Dairy husbandry in Canada

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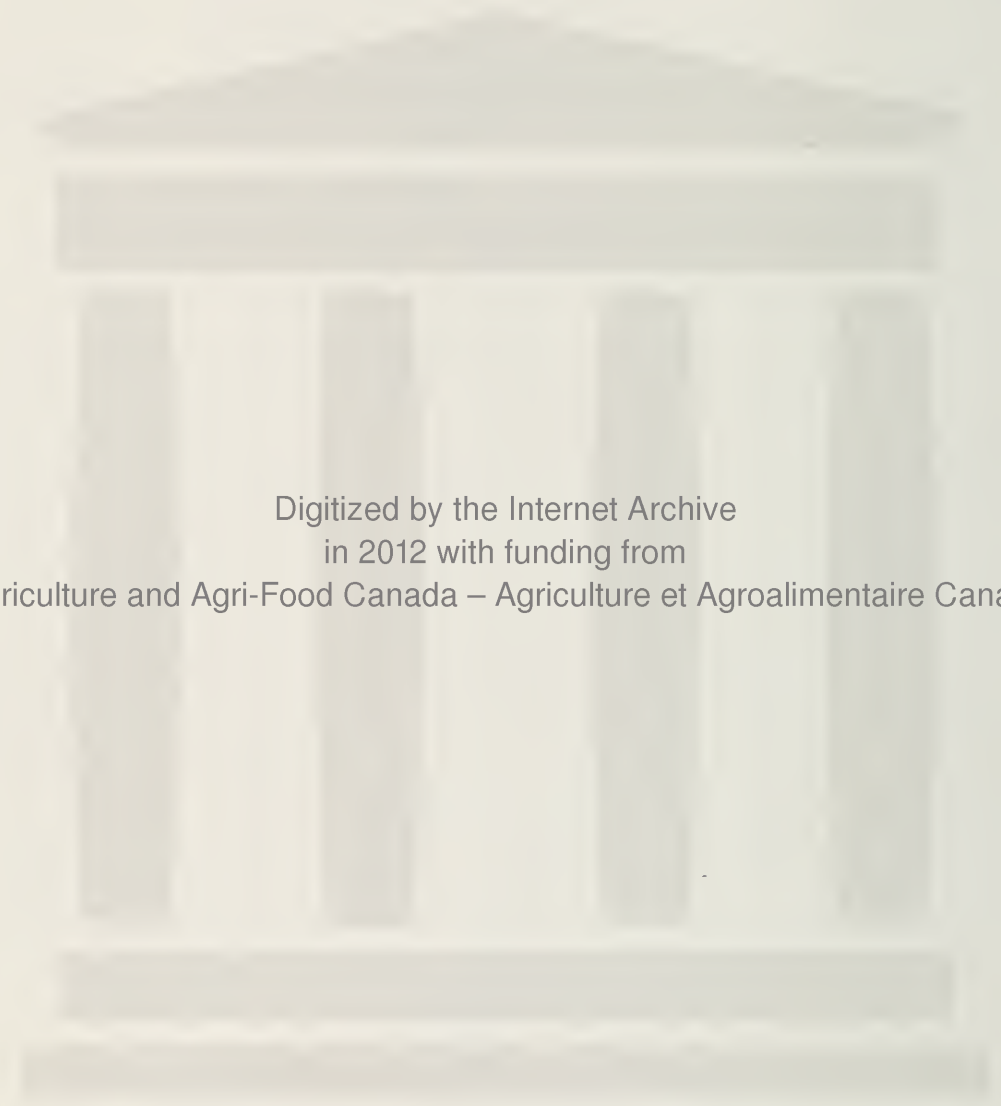

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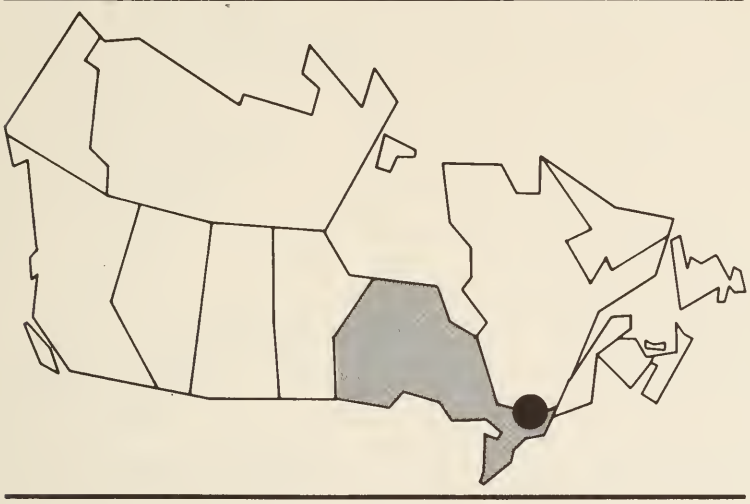

CANADA/ONTARIO

DAIRY HUSBANDRY IN CANADA

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dairy husbandry in canada

Because of the contribution she has made to the health and physical well-being of mankind, the dairy cow has frequently been described as the foster mother of the human race. This docile creature whose cud-chewing habits seem to brand her as a model of simplicity is indeed a very complex machine, one that is capable of consuming raw material of low quality and converting it into nature's finest and most nutritious food.

Although the dairy cow has contributed much to the health of mankind, she has also helped to enhance the financial status of those who have adopted her as the medium through which their primary farm products are marketed. Even so, she does not respond equally when subjected to all types of conditions; rather she produces most abundantly when given proper nourishment, adequate housing, reasonable care, and capable attention when attacked by pests or disease. Such being the case, this bulletin is being published for the purpose of providing persons interested in dairy husbandry with information which should, if applied, point the way to a more profitable dairy enterprise.

BREEDS

Six breeds of dairy cattle — Ayrshire, Brown Swiss, Canadienne, Guernsey, Holstein and Jersey — are in use in Canada. In addition, two dual-purpose breeds, the Red Poll and the Shorthorn, are used in milk production. No figures are available on the actual numbers of each breed but the registration of purebred animals in Canada provides an indication of the relative number of animals of these breeds.

From the standpoint of breed improvement, the number of purebred cows on a recognized production-testing program is of much more importance than the numbers of animals registered each year, since production records are essential for accurate selection. The last two columns in Table 1 show the number of purebred cows of each breed that were on test in 1980.

TABLE 1

Registration and production testing of dairy cattle by breeds in Canada – 1980

Breed	Number reg'd	% of total	No. on R.O.P.	% of total tested
Ayrshire	10 320	7.1	17 209	8.3
Brown Swiss	1 388	1.0	834	0.4
Canadienne	609	0.4	1 802	0.9
Guernsey	2 092	1.4	4 226	2.0
Holstein-Friesian	124 944	85.5	173 396	83.6
Jersey	6 674	4.6	9 998	4.8
	146 027	100.0	207 465	100.0

The dual-purpose breeds, as the name implies, possess some of the fleshing characteristics of beef breeds and produce considerable amounts of milk although at a somewhat lower level than the breeds which have been designated as primarily dairy (Table 2).

There is a growing awareness of the potential for meat production from the dairy animal, so that the terms "dairy type" and "beef type" are not as definitive as they once were.

Individuals planning to establish a dairy herd should stop to consider the breed of cows to be maintained. Factors of importance in this decision are:

- Milk market available
- Personal preference
- Market for surplus breeding stock, both local and export
- Availability of cattle of high genetic merit, both females and sires

TABLE 2

Production of cows tested on R.O.P. in Canada – 1980[1]

Breed	No. of records[2]	Average production		
		Milk (kg)	Fat (%)	Fat (kg)
Ayrshire	14 633	5 426	4.07	221
Brown Swiss	699	5 450	4.16	227
Canadienne	1 294	3 855	4.38	169
Guernsey	3 572	4 740	4.83	229
Holstein-Friesian	144 209	6 479	3.76	244
Jersey	8 479	4 186	5.16	216
Red Poll	1	5 238	3.93	206
Dual-purpose Shorthorn	233	4 206	3.80	160

[1] Actual production in 305 days

[2] Purebred and National Identification Program grades

No comparison between breeds has been attempted in this publication. Each of the dairy breeds demonstrates by its existence that it can make a contribution to the Canadian dairy industry.

In many classes of stock such as swine, poultry, and sheep, the commercial animal is a cross of two or more recognized breeds or strains, yet the vast majority of dairy cattle on the North American continent is purebred animals of a given breed or high-grade animals of a particular breed. Experimental evidence for distinct superiority of the crossbred dairy cow over purebreds does not presently exist and, until it is demonstrated that hybrid vigor does exist for milk yield and/or other economic traits, the commercial dairy cow will continue to be a purebred or high-grade animal of one or another of the recognized dairy breeds.

DAIRY CATTLE IMPROVEMENT

Milk Recording Systems

Dairy cows vary greatly in their ability to produce milk and butterfat even on a within-breed basis. Much of this variation is due to the manner in which cows are fed. Inheritance is a factor as well in determining variation in milk and butterfat production, and low production due to this cause cannot be corrected by feeding.

Each dairyman should institute some method of measuring each cow's performance. If a dairyman is not concerned about the butterfat content of milk, he can develop his own system of evaluating cows by simply weighing the quantity of milk produced by each cow at each milking and totaling the individual weighings at the end of each lactation. Dairymen, however, are interested in butterfat test as well as quantity and can enroll their herds on a milk-recording program that will provide detailed information.

Canadian Milk Recording Board

The Board was set up in 1974 to develop and standardize milk recording procedures. Membership includes representatives from each provincial recording program, the Dairy Farmers of Canada, Joint Dairy Breeds Committee, major dairy breed organizations, the A.I. industry and Agriculture Canada. The Board has a Technical Committee to provide scientific guidance.

Record of Performance

Record of Performance (R.O.P.) is the policy sponsored by Agriculture Canada for the purpose of providing a service to test milk production in dairy herds. At one time R.O.P. testing was limited to purebred herds, but the policy has been extended to include grade cows in herds having at least 15 purebreds. Some 240 inspectors are involved in checking the milk production and in

certifying the records of cows in R.O.P. herds. Each herd is visited about 10 times annually. Official records are based on the amount of milk produced in 305 days. Breeders wishing further particulars about the policy are advised to contact the Chief R.O.P. Inspector, Animal Production Division, Agriculture Canada.

In 1979, there were 143 150 cows enrolled on supervised programs and 314 231 on owner sampler programs throughout Canada.

Dairy Herd Improvement Programs

Each province offers milk-recording programs that are designed basically for the commercial breeder. They are the "standard" dairy herd improvement and the "owner sampler" programs.

The "standard" D.H.I. program is quite similar to R.O.P. in that it is guided by the standards set by the Canadian Milk Recording Board. Records have official status and are used for breed improvement and sire valuation. This program also includes some information on feeding and management. Applicants for enrollment are grouped into associations, each comprising 20—24 members. A supervisor assigned to an association visits each member's farm for one day each month. While on the farm he records the production of each cow at two consecutive milkings. He takes a sample from each milking and tests the composite sample of each cow. The test information is forwarded to the provincial authority where the information on each cow's lactation is accumulated.

All provinces conduct unsupervised "owner sampler" programs. These recording plans vary from province to province, but essentially they are designed to provide a culling standard for each participating herdowner. A small enrollment fee allows participation. A herdowner simply weighs the milk production of each cow once a month and takes a sample of her milk. The production figures and milk samples are then sent to a testing center. The production data will be accumulated and a statement of production issued for each completed lactation.

Dairymen interested in D.H.I. testing should contact their provincial agricultural representative.

Artificial Insemination

The artificial insemination of dairy cattle has evolved, in the past 35 years, from a novel technique to a major industry which has influenced the course and rate of dairy cattle improvement to a profound degree.

ORGANIZATION

In Canada, there are eight artificial insemination units with a complete program of semen production, insemination services and a young sire proving program for dairymen. Two of the units are in the Atlantic Provinces, one in Quebec, four in Ontario and one in British Columbia. Dairy cattle breeders in

the Prairie Provinces are mainly supplied by semen-producing businesses in other provinces. Two A.I. units in Alberta and one in Saskatchewan collect and distribute semen from dairy bulls. The A.I. units are producer owned and managed or owned and operated by provincial governments.

SCOPE OF OPERATIONS

The first A.I. unit was established at Waterloo, Ontario, in 1941 and 317 services were accomplished during the first year of operation. In 1979 1 200 000 first services were accomplished in Canada. This represents more than 70% of the total dairy cow population in Canada. It is of interest to note that about 85% of the total registrations in the pure dairy breeds in 1979 were A.I. progeny. Approximately two thirds of the services were to proven sires.

SIGNIFICANCE OF A.I.

Artificial insemination had its beginnings as a means of providing owners of commercial herds with service to superior bulls which they could not afford to buy and use in natural service. The artificial insemination industry has found, in addition to this basic purpose, a far broader application. Provided A.I. sires are truly superior and the breeder selects progeny-proven sires to use in his herd, the potential for herd and breed improvement with A.I. is greater than with natural service. The following points support this statement.

- A.I. makes possible the development and identification of genetically superior sires. These sires are referred to as "Plus Proven Sires".
- Genetically superior sires in A.I. service have an infinitely wider use than would be possible in natural service. One "Plus Proven" bull may breed many thousands of cows artificially and many such sires have been mated to over 10 000 females in a year.

More will be said about proven sires in the section entitled "Sire Selection". Other advantages associated with artificial insemination are:

- Economy – The cost of A.I. service is low compared with the cost incurred through ownership of a natural service sire.
- Disease prevention – A.I. prevents the spread of such reproductive diseases as vibriosis, brucellosis and trichomoniasis. These diseases may be spread by natural mating.

Artificial insemination is an established procedure in dairy herds throughout Canada. Under competent herd management, no problems peculiar to A.I. in respect to reproduction should be encountered. The benefit obtained in terms of increased production from the daughters of sires proven to be superior is at once the purpose and the accomplishment of artificial insemination.

Breed Improvement Programs

In addition to the milk recording policies provided by the federal and provincial governments, breed associations have provided awards and policies to encourage the improvement of dairy cattle. The awards differ from breed to breed but, generally, are intended to recognize members of breed organizations who have made significant achievements in the breeding and development of dairy cows. Recognition is also made of outstanding brood cows and sires.

Canadian breeders of dairy cattle currently have an extensive export market. In 1980, exports of purebred animals amounted to 15 200. A large number of unregistered cattle of the dairy breeds are exported annually as well and the demand for Canadian dairy cattle is keen. Breeders are well aware of the fact that presently, many buyers prefer animals that are attractive in appearance and closely resemble an ideal in conformation. As long as buyers are willing to pay higher prices for cows of a certain type, the dairyman who derives a portion of his income from cattle sales will select for cows of this type as well as for high production. If exports of Canadian dairy cattle are to be maintained there must be a continual improvement in the productive capability of our cattle. Higher levels of production will continue to become more important as world population increases. A discussion of the relationship between type and production will follow in the next section.

Breed associations have assisted the breeder in selecting for purebred stock by sponsoring type classification programs for a number of years. The basic objective of these programs is to encourage breeders to have their animals classified from the standpoint of type in the expectation that this information will be used as a basis for selection of herd replacements.

TYPE AND PRODUCTION

Numerous research studies have indicated that overall visual appraisal for conformation or type is not an accurate means of identifying superior-producing cows especially when compared to even one lactation record on the cow. In fact, overall type and milk production are essentially independent traits, genetically. This point is illustrated by the fact that A.I. sires with high production proofs do not necessarily have high type proofs.

It should be recognized by all dairymen, both with purebred and commercial herds, that selection on the basis of overall type alone will not necessarily increase milk production; nor will selection solely for milk yield bring about any improvement in body conformation. This is not to say that the two traits of good type and high production cannot be combined in the same animal. However, if both are to be improved, both must be considered in selecting animals and the rate of improvement in each characteristic will be slower than if type or production alone is considered. It simply takes longer to improve both traits than one alone. One component of type, "dairy character", is a

useful indicator of production when no production records are available, since it is positively associated genetically with production.

The utility aspect of type has long been considered of major importance. It is essential that a cow be physically sound if she is to produce large quantities of milk for several years. Many cows leave the herd annually because of udder injuries and mastitis. The cow's udder approaches the ground at a rate of 2.5 cm per lactation and deep udders are more prone to mastitis and injury. Thus selection for udders that are held up above the hocks may decrease losses from these causes.

Further research is needed to indicate the type of cow that will stand up under heavy production for a number of lactations. If research indicates that the present ideal should change in some respects, then breeders and breed associations must be willing to make these changes. Otherwise, there is danger of a departure of ideal type from utility. Certainly, overall breed improvement requires continued emphasis on increasing production.

Selection of Dairy Cattle

Selection begins when the new dairyman goes out to assemble a herd. The beginner is wise to seek the guidance of an extension specialist or a successful dairyman in making his first purchases. Once the herd is established, selection is practiced by choosing the sires and females that will be allowed to leave offspring in the herd. If the dairyman does not select superior cows and sires as the parents of the next generation of calves, and conversely cull or remove inferior cows and avoid the use of inferior bulls, his herd will not improve genetically.

The purpose of this section is to deal with some of the basic principles in establishing a breeding program for dairy cattle.

BREEDING GOAL

Each dairyman must establish an objective in his breeding program and, having established it, must pursue it with determination. A breeding goal is established by examination of the dairyman's operation to determine those traits of the dairy cow which are of the most economic importance. The relative emphasis to be placed on traits in an economic program will vary from operation to operation depending on the milk market, the potential for sale of cattle and the kind of cattle making up the dairy herd. The dairyman can hope to improve by selection only those traits that are inherited (Table 3).

Traits of importance vary in their heritability. The heritability of a trait tells us how much improvement we can expect in the next generation of offspring when we select in our herd the superior animals for that trait as parents. It is generally known that the heritability of milk yield is approximately 0.25. This tells us that about 25% of the total difference observed in production between two animals is due to differences in their genetic makeup or breeding

worth. If cow A in a given herd produces 5443 kg of milk as a 2-year-old while cow B produces only 4536 kg as a 2-year-old in the same herd, not all of this difference is due to differences in the two cows' breeding worth or value. In fact, for milk yield with a heritability of 0.25, only 25% of the difference of 907 kg or 227 kg of milk will be due to the genetic superiority of cow A. The heritability of different traits ranges all the way from 0 to 1. The heritability of most traits of economic importance ranges from 0.1 to

TABLE 3

Traits of importance to dairymen

Trait	Trait effects
Low heritability	
Days dry	Milk yield and replacement costs
Days open	Milk yield and replacement costs
Calving interval	Milk yield and replacement costs
Productive life	Replacement costs
Reproductive efficiency	Milk yield and replacement costs
Medium heritability	
Yield	Direct milk sales
Type score	Breeding sales
Mastitis resistance	Milk yield and treatment costs
Milking qualities	Labor costs
High heritability	
Fat percent	Prime differential
SNF percent	None presently
Protein percent	None presently
Mature size	Maintenance costs and sales

0.4. If the heritability of a trait is very low, ranging from 0 to 0.2, this simply indicates that differences between animals are not due primarily to differences in their breeding worth but are due mostly to environmental factors such as feeding and management. In contrast, for traits such as fat percentage, which has a relatively high heritability, observed differences between cows are largely genetic. Traits may be generally grouped into those with low, medium or high heritabilities. Traits that are considered low in heritability cannot be improved significantly by the selection of superior animals. These traits respond readily to improvement in management or feeding procedures. The discerning dairyman will not include in his selection goal traits with low heritabilities. It is essential that in shaping a breeding goal the dairyman include only traits that are inherited to at least a medium extent.

In summary, each dairyman in shaping a breeding program, should consider his operation, determine those traits that are of most economic importance in his herd, and concentrate on selection to improve those traits which are inherited. At the same time, he must improve his feeding and management practices to realize improvement in low heritability traits which respond to an improved environment.

TRAITS TO EMPHASIZE IN SELECTION

All dairymen are forced to remove from their herds annually a certain percentage of cows that are abnormal reproductively, have acute mastitis, suffer injuries, or are simply too old to perform. Generally speaking, as many good cows leave herds for these reasons as poor cows. It is only after these cows have been removed from the herd that the dairyman is free to cull cows on traits that he considers important. Sound management practices will minimize the percentage of cows leaving the herd annually for disease, injury, and other reasons of this sort, and maximize the dairyman's opportunities to select on traits included in the breeding goal.

We should narrow down the list of characters to be considered in the breeding goal by eliminating those with low heritabilities. No economic incentive presently exists for selection of cows on the basis of the solids-not-fat or protein content of milk. Recent research indicates that little emphasis should be placed on size as a means of increasing milk yield. If the herd is given adequate feeding and management, size probably should receive little attention unless particular individuals are excessively large or small. The amount of emphasis to be placed on fat percentage will vary with the market for milk but, undoubtedly, this trait must be considered under most herd conditions. One approach to maintain fat percentage at a desired level is to set a lower limit for fat percentage in the herd, and to use bulls whose daughters test high for fat percentage until this limit has been passed. Fat test can be maintained at the lower limit by the use of sires whose daughters test at least this high. Only the traits in the medium heritability group remain. These should be given the most emphasis in a dairy cattle breeding program. These are milk yield, type score, milking qualities, and possibly resistance to mastitis. A mastitis control program should eliminate mastitis as a major problem in our dairy herds, allowing us to concentrate our selection on milk yield, fat percentage and to some extent, on conformation and milking qualities.

The dairyman who wishes to cull accurately must obtain accurate records on each cow. Records of milk yield and fat percentage can be obtained by enrolling in one of the milk-testing policies previously outlined. Careful observation of the herd at milking time will provide information on milking qualities. With good records, the dairyman is well equipped to cull those cows which are inferior for the traits which he considers to be important. The

average dairyman testing his herd, derives approximately 80% of his gross income from the sale of milk and milk products and 20% of his gross income from the sale of all livestock. Undoubtedly, purebred breeders will derive a larger percentage of their gross income from the sale of breeding stock. However, milk yield will be emphasized in all breeding programs. The procedures which may be used in culling cows for milk yield are generally applicable to culling cows for fat percentage, type score and milking qualities.

