conditions.

Alphitobius laevigatus (Fabricius) [*piceus* (Olivier)]
black fungus beetle (grain mold beetle)
ténébrion du champignon (m.)

Distribution: Ontario.

Economic injury: This cosmopolitan species is closely related to the lesser mealworm and has the same habitat and food preferences (Cotton and Good 1937, Cotton 1956, Monro 1969). Although fairly common, the black fungus beetle is much less abundant than *A. diaperinus* in the United States and does very little damage to clean, dry grain or flour (Cotton and Good 1937, Cotton 1956).

Biology: *Alphitobius laevigatus* is similar in appearance and habits to those reported for the lesser mealworm (Cotton 1956).

Alphitophagus bifasciatus (Say)
twobanded fungus beetle

Distribution: Saskatchewan, Manitoba, and Ontario.

Origin: According to Hatch (1965), this cosmopolitan species is possibly introduced to Canada (Cotton and Good 1937, Good 1956).

Economic injury: *Alphitophagus bifasciatus* is of little economic importance (Cotton and Good 1937). In Saskatchewan a light infestation was reported in stored oats (CIPR 1963). This species is a general feeder on fungi and molds. It is also a scavenger in refuse grain, grain products, and decaying vegetable matter (Cotton and Good 1937, Cotton 1956). It is often found in damp and moldy grain and waste cereal products in and around mills, storehouses, and the holds of ships.

Blapstinus moestus Melsheimer

Distribution: Saskatchewan and Ontario.

Economic injury: CIPR (1931) stated that false wireworms probably cause considerable damage to crops; one infestation of over 500 000 larvae per 0.40 ha, most of which apparently belonged to *B. moestus*, was noted in samples from a field at Marengo, Sask. MacNay (1959) rèported that the species was abundant and was responsible for the girdling of various seedling crops in Saskatchewan. Light injury was observed in three fields of flax and one of canola in the province (CIPR 1961). The species was also found in bins of newly harvested grain in Saskatchewan but did not cause injury (CIPR 1964).

Cynaeus angustus (LeConte)
larger black flour beetle

Distribution: Alberta, Saskatchewan, Manitoba, and Ontario.

Economic injury: The economic injury caused by this species was described by Krall and Decker (1946), Barak et al. (1981), and Dunkel et al. (1982). The larger black flour beetle is primarily associated with products of plant origin and has only recently become an important pest of stored grain products and plant residues. *Cynaeus angustus* has progressively spread to the north and east of its centre of origin, the southwestern United States or Mexico. In its native range it is normally associated with the Agavaceae and other semisucculent plants of the Sonora and Chihuahua deserts. *Cynaeus angustus* was first recorded in Canada at Diana, Sask., in 1944, on grain (CIPR 1952). The insect attacked cereal products in a mill in Medicine Hat, Alta. (MacNay 1952), and was found in a pile of discarded corn cobs in Ontario, where it caused some concern that it might enter homes (CAIPR 1978). Previous records and food-preference tests indicate that this insect is most often taken from corn, which it prefers over such grains as barley, wheat, and oats. The species is more successful on cracked corn, but it can attack the germ of sound kernels. Corn of 14.1% moisture is most suitable for reproduction and survival. Infestations become established during the first summer of storage and increase with duration of storage, contributing to the heating of farm-stored grains. A list of agricultural or stored-grain commodities and natural substances in which *C. angustus* has been recorded is given in Dunkel et al. (1982).

Both adults and larvae may attack several kernels. The larvae most often enter the dent end or the germ area of the kernel, preferring the germ and endosperm as food. On sound corn the larvae chew a more-or-less circular hole through the pericarp to feed on the germ.

Biology: Krall and Decker (1946) studied the biology of *C. angustus* under laboratory conditions (30°C and approximately 73% RH). Both the larvae and adults can withstand long periods at moderately low temperatures, even though there appears to be no diapause or other provision to enable the insect to endure long periods of dormancy. Under favorable temperatures, the larger black flour beetle breeds continuously. During the day the adults tend to hide below the surface of the grain. Adult longevity in nature is probably a year or even longer, as many beetles lived at least 100 days and some lived as long as 6 months in the laboratory. The female deposits her eggs singly but occasionally in groups of two or more in protected places in the food, usually within 5–7 days after emergence. From four to five eggs per female per day were laid in corn with 17–18% moisture. A total fecundity of 360–450 eggs (per female) was estimated assuming an average daily oviposition of 4.5 eggs and a normal egg-laying period of 80–100 days. The incubation period is about 3 or 4 days. Of 22 larvae successfully reared in a desiccator (at 100% RH), 16 had 9 instars, 5 had 10, and 1 had 11. The duration of the larval period ranged from 46 to 55 days, which from further studies appeared to be normal. Extremes in larval development were represented by a minimum of 22 days and a maximum of 92 days. Overcrowding may greatly extend larval life and in many cases may prevent pupation. A short, quiescent prepupal period of 1–2 days normally precedes pupation, which takes place in sheltered locations in the food. The average duration of the pupal period was 5 days (range, 4–6). The newly emerged adults remain teneral for 4 or 5 days.

An undetermined protozoan (order Microsporidia) is a common parasite of *C. angustus*.

Eleodes extricata (Say)

Distribution: British Columbia, Alberta, Saskatchewan, and Northwest Territories.

Economic injury: King (1928) reported *E. extricata* as the only economically important false wireworm in Saskatchewan. The larvae have been injurious nearly every year in the Richmond district. The species was numerous, along with wireworms and cutworms, in a field located in a heavily wooded area at Strasbourg. The insect, however, is usually only encountered in districts of mixed prairie or plains.