CULLING TO INCREASE PRODUCTION

One method of improving the production of a dairy herd is to cull the low producers. There is no problem in determining what to do with very low-producing cows but cows that are close to the herd average in production create a problem. Is it better to cull an older cow and give a lower-producing, first-lactation heifer another chance, or should the older cow be retained? If kept in a herd, very low-producing 2-year-olds may do better in succeeding lactations but their future records usually will be below their herd mates by something like 50% of the differences between the herd average and their first lactations. One very practical reason for retaining the sound older cow rather than a 2-year-old is that the mature cow will produce about 25–30% more than her younger competitor.

We might summarize culling procedures for production in point form as follows:

- Enroll in a production-testing program.
- Give all females one record before culling. This procedure will be possible in most herds of 20–25 cows but it is not practical in larger herds, since the number of first lactation females would be too great. Owners of large herds should retain replacement heifers out of the highest-producing dams, and by superior production sires. All sires have some good daughters, but the top progeny-tested sires will produce a much higher percentage of these superior animals.
- Compare all females in the herd on the basis of their milk and fat yield expressed on a Breed Class Average (B.C.A.) basis. The B.C.A. index corrects records for the effects of age and enables us to compare the records of cows of different ages, thus culling the lowest-producing animals.
- Most severe culling should be done on first and second lactation females. Older cows that are consistently below the average of the herd should also be removed when possible.
- When decisions are close between two females, the dairyman should consider all differences between the two animals. Differences in age, fat test, udder soundness, temperament, milking qualities, and performance of offspring will generally indicate which animal should be retained.

- The accuracy of culling is increased by considering all records on a cow, each record being compared to the herd average at the time it was initiated. Procedures to estimate the breeding value of a cow are outlined in Appendix Table A-9. These procedures provide the most accurate evaluation of a cow on all of her records.

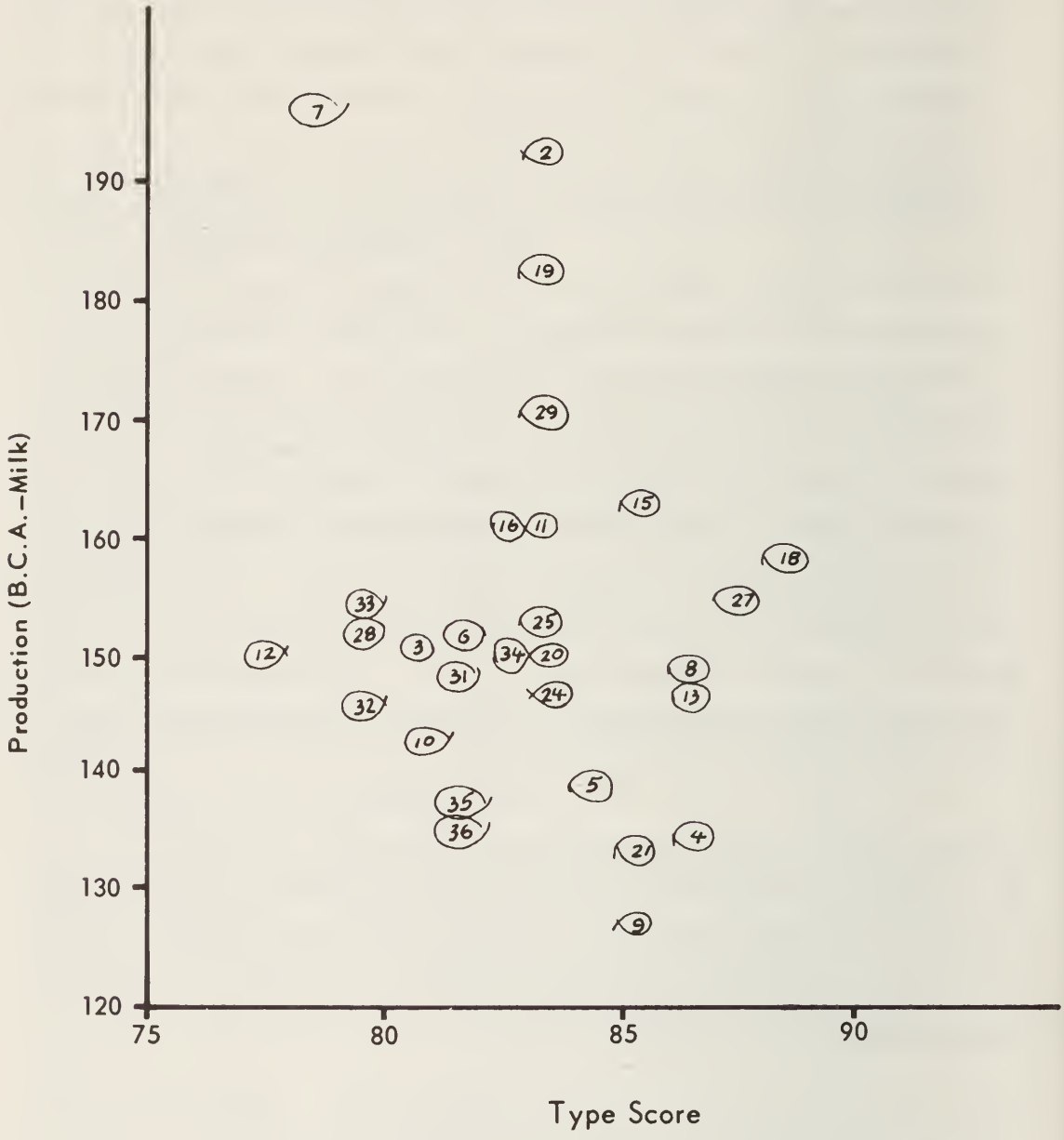
The procedures that have been outlined are most useful in evaluating cows for production. This is the most important single trait to the dairyman and must receive top priority in cow selection. When the dairyman is interested in more traits than production, information must be obtained on each of these traits and cows must be ranked on the basis of each of these traits before they can be accurately culled. There are no simple procedures to evaluate cows on a large number of traits and rank them accurately, particularly if different emphasis is to be placed on each trait in culling cows. Cows may be ranked on the basis of two traits, as shown in Figure 1. Note that the production expressed as B.C.A. for milk yield is plotted along the left-hand vertical axis, and the type score of each cow is plotted along the horizontal axis. Each number shown in Figure 1 represents a given cow, thus cow number 32 had a score for type of 80.0 and a B.C.A. of 146 for milk yield. Note that no close association is apparent between high type and high production in the herd illustrated. If the cows in this herd were to be selected solely on production, cow numbers 9 and 21 would be culled first. If the cows in the herd were to be selected solely on type, cow numbers 12 and 7 would be culled first.

Dairymen who select with some emphasis on both traits would cull cows that are inferior for both traits. In the illustration, cow numbers 10, 35, and 36 fall into this category. Such a chart is often useful to rank the herd on two traits such as milk yield and fat percentage, milk yield and type, or fat percentage and type. It does enable the dairyman to identify and weed out cows that are inferior in a number of traits.

Milk yield has been plotted in actual averages of B.C.A. indexes for milk but could also be plotted as the average difference of the cow's records from the herd average as computed in Appendix Table A-9.

The comparison of two cows that are in different herds is accurate only if each cow's record has first been compared to the average of the herd in which she made her record. As an example, one might wish to purchase one of two cows each having records with a B.C.A. index of 120% for milk. Cow A made her record in a herd averaging 100% B.C.A. for milk while cow B made her record in a herd averaging 120% of B.C.A. for milk. Cow A is 20 B.C.A. points above her herd average while cow B is only a herd average cow. Since most differences between herds are environmental rather than genetic, one is wiser to buy cow A, other things being equal.

FIGURE 1 – Method of ranking cows on two traits (each number represents a cow)



"Proven Sire Concept"

The selection of a sire to be used in a herd is the most important decision in the improvement of dairy cattle. Progressive dairymen recognize this fact and, after consideration of the information on a number of bulls, make a careful decision in favor of one or two bulls for extensive use in their herds.

The most reliable indicator of the breeding worth of a dairy bull is information on the performance of a large number of daughters scattered at random through a large number of herds. Before the initiation of artificial insemination (A.I.) few bulls sired daughters in more than one herd. The performance of the progeny of a bull in a single herd is not an accurate indicator of his breeding worth. At best the performance of up to 40

daughters in a single herd is only 50% as accurate as an A.I. progeny test on a reasonable number of daughters. Today, as a result of progeny testing through A.I., we know with a high degree of accuracy the breeding worth of a large number of sires and their services may be obtained through A.I. studs.

Some breeders will continue to select young bulls on pedigree and use them extensively in their herds. A percentage of the bulls so chosen will be good but some will be inferior and only a progeny test will separate the inferior from the superior with accuracy. It is almost inevitable that in the future, the majority of breeders will use A.I. progeny-tested superior sires extensively in their herds, sampling young, unproven bulls on the heifers and younger cows in their herds. Those breeders who will continue to use their own sires will undoubtedly arrange to sell enough semen to other breeders so that a reliable progeny test is obtained on these bulls.

In concluding, we may simply state that it is well established that the best indicator of a sire's breeding value is a progeny test based on a large number of daughters in a large number of herds. The dairyman who continually uses superior progeny-tested sires on his main cow herd will insure steady genetic improvement of his cattle. This, in a nutshell, is the "proven sire concept".

SIRE SELECTION

A sire whose daughters are superior to the daughters of other sires for a given trait is a breed improver for that trait. This does not indicate anything about his breeding worth for other traits. A truly great sire will leave daughters that are superior to the progeny of other sires for all traits of economic importance. Let us briefly outline procedures for identifying the breed improvers for traits that may be of economic importance to Canadian dairymen.

Milk Yield

All first-lactation milk records are used to evaluate dairy sires. These records are analyzed to obtain a comparison for milk production for each sire with a sizable number of daughters. The results of these comparisons are published in a semiannual report on sire appraisal by the Animal Production Division of Agriculture Canada. All breeders may obtain these reports. The same information is released to dairymen by means of A.I. Stud newsletters so that each dairyman has at his disposal the information on a large number of bulls that have been progeny-tested in a number of herds.

How do we decide if the bull is a breed improver on the basis of his progeny test? Let us consider milk yield. Table 4 shows the sire appraisal information on a number of plus-rated bulls as it is reported semiannually by the Animal Production Division.

The bulls listed have a sufficient number of daughters in a large enough group of herds to compute a reliable proof. Their 2-year-old daughters are compared

to 2-year-old daughters of other sires in the same herd. Bulls with ratings above the average for the breed group are breed improvers for milk and butterfat yield. Bulls below the breed group average will, on the average, decrease milk yield. Sire selections should be made from breed improvers (i.e., bulls with plus milk ratings). The higher the plus rating of a sire the better chance the breeder has of obtaining a high percentage of superior-producing cows. The point is illustrated in Figure 2. Bull A with a rating of +5.3 has a much higher percentage of daughters that are superior to their contemporaries in milk yield. Although bull B has some superior daughters, many more of them are low in production.

Improvement of the milk-producing capability of our dairy cattle depends in large measure on all cows in the dairy herd being mated to sires that are rated plus for milk.

There is one exception to this rule. Occasionally a dairyman has a herd that produces milk with a low percentage of butterfat. If no proven sire is available with a plus rating for milk, which will also improve fat percentage, the dairyman may be justified in using a sire with a slight minus rating for milk and a high average for fat percentage.

In Table 4, the first two digits in the semen code column indicate the A.I. unit in which the bull is maintained.

Semen may be obtained from living A.I. sires through the local A.I. Stud. Information on privately owned bulls must be obtained through the breed association and, in general, proofs based on a group of daughters in a single herd are not good indicators of a sire's breeding worth.

Fat Percentage

Sires that will improve fat percentage may be selected by comparing the average fat percentage of their daughters to the average for the appropriate breed. Breed averages for fat percentage for the year 1976 are shown in Table 5.

Feeding and other management conditions have little effect on fat test and thus a contemporary comparison is not necessary for this trait.

A.I. Stud newsletters and sire appraisal reports always show average fat percentage of the daughters of each bull. Breed improvers for fat percentage are sires whose daughters test above the breed average. Once the herd is testing at a sufficiently high level, however, the dairyman is wise to concentrate selection on sires that are breed average or better for fat percentage and above breed average for other traits.

Type

A sire which is superior for conformation will have daughters that exceed the breed average for type score or exceed the breed average for the percentage of

TABLE 4

Canadian dairy sire comparison — Holsteins
October 1980

Semen avail.	Semen code	Number	Name	BCA Milk	BCA Fat	% Fat	Rep milk	Daughters	Herds
1	39H00026	325149	Kopiah Nina Bootmaker Matt	21	14	-0.21	94	319	138
1	73H00194	335192	Doorco Elevation Major	19	17	-0.07	74	44	38
1	73H00126	315487	Ingholm Klondike	19	16	-0.08	99	2591	981
1	70H00143	333473	Clinton Camp Majesty	18	17	-0.05	77	56	45
1	73H00209	336701	Leblanc Vibration	18	14	-0.11	85	101	88
2	39H00029	323379	Carnation Sunnyside Elegance	18	16	-0.06	83	85	54
2	94H00045	336337	Browndale Sir Christopher	18	13	-0.14	60	30	23
1	71H07392	308691	Roybrook Starlite	17	21	0.11	99	2905	1212
1	73H00211	333860	Aquarius Elevator	16	12	-0.13	77	53	46
1	39H00024	321698	Madawaska Endeavor	16	7	-0.24	83	86	61
1	73H00250	339262	Roybrook Ribot	16	14	-0.06	72	38	42
1	89H00054	293681	Edgeware Commander Ray	15	5	-0.28	97	1109	259
1	73H00164	326314	Inglwae Make Rite	15	10	-0.14	79	65	46
1	28H00026	329511	Rolling-Lawns Brent	15	10	-0.15	82	84	29
1	73H00244	341252	Skokie Elevation Telstar	14	13	-0.03	74	46	46
2	69H00005	314579	Ronbeth Lucky Seven	14	15	0.04	95	443	120
1	73H00177	330643	Roybrook Tempo	14	13	-0.03	93	283	192
2	39H00047	330605	Meadow Green Portrait	14	3	-0.30	70	36	25

TABLE 4 (Continued)

Canadian dairy sire comparison — Holsteins
October 1980

Semen avail.	Semen code	Number	Name	BCA Milk	BCA Fat	% Fat	Rep milk	Daughters	Herds
1	70H00155	335958	Hilltopper Rolls Royce	13	8	-0.15	78	60	48
1	70H00135	324718	Wykholme Dewdrop Supreme	13	10	-0.10	81	76	67
2	70H00027	317750	Flemingdale Citation Fury	13	7	-0.17	92	248	152
1	72H00236	339263	Roybrook Merit (Twin)	13	17	0.09	68	35	36
1	70H00150	333194	Flintstone Royal Adam	13	14	0.03	63	23	21
1	73H00235	337679	Stanhope Cannonade	13	15	0.06	64	24	24
2	73H00140	319416	Cedelmar Black Jack	13	11	-0.05	94	312	226
1	73H00247	337521	Langholm Shalimar	13	8	-0.14	60	18	20
2	70H00003	311497	Northcroft Admiral Citation	12	9	-0.11	99	3670	1173
1	71H00704	324652	Birch Hollow Royalty	12	5	-0.21	95	473	330
1	94H00050	336166	Roybrook Celebrity	12	13	0.00	79	73	46
1	73H00236	340353	Lime Hollow Dekol	12	7	-0.14	72	38	39
1	39H00073	336331	Sunnylodge Fond Gavin	12	13	0.02	65	26	23
1	28H00032	321619	High-Silo Haven Jetstar (RF)	12	9	-0.08	87	124	48
1	72H00222	337865	Illini-Ivy Image	12	8	-0.11	91	221	157
1	73H00186	333063	Robthom Elevation Gaylord	12	10	-0.06	83	86	70
2	70H00123	289318	Tayside Pabst Rockman	12	12	-0.01	99	3243	1240

daughters scored "Good Plus" or better. All sires of each dairy breed with 10 or more classified daughters are summarized on type periodically by the Department of Animal Science, Ontario Agricultural College, University of Guelph. These summaries are available from the Department of Animal Science, as well as from Breed Associations and A.I. Studs. In each of these sire summaries, the information on individual sires is listed across the table and at the top of each table is shown the breed average for overall classification and each scorecard component. If the average of the sire's daughters is above the breed average for overall classification, as well as for any particular scorecard component, the sire may be considered a breed improver for either overall classification or the particular scorecard component. In general, if a dairyman should find that his herd is weak in a

FIGURE 2 — Distribution of daughters of two sires based on contemporary comparison

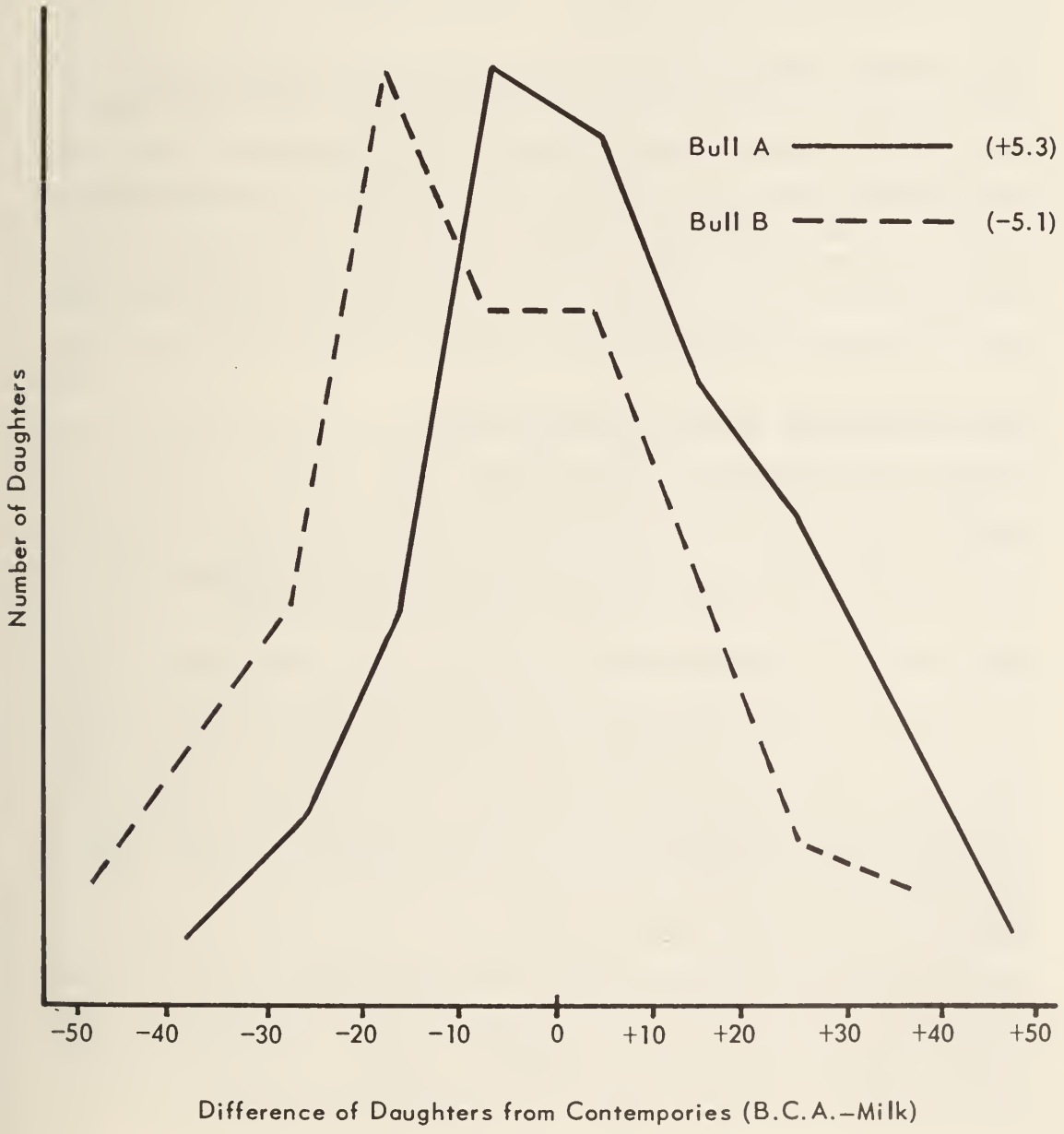


TABLE 5

Average fat percentage of diary breeds on R.O.P. 1980

Breed	% Fat
Ayrshire	4.07
Guernsey	4.83
Holstein-Friesian	3.76
Jersey	5.10

certain aspect of conformation as, for example, a high percentage of faulty or low udders, he may wish to choose a bull whose daughters score well above breed average in the scorecard section for udders. The practice of using a sire who is strong in the characteristics for which a weakness exists in a herd is known as corrective mating. Certainly, most emphasis should be given to dairy character, a good predictor of milk yield, as well as to udder shape and attachment and to feet and legs, if type is to be included in the breeding goal.

If the dairyman wishes to select for type, he will be most wise to select first those sires that have a plus rating for B.C.A. milk and are breed average or better for fat test. From this list of superior bulls, those which will improve the weaknesses in conformation in the cow herd should be selected. Such a procedure insures not only improvement in conformation but continued improvement of milk yield and fat test.

NUTRITION AND FEEDING

Nutrient Requirements of Dairy Cattle

Feedstuffs must supply energy, protein, fat, minerals, and certain vitamins to the dairy animal. The quantity of each nutrient required is dependent upon sex, age, growth rate and milk production of the animal to be fed.

Energy, which is obtainable from the carbohydrates, proteins and fats in feedstuffs, is required in large amounts for growth, lactation, and reproduction, as well as the obvious requirements for physical activity and for keeping the body warm. In young animals, insufficient energy supplies will result in poor and uneconomical weight gains. For satisfactory reproduction there must be adequate energy intake, and heavy lactation demands an even greater intake.

ENERGY

The most plentiful and economical source of energy for cattle is the carbohydrate portion of the feed, including both the nitrogen-free extract (starches, sugars) and the fiber (cellulose) fractions. The action of the microorganisms in the rumen enables cattle and other cud-chewing animals to

digest much of the fiber consumed. The feeds high in fiber are known as "roughages", and this class includes pastures, hays and silages, as well as corn fodder, stover, corncobs, and hulls of grains and other seeds. Feeds such as grains, which are high in sugars and starches but low in fiber, are known as energy "concentrates".

The term Total Digestible Nutrients (T.D.N.), used to express the energy value of a feed, includes all the digestible carbohydrates, protein and fat (the last being multiplied by 2 1/4 since it has a higher energy value than the others). The higher the T.D.N. value, the higher the energy content of a feed.

PROTEINS

Proteins are complex nutrients containing nitrogen in a special combination. They are absolutely essential to life in all animals, for the formation of muscles, organs, bones, milk, and certain other body compounds. The requirement is greater during periods of rapid growth, reproduction, and lactation.

If the growing animal is not provided with enough protein to meet the heavy demands of new tissue, growth will be slowed down. Early and rapid gains are usually the most economical, and sufficient protein to permit this type of growth should be made available. It is well to bear in mind, however, that protein is usually the most expensive nutrient item, and the feeding of more than is required is rarely economical. In pregnancy, the cow requires additional protein to build the body of her calf, and in lactation the requirement is even greater to provide the large amount of protein in the milk.

Some animal species (e.g., poultry and swine) are very exacting in their requirement for specific "high-quality" proteins. The bacteria in the cow's rumen are able to manufacture good-quality protein from poor-quality protein in the feed and, to some extent, from certain other nitrogen-containing substances which are not proteins. For example, the chemical substance urea can be used to replace a limited portion of the protein in cattle rations. Practically the only consideration in protein-carrying feeds for cattle is the digestibility of the protein contained, the proportion of the protein which is digestible varying from one feed to another.

FAT

Not all the fat in milk comes from fat in the feed, much of it being made from the carbohydrate portion. Nevertheless, the amount of fat in the ration does have an influence upon health and production. The concentrate portion of the ration should contain a minimum of 3.0% fat. While not a common problem, excessive amounts of fat (over 6%) in the ration may cause digestive upsets and scours.

VITAMINS

Vitamins are a special class of nutrients required by animals in amounts which are very small in comparison with carbohydrates and proteins.

Nevertheless, their presence is essential for good health and production. The many vitamins required have individual functions to perform but, in general, they can be described as regulators of body processes.

Only two vitamins, A and D, require special attention in cattle feeding. The rumen bacteria manufacture vitamin K and all the vitamins of the B group, and thus an outside source of these is not required after the first 2 months of life. Prior to this, the calf obtains these vitamins from milk. There is no evidence that supplements of vitamin E are required by dairy cattle on usual rations.

Vitamin A

Vitamin A is obtained from the feed in the form of carotene, a yellow-colored material which the animal changes into colorless vitamin A within its body. Some of the vitamin A, the surplus over the cow's requirement for its own body activities, is stored in the liver and the body fat and secreted in the milk. Variable amounts of unchanged carotene also occur in these places, giving the yellow color to body fat and milk fat.

This vitamin is required for growth, for vision, for the maintenance of healthy conditions in the tissues of the digestive tract, the respiratory organs and the eyes, and for successful reproduction and lactation. Shortages of vitamin A will cause poor growth, and extreme deficiencies will lead to night blindness, sore eyes, staggering, poor muscular control, and reproductive troubles. More common than marked shortages are slight or borderline deficiencies causing lowered performance in growth, lactation, and reproduction.

The common source of carotene for cattle is green plant material. It is found abundantly in fresh pasture, and the younger and leafier the growth, the higher the carotene content. Under similar conditions clovers and alfalfa are better sources than grasses.

Dried-up pasture growth is very low in carotene and sun-cured hay contains less than the freshly cut crop since exposure of the drying plant material to sunshine and air readily destroys carotene. The newer methods for the barn-drying of hay usually yield hay much higher in carotene than field-curing, since long exposure to sunlight is avoided. A gradual destruction of carotene occurs in hay during storage in the mow. When carefully done, the making of silage from pasture and hay crops will preserve good amounts of the carotene in the crops. The green color of hays and silages can be used as a rough guide to their value as carotene sources, although the green color itself is not carotene. Carotene is found also in yellow corn, and the feeding of corn grain or corn and cob meal will, therefore, make a contribution to total vitamin A intake.

The ability of cattle to store some of the vitamin A surplus during periods of excess intake from excellent pasture is very valuable in assisting them through periods of low carotene intake, such as drought periods or late winter.

Supplementary vitamin A may be supplied to calves by dry or oily preparations. Fish liver oils, especially those of low potency, should not be used as supplements for milking cows but dry preparations are satisfactory when a supplement is required by older cattle.

Vitamin D

Growing animals require vitamin D for the formation of strong bones and teeth and adult animals require it for maintaining these structures. The minerals calcium and phosphorus, which form the major portion of hard bone structure, are not used and deposited properly in the absence of adequate vitamin D. A deficiency of vitamin D results in the condition of rickets in calves, the symptoms of which include swollen joints, lameness, and, in later stages, decreased growth, dragging of hind feet, and bending or even fractures in bones.

Vitamin D is obtained ordinarily by cattle in two ways: through exposure to sunlight, which forms the vitamin in the body, and through feed. Sun-cured plant material contains vitamin D produced through the action of the sun's rays. It should be noted that methods of hay-drying which avoid exposure to sunlight result in higher carotene retention but, at the same time, prevent the formation of vitamin D in the hay. Similarly, forage preserved as silage contains little or no vitamin D.

Calves, especialy those kept indoors, require a vitamin D addition in the form of a dry D supplement mixed with the concentrate.

MINERALS

Of the numerous minerals known to be essential for dairy cattle, many are present in the usual feeds in ample amounts, and usually only calcium, phosphorus, salt (sodium chloride), iodine, and cobalt require special attention. The use of supplements to supply minerals other than these cannot be recommended at present for general use in Canada despite the possibility that deficiencies in some other trace minerals may occur in certain regions.

Calcium and phosphorus

Calcium and phosphorus are discussed together since their utilization in the body is related, and in some of the supplementary sources they occur together. They are the main mineral constituents of bones and teeth, and the demand for them is very great during growth and pregnancy to permit the manufacture of new bony structures. Since milk is very rich in both calcium and phosphorus, considerable additional supplies are required during lactation.

Insufficient supplies of either or both of these minerals will cause defects in bones resembling those described for vitamin D deficiency. Serious phosphorus shortages in rations give rise to some other symptoms such as a decrease in appetite and, as the deficiency progresses, a "depraved" appetite shown by a desire to chew bones, wood, dirt, etc. Phosphorus is also an essential mineral for normal reproductive performance in the female.

Many soils are deficient in phosphorus, and feeds grown thereon are correspondingly low in this mineral. **Cattle rations, therefore, most frequently show greater deficiency in phosphorus than in calcium.** Forages are poor sources of phosphorus, grains and seeds being better. The latter are low in calcium, whereas forages are better but variable, legumes being much richer in calcium than are grasses. Young calves receive adequate amounts of calcium and phosphorus from milk.

Deficiencies of calcium and phosphorus are overcome by supplemental feeding of such products as bone meal, dicalcium phosphate, monocalcium phosphate and *defluorinated* rock phosphates. Disodium phosphate supplies phosphorus only, whereas limestone provides calcium only. Various trade names are applied to these products by manufacturers. The amounts and proportions of the supplements to be fed depend somewhat upon the other ration ingredients, especially the nature and amount of the roughage. The best procedure is to include 1% salt and 1–2% of mineral supplement in the grain mixture and in addition allow the animals free access to a mineral-salt mixture in a separate box.

Most commercial mixed concentrates contain supplementary minerals and it is not necessary to mix in any additional mineral. When feeding these concentrates, however, it is still wise to allow the animals free access to a mineral mixture.

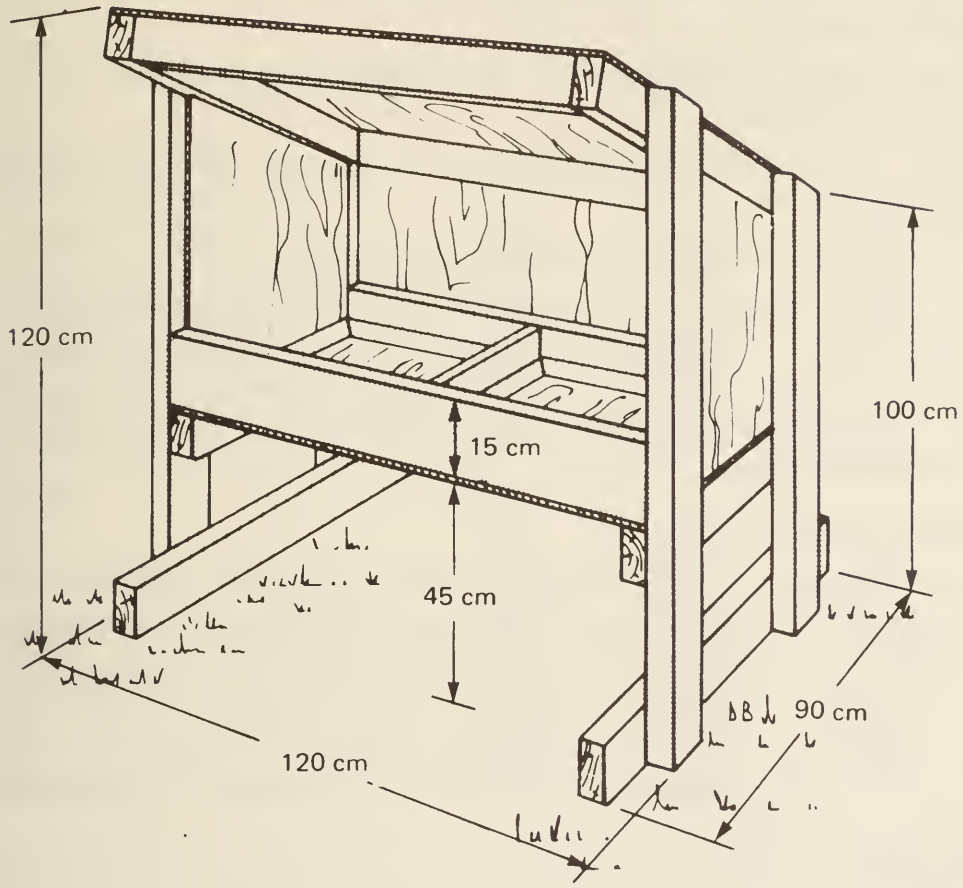
Salt, iodine and cobalt

Common salt (sodium chloride) serves many functions. It aids in milk production and serves to improve the palatability of the ration and to stimulate the appetite.

Iodine, although required in very small amounts, is a very vital mineral, essential for the activity of the thyroid gland which is the master control for all body processes. Deficiency of iodine is indicated when calves are born with goiter or "thick neck". A supplement is recommended for many regions, and the most convenient and satisfactory supplement is iodized salt.

Crops in some areas of Canada are low in cobalt, and cattle feeding on them may not receive enough of this mineral unless a supplement is fed. A deficiency leads to unthrifty, listless animals which show gradual loss of appetite, weight loss, rough coats, and anemia. A depraved appetite similar to that of phosphorus deficiency may develop and reproductive troubles may be encountered.

FIGURE 3 – A simply constructed, weather-protected salt and mineral box (see Plan 2163, Canada Plan Service)



The small amount of supplementary cobalt required can be supplied best in the form of cobaltized salt. Its use is recommended for all dairy cattle.

The cobalt-iodized salt may be mixed with concentrates at the 1% level and/or placed in a covered box in the yard or pasture field with the other minerals.

It should be borne in mind that the color of salt blocks containing iodine (red-brown) and cobalt (blue or purple) is due to added coloring substances and not to the trace minerals themselves. The fact that iodized and cobaltized loose salt may not be colored does not make it inferior nutritionally.

Mineral supplements and mixtures

Various combinations of the suggested calcium and phosphorus supplements and salt may be used to meet particular needs. Some suggested mixtures are given below:

A. 67 kg dicalcium phosphate, 33 kg cobalt-iodized salt.

B. 50 kg dicalcium phosphate, 25 kg monocalcium phosphate, 25 kg cobalt-iodized salt.

C. 50 kg dicalcium phosphate, 17 kg disodium phosphate, 33 kg cobalt-iodized salt.

D. 50 kg steamed bone meal, 25 kg disodium phosphate, 25 kg cobalt-iodized salt.

E. 50 kg steamed bone meal, 25 kg monocalcium phosphate, 25 kg cobalt-iodized salt.

F. 50 kg monocalcium phosphate, 17 kg ground limestone, 33 kg cobalt-iodized salt.

G. 67 kg steamed bone meal, 33 kg cobalt-iodized salt.

Various other combinations of available supplements may be used with satisfactory results. The individual minerals may also be placed in separate boxes for free-choice feeding. In Table 6 average figures are given for the calcium and phosphorus contents of the common supplements and for the mixtures suggested above.

Characteristics of Feeds

Livestock feedstuffs may be classified into two broad categories: (1) Roughages, and (2) Concentrates. Roughages are described as coarse bulky feeds, low in total nutrients. Concentrates are, as the name suggests, low in fiber and high in digestible material. A brief discussion of the more commonly used feeds falling into the above categories is presented in this section. For further information on the average composition of individual feedstuffs consult Appendix Table A-3.

ROUGHAGES

The term roughages refers to a wide range of feeds including all types of hay, silage, pasture, and succulent feeds such as roots. No attempt has been made to discuss all types of roughage feeds in detail in this publication. Because there is a wide range in moisture content of roughages, from dry hay to silage to succulent feeds, it is important to take this factor into consideration when assessing the value of a given weight of material.

The present trend is to an increased use of roughage feeds preserved as silage because of their adaptability to automated feed handling, and greater independence from weather at harvesttime.

Hay

Field-cured hay (stored either in loose, baled, or chopped form) has long formed the basis of dairy rations. Hay quality is highly variable and depends primarily on its stage of maturity at harvest, the forage mixture used, and harvesting conditions. Generally speaking, however, the best hay is made from forage mixtures containing a high proportion of legumes, harvested at an early stage of growth and cured with a minimum amount of weather damage. Even when a certain amount of weathering takes place, early-cut hay is superior to late-cut hay harvested under ideal weather conditions. Artificial

TABLE 6

Mineral supplements and mixtures

	Calcium		Phosphorus	
	%	Grams per kg	%	Grams per kg
Supplements				
Bone meal (steamed)	29.1	290.6	14.3	142.8
Dicalcium phosphate	26.5	164.7	20.5	204.8
Monocalcium phosphate	16.0	159.7	24.0	239.8
Disodium phosphate	—	—	18.0	179.7
Limestone (calcite)	38.3	382.6	—	—
Rock phosphate (defluorinated)	27.0	269.7	13.4	133.8
Mixtures				
A	17.8	178.0	13.7	137.1
B	17.2	172.0	16.2	161.9
C	13.2	132.0	13.3	133.1
D	14.6	146.0	11.6	115.9
E	18.6	185.7	13.2	131.8
F	14.5	145.0	12.0	120.1
G	19.5	194.7	9.6	95.9

drying of hay will reduce weather losses but the economics of a barn drying setup must be investigated before a decision to install such equipment is made.

SILAGES

Corn silage

This feed has been used extensively as a companion of hay in roughage rations for milking cows. Because of its high yields of feed per hectare and the expansion of corn-growing areas in Ontario and other provinces, the popularity of this feed is increasing.

By using earlier-maturing varieties harvested close to maturity and stored satisfactorily, a palatable, high-energy roughage feed is produced. It is, however, deficient in protein when compared with high-quality hay. Therefore, when corn silage is fed as the major portion of the roughage rations, adjustments must be made in the grain mixture to compensate for this low level of protein.

High dry-matter grass silage

Forage mixtures can be stored satisfactorily in silos at a wide range in moisture content. Most satisfactory results are obtained when this feed is

placed in storage at about 45–60% moisture. This means that some drying must take place in the field prior to storage. In this moisture range "haylage", as it is commonly referred to, is a comparable feed (on a dry-matter basis) to dry hay produced from the same forage species at the same stage of maturity. When stored at a higher moisture content as direct-cut or wilted grass silage, cows will not consume a great quantity of dry matter and lower production may result.

CONCENTRATES

Cereal grains

Corn – Corn is becoming increasingly popular as the basal portion of the concentrate mixture, especially in those areas suited to the growing of grain corn. Although it is the lowest of all grains in crude protein, it is the highest in total digestible nutrients. Corn is palatable and safe to feed in large quantities provided it is adequately supplemented with bulky protein concentrates. Medium grinding is preferred to fine grinding as corn is a heavy feed. For this reason also, when feeding heavily for high levels of milk production, corn should be mixed with bulkier feeds such as oats and wheat bran. Energy intake is often the major limiting factor in high milk production and it should be pointed out that a hectare of corn will produce about twice as much T.D.N. as a hectare of any other cereal grain.

Corn meal and cob meal – In corn-growing areas the whole ears of corn, including the cobs, may be ground for cattle feed. This mixture contains less protein, considerably more fiber, and 10–15% less T.D.N. than corn grain and is bulkier.

High-moisture corn – Either shelled corn or ground ear corn can be stored satisfactorily in a silo at a level of 25–35% moisture. Research has indicated that when stored in this manner, the product will have an equal feeding value on a dry-matter basis to the corresponding product stored in the dry state. Because of its higher moisture content, a greater weight of high-moisture corn must be fed in order to supply the same amount of nutrients as dry corn. In addition, when storing feed in this manner, it must be remembered that a sufficient quantity of material must be removed daily from the silo to prevent spoilage. This program, therefore, does not lend itself to premixing of large quantities of a grain mixture. This fact must be weighed against the convenience with which feed can be stored and handled from a silo.

Oats – Over the years this grain has formed the basis for most of the concentrate mixtures fed to producing cows. Probably this is because oats can be grown over a wide area with few crop failures and because oats are safe and palatable for stock of all ages. A major disadvantage of oats as a concentrate feed for dairy cattle is the fact that they stand lowest among the common cereal grains in production of nutrients per hectare. The recognition of this fact is leading to a steady decline in area devoted to this crop each

succeeding year. Oats are not as high in energy (T.D.N.) as other cereal grains, due to their fibrous hulls. Therefore, in rations in which energy level is critical (i.e., high-producing cows) cereal grains other than oats may predominate. Furthermore, when grains must be purchased, the lower energy value of oats should be considered. The level of protein is higher in oats than in corn and about the same as in barley and wheat. Calves, unlike older cattle, chew soft grains thoroughly and thus make good use of whole oats. For older stock, oats should be rolled or coarsely ground. Oat hulls are of low feeding value. Oats vary widely in composition; light oats are usually low in feeding value, whereas high weight per bushel usually indicates superior feed.

Barley — Barley is higher in total digestible nutrients than oats though not as high as corn or wheat. Its fiber content is only about one half that of oats. Barley is added to rations primarily as a source of energy. Ground barley makes a heavy meal and thus should not constitute over one half of the grain mixture for dairy cows. Barley is usually combined with bulky feeds such as rolled oats and wheat bran and a bulky protein concentrate in dairy rations.

Wheat — Wheat may replace barley in a dairy ration when it is economical to do so. The protein and energy levels of wheat compare favorably with those of barley. For milk cows, wheat should be coarsely ground or crushed and should not make up more than one third of the grain mixture as it is a very heavy feed. Due to its pasty nature, wheat should be mixed with some bulky concentrates. Soft winter wheat may be rolled to give good bulk.

Protein-Rich Feeds

Soybeans — Soybeans are the richest in protein of all the common seeds and may be used as a protein concentrate. Ground or cracked, soybeans are moderately well liked by cattle and are slightly laxative. They are high in fat and, when fed in quantity, result in soft butter though no effect is noticeable on the flavor of the milk. High intake of soybeans by animals decreases their utilization of carotene. Therefore, milk from such cows may lack the normal yellowish color unless an abundance of good roughage or other source of carotene is supplied.

Soybean meal — One of the many important by-products of soybean oil production is soybean meal. This meal is very rich in good-quality protein, high in T.D.N., and its palatability and availability at competitive prices make it the most widely used protein supplement in rations for all classes of stock today. Soybean meal with its handling and mixing qualities furnishes an ideal means of raising the protein content of grain mixtures.

Linseed meal — The residue from the production of linseed oil from flaxseed is popularly known as "oil cake" or "oil cake meal" as well as "linseed meal". It is relatively high in protein and is used to increase the protein content of meal mixtures. It is very palatable and is highly regarded for "show" cattle of all ages and for freshening cows. Linseed meal is not as high in protein or

T.D.N. as soybean meal and these facts should be considered when buying protein supplements.

Cottonseed meal — When available, cottonseed meal forms one of the richest sources of protein for dairy cattle. Cottonseed meal consists of the residue from the production of cottonseed oil. It is not recommended for freshening cows but is quite satisfactory for cows in milk when combined with grain and other feedstuffs in mixtures. For instance, wheat bran and soybean meal are excellent feeds to use along with cottonseed meal and grain.

Brewers' grains, dried — The residue from barley used in the production of malt liquors is known as brewers' dried grains. In the cooking process most of the starches and sugars are removed and consequently brewers' grains are low in soluble carbohydrates and proportionately high in fiber and crude protein. Brewers' grains are about equal to wheat bran in T.D.N. and have decidedly more digestible protein than bran. Brewers' dried grains are not particularly palatable to stock and, therefore, should be mixed with well-liked grains. They produce good results when forming not over one third of concentrate mixture fed to dairy cows. Because of their bulk they are useful when feeding heavy meals and in addition, their high fat content helps to supply the amount of fat desirable in dairy rations.

Distillers' grains, dried — The dried residue obtained in the manufacture of alcohol and distilled liquors from cereal grains, such as corn and rye, are known as distillers' dried grains. They make a very satisfactory supplement for milking cows, particularly when corn predominates over rye.

Corn gluten feed — This product, sometimes known simply as gluten feed, is a by-product from the manufacture of cornstarch. It is quite high in protein, usually supplying about two thirds as much digestible protein as linseed meal. Since corn gluten feed consists of corn gluten meal and corn bran, the fiber content is moderately high. Gluten feed is not quite as palatable as corn, oats, or wheat bran, and is usually mixed with well-liked feeds. The T.D.N. averages about 74—75%, not as high as corn but higher than oats or bran.

Urea — Feeding urea can provide dairy cattle with a protein substitute. They are able to use urea because rumen bacteria are able to build amino acids out of the nitrogen contained in urea and the carbohydrates present in the rumen contents. For bacteria to produce protein from urea it is necessary to have a source of readily digestible carbohydrates (starch or sugar) present in the rumen. For instance, urea is not used efficiently when fed with a ration such as mature timothy hay where most of the carbohydrate is present in the form of cellulose and fiber which is difficult to digest.