Biology: False wireworms in Saskatchewan are most abundant in the drier areas of the southwest, but are also found in small numbers as far as the outer margin of the savanna belt.

Eleodes granulata LeConte

Distribution: British Columbia.

Economic injury: Hatch (1965) reported the species to be an important pest of wheat and corn in eastern Washington. *Eleodes granulata* (as *vandykei* Blaisdell) caused appreciable damage to the seed of wheat in Washington, the larvae being very busy in the dust during fall seeding and again in the spring (CIPR 1923).

Biology: Oviposition was noted on 1 May in Washington (CIPR 1923). The new adults appear in July.

Eleodes hispilabris (Say)

Distribution: British Columbia, Alberta, Saskatchewan, and Manitoba.

Economic injury: *Eleodes hispilabris* is one of several species of false wireworms that usually cause little damage (Strickland 1956, Davidson and Lyon 1979). According to Davidson and Lyon (1979), false wireworms show a preference for wheat but also attack other grasses, cotton, legumes, sugar beets, and garden crops. The larvae feed on the sprouting seeds and young seedlings, and the adults, to a lesser extent, attack various plants above ground. The insect is most injurious in the fall. Strickland (1965) stated that the larvae prefer nibbling at the roots of grain to feeding on the stem and that the adults feed on the foliage of various weeds. The distribution of this species in Alberta is largely limited to the open prairie, especially the drier areas in the south and east. Calkins and Kirk (1975) found *E. hispilabris* to be more prevalent in lighter soils (loam and sand) than in heavier soils (clay). Richard (1971) observed decreases in the abundance of this insect with increasing altitude, a result of cooler temperatures.

Biology: The species overwinters in the adult stage under dense masses of dead weeds as well as in the soil through cracks or rodent burrows and as partly grown larvae in the soil (Strickland 1956, Richard 1971, Davidson and Lyon 1979). The overwintered adults become active in the spring, feeding on young Russian thistle and other weeds (Strickland 1956). When disturbed, they have a habit of standing perfectly still on their heads. Depending on the temperature at the surface of the soil, the beetles may be more active at night or during the day (Richard 1971). Both the adults and larvae burrow deep enough into the soil to minimize the effects of daily and seasonal temperature variations. Oviposition begins around the middle of June in Alberta, and the eggs are deposited just below the surface of the soil (Strickland 1956). These adults may survive until the following fall or even longer. Davidson and Lyon (1979) reported that adults may live for as long as 3 years.

Hatching occurs in July in Alberta, and the larvae are half-grown by winter (Strickland 1956). Feeding is resumed in the spring, and maturity is reached by August when they pupate in the soil. The new generation emerges, and the adults feed on weeds and then hibernate. Davidson and Lyon (1979) noted that eggs may be laid in the spring or late summer (or both), and in the fall, and that larvae feed most actively immediately after hatching. These authors also reported overwintered larvae pupating in the spring and emerging as adults over a period of several weeks. The life cycle of this species may take 2 years to complete (Beirne 1971, Davidson and Lyon 1979).

A species of *Calosoma* is mentioned as a possible predator of *E. hispilabris* (Richard 1971). Although a chemical secreted by this species protects it to some degree from common vertebrate predators, it is nevertheless preyed upon by the grasshopper mouse (*Onychomys leucogaster*).

Eleodes novoverrucula Boddy

Distribution: British Columbia and Alberta.

Economic injury: *Eleodes novoverrucula* is considered to be an important pest of wheat and corn in eastern Washington (Hatch 1965). It has not been reported to damage these crops in Canada.

Eleodes tricostatus (Say)

Distribution: Alberta, Saskatchewan, Manitoba, and Northwest Territories.

Economic injury: *Eleodes tricostatus* is one of several species of false wireworms that are usually only of minor importance (Davidson and Lyon 1979). King (1928) reported that the insect occurs in small numbers mostly in gardens in Saskatchewan but causes no real damage. The larvae feed on the sprouting seeds and young seedlings; the adults, to a lesser extent, attack various plants above ground. Most false wireworms favor wheat, but they may also attack other grasses, cotton, legumes, sugar beets, and garden crops (Davidson and Lyon 1979). The insects are most injurious in the fall. According to Criddle (1919), the larvae, which closely resemble cutworms in habit, emerge above ground at night to devour the leaves of suitable hosts and occasionally to cut the stem off close to the surface. These larvae feed above ground, differing from cutworms, which partly drag their food underground to feed. Although wheat was readily eaten by these general feeders, lamb's-quarters was favored. In captivity, the larvae ate redroot pigweed, lamb's-quarters, Russian thistle, tumbleweed, Russian pigweed, wild buckwheat, hare's-ear mustard, tumble mustard, cabbage, turnip, beet, wheat, oats, barley, rye, and bran. Calkins and Kirk (1975) noted that *E. tricostatus* was evenly distributed among the three soil classes (clay, loam, and sand).

Biology: According to Davidson and Lyon (1979), the life cycles of the various species of false wireworms vary to some extent. Oviposition occurs in the spring or late summer (or both), and in the fall, and the larvae feed most actively immediately after hatching. These false wireworms spend the winter as partly grown larvae and pupate in the spring; the adults emerge over a period of several weeks. The adults, which may also overwinter, live for as long as 3 years. Criddle (1919) reported *E. tricostatus* to pupate about 18 August in Manitoba, with adults emerging the second week in September.

Gnathocerus cornutus (Fabricius)
broadhorned flour beetle

Distribution: British Columbia, Ontario, and Nova Scotia.

Economic injury: The broadhorned flour beetle has been reported to be a pest of stored products in mills and warehouses in British Columbia (MacNay 1959, Sinha 1965*b*). According to Cotton and Good (1937), this cosmopolitan species rarely occurs in numbers sufficient to cause much damage. *Gnathocerus cornutus* prefers flour and meal but also occurs in a variety of other grains (Cotton 1956).