Easily digested carbohydrate feeds, such as cereal grains or molasses, generally are used with urea. Starch from grains is more effective than sugar from molasses. The following precautions might be outlined:

- Urea must be thoroughly mixed with the ration. For this reason it is often not advisable to attempt home-mixing of this feed.
- Do not use urea to increase the protein level of concentrate mixtures above 16%.
- Do not add urea in quantities greater than 3% of the grain ration. The ration is likely to be less palatable when containing higher amounts.
- Do not use urea to supply more than one third of the protein equivalent of the total ration. Urea is not palatable to cows and is not as readily consumed as oil meal.
- Do not mix urea with cheap concentrate feeds, high in fiber, merely to meet the protein equivalent needed by producing cows. Such a grain mixture would be of poor quality, low in energy and unsatisfactory for milking cows.
- The addition of at least 5% molasses to a grain mixture containing urea should improve palatability.

Miscellaneous concentrates

Hominy feed — This by-product from the manufacture of hominy flour or grits from corn is similar to corn in overall feeding value and can be used in the same way as corn.

Wheat bran — Wheat bran is a milling by-product of wheat and is widely used in dairy rations. It is higher in protein, in minerals (especially phosphorus), and fiber than whole wheat, but lower in T.D.N. It is palatable, laxative, and because of its bulk is useful for mixing with heavier grains.

Wheat shorts — A somewhat heavier by-product than bran, shorts are higher in T.D.N., lower in fiber, and similar or slightly higher in protein. Their use in cattle rations is limited somewhat by their slightly sticky texture.

Beet pulp, dried — A product of sugar refineries is often fed as a substitute for silage or roots. It is a bulky feed, laxative, and low in protein. Beet pulp is especially palatable when moistened with about three times its weight of water before feeding. Molasses may be added when soaking, though much of the beet pulp today has been pretreated with beet molasses.

Molasses — This feed is often incorporated into grain mixtures to improve palatability and reduce dustiness of mixtures. It also enhances the carbohydrate content of a ration, but contains very small amounts of protein.

Feeding dairy cows

Studies of cattle feeding by many investigators in many locations have made it possible to recommend actual amounts of the individual nutrients that should be provided for animals of various sizes and ages, and at different stages of production. All animals do not have exactly the same requirements

even under similar circumstances and, usually, the amounts recommended are near the maximum requirement. Recommendations have been presented in different forms by different investigators and groups, usually under the names of "Feeding Standards" or "Recommended Allowances". See Appendix Table A-1 for specific nutrient requirements of dairy cattle.

Best results in rationing cows are obtained when emphasis is placed on the feeding of liberal amounts of good-quality roughages rather than on the feeding of large amounts of grain or concentrates. However, cows capable of producing large amounts of milk will not reach or maintain a high level of production if fed roughages only. They cannot eat enough of the bulky feeds to supply all the nutrients required and the grains and by-products must be used to provide a portion of the nutrients in a more concentrated form.

ROUGHAGE FEEDING

The best hay for cows is green-colored, leafy, fine-stemmed legume or mixed grass-and-legume hay free from mold, mustiness, and weeds. In general, cows should receive all the hay they will eat without undue waste. More good-quality hay will be consumed than poor-quality, stemmy, coarse hay and the intake is greater when fed three times a day than when fed twice a day. If the hay supply varies in quality, feed some good hay and some inferior each day rather than all the good hay for a time and then all the poor hay. Also, under these conditions, an attempt should be made to give the high yielders rather larger amounts of good hay than the nearly dry cows. Silage, corn, or grass of good quality makes an excellent roughage-type feed for cows and growing heifers. The amount consumed will depend on the quality of the silage and on the volume of hay fed.

When fed liberally, cows should consume about 2–3% of their body weight in roughage dry matter per day with the average being about 2.5%. If the forage quality is below average or if a large proportion of the ration is a high-moisture silage, roughage dry-matter consumption may drop to 2% of body weight or less. For ease of calculation, 1 kg of dry hay contains approximately the same amount of dry matter as 2 kg of haylage (55% moisture) or 3 kg of corn silage (65–75% moisture). Based on this information the following are useful "thumb rules" to follow for feeding roughages:

Feed 1–1.24 kg hay per 50 kg liveweight
or
0.74 kg hay plus 1.50 kg corn silage per 50 kg liveweight
or
0.74 kg hay and 1 kg haylage per 50 kg liveweight
or
1 kg haylage and 1.50 kg corn silage per 50 kg liveweight
or
2 kg haylage per 50 kg liveweight
or
3 kg of corn or grass silage per 50 kg liveweight.

In the event that roughages are in short supply, considerably less than the above amounts of roughage may be fed, providing that a compensating adjustment is made in the grain feeding program. However, the feeding of less than 1% of body weight of roughage dry matter per day may result in a lower butterfat content of the milk.

SUMMER FORAGE PROGRAMS

Pasture

Fresh, green pasture is the most nearly ideal feed for dairy cows. Excellent pasture is capable of supporting higher milk production than ordinary barn feeding and is the most important single factor in economical milk production. Unfortunately the period of time when excellent pasture is available is often quite short and to provide sufficient nutrients for high milk production supplemental feeding is necessary.

Spring pastures are high in water content, rich in protein, low in fiber, and palatable. As pastures mature the protein content lowers, the fiber increases, and palatability and digestibility decrease. A proper appreciation of the wide variation in the feeding value of pasture throughout the season is fundamental. The lack of uniformity can be overcome only by proper management and the use of alternate summer forage programs.

The more important considerations in pasture management are avoiding too early grazing and overgrazing, fertilizing, and controlling weeds and excess growth. Overgrazing reduces the yield, increases injury from drought, and encourages the growth of weeds. Undergrazing is not as common or as serious a fault as overgrazing; however, it is wasteful and stimulates the growth of coarse, woody herbage. Harrowing pastureland late in the fall will tend to spread the manure droppings and prevent excessive bunching of the pasture.

The amount of grass consumed daily varies and intake is dependent chiefly on the palatability and abundance of the pasture. Medium- to large-sized cows will eat from 56–68 kg of grass per day, which should provide nutrients sufficient to maintain the cow and a level of milk production at about 14–16 kg per day. These are nearly maximum figures and would apply only under nearly ideal conditions.

Since many cows produce more than 16 kg per day on pasture, extra feed is necessary if herd production and body weight are to be maintained. Grain feeding cows when on pasture requires careful thought and management on the part of the feeder to prevent wastage of feed on one hand or a drop in milk yield and in body weight on the other. Feeding schedules are given, but before applying, due consideration should be given to the pasture conditions, the time of the year, and the level of milk production.

Since young grass is high in protein, the grain fed while the cows are on this need not have a high protein content but should supply readily available

nutrients to meet the energy requirements. Home-grown grains may suffice. As the pasture herbage matures, the protein content of the grain mixture should be increased. In selecting a grain mixture due consideration must be given to the condition of the pasture, the production of the cattle, the price of the feed and the market price of the product.

Cows are creatures of habit and respond to regularity and routine in management practice. In addition to supplying a uniform amount of roughage throughout the summer season and supplementing this where necessary with grain, some attention must be given to factors other than feeding if high milk yield is to be maintained.

Cows require large amounts of fresh water (milk contains about 85%). If possible, have a continuous supply of fresh water in the pasture field and definitely avoid stagnant water from mud holes and swamps. While not absolutely necessary, shade undoubtedly adds much to the comfort of the cattle. A few trees in the field or along the fence line will give protection against the sun during the heat of the day.

Regular pastures must of necessity be a part of the farm crop rotation. Wherever possible, however, pastureland should be located near the barn. Walking cows long distances to and from the pasture field is not conducive to high milk yields for, in addition to using much energy, it predisposes the cows to udder injury and sore and cracked feet.

Alternate summer forage programs

Some of the limitations of a summer feeding program based primarily on pasture have been pointed out earlier. While good pasture promotes a high level of milk production at relatively low feed cost, yields of milk on a per hectare basis may be improved by using system making limited use of pasture grazing. When land values are high and production per unit of land is important, alternate systems should be investigated. In addition, because of the variability in pasture quality and volume during the growing period, milk production is likely to fluctuate as well. This situation can largely be corrected by: (1) feeding supplementary roughages (hay, silage, or green chop) and/or additional grain when pasture supply or quality is low: (2) placing all feed in storage and following the same feeding program the year round; (3) cutting and feeding chopped green feed daily (zero grazing) or (4) using emergency pasture crops.

Feeding supplementary roughages

This program offers the simplest and cheapest means of maintaining a uniform feed supply and milk production throughout the summer. Advantage is taken of the fact that highest levels of milk production are made during the early part of the pasture season and that a surplus of pasture often exists at this particular time of the year. This surplus feed can be harvested and stored as either hay or silage for feeding during periods of less abundant pasture

supplies. Surplus hay or silage from the winter feeding period can also be used as a supplement to pasture. When feeding silage to cows on pasture, it must be borne in mind that sufficient feed must be fed out daily to prevent spoilage, this being particularly critical during warm weather. Feeding supplementary hay in summer provides the added advantage of some insurance against bloat problems.

Year-round, out-of-storage feeding

Basing a feeding program entirely on stored feed makes maximum use of forage-producing land. Forages can be harvested close to a stage of maturity that will give greater yields of digestible nutrients per hectare than either grazing or zero-grazing because they can be harvested within a short period of time. Therefore, the feed produced should also be uniform in quality and promote uniform levels of milk production. There are, of course, additional requirements in terms of labor, feed storage facilities, and suitable facilities for feeding and housing cows during the summer months. More grain is likely to be needed to produce the same level of production per cow on this system as compared to cows on good pasture. There are presently many farms which have sufficient storage space for additional feed during the summer months if this system is being considered. However, a year-round stored-feed program is best suited to large dairy units already equipped to handle feed mechanically.

Zero-grazing

The daily cutting of green forages, and subsequent feeding to dairy cows housed in dry-lot, provides increased use of pastureland over grazing and also provides a succulent, fresh feed for cows. Less wastage of feed results from this system than either pasturing or storing feed. While no extra feed storage facilities are required, additional harvesting and feeding equipment is often needed. There is also an increased daily labor requirement for cutting and hauling fresh feed which makes this system less attractive to dairymen.

Emergency pasture crops

Occasionally emergency pasture crops are used to make up for lack of pasture volume. Green oat pasture, sudan grass or sudan-sorghum hybrids, fall rye, and other growing crops or combinations can be used for this purpose. These emergency or temporary pastures do not yield as much as those regularly used, often do not stand treading well, and always necessitate labor and expense in seeding. They are important as supplements to the regular pastures and in lengthening the grazing season.

Hybrid sudan grass of sudan-sorghum hybrids make excellent midsummer pasture particularly during a hot, dry season. They are high yielding and very palatable and should be seeded in late May or early June at the rate of 13.5 kg/ha. These forages are also quite suitable for zero-grazing programs as well as for pasture. Unfortunately, they have some liabilities. During a cold,

wet season, the yield is frequently low and, like all members of the sorghum family, there is some danger from prussic acid poisoning. Sudan grass is not a serious offender, but as a precautionary measure do not pasture when the plants are small or when badly stunted or frozen. Turn the cows on the pasture or harvest when growth is at least 60 cm high.

Fall rye, seeded at the rate of about 12.5 kg/ha between August 1st and 15th, is useful as late fall and early spring pasture. In pasturing rye, care must be exercised to prevent a feed flavor occurring in the milk. Allow the cows on rye pasture for a few hours each day and have them off the rye for about 2 hours before milking time to overcome flavor difficulties. Some dairymen will mix oats with the rye to thicken the pasture for fall grazing.

SUPPLEMENTING ROUGHAGES

The amount and kind of grain mixture needed is dependent on the amount and quality of roughage fed. In general, the more nearly the roughage is all legume and the earlier the stage of maturity, the lower the amount of protein needed in the grain mixture.

Tips on feeding concentrates

- A basic standard for the meal mixture for milking cows is: total protein 14–18% (depending on forage); total digestible nutrients 72–77%; total fiber not more than 10–12%; and total fat 3% or more.
- Feed concentrates according to the cow's level of production and the quality of roughage (usually about 1 kg of grain mixture for every 3–5 kg of milk produced daily).
- Mix 2–3 kg of suitable salt-mineral mixture with each 100 kg of grain mixture; or provide commercial mineral mixture in amounts recommended by manufacturers.
- Avoid fine grinding – coarse grind or roll grains.
- Feed definite amounts at regular hours.
- Avoid sudden changes in the amount and kinds of feed.
- Keep mangers clean.
- Provide adequate amounts of water.

Grain mixtures for certain forages

Grain Mixtures Containing 11–14% Crude Protein – These mixtures are suitable for cows fed roughages that are mainly legumes of high quality as follows:

- Leafy, early-cut legume hay (choice quality)
- Mixed grass-legume hay containing a high proportion of legumes (early-cut, choice quality)

- Well-preserved silage made from the above crops
- Peavine silage of good quality
- Excellent pasture

TABLE 7

Mixtures containing 11 – 14% protein

Feedstuffs (kg)	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5	Mix 6
Corn	431	454				
Corn and cob meal			272	544	363	771
Oats	227	180	368	272	227	
Barley					227	
Wheat bran	113	180	180			
Soybean meal	68	90	90	90	90	136
Corn gluten feed	68					

Feedstuffs (kg)	Mix 7	Mix 8	Mix 9	Mix 10	Mix 11
Oats	454	295	272	454	317
Barley	227	272	272		
Corn				272	295
Wheat	227	272			
Wheat bran			180	180	113
Soybean meal		68	90		113
Molasses			90		68

Grain Mixtures Containing Approximately 16% Crude Protein – These are suitable for cows fed roughages of medium protein content. Quality of roughages should be fairly good and include the following:

- Legume hay – later cut, more leaf loss, more weather damage than in preceding table
- Legume – grass hay mixture of average quality with lower legume content and later cut
- Grass hay of good quality
- Well-preserved silage made from the above crops
- Combination of top-quality hay and corn silage
- Good to fair pasture

TABLE 8

Mixture containing about 16% protein (kg)

Feedstuffs (kg)	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5	Mix 6
Corn	431		454	317	385	
Corn and cob meal		454				544
Oats	237	272		295	237	136
Wheat bran	90		136	90	90	
Soybean meal	159	180	113		113	180
Linseed meal				204		
Corn gluten feed					90	
Distillers' grains, dried			136			
Molasses			68			45

Feedstuffs (kg)	Mix 7	Mix 8	Mix 9	Mix 10	Mix 11	Mix 12
Corn		408				
Corn and cob meal	680		272	454		
Oats		272	317	180	408	317
Barley			90		180	317
Wheat					136	
Wheat bran			90			
Soybean meal	180	136	136	136		136
Linseed meal					180	
Brewers' grains, dried		90		136		68
Molasses	45					68

Use of a 32 or 34% dairy concentrate to produce 16% protein mixtures

Feedstuffs (kg)	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Oats	363	363	159	180	
Barley	363	180			
Wheat		180			
Wheat bran			180		
Corn			363		
Corn and cob meal				454	590
Concentrate, 32 or 34%	180	180	204	272	317

Grain Mixtures Containing 17–19% Crude Protein – These are suitable for cows on poor pastures or receiving roughages low in protein. Cows included in this group are those receiving the following:

1. Legume hay – mature, stemmy, coarse
2. Grass hay – late-cut and/or weathered
3. Good-quality corn silage (without other forages)

TABLE 9

Mixtures containing 17 – 19% protein

Feedstuffs (kg)	Mix 1	Mix 2	Mix 3	Mix 4
Oats	340	227	180	363
Barley	180			180
Wheat	159			180
Corn and cob meal		454	454	
Wheat bran				
Linseed meal				
Soybean meal	159	227	272	180
Molasses	68			

Feedstuffs (kg)	Mix 5	Mix 6	Mix 7	Mix 8	Mix 9
Oats	272	227	272	227	180
Corn	363	317	272	317	317
Wheat bran		90	180	90	136
Soybean meal	136	113	180	136	204
Corn gluten feed				136	
Brewers' grains, dried	136				
Distillers' grains, dried		159			68

Grain feeding guides

The amount of grain mixture that should be fed to cows depends on the level of milk production and butterfat test, the amount and quality of forage being fed, the body condition of the animal, and the relationship between the cost of the grain mixture and the price received for milk. It is obvious then that cows should be fed grain according to their individual needs to obtain best results. For the same reasons, the use of simple "thumb rules" (e.g., 1 kg of grain for every 4 kg of milk) is an inadequate plan to follow and usually results in the high-producing cows being underfed and the low producers being overfed.

The cow's highest requirements for energy occur during very early lactation and it is therefore necessary to increase the grain ration rapidly following calving. Most cows reach their peak milk yield within 3–6 weeks following calving and usually the higher the level of production at peak period, the higher will be the total lactation yield. If sufficient energy is not provided to the cow during the first few weeks following calving, either her potential maximum milk flow will not be reached or losses in body weight will be excessive. The best program to follow is to have the cow consuming a moderate level of grain prior to calving (as discussed in the section on Dry Cows) and, without drastically reducing grain intake at calving time, increase grain feeding by 0.5 kg per day (or more rapidly if the cow will take it) up to the point where the cow has reached her peak of production. This concept is known as *challenge* or *lead feeding* and is not wasteful of feed since grain increases are made only as long as the cow is responding with increases in milk production.

After the cow reaches her maximum she can be fed according to a grain feeding guide.

The following tables have been prepared from feeding standards to equate the proper level of grain feeding to production level and forage quality.

TABLE 10

Recommended feeding of concentrates for cows on excellent pasture

	Butterfat in milk			
Milk produced daily kg	3.0% kg	3.5% kg	4.0% kg	5.0% kg
15	–	–	0.50	0.75
17.5	0.75	1.00	1.25	1.25
20	1.25	1.75	2.25	2.50
22.5	2.25	2.75	3.25	3.75
25	3.50	4.00	4.25	5.00
27.5	4.75	5.25	5.50	6.25

TABLE 10 (Continued)

Milk produced daily kg	Butterfat in milk 3.0% kg	3.5% kg	4.0% kg	5.0% kg
30	6.00	6.50	7.00	8.00
32.5	7.00	7.75	8.50	9.75
35	8.25	9.00	10.00	11.50
37.5	9.50	10.50	11.50	13.25
40	11.00	12.00	13.00	15.00
42.5	12.50	13.50	14.50	—
45	14.00	15.00	16.50	—

TABLE 11

Recommended feeding of concentrates for cows on excellent hay or silage, or good pasture

Milk produced daily kg	Butterfat in milk 3.0% kg	3.5% kg	4.0% kg	5.0% kg
7.5	—	—	0.50	0.75
10.0	0.50	0.75	1.00	1.50
12.5	1.00	1.25	1.50	2.00
15.0	1.75	2.00	2.25	2.75
17.5	2.50	2.75	3.00	3.75
20.0	3.50	3.75	4.25	5.00
22.5	4.75	5.00	5.50	6.25
25.0	5.75	6.25	6.75	7.75
27.5	7.00	7.50	8.25	9.50
30.0	8.25	9.00	9.75	11.25
32.5	9.50	10.50	11.25	13.00
35.0	11.00	12.00	13.00	15.00
37.5	12.50	13.50	14.75	—
40.0	14.00	15.00	16.50	—

TABLE 12

Recommended feeding of concentrates for cows on good hay or silage, or fair pasture

Milk produced daily kg	Butterfat in milk			
	3.0% kg	3.5% kg	4.0% kg	5.0% kg
7.5	–	–	0.50	0.75
10.0	0.50	1.00	1.25	2.00
12.5	2.00	2.25	2.50	3.00
15.0	3.25	3.50	3.75	4.25
17.5	4.00	4.50	4.75	5.50
20.0	5.00	5.50	6.00	7.00
22.5	6.25	6.75	7.50	8.75
25.0	7.50	8.25	9.00	10.50
27.5	9.00	9.75	10.50	12.00
30.0	10.50	11.25	12.25	14.00
32.5	12.00	13.00	14.00	16.00
35.0	13.50	15.00	15.75	–
37.5	15.00	–	–	–

MANAGEMENT OF THE MILKING HERD

Record keeping

It has often been contended that the dairy cow is a creature of habit, has individual characteristics and thus responds to individual attention. However, as the size of dairy herds increases, it becomes increasingly difficult to treat cows as individuals unless a sound system of keeping records is practiced. Individual records on each animal in the herd have to be based on satisfactory identification of animals by eartag, tattoo, or neckchain numbers. Regardless of whether the animals are purebred or grade, all calves should be identified soon after birth and record keeping on the animal should begin at this time.

The type of records to be kept includes those for milk production (not only to aid in selection and culling but also to serve as a guide for feeding), reproduction, and health problems.

Probably the most satisfactory means of keeping all of these records up-to-date for individuals in the herd is to maintain a barn book, containing a single sheet for each cow. This can serve as a handy reference for the current status of any individual in the herd. An example of a herd record form incorporating some of these details is shown in Appendix Table A-8.

Milking operation

When the milking operation is performed properly, high-quality milk will be produced, udder health problems will be minimized, and milking will be done

quickly and efficiently. In order to accomplish these objectives a work routine has to be established to assure that all points are followed.

- Proper milking machine function — To do the job of milking rapidly, efficiently, and with minimum stress on the cow's udder, the milking machine must be operating properly. Factors such as vacuum level, pulsation rate, tension, and size of teat cup liners, airflow, and pump capacity are a few of those to be considered. Most manufacturers have definite recommendations for the best operation of their machines and these should be followed closely. These companies also have servicemen qualified to diagnose problems of machine function.
- Preparation of the cow — Two points of preparation are important. They are first, stimulation of the cow for satisfactory milk "letdown" and secondly, washing the udder and teats to remove any dirt which might otherwise contaminate the milk. These operations are accomplished most effectively by washing udders with individual disposable paper towels soaked in a warm disinfectant solution. This should be done approximately 30 seconds to 1 minute prior to placing the machine on the cow. To prevent excess moisture staying on the cow's teats, the towel should be squeezed out before application to the udder. In addition, many dairymen like to remove a few streams of milk from each quarter into a strip cup with a fine mesh screen to detect abnormal milk.
- Milking — About 1 minute and no later than 2 minutes after stimulation, the milking machine should be placed on the cow. There is considerable variation in the length of time it takes for different cows to milk out so the operator should know the individual characteristics of each cow. Under no circumstances should the milking machine be left on the cow (or any individual quarter) after milk flow has ceased as this may be harmful to udder tissues. On the other hand, it is usually necessary and advisable to "machine strip" cows to do a complete milking job. By this we mean applying downward pressure on the teat cup cluster, toward the end of the milking period.
- Sanitation — To produce high-quality milk and prevent the spread of udder infection, it is important to ensure that all milking equipment, machine operators, buildings, and the cows are clean. Milking equipment should be washed promptly after each milking with more thorough cleaning of all component parts taking place at weekly intervals. For prevention of the spread of infection, immersion of teat cups in a hot water bath at 77°C for 10 seconds or in disinfectant for 30 seconds between each cow is beneficial.