Biology: Adults often live a year or more (Cotton 1956). Each female deposits 100–200 eggs that hatch in 4–5 days in warm weather. Approximately 8 weeks are needed for development from egg to adult.

Gnathocerus cornutus thrives at moderate temperature and needs a moderate RH. According to Howe (1965), 16°C and 40% RH constitute the minimum temperature and humidity at which it can multiply in numbers sufficient to become a pest. The optimum temperature range is 24–30°C, and the maximum rate of increase every 4 weeks is about 15-fold.

Sclerodermus immigrans Bridwell and the mites *Acarophenax tribolii* Newstead and Duvall and *Pediculoides ventricosus* Newport are mentioned as parasites and predators by Cotton and Good (1937).

Latheticus oryzae Waterhouse
longheaded flour beetle

Distribution: Quebec and New Brunswick.

Origin: This species is widely distributed throughout the tropics and subtropics. It is not known to be established in Canada but is often intercepted at ports.

Economic injury: *Latheticus oryzae* is a pest of grain, cereal, and other produce (Monro 1969, Nowosielski-Slepowron and Aryeetey 1980). In the United States it is of little economic importance except in the Southwest (Cotton and Good 1937). The longheaded flour beetle is destructive in mills, granaries, and holds of ships (Cotton and Good 1937, Monro 1969). Stored products injured by the species in various parts of the world include pasta, dried cassava, oatmeal, provender, tea, sorghum, and maize (Nowosielski-Slepowron and Aryeetey 1980).

Biology: Nowosielski-Slepowron and Aryeetey (1980) conducted rearing experiments with four populations of this species to study the biology of laboratory and field populations under various conditions of temperature and humidity. Although these authors noted the duration and mortality of each development stage of the four populations, only the duration of the laboratory population (at a relative humidity of 75%) is reported here. The eggs hatched in an average of 3.6 $\pm$ 0.5 days (range, 3–4) at 37°C. The incubation period for all populations was longest at 25°C and shortest at 37°C. All eggs shriveled and died within a week at 20°C. Tenebrionids rarely have fewer than six larval instars, but at temperatures of 30°C and above, pupation occurred after only four or five instars. The number of larval instars varied from four to eight at temperatures of 37–27.5°C. The prepupal stage requires at least 24 h at 37°C and up to 3 days at 27.5°C. The pupal period ranged from 3 to 8 days at temperatures of 37 and 27.5°C, respectively. The total development period (egg to adult) is inversely related to temperature and required an average of 42.6 days (range, 40–46) at 27.5°C to 19.1 days (range, 18–22) at 37°C. The lower development limit of *L. oryzae* is substantially higher than that of other stored-product beetles. Because of the long development period and high mortality, the insect does not thrive at temperatures below 27.5°C.

According to Howe (1965), 26°C and 30% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 33–37°C, and the maximum rate of increase every 4 weeks is 10-fold.

Cotton and Good (1937) reported *Acarophenax tribolii* Newstead and Duvall to be a parasite of the longheaded flour beetle.

Palorus ratzeburgi (Wissmann)
smalleyed flour beetle

Distribution: Ontario and Quebec.

Origin: This species is cosmopolitan in distribution. Biological and systematic evidence indicate that it originates in North Africa (Halstead 1967).

Economic injury: The smalleyed flour beetle has been reported to be a stored-product pest in Quebec (Sinha 1965*b*). It is commonly found in flour mills in the United States, where it is the smallest of the so-called flour beetles known to attack grain and grain products (Cotton 1956). *Palorus ratzeburgi* possesses much the same habits and appearance as the closely related depressed flour beetle. The species prefers to breed in milled products but frequently occurs in stored grain. Both adults and larvae attack grain, flour, chicken feed, and milled products (Cotton and Good 1937). Halstead (1967) noted several records of the species in stored produce from various parts of the world and stated that its occurrence under bark may represent a recolonization of the natural habitat from that of stored products.

Biology: Halstead (1967) described the biology of this species from specimens taken on moldy grain residues at a farm in Kent, England. At a temperature of 30°C and a relative humidity of 80%, the minimum preoviposition period was 2–3 days, the peak oviposition period (days after pairing) was 9–36 days, the maximum egg production per female per 3-day period was 20 eggs and the mean daily egg production per female was 3.4 eggs for 13 pairs (1–2 days old) over a period of 96 days, after which all pairs were still alive. At temperatures of 17.5 and 40°C and 70% RH, the eggs required an average of 33.3 days (range, 29–39) to 4.3 days (range, 4–5) to hatch, respectively. The eggs failed to hatch at temperatures of 13 and 42.5°C.

Halstead (1967) did not determine the number of larval instars but reported that Butler (1949) found from six to eight instars at about 30°C and 65% RH. At temperatures of 20–37.5°C and 70% RH, the average larval and pupal periods varied from 55.1 and 13.8 days at 20°C to 26.9 and 3.8 days at 37.5°C. No adults were produced at

17.5 and 40°C, and most of the larvae died in the first or second instar. At 70% RH the minimum and maximum development periods from egg to pupa were 67–78 days at 20°C and 20–29 days at 35°C. Relative humidity did not appear to affect the duration of the pupal period.

Cotton and Good (1937) stated that *Acarophenax tribolii* Newstead and Duvall is a parasite of the smalleyed flour beetle.

Palorus subdepressus (Wollaston)
depressed flour beetle

Distribution: Manitoba.