In addition, for efficient milking:

- Follow a regular routine in the milking operation including the time of milking each day. It is more important to milk at the same times each day than to have an equal interval of 12 hours between each milking. In

addition, cows become conditioned to a regular routine and milk letdown is likely to be affected if this routine is disturbed.

- Do not try to handle more milking machine units than can be operated satisfactorily. Operating more than two units per man in a stall barn or three units per man in a milking parlor does not necessarily speed up the milking operation. Do not allow other chores to interfere with milking.
- If possible, arrange to milk slow milkers or diseased cows at the end of the milking period.
- Do not feed any strong feeds that might impart an objectionable flavor to milk within 3 hours before or during milking. Silage feeds are common offenders in this regard.
- Do not leave milk exposed in open containers. Rather, it should be removed promptly to the milk house.
- Cool milk promptly and make sure that cooling facilities are operating satisfactorily.

Maintaining breeding efficiency

Profitable dairy production is, to a large extent, dependent on having the cows calve regularly each year. The ideal should be a uniform 12-month interval between calvings for the entire milking herd. This will result in increased total milk production by individual cows over their lifetime when compared with longer intervals between calving. In addition, more calves will be produced in a given period of time and, as a result of these two factors, returns should be higher. As most of the variation in herd breeding problems can be attributed to differences in herd management rather than to inherited characteristics, the following points should help improve breeding performance:

- Keep accurate and complete records of dates of heat, breeding, calving, and symptoms of abnormal conditions of the reproductive system. The following is an example of the type of form which might be used for this purpose.

Cow name or No.	Calving date	Dates of heat				Record of service						Preg-nancy check	Expected calving date
						1st		2nd		3rd			
		1	2	3	4	Date	Sire	Date	Sire	Date	Sire		

- Observe cows or heifers carefully for signs of heat at least twice daily. Turning out cows housed in a stanchion barn at least once a day during winter months will pay good dividends in heat detection.
- Give cows a rest of at least 60 days following calving. All normal cows should be bred during the first heat period after 60 days if a 12-month calving interval is desired.
- Provide service at the most opportune time for conception. Do not breed cows during the early part of the heat period. Cows first observed in heat in the morning should be bred later the same day for best results, while cows first observed during the afternoon should be bred the following morning.
- Breed females to a sire known to have a high fertility level.
- Follow a program of regular pregnancy diagnosis after 6 weeks from the date of last service.
- Supply adequate amounts of energy, protein, phosphorus, and vitamin A in the ration for optimum reproductive performance.
- Consult your veterinarian for treatment of problem cows, (a) when a cow fails to conceive after three services to a fertile sire, (b) when a cow does not exhibit signs of estrus within 60 days following calving or has irregular heat cycles, and (c) cows show symptoms of cystic ovaries or other abnormal conditions.
- Do not breed a cow showing an unnatural discharge and isolate aborted cows until all discharge has ceased.

Feeding and management of the dry cow

Dairy cows should be given a rest by drying them about 6–8 weeks before refreshening. A longer rest period may be necessary to properly fit very thin cows or the young cows that may need extra size. Records of service dates are necessary to ensure a dry period of adequate length yet not so long that many of the cows are nonproductive for many months. The milk market and the market for surplus breeding stock are factors to consider in planning the dates of breeding, rest periods, and freshening dates.

Drying the cow may be difficult, particularly if she has been milked to within 2 or 3 weeks of freshening. If this has happened it is wise to continue milking, feed liberally, and expect production in the next lactation period to be lower than normal. Cows, some weeks from freshening, may be dried by reducing the feed and water intake, milking occasionally and, if possible, removing them from the regular milking line.

Another method of drying is to discontinue milking abruptly, change the milking routine, remove the protein-rich feeds and reduce the grain and water intake. Allow the udder pressure to build up and in this way prevent the secretion of milk. If the udder should become unduly congested, milk out

thoroughly and start over. This method is not advised for cows with a history of mastitis trouble.

After drying, the cow should be liberally fed to increase body weight, build up a reserve of minerals, and develop a strong, vigorous fetus. This requires the use of good roughages and of grain mixtures that are more than just fattening feeds. The regular production grain ration is satisfactory or a special dry and fitting mixture can be used.

The amount of grain fed will depend on the condition and size of the cow. It may range from no grain to 3–4 kg per day. Cows in good condition on pasture are not likely to require additional feeding in the form of grain.

It is recommended that during the last week before calving and the first 3 weeks after calving the cow be fed fairly liberally. To accomplish this, start increasing the grain ration about 3 weeks prior to expected calving date so that the cow is eating at least 1% of her body weight per day of grain by calving time. Do not restrict grain feeding at this time because grain does not cause excess swelling of the udder and fairly liberal feeding has been helpful in the prevention of ketosis.

Calving

Cows vary in symptoms indicating calving but the individuals are fairly constant in the symptoms at each lactation. Some "make up" quickly, others slowly. The signs indicating the approach of calving are as follows:

- Swelling of the udder with the teats filling and showing a waxy appearance a few hours before freshening
- The vulva is swollen and a relaxing of the muscles around the tail head is characteristic
- Restlessness and, if on pasture, a tendency to segregate from the main part of the herd

During the stable-feeding period, the cow should freshen in a clean, disinfected, well-bedded box stall. Even during the pasture season, it is wise to freshen the cow in a box stall or a paddock near the barn where she can be observed frequently. After freshening, the cow should be allowed to lick the calf and be kept warm. A drink of warm water and a warm bran mash, improved by the addition of molasses, is a recommended practice in getting the cow over the strain of calving. Observe the cow at intervals to detect the early symptoms of milk fever or acetonemia. (See section on Herd Health.) If the afterbirth membranes are not expelled after approximately 2 days, procure the services of a veterinarian.

Feeding and care of calves and heifers

Rearing replacement heifers is an essential operation in any dairy herd. On the average, 25% of the cows need to be replaced annually because they have

become unprofitable. Allowing for calfhood mortality, three or four heifer calves are needed each year for every 10 cows in the herd.

Within 4 hours after birth, the newborn calf should nurse or be pail-fed colostrum and a second feeding within 12 hours of birth is recommended. The colostrum or first milk is essential to the calf because of its high content of many nutrients, because it contains antibodies for resistance to disease, and because of its laxative effect. An injection of vitamins A, D and E within 24 hours of birth may give added protection against scours and respiratory infections. The calf and dam may be separated immediately after birth or they may remain together for several days. Early separation reduces the chances of the calf overeating while nursing and usually makes it easier to teach it to drink.

FEEDING THE CALF

The calf should receive its mother's colostrum for the first 3 days. It is important not to overfeed the calf during this period: 2–3 kg daily is a sufficient amount for larger calves, 1–2 kg for smaller calves. After the 3 days, several liquid feeding programs can be considered. These include limited whole milk, fermented colostrum and early weaning, milk replacer, and skim milk. Also, a calf starter ration may be fed, beginning during the calf's first week of life.

Limited whole milk

This method requires 145–150 kg of milk. Calves of larger breeds will receive more milk than those of smaller breeds. Milk should always be fresh and fed at about the same temperature within the range of 32–37°C. Be careful not to overfeed. See Table 13 for a recommended schedule of feeding. The amounts shown in the Table are for larger breeds and should be reduced somewhat for calves of smaller breeds. When 6 weeks old, the calves may be weaned abruptly onto dry feed. Feeding hay during the first 2–3 months is not essential. Free-choice feeding of calf starter without hay ensures a high energy intake for rapid growth. If desired, 5–10% coarse-ground hay may be included in the starter mixture.

Milk replacer

Calves may be fed milk replacer after they are 4 days old. The manufacturer's directions should be followed, but general guidelines for replacer feeding are given in Table 13. Research has indicated that milk replacer may be fed once daily with no detrimental effect on the calves. This enables them to be fed at the most convenient time of day. With once-daily feeding, fresh water must be available at all times. Once-a-day feeding should be attempted only by those prepared to provide a high level of management. Calves may be weaned onto dry feed at 6 weeks of age, but some may be weaned earlier if desired. A useful guide for weaning: wean when the calves are consuming 0.5 kg of dry starter daily, which may occur as early as 4 weeks of age. Recent research has shown that calves can be weaned successfully as early as 3 weeks if a

TABLE 13

Feeding schedule for calves and heifers

Age	Limited whole milk (kg/day)	or	Milk replacer (kg/day)	Starter and grower	Water	Forage
1–4 days	2.7–3.6		—	—	—	—
5–9 days	3.6		0.3	Small amount of starter ration, fresh daily	—	Hay
2nd week	4.1		0.45	Small amount of starter ration, fresh daily	—	is
3rd week	4.5		0.45	Keep dry feed before calf, fresh feed daily	Warm water 0.5–0.9 kg with milk	optional
4th week	4.1		0.54	Keep dry feed available, free choice	Increase water to compensate for reduced milk	up to
5th week	3.6		0.54	Keep dry feed available, free choice	Increase water to compensate for reduced milk	8 weeks
6th week	3.6		0.54	Keep dry feed available, free choice	Fresh water available at all times	of age

TABLE 13 (Continued)

Age	Limited whole milk (kg/day)	or	Milk replacer %	Starter and grower	Water	Forage
7–8 weeks	—		—	Keep dry feed available, free choice	Fresh water available at all times	
9–14 weeks	—		—	Starter ration 1.8–2.7 kg daily with hay, or complete starter ration, free choice	Fresh water available at all times	Feed hay free choice, if desired.
15 weeks to 9 months	—		—	Feed 1.8–2.7 kg grower ration daily	Fresh water available at all times	Feed hay free choice. Silage feeding may be started if desired.
9–24 months	—		—	Adjust amount & composition of grain mixture to balance ration & maintain growth rate	Fresh water available at all times	Good quality forage. Restrict corn silage to one half forage dry matter intake.

high-protein (20—21%), high-energy starter ration is used to replace the liquid feed.

Fermented colostrum

Many dairymen have adopted a liquid feeding program using fermented colostrum which, along with early weaning, provides an economical method of rearing calves. This practice involves storing surplus colostrum from the first 6—8 milkings; in the past, any of this early milk not fed to the calves during the first few days was thrown out. The milk is stored in a covered plastic container (a plastic garbage pail is suitable) and is either allowed to ferment (sour) naturally or is inoculated with yoghurt or cultured buttermilk to avoid an undesirable fermentation. Colostrum from more than one cow can be mixed. For feeding, mix 1 part hot water with 3 parts fermented colostrum and feed the mixture in the same amount as for whole milk. The first 6—8 milkings usually provide enough colostrum to feed calves for 3—4 weeks, by the end of which time they may be weaned abruptly onto dry feed. A calf starter providing 21% crude protein is recommended (Table 14). Should the producer wish to continue liquid feeding after his supply of fermented colostrum has been exhausted, the calves may be switched to milk replacer or whole milk without difficulty.

Skim milk

Fresh skim milk, if available, can be substituted for whole milk when the calves are 2—3 weeks old. The change can be made abruptly or gradually over a 3-day period. When the calves are about 4 weeks old the amount may be increased gradually to 9 kg daily for large calves. Skim-milk feeding may be continued until the calves are 4—5 months old if the milk is available, but the transition to dry feed should be gradual regardless of age. Skim milk does not contain vitamins A and D and these should be provided by injection. Grain ration, hay, minerals and water should be available to calves being fed skim milk.

Calf starter

Regardless of the type of liquid feeding program being followed, a calf may begin receiving a starter ration when it is less than a week old. To start the calf on the ration, put a small amount of starter meal in the pail as it finishes its milk. Feed a small amount of fresh meal daily at first but step up the amount as the calf's appetite increases. It is important that it have free access to a suitable starter ration immediately after weaning to provide nutrients previously supplied by the milk or milk replacer. Hay feeding appears unnecessary during the first 2 months and will only dilute the calf's nutrient intake. Guidelines for starter feeding are given in Table 13.

Calf starter formulations need not be complex. Several farm-grown grains, combined with the necessary protein supplement, minerals, vitamins and molasses, make a satisfactory starter mixture. Some formulations are shown in Table 14. These should provide 18—20% crude protein.

TABLE 14

Calf starter mixtures

Ingredients	Ration 1, parts	Ration 2, parts	Ration 3, parts	Ration 4,[1] parts	Ration 5,[2] parts
Ground hay			10		
Rolled barley	50		57	50	48
Rolled oats	20	28	10	24	15
Cracked corn		40			
Soybean meal (50%)[3]	18	20	15	14	25
Alfalfa meal	5	5		5	5
Molasses	5	5	5	5	5
Calcium phosphate	1	1	2	1	1
Salt (cobalt-iodized)	1	1	1	1	1
Vitamin A		2200 IU/kg in all rations			
Vitamin D		330 IU/kg in all rations			

[1] Low-protein mixture may be combined with skim-milk feeding.
[2] High-protein mixture for calves weaned at 3 – 4 weeks of age.
[3] Linseed oil meal or rapeseed meal (up to 10%) may be substituted for soybean meal. Adjust the quantity added according to the crude protein level of the supplement used.

Hay may be introduced into the diet when the calves are 8 weeks old, with feeding of a starter mixture containing 18–20% crude protein continuing until the age of 14 weeks (Table 13). As an alternative, a complete starter mixture containing 10% coarse-ground hay and about 16% crude protein may be fed free choice. With a lengthy milk-feeding period, a 16% crude protein content is adequate in the starter. When calves are weaned early (at 3–4 weeks), a starter with 20–22% crude protein should be fed free choice.

At about 14 weeks of age, calves may be switched to a lower-protein grower mixture (about 15–16% crude protein, depending on the forage being fed). A dairy ration with a suitable protein content may be fed if desired. The grower mixture should be fed at 2–3 kg a day up to the age of 9 months. Make sure that good-quality hay is available. Silage feeding may be started at about 3 months of age. As the calf gets older, maximum use should be made of forages. Although the feeding of grain is needed to maintain good growth rates, care must be taken to avoid excessive fattening. During this period, calves may be pastured providing good-quality pasture is available but they should continue to receive supplemental grain to sustain growth rates. Because of their susceptibility to lungworms and gastrointestinal roundworms, calves should not be put on a pasture that was grazed earlier in the season by older animals.

CARE OF THE YOUNG CALF

Regardless of the feeding method used, certain basic management practices

must be followed carefully to reduce calf losses and to promote rapid growth. Cleanliness of pens and feeding utensils; regularity of feeding; fresh, good-quality feeds; good ventilation with freedom from drafts and excessive humidity, and control of flies and lice are some of the factors that play an important role in successful calf rearing. Individual calf pens are recommended to reduce sucking after pail feeding, which can damage the developing udder and may persist as an undesirable habit.

Calves should be identified by ear tagging, tattooing, photographing or drawing as soon as possible after birth. Dehorning should be done as soon as horn buttons develop. Electric dehorners are probably best, but caustic preparations are also effective. Extra teats should be removed at about 1 month of age.

FEEDING THE HEIFER

Calves can be considered heifers at 9 months of age. At this time, grain feeding is usually reduced and may be eliminated when the animals are a year old if top-quality forage is available. However, when the target age for first calving is 24 months, grain should be fed to compensate for reduced forage quality and maintain growth rates during the second year.

Normal growth

The standards used to measure growth rate and development are actual body weight, withers height and heart girth. Using Appendix Table A-7, the weight of the animal can be estimated from its heart girth. The normal weight and height of dairy cattle are given in Appendix Table A-6.

WHEN TO BREED

Size and maturity are as important as age in determining when to breed heifers. Calving at a specific season of the year to meet a specific milk market may be the governing factor in some cases. It is now generally accepted that 24 months is a desirable age for first calving and this requires well-grown heifers that can be bred at 15 months of age. In some herds, heifers are being bred for calving as early as 21 months, which requires a high degree of management of the calf and growing heifer. On the basis of size, heifers may be bred when they have reached the following weight ranges: Ayrshire, 275–295 kg; Guernsey, 250–275 kg; Holstein, 340–365 kg; Jersey, 230–250 kg.

VEAL PRODUCTION

Each year many dairy calves are marketed as veal. The original weight of the calf, the value of the feed, the price of veal, and the availability and efficiency of labor are some of the factors that must be considered in evaluating the efficiency of veal production. The selling weight for which top price is received depends on the market and may vary from 90–135 kg. Whole milk is still the best feed for producing top-quality veal. It requires about 4.5

kg of milk to produce 0.45 kg of gain. However, the use of milk replacers has gained a good deal of popularity for veal because of lower costs of production.

To produce rapid weight gains and a degree of finish on calves comparable to that obtained by feeding whole milk, a milk replacer or vealer ration should contain a high level of energy. Many manufacturers market special milk replacers for veal calves containing 10–25% added animal fat to increase the energy level of these feeds. As the utilization of feed is affected by the method used to incorporate added fat in the vealer, home mixing of this type of feed is not recommended. Skim milk may also be used to raise veal calves and, when available, forms the basis of a reasonably inexpensive ration. However, calves will make slower gains and will not bring as high a market price as those fed either on whole milk or on a high-energy milk replacer.

The value of feeding calf starters or grain mixtures to veal calves depends on the milk program followed and the weight at which calves are marketed. It should be pointed out that feeding large amounts of grain or hay will likely result in a darkening of the color of veal meat which is objectionable in the meat trade. Feeding grain will likely give best results in terms of promoting growth and improving returns over feed costs when fed to calves on a skim milk or low-energy diet or when calves are marketed at heavier weights than mentioned above.

HERD HEALTH

Canadian dairy cattle are recognized throughout the world for their type, production, and health qualities. Agriculture Canada and the provincial governments administer several Acts, policies, assistance programs and veterinary diagnostic laboratories for the livestock owners to ensure that the many diseases of cattle are under constant surveillance and control. The federal Health of Animals Directorate, through the Animal Disease and Protection Act, has eliminated, controlled, or prevented the entry of many diseases which have ravaged the livestock industry in other parts of the world. Tuberculosis has been virtually eliminated in cattle and through a joint federal-provincial program, the incidence of brucellosis has been reduced significantly.

Diseases still cost the dairymen millions of dollars a year. However, by a combination of good management practices and veterinary services, many of these diseases can be prevented. Recently, herd health programs have contributed towards the prevention and early disease detection in herds. In such a program the livestock owner and his veterinarian make arrangements for routine pregnancy diagnosis, mastitis detection, and other health examinations to be carried out on a regular basis. Such procedures contribute substantially to the productive capacity and health of the herd.

Common diseases and conditions

MASTITIS

Mastitis is the most costly disease affecting the dairy herd today. It has been established that nearly 50% of the dairy cows have mastitis in some form at any one time. This means that a far higher percentage of cows are affected with this disease than were ever affected with tuberculosis or brucellosis prior to their eradication programs. Mastitis is primarily the result of management practices and it is only through farmer awareness and education that the disease can be brought under control. The term "mastitis" means inflammation of the udder regardless of the cause. Mastitis may be of the noninfectious form, which is a result of some udder stress without the presence of an infectious agent (for example, stress caused by fluctuations in milking-machine vacuum or other machine malfunctions), or it may be the infectious form, which is the more common. There are many different bacteria or organisms that are known to cause mastitis. Of these, some half dozen are commonly involved. Two species of bacteria account for over 80% of the mastitis that occurs in dairy cows. The two organisms or bacteria that cause mastitis most commonly are *Staphylococcus aureaus* and *Streptococcus agalactiae*. Fortunately the principles that apply to the control of these two species, apply equally well to all the other bacteria that may cause mastitis.

The bacterium, *Streptococcus agalactiae,* lives in the mammary gland of the cow. It will not live for any length of time outside the gland. Once *Streptococcus agalactiae* has been eliminated from a herd by treatment and sanitation procedures are instituted, the herd will remain free of this infectious agent. *Staphylococcus aureaus* lives on the skin of the udder, the hands of the milker, on the milking equipment and in the general barn environment. Control of this infectious agent is made more difficult by its many habitats and its ability to live under many conditions. It too can be controlled by sound sanitary procedures, good management practices and proper treatment methods.

Mastitis usually becomes apparent to the farmer in two ways. In the flare-up stage, the udder or quarter becomes hot and swollen and frequently the cow is visibly sick. It may also exhibit itself by the presence of clots, flakes, or other abnormal content of milk. Actually the type of mastitis which is evident to the farmer accounts for a very small percentage of the actual cases that may be present in the herd. Eighty percent of the mastitis that is present in a herd is not readily apparent to the dairyman and it is spoken of as the sub-clinical "chronic" or "hidden" type of mastitis. While this type of mastitis may not appear to be causing any damage to the cow, it has been proved conclusively that it markedly reduces the production of the cow. An average herd of 30 cows has its total production reduced by about 7250 kg of milk per year by the hidden cases of mastitis. In addition, these cows are a potential threat to the healthy cows within the herd.

Control of mastitis

To control mastitis effectively, the approach must be on a herd basis rather than on an individual cow basis. The disease can be controlled if the milking management is properly carried out, an effective sanitation barrier is instituted, and adequate treatment procedures are used. Attention to the following points and those outlined in the section on milking operation will substantially reduce the number of chronic and acute udder infections in a herd.

- Additions to the herd – The introduction of new and perhaps resistant types of bacteria into the herd through the purchase of chronically affected cows is a frequent occurrence. Buying tested cows or heifers is a useful safeguard.
- Detection of all infected quarters – As many of the quarters will be chronically affected, special tests must be applied to the milk. Tests such as the Whiteside test or California mastitis test (C.M.T.) react when the leukocyte count of the milk is above normal, indicating an inflammation. The milk from such quarters must then be cultured in a laboratory to determine the causative bacteria. A sensitivity test on the bacteria will offer helpful information to the veterinarian in prescribing the correct treatment.
- Treatment – In a control program, the treatment employed must eliminate the organism from the gland to be considered successful. In acute cases, treatment may produce a clinical improvement but the animal remains a carrier. A few infections will not respond to any treatment known at present, so the animal should be slaughtered.