Origin: This species is widely distributed throughout the tropics and southern temperate regions. According to Halstead (1967), the depressed flour beetle may have originated in West Africa and is now, except for the north-temperate region, almost cosmopolitan in distribution. Smith (1975) reported that the first Canadian record of the insect was made in southern Manitoba in April 1974 and suggested that the species may have been introduced with corn from the Great Plains region of the United States.

Economic injury: Adults and larvae have been discovered in residues of coarsely ground feed on the floor of hog parlors in southern Manitoba (Smith 1975). The species is similar in habit and appearance to the closely related smalleyed flour beetle (Cotton and Good 1937, Cotton 1956). Both adults and larvae of the depressed flour beetle reproduce in grain and milled products (particularly in flour mill basements) (Cotton and Good 1937). Halstead (1967) listed several records of the species in stored products from other parts of the world and also noted instances in which the insect occurred under bark, which may represent a recolonization of the natural habitat from stored products. Although *P. subdepressus* is unlikely to withstand winter temperatures in unheated granaries in Canada, it may, however, become established in heated buildings or in heating grain or grain products (Smith 1975).

Biology: The life history of this species was described by Halstead (1967). The oviposition of the depressed flour beetle was studied at 25, 30, and 35°C, and 70 and 80% RH, with two food renewal periods (6- and 30-day intervals). The minimum temperature for egg laying is near 20°C at 70% RH. A shorter life span was noted at 30°C than at 25°C, and a higher rate of oviposition resulting in a higher mean total egg production was recorded at the higher temperature. The optimum temperature for oviposition was near 30°C. At 80% RH the maximum oviposition (635 eggs) more than doubled that recorded at 70% RH, and the maximum life-span was greater. The general oviposition performance was greatest at 30°C, 80% RH, with food renewal after 6 days. Under these conditions, the minimum preoviposition period was 2 days, the peak oviposition period (days after pairing) was 6–33 days, the mean daily egg production per female was 2.5 eggs, the maximum life span (and eggs laid by the individual) was 240 days (635 eggs), the maximum individual egg total (and length of period in which they were laid) was 635 eggs (237 days), and the maximum postoviposition period was 15 days.

The effect of temperature and humidity on the duration of the egg period was determined by exposing eggs at 70% RH to various temperatures and at 25°C to various levels of humidity. At 70% RH the eggs hatched from an average of 20.2 days at 17.5°C to 3.3 days at 32.5°C. Hatching occurred at all temperatures between 17.5 and 37.5°C but not at 15 or 40°C. The percentage of hatch was very high over the 20–35°C range (at which the life cycle may be completed) but was lower at 17.5 and 37.5°C. Neither the incubation period nor mortality of the eggs was affected by humidity at 25°C. Hatching occurred after 6.5 days at 0–2% RH and 8 days at 100% RH.

Seven larval instars appeared to be typical for this species, with occasionally eight or nine instars occurring before pupation. The effect of temperature on the larval and pupal periods was determined at 70% RH over the range 17.5–37.5°C. At 70% RH the respective mean larval periods at temperatures of 20 and 35°C were 96.3 to 28.2 days, respectively. The larvae completed development over the 20–35°C range but failed to develop at temperatures of 17.5 and 37.5°C, dying in the first or second instar. Temperatures between 30 and 32.5°C appeared to favor a minimum development period and mortality. The optimum humidity for the temperatures studied was about 80%. Larval development may be completed at a relative humidity as low as 70% but not 60% at 20°C, and 50% but not 40% at 25 and 30°C. The duration of the larval period decreased at higher levels of humidity. The larvae construct a cell in the substrate and enter a quiescent, prepupal period that lasted 3 days at 25°C and 1–2 days at 30°C. At 70% RH the pupal period, at temperatures of 20 and 35°C, lasted an average of 14.5 to 3.5 days, respectively. The pupal period was not affected by humidity at 25 and 30°C, but at 20°C the pupal period was longer at 70% RH than at 80 or 90% RH. There was little pupal mortality.

Tenebrio molitor Linnaeus
yellow mealworm (European meal worm)
ténébrion meunier (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Origin: Cotton (1956) noted that the yellow mealworm is probably of European or Asiatic origin, but is now almost cosmopolitan in distribution.

Economic injury: According to MacNay (1952), *T. molitor* is an incidental pest in flour and feed buildings in coastal areas of British Columbia and in farm granaries throughout Canada. Cotton and Good (1937) reported the species to be a moderately important pest of stored grain and milled products. The mealworms prefer decaying grain or milled cereals that are moist and out of condition but also eat products that are not decaying such as meal, flour, bran, grain, coarse cereals, bread, crackers, mill sweepings, meat scraps, feathers, and dead insects (Cotton 1956). They are most often in and around the following: dark, damp places, grain bins, sacks of feed, litter of chicken and bird houses, mills, elevators, feed plants, and warehouses (Cotton 1956, Neilson and Arrand 1958, Monro 1969). Monro (1969) reported a tendency of the insect to migrate into sound material. The yellow mealworm may occasionally cause damage in unexpected places such as bags of fertilizer and salt, boxes of soda ash, bales of tobacco, and ground black pepper. Its presence alone may cause more damage to owners than actual feeding, as large numbers of the larvae may deter prospective buyers (Cotton 1956). Adults have occasionally been numerous in homes, and it is believed that they have originated outdoors. In some cases they have been attracted to homes by lights (MacNay 1951, 1952). MacNay (1949) found *T. molitor* to be one of the species that occurred most frequently in the residues of grain storage boats docked at Fort William and Port Arthur, Ont. Monro (1969), however, stated that the pest is of secondary importance on ships.

The yellow mealworm and the dark mealworm have practically the same life history and habits and are often found feeding together (Metcalf et al. 1951, Cotton 1956). These beetles are the largest known to attack grains and cereal products (Davidson and Lyon 1979).

Biology: The biology of this species is described from Metcalf et al. (1951) and Cotton (1956). The species normally overwinters in the larval stage. Pupation occurs in the spring and early summer at which time the adults begin to appear. The female deposits from 250 to 1000 eggs, averaging between 400 and 500, singly or in clusters in the food material. The adults die after 2–3 months. The incubation period lasts for 4–18 days, averaging about 2 weeks. The larval stage usually lasts for 6–9 months. It was noted, however, that a complete generation may take from 4 months to nearly 2 years. Mature larvae often wander in large numbers into unusual places (probably in search of a suitable location to pupate). No cocoon or protective covering is constructed for the pupa. Under natural conditions, only one generation is produced annually.

Cotton and Good (1937) reported *Caloglyphus mycophagus* Megnin to be a predator of the species.

Tenebrio obscurus Fabricius
dark mealworm (American meal worm)
ténébrion obscur (m.)

Distribution: British Columbia, Alberta, Ontario, Quebec, and Newfoundland.

Origin: This species is cosmopolitan in distribution. According to Cotton (1956), T. obscurus is probably native to Europe or Asia.

Economic injury: Cotton and Good (1937) reported T. obscurus to be a moderately important pest of stored grain and milled products. The mealworms prefer decaying grain or milled cereals that are damp and have been left undisturbed for some time, but they also eat products that are not decaying such as meal, flour, bran, grain, coarse cereals, bread, crackers, mill sweepings, meat scrap, feathers, and dead insects (Cotton 1956). They are most often found in and around the following: dark, damp places, grain bins, sacks of feed, litter of chicken coops and birdhouses, mills, elevators, feed plants, and warehouses (Cotton 1956, Neilson and Arrand 1958, Monro 1969). Monro (1969) noted a tendency of the insect to migrate into sound material. The dark mealworm may cause more trouble by its presence in unusual places (e.g. bags of fertilizer and salt, boxes of soda ash, bales of tobacco, ground black pepper) than by its actual feeding, because large numbers of the larvae may deter prospective buyers (Cotton 1956). The insect was found in abundance in a house in Hamilton, Ont. in 1939 (Gibson and Twinn 1939). MacNay (1949) found *T. obscurus* to be one of the most frequently occurring species in the residues in grain storage boats at Thunder Bay, Ont. Monro (1969), however, pointed out that the pest is of secondary importance on ships.

The dark mealworm and the yellow mealworm have a similar life history and habits and are often found feeding together (Metcalf et al. 1951, Cotton 1956).

Biology: The biology of this species as reported by Metcalf et al. (1951) and Cotton (1956) is not significantly different from that reported for *T. molitor*.

Tenebrio picipes Herbst

Distribution: British Columbia, Ontario, and Quebec.

Economic injury: *Tenebrio picipes* usually occurs under the bark of dead wood, but it is also known to feed on cereal products (CIPR 1946). An apartment was infested in Quebec City, Que. Cotton and Good

(1937) reported this cosmopolitan species from stored cereals in the United States and from stored grain in Japan.

Tribolium audax Halstead
American black flour beetle (black flour beetle)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Economic injury: This species has been reported as a food pest that occurs in stored grain in Saskatchewan (CAIPR 1976, 1978). According to Watters (1976), *T. audax* is occasionally detected in empty granaries in the Prairie Provinces but does not normally infest stored grain. The American black flour beetle is sometimes found in retail stores and warehouses, where it frequently infests packaged foods (Northwest Line Elevators Association 1959). *Tribolium audax* occasionally occurs in boxcars carrying flour (along with the very closely allied *T. madens*) and in cells of the bee *Megachile rotundata* (Fabricius) (Becker 1982). Davidson and Lyon (1979) noted that it is found mostly in flour mills of the northern and western United States. According to Cotton and Good (1937), the species usually occurs under bark but is sometimes taken in flour, meal, seeds, and grain. Leech (1943) reported the insect under the bark of *Pinus ponderosa* and *P. monticola* and also mentioned that it attacked and killed fly larvae of the family Bibionidae in leaf mold under a log in British Columbia.

Biology: In boxcars, *Tribolium audax* (like *T. madens*) probably breeds in spaces where grain and other refuse can accumulate and remain undisturbed (Becker 1982).

Comments: As the true *T. madens* has been discovered only recently in North America (1977 according to Becker 1982), early reports referring to the American black flour beetle as *T. madens* (i.e., Cotton and Good 1937, Leech 1943, Northwest Line Elevators Association 1959 and Sinha 1965*b*) are misidentifications of *T. audax*. The earliest known specimens of *T. madens* are those taken by Loschiavo from a boxcar in Winnipeg in August 1979 (S. R. Loschiavo, personal communication).

Tribolium castaneum (Herbst)
red flour beetle (rust-red flour beetle)
tribolium rouge de la farine (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec.

Origin: The red flour beetle is cosmopolitan in distribution. According to Lepesme (1944), *T. castaneum* possibly originated in India, where it is still found in natural conditions under the bark of trees. The species was first recorded in Canada in Saskatchewan, in 1955 (MacNay 1955).