  "Dry treatment" of all quarters with antibiotics has become a routine procedure in many dairy herds. There is ample evidence to suggest that dry treatment, with long-acting antibiotic products designed for this purpose, will substantially reduce the incidence of mastitis in a well-managed herd.

  Vaccination has been shown to be of limited value in staphylococcal infection.

Additional information on this disease may be obtained from Agriculture Canada Publication 1596, **Control of Mastitis in Canada.**

KETOSIS (ACETONEMIA)

Ketosis is one of the more serious disease problems confronting dairymen in Canada. In many herds it causes heavy financial loss each year, particularly during the winter months, through lowered production, off-flavored milk, and occasional deaths.

Although ketosis can occur as a specific disease, it also occurs as a secondary complication to many other conditions. Examples of such conditions are kidney disease, hardware disease or traumatic reticulitis, retention of fetal or

placenta membranes, and indigestion. In fact, any condition which will cause a high-producing cow to go off feed can cause ketosis.

The condition is characterized by a high level of ketone bodies (fat breakdown products) in the blood, urine, and milk, and a low level of sugar in the blood. This indicates a switch from carbohydrates to fats as the principal source of energy for the cow. This excessive burning of body fat causes rapid loss of condition. This loss, along with partial loss of appetite and lowered milk production, is frequently the first symptom to be observed. A peculiar, sweetish odor may be noted from the cow's breath and from her milk. A degree of constipation usually accompanies this condition, with the manure having a slimy, glossy appearance. Nervous symptoms such as licking the manger or forelegs, staggering, or even convulsions may occur. Care must be taken to avoid confusing this condition with rabies.

Due to the variety of conditions that can initiate ketosis it is wise to have the animal examined by a veterinarian before treatment is instituted. It is not possible at present to formulate a preventive program that will be completely effective. However, the following points may assist in the prevention of the condition:

- Adequate energy should be supplied in the ration prior to calving, and should not be curtailed at calving time as has been a common practice.
- Cows should receive an adequate amount of properly formulated mineral supplement.
- Observe high-producing cows closely because any slight upset may give rise to ketosis.
- When ketosis is suspected, have the cow examined promptly by a veterinarian.

MILK FEVER

Milk fever occurs most frequently within the first 48 hours after calving, but it can also occur just before calving. It is characterized by progressive paralysis with eventual inability to rise, normal to subnormal temperature, and eventual death unless treatment is administered.

There are many other conditions that will cause cows to go down after calving, and a veterinarian should be consulted for confirmation of diagnosis. It is important to remember that, due to throat paralysis, it is dangerous to attempt to drench a cow when milk fever is suspected.

It has been suggested that the incidence of milk fever can be reduced by increasing the phosphorus content of the mineral supplement in proportion to the calcium content.

Although practical and dependable measures for the prevention of milk fever are lacking, the following are sometimes suggested:

- Injection of calcium salts intravenously or subcutaneously immediately

after calving — This will undoubtedly help prevent the condition but is hardly practical as a routine procedure. It is recommended in dealing with cows having a history of repeated attacks.

- Feeding extra calcium and phosphorus — Although cows with milk fever show a very low blood calcium level, feeding high levels of calcium before calving is not effective in preventing the condition and may predispose to milk fever. Feeding additional phosphorus and a proper balance of calcium and phosphorus during the dry period may decrease the incidence in some herds.
- Incomplete milking for 2 or 3 days after calving — This may be of some value but it is dangerous if mastitis infection exists in the udder.
- Administration of high doses of vitamin D for up to 1 week before calving has been recommended as a preventive measure. Care should be taken not to continue treatment longer than the period recommended by the manufacturer.

FOOT ROT

Foot rot is a common cause of lameness in cattle. Its economic importance is due to weight and/or milk loss rather than death losses. Foot rot is caused by infection gaining entry to the flesh of the foot through minor injuries. If treated promptly recovery is usually rapid, but if neglected, surgery may be required to save the foot.

A program for foot-rot prevention should include the removal, or the exclusion, of livestock from areas that may cause injury to the feet. These areas include gravel or crushed stone yards and roadways and mud holes. Antiseptic footbaths might be placed so that cattle must walk through them coming and going from the stable. Iodine compounds added to the salt or mineral ration also have proved beneficial.

It should be noted that at present there is no effective vaccine against this condition.

BLOAT

The term bloat refers to an excessive accumulation of gas in the paunch. Bloating is a common symptom of digestive upset and may be due to a variety of causes. It occurs in its most dangerous form among cattle grazing in lush pasture, particularly one that contains a high proportion of legumes and under these conditions, may cause heavy death loss. Not all legume pastures cause bloat. However, pastures either growing rapidly or wilted by drought after a period of rapid growth appear to be especially dangerous.

The relief of bloat may require the use of a stomach tube or operative procedures, in severe cases. Give 225–350 mL of mineral oil or other nontoxic oil, preferably one containing a wetting agent, in simple cases, but drenching should be done slowly and carefully. Placing a gag in the mouth, standing the

animal with the front quarters elevated, and kneading the rumen with the fist all help to expel gas.

Recognition of the following points may be helpful in preventing pasture bloat.

- Mixtures of grasses with legumes cause much less bloat than legumes alone. Practical tests show that serious bloat rarely occurs if grasses make up at least 50% of the mixture.
- Supplemental feeding of hay in drylot at night will reduce the incidence of bloat on legume pasture. Feeding hay on pasture may also help.
- Grass pasture at night will help prevent bloat on legume pasture the next day.
- Administering about 110 mL of peanut or other edible oil either by drench or in the feed immediately before the cattle are allowed to graze bloat-producing pasture usually controls the condition for 8 or 10 hours.
- A system that has proven economically sound in New Zealand, and which deserves trial in Canada, is to strip graze in conjunction with daily spraying of oil on the pasture.

BREEDING PROBLEMS

Sterility or delayed breeding is a complex problem that is of concern to all animal breeders. The fundamentals that make up breeding efficiency are:

- Observation of heat
- Rest after calving
- Isolating cows during heat
- Control of reproductive diseases
- Proper nutrition

It will be noted from the above that management is the biggest single factor in the maintenance of breeding efficiency.

Some suggested measures to improve the breeding efficiency in the dairy herd are given in the section Maintaining Breeding Efficiency.

ABORTION

There are numerous causes of abortion in cattle, some of which are infectious. Among the infectious diseases causing abortion are the following: brucellosis, once a common cause of abortion and now well controlled; trichomoniasis and vibriosis which are venereal in nature. Certain virus diseases such as infectious bovine rhinotracheitis can also cause abortion.

Among the noninfectious diseases causing abortion are dietary deficiencies and certain poisons.

Differential diagnosis can only be made through clinical observation and laboratory procedures. All aborted calves should be submitted for laboratory

examination. Veterinary advice should be sought regarding testing of blood or discharges from the dam.

LEPTOSPIROSIS

Leptospirosis is a bacterial disease of cattle and other animals. It is known to have a wildlife reservoir. The disease causes abortion in cattle and other symptoms. Diagnosis of leptospirosis is based on laboratory tests, and treatment may be successfully carried out by a veterinarian.

TUBERCULOSIS

All of Canada is now included in the Restricted Area Plan for bovine tuberculosis. Intermittent retesting of cattle in Canada will be continued. Discovery of any lesions of tuberculosis in slaughtered cattle will result in testing of all cattle in the herd of origin. The test interval of areas is dependent on the incidence of the disease at the time of the last test, and on evidence of new cases being found in particular areas.

Individual herds may still be tested and accredited but this is no longer financed by the government since the emphasis is now on area testing.

While complete eradication of tuberculosis is the ultimate aim, it would appear that many years of careful application of the test and slaughter program are still required before that very desirable goal is achieved.

Inquiries concerning the tuberculosis eradication scheme should be addressed to the nearest office of the Health of Animals Directorate, Agriculture Canada.

Diseases of the Digestive Tract

CALF SCOURS

Calf scours is one of the most serious problems that may confront a livestock owner. Many more cases occur in pail-fed calves than in nursing calves, though it can become a problem in nursing beef calves.

The cause of calf scours is an infection in the intestines but many other factors play a role in allowing the infection to take place in the calf.

These factors include overfeeding, irregular feeding times, and, probably very important, the raising of calves under 1 week of age with older calves or confining these young calves to dirty, damp, poorly bedded quarters. Over a period of time, when calves are kept in the same stall, it becomes very contaminated and such an environment is not suitable for a newborn calf. All newborn calves should be given ample bedding and kept in clean quarters.

For prevention of calf scours, the dam should be placed in a cleaned and disinfected calving stall that is well bedded. As soon as the calf is born, the navel should be dipped in a suitable disinfectant. The calf should next be assisted to nurse within 1 hour after birth. Colostrum milk or first milk contains many protective substances and these substances can only be

absorbed for a short time by the calf's intestine. Leave the calf with the cow for the first 24–48 hours or feed it at no more than 4-hour intervals for the first 24 hours of life. When the calf is taken from the dam it should be placed in a separate, individual stall. By so doing, spread of disease is prevented and the earliest signs of scouring can be observed. After 24–48 hours, the calf should receive not more than 6–8% of its body weight of milk (or its equivalent in milk replacer) per day during the first week of life, divided into two or, for small weak calves, three feedings.

If diarrhea is noticed, the milk intake should be reduced by one half. However, it is very important to replace this volume of milk with an equal amount of water because with diarrhea the calf loses much fluid from its tissues. Treatment must commence soon after diarrhea is noticed, otherwise the effectiveness is reduced. The best treatment for an individual herd varies considerably. Consequently, it is desirable to have the feces tested periodically in a laboratory to determine the most effective drug.

In some herds, calf scours has been a problem very soon after birth (less than 24 hours of age) and in these cases the measures listed above under prevention must be instituted and strictly followed. In addition, treatment with drugs prior to the onset of diarrhea has on these occasions, been shown to be somewhat beneficial. In particular, care should be taken to ensure that vitamin A is present in adequate amounts because a deficiency of this vitamin predisposes to scours.

COCCIDIOSIS

Coccidiosis is an intestinal disease, usually of calves as young as 1 month and up to 9 months of age. The condition is more common in housed animals. The symptoms are severe diarrhea containing blood and mucus. The intestinal irritation may be so severe in acute cases that there is straining which on occasions causes the rectum to protrude and even prolapse. There may be considerable loss of blood with consequent anemia, the calves become weak and some may die.

Diagnosis is made on the symptoms and the findings of the infective agent in the manure by microscopic methods.

Treatment usually involves the administration of sulfonamide drugs. These may be given individually to affected animals or to the whole group, including unaffected contacts, in the feed or drinking water. This is carried out for 7 days. Prevention is difficult in infected premises but is based on thorough cleaning of the pens and avoiding contamination of the feed and water.

INTERNAL PARASITISM

Many calves and adult cattle are infected, to a varying degree, with stomach and intestinal worms. The severity of the parasite problem is directly related to factors that enhance the exposure to parasitic eggs shed in the feces and

reduce the animal's resistance to disease. Some of the more important factors are inadequate nutrition, crowded stable conditions, overgrazing pastures, lack of pasture rotation, and warm, wet climatic conditions.

Usually only young animals are affected and symptoms are those of diarrhea with intermittent periods of constipation. Anemia, loss of condition, weight, and death may occur in that order.

The diagnosis of internal parasitism can be made by a veterinarian who, by carrying out tests on the manure, is able to estimate the extent of infection and the most economical and effective treatment indicated.

In the past, treatment was limited to phenothiazine but recently a number of new, highly effective drugs have been marketed and are available to veterinarians.

Control measures are designed to reduce the exposure to parasite eggs shed in the feces of infected animals and towards ensuring adequate feed intake to enhance resistance.

BOVINE VIRUS DIARRHEA

Previously this was considered to be two diseases, mucosal disease and virus diarrhea; the two were sometimes discussed together under the title of mucosal disease complex. It is now believed that the two diseases are caused by the same virus but that under some as yet unknown circumstances, there may be a difference in the disease as seen in the field.

The disease is characterized by a diarrhea which is almost always present, straining, and ulcer formation in the gut and mouth. Other signs are inappetence, depression, and drooling to a variable extent. Later, weakness is evident and nasal discharges are common. In some cases outbreaks are limited to one or a very few animals; in others a herd problem arises in which several animals are affected. Usually it is a problem for only a short period of time, after which no new cases are seen in the herd. In some cases nearly all sick animals die, in others mortalities are very low. Treatment is largely a matter of good nursing; no drugs which have a specific effect on the disease are available. However, virus diarrhea vaccines are available to veterinarians.

It has recently been demonstrated that pregnant cows infected with virus diarrhea may subsequently deliver calves with nervous system disorders (cerebellar hypoplasia). Fortunately the incidence of this previously considered inherited disease is low as effective control procedures are not well established.

WINTER DYSENTERY

Winter dysentery of cattle is a severe infectious disease usually affecting housed cattle. It appears to be transmitted from farm to farm by visitors, animals, and equipment moved from an infected farm to a noninfected one. The loss in milk production is severe, but very few animals die during the

course of the disease. Because of the explosive nature of the disease, veterinary assistance is required. Blood transfusions or electrolyte injections are frequently required in the treatment of badly dehydrated animals.

Respiratory Diseases

CALF PNEUMONIA

Virus or enzootic pneumonia may be a serious problem in stabled calves, from birth to six months of age. The predisposing factors are usually related to overcrowding and inadequate ventilation.

Affected calves are bright and will still eat but a dry, harsh cough and rapid breathing are evident. Infected calves should be isolated, treated promptly with antibiotics and treatment should continue for 3–5 days to prevent secondary bacterial pneumonia. With adequate treatment, losses due to this condition are negligible but failure to treat early enough or adequately may result in a stunted calf which will never do well.

Control measures must center on adequate housing and good ventilation. In severe outbreaks, it is necessary to separate the calf at birth from the adult cattle, which carry the virus, and raise it in a separate pen or building until 6 months of age.

Outbreaks of bacterial pneumonia also occur in calves, either as a primary disease, or following infections of virus pneumonia. For most of these bacterial pneumonias, antibiotics or sulfonamides are effective if treatment is commenced early.

BOVINE RESPIRATORY DISEASE COMPLEX

This condition is now considered to be due to a combined attack by respiratory viruses and pasteurella bacteria. Unvaccinated cattle that have been under stress from transport or other causes, and subsequently exposed to respiratory viruses, become susceptible to infection from the bacteria. Studies have indicated that the viruses act as a mechanism that allows the pasteurella bacteria to gain entry.

Most outbreaks occur in the first week after the arrival on the premises, either following herd additions or return from shows. The disease is characterized by loss of appetite, depression, increased rate of breathing and high body temperature. There is usually a nasal discharge and a moist cough. Without prompt treatment, death loss may be high because of severe respiratory difficulty.

To reduce losses from this condition:

- Isolate new arrivals from cattle already on the farm for at least 2 weeks.
- Provide cattle with dry, well-ventilated shelter.
- Take the temperature of any "off-color" herd additions and, if the temperature is above the normal range (38–39°C), isolate the animal and call your veterinarian for accurate diagnosis and prompt treatment.

- Supply fresh, clean water, cobalt-iodized salt, and mineral mixtures to cattle free choice. If the cattle are very thirsty on arrival, limit water during the first day to about half the normal supply.

Prevention of bovine respiratory disease complex is difficult but all steps should be taken that will lower the stresses that cattle undergo in shipment. Recommendations are:

- Wean calves at least 1 month before they are shipped.
- The vaccination of cattle with a respiratory virus vaccine before the animals are shipped may be of value in preventing or lessening the severity of an outbreak of the disease.
- Before cattle are loaded, have them well rested, fed hay and watered.
- Make sure that stockcars and trucks are well bedded, and cattle protected from draughts as much as possible.
- Avoid overcrowding in stockcars and trucks.
- Have the shipment made as rapidly as possible. If it is a long journey, cattle should be unloaded, fed and watered, and rested at regular intervals.

Bovine respiratory disease complex is less of a problem in dairy than in beef cattle but care during shipment, and isolation and observation of all new animals or returnees is important.

INFECTIOUS BOVINE RHINOTRACHEITIS (IBR)

IBR, also known as "red nose", is an infectious virus disease of cattle. Although IBR affects all ages and classes of cattle, the symptoms of the disease observed are directly related to the age of the animal affected. For example, affected newborn calves may have a fever and symptoms suggesting a gastrointestinal disorder. Older animals, i.e., calves 3–4 months of age to adults, show symptoms related to an infection of the nasal cavities and trachea or windpipe. The nostrils may be reddened, a hard, dry cough is evident, the appetite may be reduced, a discharge may be evident at the nostrils, and sore eyes resembling pinkeye are some of the major symptoms produced by IBR infection. In this age group, a high fever and an increased respiration rate are commonly observed. Pregnant cows infected with IBR may abort within 30 days, or have weak calves which appear to have a digestive disorder as mentioned above.

Death losses due to IBR will be confined mainly to abortions, newborn calves, and older animals that develop secondary bacterial pneumonia.

There is no specific treatment for this disease. Consequently good care, nursing and, if indicated, antibiotics to prevent secondary bacterial infection are the major aids in minimizing the effects of IBR.

IBR vaccines are available but care must be exercised in using them because abortions following the use of some of these vaccines have been reported.

However, intranasal vaccines have been shown not to cause abortion following their use.

LUNGWORM DISEASE

Outbreaks of lungworm disease occur sporadically and usually follow the continuous use of small shaded pens, orchards, small pasture areas or other areas where manure is constantly present. Calves, 4—10 months of age, are the age group most commonly affected. Wet, cool weather facilitates the establishment of lungworm disease and for this reason most infections occur in the autumn months following prolonged periods of high rainfall.

The condition resembles pneumonia and differentiation from this disease can usually be made only by a veterinarian.

Usually the whole group of calves of a susceptible age may scour slightly. In a few days they cough and develop rapid breathing, often interrupted by a grunt. Although the animals may continue to eat, they lose condition rapidly, as in an experimental infection a 200 kg calf lost 20 kg in 30 days.

Diagnosis is based on the history, the symptoms, and the demonstration of developed lungworm eggs in the manure, which of course can only be done by microscopic examination. When this condition is diagnosed, all the calves should be treated. Since stomach and intestinal worms usually accompany lungworms, treatment should be given simultaneously for all three. Adequate nutrition, shelter, and pasture rotation are important aspects in the prevention of lungworm disease.

External Parasites

The common external parasites affecting dairy cattle in Canada are lice, mange mites, and warble flies and their grubs.

The presence of warble flies, grubs, and lice is easily noted by examination of the animals. Many compounds are available for the control of these parasites, some of which are applied to the skin and some of which may be given by mouth. It should be noted that one must adhere strictly to the manufacturer's recommendations, as overdoses of these drugs may be toxic to the animal or result in poisonous residues in the meat or milk.

Suspected cases of mange must, by law, be reported to the local Agriculture Canada veterinarian.

Disinfection

The contamination of bedding, floors, stalls, and yards by the discharges of infected animals is the principal means by which an infectious disease is spread.

To destroy infection, all bedding and manure accumulating from sick animals should be burned or spread thinly on ground to which other animals do not have access. Stalls and floors should be thoroughly cleaned and disinfected.

CHEMICAL DISINFECTANTS

Lye – 0.5 kg to 100–150 litres of boiling water.
Creolin – 2% solution.
Liquor cresol compound U.S.P. – 2 to 3% solution.
Carbolic acid – 3 to 5% solution.
Bichloride of mercury – 1 part to 1 000 parts of water by weight.
Other disinfectants – use according to manufacturers' directions.

As a rule, chemical disinfectants are more effective when used hot. This is especially true of lye, which is a cheap and effective disinfectant against most disease organisms.

Solution	In 1 litre of water	In 5 litres of water
2% solution	6 teaspoons	90 g
3% solution	$2^1/_2$ tablespoons	140 g
4% solution	3 tablespoons	180 g
5% solution	$3^1/_2$ tablespoons	215 g

Flies

All dairy herd owners experience insect problems during the late spring, summer, and early autumn months. In general, the warmer the summer the bigger the problem as the insects reproduce more rapidly. Some of the insects common on dairy farms can be thought of as pests of grazing animals, others are more or less limited to the stable and barnyard, while others are troublesome in both places.

The cattle face fly, a new pest compared with some of the other dairy farm insects, seldom if ever enters stables when the herd comes in for milking. Horn, house, stable, deer, and horse flies, on the other hand, will enter stables along with the cows and continue to irritate them unless controlled.

Some flies are equipped with mouthparts which enable them to "bite" and suck blood. These include the tabanids (deer, moose, and horse flies), the biting house flies (stable flies), horn flies, and mosquitoes. Others, such as house and face flies, have mouthparts modified for lapping up liquids and cannot pierce the hide and feed on blood. The latter group, however, by their persistence annoy the animals a great deal.

Control of these pests around the dairy farm is difficult and costly; it will pay off, however, if:

- The breeding places of the flies either in or around the stable are eliminated or reduced to a minimum. (Without adequate disposal of manure and garbage of all kinds, the remaining two suggestions are of little value.)
- Controls are started early in the season.

- The proper insecticide is purchased and the label instructions are followed with care.

No discussion of insecticidal control of flies will be included here. The picture changes so rapidly in this connection that recommendations will be made available annually and kept up-to-date by revision as needed.

Sanitation is of prime importance. If insects are developing in and emerging as adults from manure piles and calf and bull pens that haven't been cleaned out for a week or more, no amount of insecticide will provide satisfactory control. With summer temperatures, flies will develop from egg to adult in 10 days or even less, and as many as 400 housefly maggots can develop to the fly stage in a pound of manure.

Remove the manure from stables every other day. If a pile accumulates in the barnyard, it should be taken to the fields and scattered thinly every 5—7 days. If pigs or poultry form a part of your overall operation, their manure should be disposed of in the same manner.

If conditions are such that manure must be stored for a time before being spread, have only one pile, preferably somewhat rectangular in shape.

A well-drained, concrete floor or platform under the pile will permit all-weather hauling out. Keep the pile packed down and the sides as nearly vertical as possible; use a spade or shovel to trim and pack. In some situations, it may be practical to dig a narrow ditch around the pile into which crude oil can be poured. As the maggots mature, they tend to leave the manure, evidently searching for a drier location in which to transform to the fly stage. Many of these larvae will drop into the oil and be killed.