Economic injury: The red flour beetle is second only to the confused flour beetle in importance as a pest of ground cereal products (Cotton 1956). The species chiefly attacks milled-grain products, feeding only on grain dust, and broken kernels in whole-grain storage (Davidson and Lyon 1979). Watters (1976) noted an increase in the occurrence of the insect in stored grain over the previous 5 years and reported serious infestations in farm-stored grain and in country elevators in various areas throughout the Prairie Provinces. CAIPR (1971) stated that in the Prairie Provinces this species is usually found in grain that has become heated. *Tribolium castaneum* has been numerous in hammered oat straw in Saskatchewan and in wheat and barley in the other Prairie Provinces; the species occasionally occurs in retail stores and warehouses, where it frequently infests packaged foods (Northwest Line Elevators Association 1959). Monro (1969) reported the red flour beetle to be a common pest in both food stores and cargo spaces of vessels. This insect, although incapable of feeding on sound, unbroken grain kernels, quickly becomes established on grain that has been physically damaged by other insects. When disturbed, the species produces a malodorous secretion that may cause a food to acquire an unsuitable, pungent odor when large populations are present. Infestations in homes have been noted in Saskatchewan (MacNay 1955, 1956) and Ontario (MacNay 1948). The species is usually found indoors, occurring infrequently outdoors under bark (Cotton and Good 1937). Both adults and larvae attack a great variety of products including most kinds of grains, cereal products, flour, starchy materials, beans, peas, baking powder, ginger, dried plant roots, dried fruits, dead insects, herbarium specimens, nuts, chocolate, certain drugs and spices, yeast, snuff, and cayenne pepper (Cotton and Good 1937, Metcalf et al. 1951, Philip 1977). Seeds of clover cultivars were found to be suitable for development but not for multiplication (Sinha 1972). Sinha (1976) reported that the species reproduced well on both rapeseed and sunflower seed and indicated that the insect may become a pest of farm-stored oilseeds in Manitoba.

The red flour beetle is similar to the confused flour beetle in appearance and habit but is less abundant in temperate regions, preferring a more subtropical climate (Cotton 1956, Neilson and Arrand 1958, Davidson and Lyon 1979). Unlike the confused flour beetle, this pest is capable of flight in warm weather and may be blown into farm houses and buildings (Neilson and Arrand 1958, Watters 1976).

Biology: Each female of *T. castaneum* deposits 400–500 eggs (maximum of almost 1000) on sacks or in cracks in the floor (Metcalf et al. 1951, Davidson and Lyon 1979). Philip (1977) reported a fecundity of 300–400 eggs per female over a period of 5.5 months. According to Davidson and Lyon (1979), the eggs hatch in a week or more; Philip (1977) reported a period of about 9 days and Metcalf et al. (1951), 5–12 days. Howe (1956*b*) recorded the duration of the egg period (and percentage of hatch) at various temperatures from 20 to 40°C. At 20°C, 77% of the eggs hatched and the egg period was 13.9 days; at 40°C, 86% of the eggs hatched and the egg period was only 27 days. The eggs failed to hatch at any humidity at 15 or 17.5°C. Humidity did not affect the percentage of hatching or the duration of the egg period at a higher temperature except at 40°C and 10% RH, when the eggs did not hatch. The optimum temperature for egg development was about 37.5°C, with very rapid development occurring at all temperatures between 32.5 and 40°C. The average life span of the adults is approximately 1 year (Davidson and Lyon 1979). According to Metcalf et al. (1951), the adults frequently live for 2 years or more and are capable of withstanding moderately cold winters in unheated buildings.

Workers in Howe (1956*b*) recorded from four to eight larval molts. Larval development requires from 22 to more than 100 days (Philip 1977), depending on temperature and type of food. On wheat feed at 90% RH, the mean larval period at temperatures between 37.5 and 22.5°C was 12.7–44.9 days, respectively. All larvae died at 40 and 20°C (Howe 1956*b*). Larvae are somewhat more sensitive than eggs to extreme conditions. They failed to complete development at 20°C and did not pupate at 90, 30, or 10% RH at 40°C. A few, however, completed development to the adult stage at 70 and 50% RH at 40°C. Both temperature and humidity influence the length of the larval stage. The larvae developed fastest at the highest humidity used at any temperature and at 35°C for each level of humidity.

At maturity the larvae pupate and remain in this stage for 1–2 weeks (Davidson and Lyon 1979, Metcalf et al. 1951, Philip 1977). The length of the pupal period at temperatures between 40 and 20°C varied from 4.4 to 24.4 days (Howe 1956*b*). Humidity does not influence the length of the pupal period. Pupal development was fastest at 37.5°C. Pupal mortality is low (except at 20°C, when they all died at emergence). The insect required an average of 20.3 days to develop from egg to adult at 35°C and 70% RH.

The species requires high temperature and is tolerant of low humidity. According to Howe (1965), 22°C and 1% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 32–35°C, and the maximum rate of increase in 4 weeks is 70-fold (see also Watters 1976). Sinha (1971) reported the temperature limits for growth and reproduction to be 21 and 38°C.

Metcalf et al. (1951) noted that a complete generation is passed in 3–4 months at high temperatures and that four or five generations are produced annually in heated storehouses or mills under Kansas conditions. In such places, all stages of the red flour beetle may be found at any time of the year.

Triboliocystis garhami Dissanaike (Gregarinida: Ophryocystidae) and *Gregarina polymorpho* Steiner (Gregarinida: Gregarinidae) are parasites of *T. castaneum* (Graham 1965). Cotton and Good (1937) listed the following parasites and predators: *Acarophenax tribolii* Newstead & Duvall, *Lebia* sp., *Pediculoides ventricosus* Newport, *Rhabdepyris zeae* Turner & Waterston, and *Sclerodermus immigrans* Bridwell.

Tribolium confusum Jacquelin duVal
confused flour beetle
tribolium brun de la farine (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: This cosmopolitan species was first reported in the United States in 1893 (Metcalf et al. 1951).

Economic injury: The confused flour beetle is the most common and injurious insect pest of flour mills in North America (MacNay 1954*b*, 1958, 1960; Cotton 1956; Neilson and Arrand 1958; CIPR 1964; Davidson and Lyon 1979). The species primarily attacks milled-grain products (Neilson and Arrand 1958, Davidson and Lyon 1979). In whole-grain storage, only grain dust and broken kernels are eaten. The pest is commonly found in mills and warehouses, granaries, grain shipments, grocery stores, and houses (Metcalf et al. 1951, Cotton 1956, Philip 1977). MacNay (1951) reported the development of moderate to severe infestations in mills and warehouses in Saskatchewan; Cotton (1956) noted that *T. confusum* may be found in all parts of the milling machinery and that it is the most frequently occurring insect in flour after it has been taken from the mill. The species has been reported as one of the three most common insects in farm granaries in eastern Canada (MacNay 1952). In Ontario the insect has been prevalent and injurious to stored wheat, usually occurring together with the sawtoothed grain beetle and the granary weevil (Ross and Caesar 1931). It also attacks stored grain in western Canada (rarely) (Sinha 1971, CAIPR 1975). The species may be associated with heating grain (Watters 1967). According to MacNay (1951), food materials in stores and dwellings are frequently infested in most provinces. Monro (1969) stated that the insect very commonly occurs in both food stores and cargo spaces of ships. Even though the confused flour beetle cannot feed on sound, undamaged grain kernels, it can quickly establish itself in grain that has been physically damaged by other insects. When disturbed, the species produces a malodorous secretion which may cause a food to acquire an unsuitable, pungent odor, and even a pinkish color when a large number of insects are present. *Tribolium confusum* is usually found indoors and is only rarely taken outdoors under bark (Cotton and Good 1937). Both adults and larvae attack a great variety of products including all kinds of grains, cereal products, flour, starchy materials, animal feed, meal, corn, beans, peas, baking powder, ginger, dried plant roots, dried fruits, dead insects, herbarium specimens, nuts, chocolate, certain drugs and spices, yeast, snuff, and cayenne pepper (Gibson and Twinn 1931, 1939; Cotton and Good 1937; Metcalf et al. 1951; Watters 1967; Philip 1977). The insect has also been found in the malt mill of a brewery (MacNay 1953) and in a marijuana shipment (CAIPR 1974). In studying the seeds of 16 cultivars (flax, mustard, canola, sunflower, millet, and clover), Sinha (1972) found that *T. confusum* reproduced only on sunflower and millet. Only the seeds of clover and flax cultivars were suitable for development.

The confused flour beetle and the red flour beetle are similar in life history, habit, and appearance (Philip 1977). The former species, however, predominates in temperate regions, the latter preferring a more subtropical climate (Davidson and Lyon 1979).

Biology: Adults of the species are active and move quickly when disturbed (Metcalf et al. 1951) but cannot fly (Monro 1969, Philip 1977). Each female lays 400–500 eggs (maximum near 1000) on sacks or in cracks in the floor (Metcalf et al. 1951, Cotton 1956, Neilson and Arrand 1958, McFadden 1966, Davidson and Lyon 1979). Philip (1977) reported a fecundity of 300–400 eggs over a period of 8 months. The eggs hatch in 5–12 days (Metcalf et al. 1951). The adults live for an average of about 1 year (Neilson and Arrand 1958, Davidson and Lyon 1979), although they can often live for 2 years or more and withstand moderately cold temperatures in unheated buildings (Metcalf et al. 1951).

Larval development requires from 22 to more than 100 days (Philip 1977), depending on temperature and type of food. The mature larvae pupate in the food material; the pupal stage requires 1–2 weeks according to Metcalf et al. (1951). Davidson and Lyon (1979) reported that the development from egg to adult takes approximately 4 weeks in warm habitats.

The species requires a high temperature for development and is tolerant of low RH. According to Howe (1965), 21°C and 1% RH constitute the minimum temperature and humidity at which the species can multiply in numbers sufficient to become a pest. The optimum temperature range is 30–33°C, and the maximum rate of increase in 4 weeks is 60-fold.

Metcalf et al. (1951) stated that a complete generation lasts 2–4 months at high temperatures and that four or five generations are produced annually in heated storehouses or mills under conditions in Kansas. In such places, all stages of the confused flour beetle may be found at any time of the year. Neilson and Arrand (1958) reported as many as six generations each year.

Triboliocystis garhami Dissanaike (Gregarinida: Ophryocystidae) and *Gregarina polymorpho* Steiner (Gregarinida: Gregarinidae) are parasites of *T. confusum* (Graham 1965). Cotton and Good (1937) noted the following additional parasites and predators: *Acarophenax tribolii* Newstead & Duvall, *Pediculoides ventricosus* Newport, *Rhabdepyris zeae* Turner and Waterston, and *Xylocoris cursitans* Fallén (Anthocoridae).

Tribolium destructor Uyttenboogaart
(large flour beetle)
tribolium de la farine (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia, Prince Edward Island, and Newfoundland.

Origin: Cotton and Good (1937) reported the native distribution of this species to be Germany and the Netherlands. It was first recorded in Alberta in 1945, in British Columbia in 1951, and in Saskatchewan in 1956 (MacNay 1950, 1961).

Economic injury: According to Cotton (1956), *T. destructor* is not as yet of great importance in North America. The species is well established as a pest of flour in Alberta (MacNay 1950) and appears to be more abundant than *T. confusum* in that province (McFadden 1966). It has also been reported to be a minor food-infesting insect (MacNay 1955), occurring infrequently in flour mills in the Prairie Provinces (MacNay 1957*b*). CAIPR (1978) noted the appearance of this food pest in stored grain in Saskatchewan. The insect has also been found in cereal products in houses in British Columbia (CAIPR 1975), in rolled oats in a supermarket, in a house in Prince Edward Island (CIPR 1963), and in a dwelling in Ottawa, Ont. (MacNay 1953). Cotton and Good (1937) reported the species in seed houses, warehouses, and flour mills in Germany and the Netherlands. It is injurious to seeds and also occurs in flour, meal, and animal products.