Screen milk houses, stables, and piggeries, if at all possible. The window screens and screen doors should fit snugly and the screening must be sound; a hole or two in a screen is no better than no screen at all. Screen doors should always open outwards.

HOUSING THE DAIRY HERD

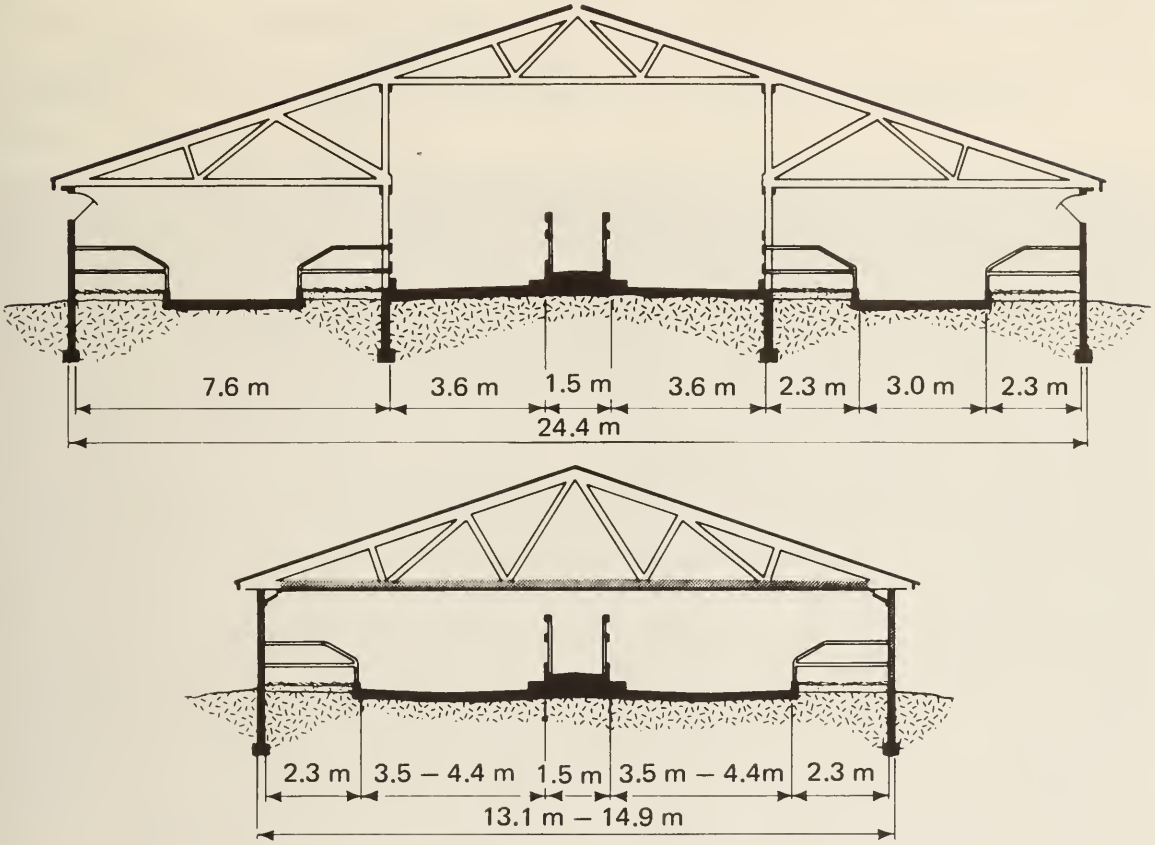
Proper housing of the dairy herd is an important consideration in the overall planning for quality milk production. An efficient and well-designed building layout should not only provide adequate housing, pleasant working conditions, improved labor efficiency, optimum feed conversion, and efficient milk production, but should also ensure a sanitary and comfortable environment for the dairy herd.

A thorough discussion of these various factors is beyond the scope of this publication; therefore, only a brief discussion of the more important factors is presented.

Management

The three basic management practices are the stall barn system, the loose housing system, and the free-stall housing system.

FIGURE 4 — Typical sections of free-stall dairy barns for large and small herds



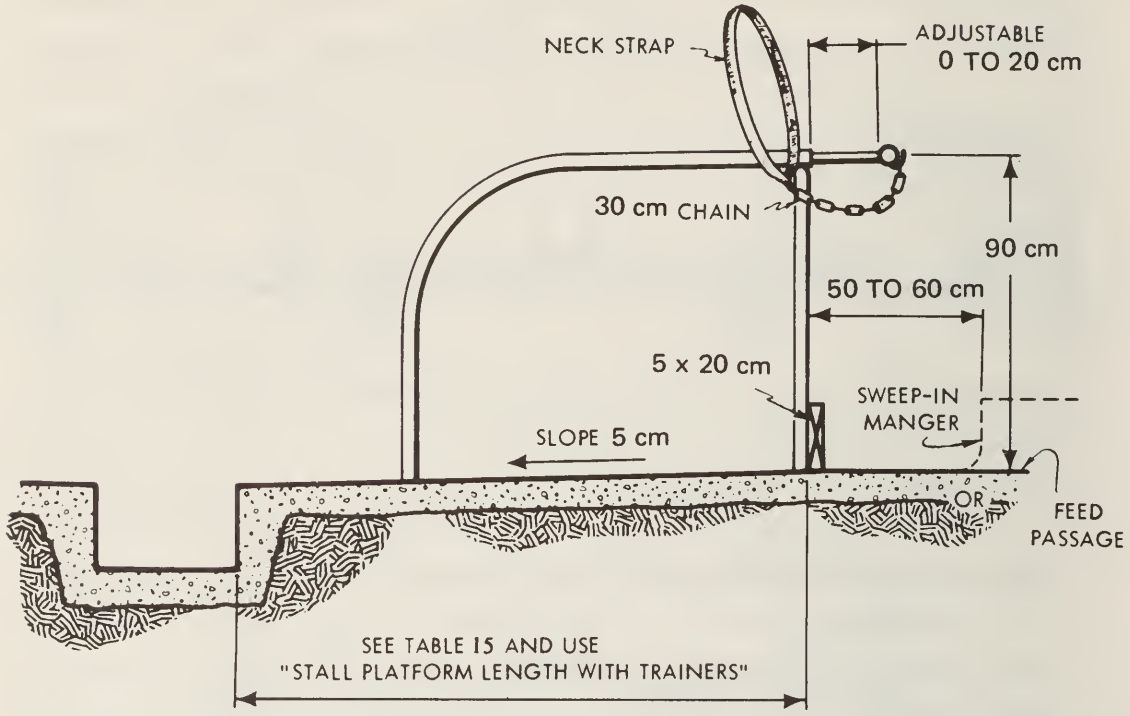
The stall barn management system is the most common in Canada and has been developed through many years of research and practical experience. The system consist of a separate stall for each cow to permit individual attention for feeding, grooming, and milking, with additional pens designed to accommodate calves, young stock, and freshening cows.

Loose housing systems originally used a deep-bedded resting area plus separate feeding, holding and milking areas. Bedding requirements were excessive for this system, and it is therefore seldom used now except where bedding is cheap and abundant.

The free-stall system is the newest concept in herd management and is a popular system where new facilities for 50 or more head are being built. The major difference from the loose housing system is that the bedding area is divided into individual stalls and the alleyways between the stalls are paved. The cows are not tied in the stalls. This arrangement requires scraping the alleyways between these stalls, but bedding requirements are greatly reduced and the cows keep themselves remarkably clean.

The most obvious advantages of free-stall barns over stall barns are flexibility of herd size, economical future expansion, improved herd health, less bedding, less boredom in the milking chore, and saving of labor under good management practices.

FIGURE 5 — Construction details of single headrail stall for tie-stall barn; use of electric cow trainer is recommended with single headrail and other types of tie stalls



Construction Materials

The careful selection of the construction materials is essential with particular attention to the following properties: sanitation, durability, strength, fire-resistant qualities, and thermal insulation. The general trend in dairy structures is toward one-story, light frame construction using many of the new building materials that are easily handled, yet strong and durable.

The initial and maintenance costs are of prime importance in constructing dairy buildings and these are largely determined by the materials used in construction. Concrete is one of the better materials for footings, floors, ramps, and steps because it has low maintenance cost, is workable in its initial state, is durable, and above all is sanitary.

Wood framing is used primarily for walls, partitions, and roof construction because wood is readily available, is easily cut to fit any requirement, and practically all new building panels can be applied directly to the wood frame. Good insulation is necessary for proper ventilation in enclosed buildings and this insulation can be placed between the framing members as loose-fill, semi-rigid plastic foam. Durable weatherproof materials are recommended for exterior surfacing. Interior surfacing, exposed to a high humidity environment such as in a milk house, needs a surfacing material that will be impervious to water.

Windows are often dirty and wet due to heat loss and condensation. Therefore, many new dairy barns are being built with few or no windows except where local regulations require them.

FIGURE 6 — Interior of barn with chain-tie stalls (note neck strap and tie chains, and electric trainer over cow's back)

Many new products such as plastics and sandwich panels for curtain walls and roof construction are available for farm building construction. However, many of these new materials are more expensive than conventional building materials and have not proved themselves in long-term use. Consequently, they should be selected with discretion.

Types of Stall Barns

The most common type of stall barn is the conventional two-story structure with space for grain, hay, and bedding in the second story or loft area, and accommodation for livestock below in the first story. Many variations are possible in detailed arrangements but basic design and dimension have become standard. The two-story barn, requiring one foundation and one roof, will provide economies in building and maintenance costs that are difficult to duplicate in two conventional one-story barns of similar capacity.

Present trends, however, indicate an increased interest in one-story barns. The danger of spontaneous combustion with a possible loss of livestock is reduced

for single-story structures. More important, though, the rapidly expanding use made of silage, and the fact that most hay is now baled or chopped, have reduced the need for large loft areas. Special labor-saving equipment has been designed to facilitate the horizontal movement of silage and dry roughages, and gravity flow is no longer a prerequisite for efficient handling of materials.

Planning the stall barn

In planning the stall barn a number of factors require special consideration, including the following:

FUNCTIONAL REQUIREMENTS

1. Stall arrangement — If dairy cows are to be milked in the stall, then a face-out arrangement is recommended since more time is spent behind the cow than in front. A face-in arrangement, however, has considerable merit if complete mechanical feeding is to be used in the stalls, or if the cows are to be milked elsewhere.

2. Type of stall — The four most common types of tie stalls are the stanchion, the chain-tie stall, the comfort stall and the single headrail stall.

The stanchion stall was the most common type. Other types, however, provide more cow freedom and are now being used in new installations.

The chain-tie stall gives the cow more freedom of movement, and the absence of hardware above the cows provides a neat-appearing interior. Cows are tied individually with chains and neck strap (Fig. 6).

The single headrail stall is the least expensive type to construct. The headrail provides attachment for a single chain that snaps onto the cow's neck strap.

Stall dimensions are given in Table 15.

FEED STORAGE

Hay, grain and bedding may be stored above the dairy stable area to permit gravity flow of material through the floor. In single-story construction they are stored in a separate building. This reduces storage costs in new construction, and reduces dust in the barn.

TABLE 15

Dimensions for tie stalls for dairy cattle

Animal weight (kg)	Stall platform width (cm)	Stall platform length	
		Without trainers (cm)	With trainers (cm)
400	101	137	147
500	112	142	152
600	122	152	162
700	132	162	173
800	142	173	183

For large herds, a separate processing area is useful to facilitate processing and mixing of homegrown grains. Simple augers and elevators convey the material from storage to processing equipment and can also be used to convey the processed feed directly to the cow.

Silage is stored in upright silos or horizontal silos.

Upright silos with silo unloaders and feed conveyors are more convenient for feeding and usually waste less feed. Horizontal silos are more economical in the larger capacities — 1000 tons and over — since the extra silage-handling costs are offset by reduced initial investment.

The capacities of various sized silos are shown in Appendix Table A-4.

MECHANICAL EQUIPMENT

Much of the drudgery of farm chores is being relieved by use of mechanical equipment such as gutter cleaners, feed conveyors and pipeline milkers. Because of the complexity and wide diversification of barn layouts, this equipment must be selected for each individual application.

VENTILATION

Ventilation must provide a suitable atmosphere within the barn to maintain the health and production of the dairy herd, and must also produce the following effects:

- Keep the stable dry.
- Remove stale air and strong odors.
- Bring in fresh air without drafts.
- Remove excess heat and maintain optimum temperature.
- Remove excess moisture and thereby prevent the rotting of wood, the peeling of paint, the corrosion of metal and electrical fixtures.

Amount of Ventilation Required

The dairy cow gives off considerable body heat which is utilized to keep the stable warm. A stable temperature of 5—13°C is the best for the comfort and health of the animals. With outside temperatures below -17°C it requires 0.7 to 0.8 m^3 for each 450 kg cow to maintain correct stable temperature. During very cold weather (below -20°C), additional heating is required to avoid excessive humidity which can result in condensation on the walls and ceiling, and in unhealthy conditions for the animals. As outside temperatures rise to summer temperatures, ventilation requirements increase to 15 times the winter minimum.

Since the outside temperature is constantly changing over a wide range, a varying volume of air is required to maintain a satisfactory condition within the dairy stable. A system of fans, properly installed and located and equipped with thermostat controls will maintain a more uniform temperature within the stable.

TABLE 16

Ventilation recommendations (C.F.M. per unit)

Type of livestock	Type of housing	Low level (moisture control) (m^3)	Additional levels (temperature control) (m^3)	Total ventilation required (m^3/min per unit)
DAIRY				
450 kg cow or *1 animal unit	Fall to spring stabling Ventilation by windows during summer	0.8 (C)	2.8 (T)	3.6 per animal unit
90 kg calf		0.1–0.2 (C)	0.4–0.7 (T)	
450 kg cow or *1 animal unit	Year-round housing	0.8 (C)	6.2 (T)	7.0 per animal unit

*Animal unit is a 450 kg cow or its equivalent
(T) Fans on thermostat controls
(C) Fans on continuous operation

Planning the free-stall housing system

The free-stall housing system is centered around six different component areas. Each of these areas can be further divided into two or more component parts. Different designs can be incorporated into the components of each area. Consequently, quite a variety of layouts and building designs can be found in any successful free-stall housing system. However, certain principles, if adhered to during the planning and construction, will help to assure the successful management of any layout for the free-stall housing of dairy cattle.

THE MILKING AREA

The milking area is the heart of the free-stall housing system and is comprised of the milk house, milking room, holding area, and concentrate feed storage and handling facilities. Its main function is to supply a sanitary and efficient arrangement for milking cows and for the handling, cooling and holding of milk. This area demands the greatest investment in buildings and equipment, the greatest use of time and labor, and the greatest rigidity in sanitation requirements. Since sanitary requirements vary on a regional basis, local health or dairy officials should be contacted before construction begins.

The holding area is a paved and preferably covered area of 1.2–1.6m^2 per cow outside the milking room where cows are held in waiting to be milked.

The milking room or parlor is the room equipped for the milking of cows on a continuous basis. Milking stall types include tandem walk-through, tandem

side-opening and herringbone (saw-toothed) stalls. Cows are usually fed part or all of their concentrates as they pass through these stalls. The same general requirements of cleanliness, sanitation, light, ventilation, and insulation are necessary here as for the milk house.

The milk house is a building attached to but partitioned off from the milking room. Here milk is cooled and held for pickup, and milking equipment is cleaned and stored between milkings. This building must meet strict sanitary requirements.

Grain concentrate storage and handling facilities are either over the milking room or in adjacent bulk storage bins. The use of automatic conveyors to move this material to the individual stall mangers is receiving widespread acceptance.

TABLE 17

Free-stall dimensions for dairy cattle and replacements

Liveweight kg	Age (Holsteins) (mo)	Stall width (cm)	Length, including heel curb (cm)
Calves and heifers			
45 – 115		60	120
90 – 200	3–8	70	140
180 – 300	8–12	75	150
275 – 385	12–16	85	170
360 – 475	16–22	100	200
450 – 570	22–26	115	225
Cows and springing heifers			
360 av		102	210
450 av		110	220
545 av		115	235
630 and over		120	245

Alleyways should be 2.4 – 3.6 m wide and you should have at least 2.7m of headroom in the building to allow for scraping the alleyways with tractors. Bedding storage can be completely away from this area as a minimum amount of bedding is required and it is usually most convenient to load and drive up the alleyways distributing the bedding on each side directly into the stalls. The stalls should require bedding only two or three times a month.

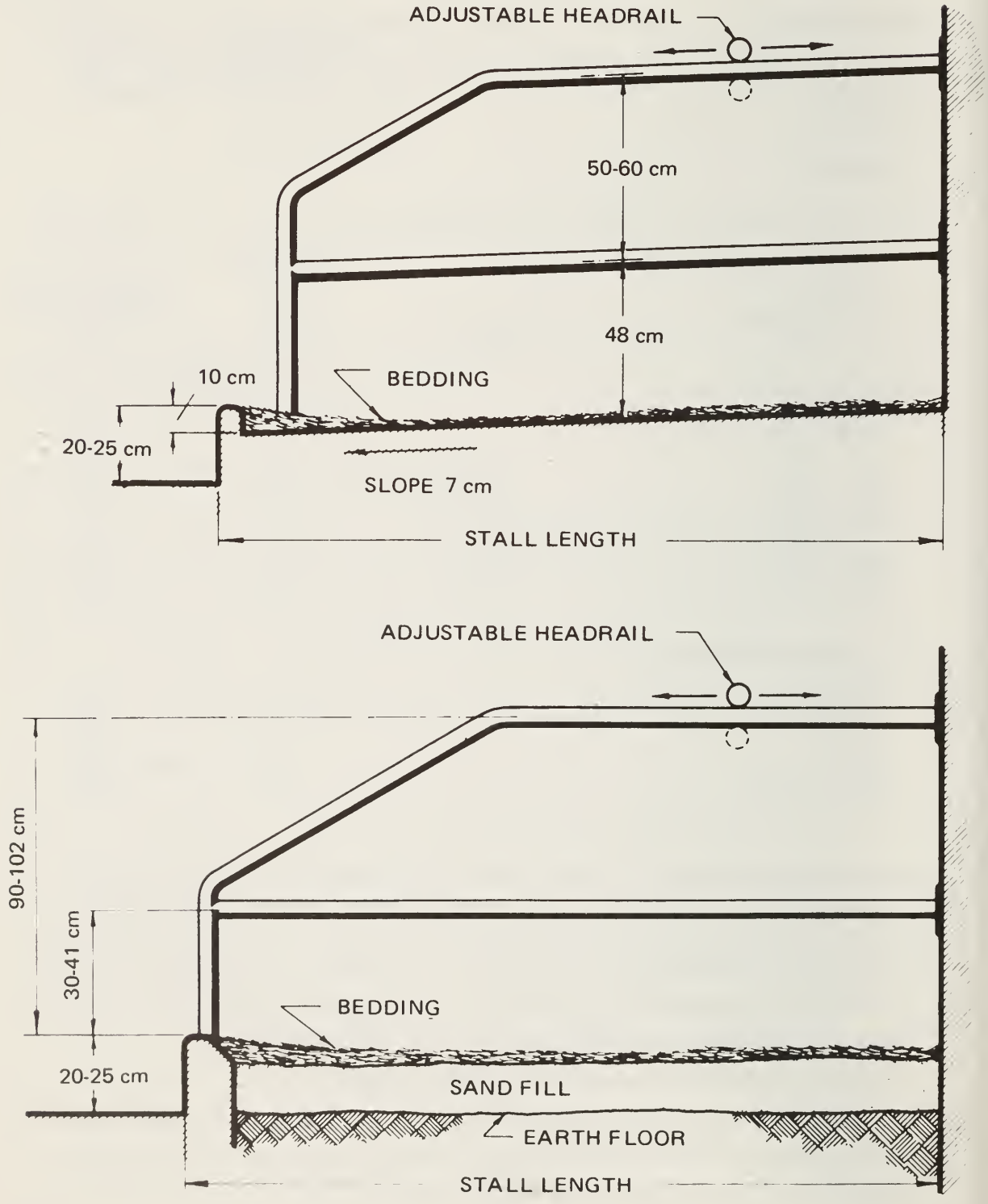
FEEDING, WATERING, AND RESTING AREAS

The modern trend in dairy barn construction is to include the free stalls, feeding, and watering all in the same area. This area may be well insulated and equipped with a ventilation system for controlled winter temperature. Or, it

may be insulated just enough to minimize condensation on the ceiling, and ventilated naturally by open slots at the eaves and ridges. In this case, it is necessary to provide heated waterers to keep water from freezing.

The typical cross sections for free-stall barns illustrate the two space arrangements that are most popular.

FIGURE 7 — Construction details of paved (top) and unpaved (bottom) free stalls



More complete information on construction of paved yards, of placement of buildings, silos, and fences to minimize wind effects, can be obtained from the local Agricultural Representative.

MATERNITY, HOSPITAL, SERVICE AND CALF PEN AREA

Most operators prefer to have this area in an enclosed, insulated building, or section of building, where they have reasonable control over the environment. Very often part of the stable section of an existing barn can be converted into an efficient unit for this purpose. The area must be dry, draft-free well lighted, insulated, and ventilated.

YOUNG STOCK AND DRY COW AREA

Provision for these classes of stock should be separate from the milking herd but should be a loose housing system of management, to conserve labor. It is desirable to separate the heifers into two groups depending on size. If this is not done, liberal amounts of feeding space should be allowed so that smaller animals will not be crowded out.

Plans

Plans for all types of dairy cattle housing are available through the Canada Plan Service. These plans may be obtained from the office of your provincial Department of Agriculture.

Advice and assistance in planning a layout may be obtained from the Agricultural Engineering Extension Specialist for your area.

APPENDIX

Figures on feed composition adapted from "Tables on Feed Composition" (U.S. National Research Council Publication 659) and Morrison's "Feeds and Feeding" (22nd edition).