Biology: According to Philip (1977), this species has a similar life cycle to that of *T. castaneum* and *T. confusum*. The adults live for about a year, and a female may deposit 400–500 eggs (McFadden 1966). Hatching occurs within a week. The larvae become full grown in a month and then pupate.

Tribolium madens (Charpentier)
(black flour beetle)

Distribution: Manitoba, Ontario, Quebec, New Brunswick, and Nova Scotia.

Origin: The discovery of a few specimens of *T. madens* in stored products at the United States army base at Fort Knox, Ky., on 27 July and 16 November 1977 constituted the first North American records of this native European species (Becker 1982). The species was first taken in Canada from a boxcar in Winnipeg, Man., on 3 August 1979. Since then the insect has been found in boxcars containing flour for export at Halifax, N.S., and Saint John, N.B., in 1980, and in boxcars carrying bagged flour from several mills in Ontario and Quebec to Halifax and Saint John, in 1981.

Economic injury: *Tribolium madens* infested over 100 boxcars in Canada in 1981, in some cases with hundreds or even thousands of specimens occurring (Becker 1982). Occasionally, small numbers of the very closely allied *T. audax* are also reported in boxcars carrying flour, but *T. madens* is the dominant species. Now firmly established in North America, the insect may become an important pest of flour. In Europe *T. madens* has been a pest in flour mills and has caused significant injury in honey bee hives.

Biology: The species is thought to breed in spaces on boxcars where grain and other refuse can accumulate and remain undisturbed for some time (Becker, in press).

Comments: Earlier reports of *T. madens* in the literature are misidentifications of *T. audax*. The two species are difficult to distinguish.

Upis ceramboides (Linnaeus)
(roughened darkling beetle)
ténébrion rugueux (m.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Northwest Territories, and Yukon Territory.

Economic injury: In western Canada, particularly Manitoba, this foul-smelling beetle often occurs in kitchens, especially in boxes where firewood is stored (Gibson and Twinn 1931). *Upis ceramboides* is commonly found outdoors under the bark of decayed or decaying trees.

TROGOSITIDAE trogositid beetles

Most larvae of this family are predaceous, but one species is a widely distributed pest of stored products. About 600 species are estimated from all faunal regions, 25 of which occur in Canada.

Tenebroides mauritanicus (Linnaeus)
cadelle
cadelle (f.)

Distribution: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, and Newfoundland.

Origin: This introduced species is a native of the western Mediterranean region (Hatch 1962).

Economic injury: The cadelle is a common pest in ships, mills, warehouses, and elevators (Bond and Monro 1954). It also occurs in farm-stored grain (MacNay 1949, 1950) and as a household pest (Gibson and Twinn 1939, Neilson and Arrand 1958, CIPR 1976). The species feeds on grain, grain products, cereal, nuts, spices, fruit, and biscuits (Neilson and Arrand 1958) in both adult and larval stages (Hatch 1962). Monro (1969) explained that the loss of grain caused by *T. mauritanicus* is out of proportion to the amount consumed. This results from its habit of devouring the germ and leaving the rest of the kernel untouched. Both larvae and adults bore into the woodwork of storage compartments and emerge later to reinfest new shipments. They also damage packaging, spilling the contents. Their activity also provides hiding and breeding sites for other stored-product pests. According to Yoshida (1975), the cadelle is also predacious, feeding on other stored-product insects that play an important role in the natural control of these insects.

Biology: Rout and Patnaik (1978), in India, studied the life history of *T. mauritanicus* under various conditions of temperature and food. The summary of their results is supplemented by other observations where indicated.
Copulation took place 1–3 days after adult emergence. The preoviposition period varied from 23 to 54 days, depending on food type. Eggs are deposited in clusters of 16–90 at 2- to 7-day intervals. Oviposition sites included food material and protective crevices (Bond and Monro 1954). The average number of eggs deposited by single females ranged from 316 to 677, depending on the type of food supplied. According to Monro (1969), a single female may lay up to 3000 eggs under favorable conditions. At 30°C, the mean incubation

period was 5.2 days. At the same temperature, adults lived an average of 242 days.

The larvae passed through four or five instars during the course of their development. Back and Cotton (1926) reported a maximum of 11 larval molts. Larvae that were fed white or whole wheat flour had five instars, whereas larvae that were fed rice or wheat had only four instars. At 30°C the mean duration of each larval instar was 14.6, 13.7, 15.9, 16.3, and 13.2 days, respectively. At variable temperatures of 27.2–34.7°C, the five larval instars averaged 14.0, 22.3, 21.0, 24.7, and 13.0 days, respectively. First-instar larvae were observed boring into the grain of wheat and rice, and the second-instar larvae fed on the germ portion but did not enter the grain. During the third-instar stage, the larvae were more active and negatively phototactic.

At maturity the larvae bored into wood or cork to pupate. The chamber was sealed with excavated material mixed with larval secretions (Back and Cotton 1926). The prepupal stage lasted 8–9 days, and the pupal stage varied from 9 to 13 days. The total life cycle was shortest on a diet of whole wheat and longest on white flour. Newly formed adults required at least an additional week to harden their exoskeletons (Bond and Monro 1954). According to Neilson and Arrand (1958), there is probably only one generation a year in British Columbia.

The species overwinters in the adult or larval stage, the eggs and pupae being less cold resistant (Back and Cotton 1926). According to Cotton and Good (1937), the species is parasitized by the bethylids *Cephalonomia nigricornis* Sarra and *Sclerodermus immigrans* Bridwell.

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