TABLE A–1

Daily nutrient requirements of dairy cattle[1]

Body wt kg	Daily gain kg	Protein kg	Digestible protein kg	T.D.N. kg	Ca g	P g	Carotene mg
Growth of heifers for herd replacement							
25	0.30	0.09	0.08	0.50	2	2	2
50	0.55	0.20	0.18	1.00	4	3	6
75	0.60	0.34	0.24	1.50	9	7	9
100	0.70	0.43	0.28	2.00	11	8	11
200	0.75	0.52	0.38	3.25	14	13	22
300	0.65	0.66	0.41	4.25	15	14	33
400	0.60	0.74	0.45	4.75	18	17	43
500	0.50	0.80	0.48	5.30	18	17	53
600	0.35	0.84	0.51	5.50	18	17	64
Maintenance of mature cows							
400		0.41	0.25	3.00	11	11	44
500		0.50	0.30	3.50	13	13	53
600		0.58	0.35	4.10	17	17	64
700		0.67	0.40	4.60	19	19	76
800		0.76	0.45	5.10	22	22	88
Reproduction (add to maintenance during last 2 to 3 months of gestation)							
400		0.40	0.24	2.40	11	9	24
600		0.50	0.30	3.30	14	12	33
800		0.62	0.36	4.00	18	15	42
Growth of veal calves for slaughter							
50	0.75	0.27	0.24	1.41	6	4	6
75	1.00	0.40	0.36	2.30	9	7	9
100	1.20	0.60	0.45	3.00	10	9	11
125	1.25	0.62	0.46	3.10	12	11	14
175	1.30	0.64	0.48	3.20	13	12	18

[1] Adapted from Nutrient Requirements of Dairy Cattle, U.S. National Research Council, Publication 1349.

TABLE A–1 (Continued)

Body wt kg	Daily gain kg	Protein kg	Digestible protein kg	T.D.N. kg	Ca g	P g	Carotene mg
Growth of dairy bulls (use tables for growing heifers up to 200 kg body wt)							
200	1.1	0.61	0.42	3.50	15	14	23
400	1.0	0.80	0.55	5.50	19	17	44
600	0.85	0.95	0.60	6.50	20	19	64
800	0.65	1.10	0.70	7.50	22	21	88
1000	—	1.20	0.75	8.50	24	22	105
Maintenance of mature breeding bulls							
600		0.77	0.51	5.15	13	13	66
800		0.88	0.59	6.40	18	18	88
1000		1.05	0.70	7.70	22	22	105
1200		1.22	0.81	9.25	26	26	129

Lactation (add to growth or maintenance for each kg of milk)

	% Fat	Total crude protein g	Energy (T.D.N.) g	Calcium g	Phosphorus g
For cows producting more than 35 kg of milk daily	3.0	78	282	3.0	2.0
	4.0	88	326	3.2	2.2
	5.0	98	365	3.5	2.3
	6.0	108	410	3.7	2.5
For cows producing 20 to 35 kg of milk daily	3.0	70	254	2.5	1.8
	4.0	78	296	2.7	2.0
	5.0	86	330	3.0	2.1
	6.0	94	352	3.2	2.3
For cows producing less than 20 kg of milk daily	3.0	62	226	2.2	1.5
	4.0	70	268	2.4	1.7
	5.0	78	296	2.7	1.8
	6.0	86	328	2.9	2.0

TABLE A–2

Nutrient requirements of total protein, digestible protein, and total digestible nutritients for milk production (To be added to requirements for growth or maintenance)

kg milk		% Fat						
		3.0	3.5	4.0	4.5	5.0	5.5	6.0
5	Total protein	0.83	0.85	0.88	0.90	0.93	0.97	0.99
	Digestible protein	0.54	0.56	0.57	0.59	0.61	0.63	0.65
	T.D.N.	5.24	5.36	5.48	5.57	5.69	5.81	5.93
10	Total protein	1.23	1.28	1.33	1.38	1.44	1.49	1.54
	Digestible protein	0.80	0.83	0.86	0.90	0.94	0.97	1.00
	T.D.N.	6.82	7.04	7.26	7.44	7.65	7.87	8.10
15	Total protein	1.62	1.69	1.77	1.84	1.93	2.01	2.08
	Digestible protein	1.05	1.10	1.15	1.20	1.25	1.31	1.35
	T.D.N,	8.23	8.56	8.89	9.16	9.48	9.81	10.15
20	Total protein	2.00	2.10	2.20	2.30	2.42	2.52	2.62
	Digestible protein	1.30	1.37	1.43	1.50	1.57	1.64	1.70
	T.D.N.	9.64	10.08	10.52	10.88	11.30	11.74	12.20
25	Total protein	2.39	2.51	2.64	2.76	2.91	3.04	3.16
	Digestible protein	1.55	1.63	1.72	1.79	1.89	1.98	2.05
	T.D.N.	11.05	11.60	12.15	12.60	13.13	13.68	14.25
30	Total protein	2.77	2.92	3.07	3.22	3.40	3.55	3.70
	Digestible protein	1.80	1.90	1.99	2.09	2.20	2.31	2.41
	T.D.N.	12.46	13.12	13.78	14.32	14.95	15.61	16.30
35	Total protein	3.15	3.33	3.51	3.68	3.89	4.07	
	Digestible protein	2.05	2.16	2.28	2.39	2.53	2.65	
	T.D.N.	13.87	14.64	15.41	16.04	16.78	17.55	
40	Total protein	3.54	3.74	3.94	4.14	4.83		
	Digestible protein	2.30	2.43	2.56	2.69	2.85		
	T.D.N.	15.28	16.16	17.04	17.76	18.60		
45	Total protein	3.93	4.15	4.38	4.60			
	Digestible protein	2.55	2.70	2.85	2.99			
	T.D.N.	16.69	17.68	18.67	19.48			

This table is adapted from the milk production requirements of Table A–1.

Select the kilograms of milk in the left-hand column and follow across to the vertical column for the correct percent fat. A cow producing 25 kg of 4% milk would have a daily requirement for milk production of 2.64 kg of total protein or 1.72 kg of digestible protein and 12.15 kg of T.D.N.

TABLE A–3

Average composition of feeding stuffs as fed

Feeding stuff	Dry matter %	T.D.N. %	Crude protein %	Digestible protein %	Fat %	Fiber %	N.F.E. %	Calcium %	Calcium Grams per kg	Phosphorus %	Phosphorus Grams per kg
PASTURE AND GREEN ROUGHAGES											
Alfalfa, green average	24	15	4.6	3.5	0.9	6.7	10.0	0.40	4.00	0.06	0.59
Alfalfa, before bloom	20	12	4.4	3.3	0.7	4.7	8.2	0.45	4.51	0.07	0.70
Alfalfa, past bloom	30	15	3.6	2.7	0.7	11.9	10.9	0.36	3.61	0.06	0.59
Alfalfa and bromegrass, half alfalfa	23	14	4.8	3.3	0.8	5.3	9.4	0.28	2.79	0.07	0.70
Alfalfa and timothy, half alfalfa	22	14	4.6	3.5	0.8	4.7	9.6	0.30	2.99	0.08	0.79
Bluegrass, Kentucky	30	21	5.5	4.1	1.2	7.6	13.4	0.16	1.61	0.13	1.30
Clover, ladino	17	13	4.1	3.3	0.8	2.5	7.5	0.21	2.09	0.07	0.70
Clover, red pasture	18	13	3.7	2.8	0.9	2.9	9.0	0.35	3.50	0.05	0.51
Clover and mixed grass, pasture	20	14	4.5	3.4	0.8	3.6	9.6	0.23	2.29	0.07	0.70
Clover, sweet, before bloom	21	13	4.1	3.2	0.7	4.9	9.2	0.34	3.39	0.10	0.99
Corn fodder, dent, tassel stage	15	10	1.6	1.0	0.3	4.2	7.8	0.07	0.70	0.05	0.51
Grasses, mixed pasture	28	19	4.9	3.7	1.4	6.1	12.9	0.16	1.61	0.09	0.90
Kale	12	8	2.4	1.9	0.5	1.6	5.5	0.19	1.89	0.06	0.59
Oat pasture, before heading	14	9	3.2	2.4	0.6	2.8	5.5	0.06	0.59	0.09	0.90
Oats and peas	23	14	3.2	2.4	0.9	6.4	10.3	0.17	1.69	0.07	0.70
Rye pasture	20	13	5.3	4.0	0.9	3.4	7.5	0.13	1.30	0.10	0.99
Sudan grass pasture	22	14	3.3	2.4	0.6	5.6	10.2	0.12	1.19	0.10	0.99
Timothy, young pasture	24	16	4.7	3.5	0.9	4.6	11.1	0.14	1.41	0.09	0.90

TABLE A–3 (Continued)

Feeding stuff	Dry matter %	T.D.N. %	Crude protein %	Digestible protein %	Fat %	Fiber %	N.F.E. %	Calcium %	Calcium Grams per kg	Phosphorus %	Phosphorus Grams per kg
SILAGES											
Clover, ladino and grass	30	21	5.4	3.9	1.5	7.5	12.9	0.31	3.10	0.07	0.70
Clover, red, and grass, wilted	35	22	4.3	2.5	1.1	11.0	15.7	0.39	3.89	0.07	0.70
Corn, dent, well-matured, well-eared	28	18	2.3	1.2	0.8	6.7	16.2	0.10	0.99	0.07	0.70
Corn, dent, well-matured, few ears	26	16	2.2	1.1	0.8	8.5	12.9	0.09	0.90	0.05	0.51
Corn, dent, immature before dough	20	13	1.8	0.9	0.6	5.8	10.8	0.11	1.01	0.07	0.70
Grass silage, considerable legumes, wilted	33	19	5.2	2.9	1.3	8.8	14.2	0.25	2.51	0.12	1.19
Grass silage, small proportion of legumes	28	15	3.2	1.9	1.1	9.7	11.1	0.19	1.89	0.09	0.90
ROOTS AND MALT											
Brewers' grains, wet	24	16	5.7	4.2	1.6	3.6	11.8	0.07	0.70	0.12	1.19
Mangels	9	7	1.3	0.9	0.1	0.8	6.0	0.02	0.20	0.02	0.20
Sugar beets	16	14	1.6	1.2	0.1	1.0	12.6	0.04	0.40	0.04	0.40
Turnips	9	8	1.3	0.9	0.2	1.1	5.8	0.06	0.59	0.02	0.20
HAY, OTHER DRIED ROUGHAGES											
Alfalfa hay, all analyses	90	51	15.3	10.9	1.9	28.6	36.7	1.47	14.67	0.24	2.40
Alfalfa meal, dehydrated	93	55	17.7	12.4	2.5	24.0	38.4	1.60	15.97	0.26	2.60
Alfalfa and brome, grass hay	89	53	11.8	7.6	2.0	32.5	36.7	0.77	7.70	0.20	2.00
Bird's-foot, trefoil, hay	91	55	14.2	9.8	2.1	27.0	41.9	1.60	15.95	0.20	2.00
Clover hay, ladino	90	55	18.5	14.2	1.7	21.6	38.4	1.53	15.29	0.29	2.88

TABLE A–3 (Continued)

Feeding stuff	Dry matter %	T.D.N. %	Crude protein %	Digestible protein %	Fat %	Fiber %	N.F.E. %	Calcium %	Calcium Grams per kg	Phosphorus %	Phosphorus Grams per kg
Clover hay, red	88	52	12.0	7.2	2.5	27.1	40.3	1.28	12.78	0.20	2.00
Clover and timothy hay, 30 to 50% clover	88	51	8.6	4.7	2.2	30.3	41.2	0.69	6.89	0.16	1.61
Corn fodder, well-eared, very dry	91	59	7.8	3.8	2.2	27.1	47.6	0.27	2.71	0.16	1.61
Corn stover, ears removed	91	52	5.9	2.1	1.6	30.8	46.5	0.54	5.39	0.09	0.90
Millet hay	90	50	9.3	5.6	2.2	23.9	47.6	0.29	2.90	0.16	1.61
HAY, OTHER DRIED ROUGHAGES											
Mixed grass hay	89	52	7.0	3.5	2.5	30.9	43.1	0.48	4.80	0.21	2.09
Oat hay	88	47	8.2	4.9	2.7	28.1	42.2	0.21	2.09	0.19	1.89
Straw, oat	90	44	4.1	0.7	2.5	36.3	40.9	0.24	2.40	0.09	0.90
Straw, wheat	93	40	3.4	0.3	1.5	37.0	41.9	0.15	1.50	0.07	0.70
Timothy hay	89	49	6.6	3.0	2.3	30.3	44.8	0.35	3.50	0.14	1.41
GRAINS, SEEDS, BY-PRODUCTS CONCENTRATES											
Barley	90	78	12.5	10.9	1.9	5.4	66.6	0.06	0.50	0.40	4.00
Beet pulp, dried	91	68	9.1	4.3	0.6	19.6	58.7	0.69	6.89	0.08	0.79
Beet pulp, molasses, dried	92	72	9.1	6.0	0.5	15.2	61.8	0.57	5.70	0.07	0.68
Brewers' grains, dried	92	66	25.9	20.7	6.2	15.6	43.7	0.29	2.90	0.05	4.80
Corn, yellow	86	80	8.7	6.7	3.8	2.4	71.5	0.03	0.31	0.03	2.71
Corn and cob meal	86	73	7.4	5.4	3.2	8.0	66.2	0.04	0.40	0.02	2.20
Corn gluten feed	90	75	25.3	21.8	2.5	7.2	48.1	0.41	4.09	0.76	7.59

TABLE A–3 (Continued)

Feeding stuff	Dry matter %	T.D.N. %	Crude protein %	Digestible protein %	Fat %	Fiber %	N.F.E. %	Calcium %	Calcium Grams per kg	Phosphorus %	Phosphorus Grams per kg
Cottonseed meal	93	72	41.6	33.3	6.0	10.7	28.1	0.20	2.00	1.11	11.09
Hominy feed	91	84	10.7	7.5	6.5	4.7	65.4	0.05	0.51	0.57	5.70
Linseed oil meal, old process	91	76	35.3	30.6	4.6	8.9	36.7	0.41	4.09	0.86	8.58
Linseed oil meal, solvent process	91	71	35.1	29.5	1.0	9.3	38.3	0.40	4.00	0.83	8.27
Molasses, cane, blackstrap	74	55	3.2	0	0.1	0	61.7	0.66	6.62	0.81	8.07
Oats	90	70	12.0	9.4	4.6	11.0	58.6	0.09	0.90	0.33	3.30
Oats, lightweight	91	60	12.0	8.3	4.5	15.1	54.9	—	—	—	—
Rye	90	76	12.6	10.0	1.7	2.4	70.9	0.07	0.70	0.33	3.30
Soybean oil meal, expeller	90	77	43.8	36.8	4.9	5.9	30.0	0.27	2.71	0.63	6.29
Soybean oil meal, solvent process	89	77	45.8	42.1	1.3	5.9	31.4	0.29	2.90	0.64	6.40
Soybeans	90	87	37.9	33.7	18.0	5.0	24.5	0.25	2.51	0.59	5.90
Wheat	90	80	13.2	11.1	1.9	2.6	69.9	0.04	0.40	0.39	3.89
Wheat bran	89	66	16.0	13.0	4.5	10.0	53.1	0.13	1.30	1.29	12.89
Wheat middlings	90	77	17.2	14.3	4.9	7.3	55.9	0.09	0.90	0.92	9.24
Wheat shorts	90	77	16.4	13.8	3.9	6.0	58.6	0.13	1.30	0.84	8.38

TABLE A–4

Tonnage capacity of tower silos

Standard silage capacity table for estimating approximate farm silage capacity in metric tonnes of all silage crops at 70% moisture

Settled silage depth m	Silo diameter – m, (*ft*)					
	4.3 (*14*)	4.9 (*16*)	5.5 (*18*)	6.1 (*20*)	7.3 (*24*)	9.1 (*30*)
9	85.0	111	140	173	249	389
10.5	106	137	175	215	310	484
12.0	129	168	213	263	379	593
13.5	154	201	254	314	452	706
15.0	180	235	298	368	530	827
16.5	205	268	341	419	604	944
18.0	233	305	380	476	686	1071
19.5	262	342	433	535	770	1202
21.0	292	380	481	594	856	1338
22.5	320	419	530	655	943	1472
24.0	352	459	581	718	1034	1616
25.5	384	501	635	784	1129	1764
27.0	416	544	688	850	1224	1913
28.5	451	589	746	920	1325	2070
30.0	484	633	802	990	1425	2226

Note: The silo diameter is also given in feet since most silos were built before the conversion date to metric.

TABLE A–5

Gestation table for cows

Breeding dates	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Day 1	Oct. 10	Nov. 10	Dec. 8	Jan. 8	Feb. 7	Mar. 10	Apr. 9	May 10	June 10	July 10	Aug. 10	Sept. 9
2	11	11	9	9	8	11	10	11	11	11	11	10
3	12	12	10	10	9	12	11	12	12	12	12	11
4	13	13	11	11	10	13	12	13	13	13	13	12
5	14	14	12	12	11	14	13	14	14	14	14	13
6	15	15	13	13	12	15	14	15	15	15	15	14
7	16	16	14	14	13	16	15	16	16	16	16	15
8	17	17	15	15	14	17	16	17	17	17	17	16
9	18	18	16	16	15	18	17	18	18	18	18	17
10	19	19	17	17	16	19	18	19	19	19	19	18
11	20	20	18	18	17	20	19	20	20	20	20	19
12	21	21	19	19	18	21	20	21	21	21	21	20
13	22	22	20	20	19	22	21	22	22	22	22	21
14	23	23	21	21	20	23	22	23	23	23	23	22
15	24	24	22	22	21	24	23	24	24	24	24	23
16	25	25	23	23	22	25	24	25	25	25	25	24
17	26	26	24	24	23	26	25	26	26	26	26	25
18	27	27	25	25	24	27	26	27	27	27	27	26
19	28	28	26	26	25	28	27	28	28	28	28	27
20	29	29	27	27	26	29	28	29	29	29	29	28
21	30	30	28	28	27	30	29	30	30	30	30	29
22	31	Dec. 1	29	29	28	31	30	31	July 1	31	31	30
23	Nov. 1	2	30	30	Mar. 1	Apr. 1	May 1	June 1	2	Aug. 1	Sept. 1	Oct. 1

TABLE A–5 (Continued)

Breeding dates	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
24	2	3	31	31	2	2	2	2	3	2	2	2
25	3	4	Jan. 1	Feb. 1	3	3	3	3	4	3	3	3
26	4	5	2	2	4	4	4	4	5	4	4	4
27	5	6	3	3	5	5	5	5	6	5	5	5
28	6	7	4	4	6	6	6	6	7	6	6	6
29	7	–	5	5	7	7	7	7	8	7	7	7
30	8	–	6	6	8	8	8	8	9	8	8	8
31	9	–	7	–	9	–	9	9	–	9	–	9

TABLE A–6

Normal growth in weight and height of female dairy cattle

	AYRSHIRE		GUERNSEY		HOLSTEIN		JERSEY	
AGE	Weight kg	Height cm	Weight kg	Height cm	Weight kg	Height cm	Weight kg	Height cm
1 mo	40	73	35	72	51	78	30	69
2 mo	54	77	46	76	67	82	41	73
4 mo	90	86	78	85	110	92	72	83
6 mo	133	94	118	94	161	101	110	92
8 mo	176	101	159	101	210	107	147	99
10 mo	213	106	194	106	250	113	178	104
12 mo	244	110	222	110	287	117	204	107
18 mo	329	118	301	118	383	125	273	115
24 mo	409	123	371	122	485	131	332	119
3 yr	439	124	409	127	528	134	388	122
4 yr	469	127	449	128	559	135	407	123
5 yr	490	128	479	129	603	136	425	124

TABLE A–7

Estimation of weight according to heart girth

Circ. of chest (cm)	Wt in kg	Circ. of chest (cm)	Wt in kg
80	52.53	152	291.59
82	56.50	154	303.50
84	60.47	156	315.41
86	64.44	158	327.32
88	68.41	160	339.23
90	72.38	162	351.60
92	76.35	164	363.95
94	80.32	166	376.30
96	84.29	168	388.65
98	88.26	170	401.00
100	92.23	172	413.35
102	98.74	174	425.70
104	105.25	176	438.05
106	111.76	178	450.40
108	118.27	180	462.75
110	124.78	182	478.69
112	131.29	184	494.67
114	137.80	186	510.65
116	144.31	188	526.63
118	150.82	190	542.61
120	157.33	192	558.59
122	165.48	194	574.57
124	173.63	196	590.55
126	181.78	198	606.53
128	189.93	200	622.51
130	198.08	202	638.88
132	206.23	204	655.25
134	214.38	206	671.62
136	222.53	208	687.99
138	230.68	210	704.36
140	238.83	212	720.73
142	246.98	214	737.10
144	255.13	216	753.47
146	263.28	218	769.84
148	271.43	220	786.21
150	279.68		

TABLE A–8
Herd record form

NAME _____ REG. # _____

DATE OF BIRTH _____ VACCINATED _____
Date

SIRE _____ REG. # _____

DAM _____ REG. # _____

DATE SOLD _____ BUYER'S NAME _____

REASON _____ BUYER'S ADDRESS _____

HERD NO.

Date	Classification

BREEDING RECORDS

PRODUCTION RECORDS

Date Bred	Sire	Date Calved	Sex of Calf	Herd No.	Days In Milk	Milk	Fat	%	BCAM	BCAF

TABLE A–9

a

Estimating the cow's breeding value

Cow number	Year calved	B.C.A. milk	Deviation or difference from herd average (B.C.A.)	Average deviation	Breeding value (B.C.A.)
1	1959	133	+ 1		
	1961	118	− 14		
	1962	139	− 1		
	1963	159	− 6	− 5.0	− 2.0
2	1960	157	+ 25		
	1961	146	+ 14		
	1963	190	+ 25	+ 21.3	+ 7.9
3	1963	130	− 35	− 35	− 8.7
9	1963	193	+ 28	+ 28	+ 7.0

b

No. of records in average deviation	Factor
1	0.25
2	0.33
3	0.375
4	0.40
5	0.42
6 or more	0.43

Procedure to estimate breeding value of a cow using all her records

The breeding value is the most accurate means of comparing cows with varying numbers of records. This procedure is useful in comparing cows on their milk yield.

1. Draw up a table for each cow in the herd, listing the year each cow calved, the cow's B.C.A. for milk and the herd average for B.C.A. milk in the appropriate year. (See Table A-9a.)

2. Subtract the herd average for B.C.A. milk from the cow's B.C.A. milk for each record obtaining a difference of deviation of each record from the herd average in terms of B.C.A. milk.

3. Obtain the average deviation for each cow (i.e., sum of the deviations for each cow divided by the number of deviations or records on the cow).

4. Multiply the average deviation by the factor (taken from Table A-9b) which is appropriate for the number of records that each cow has. Example: In Table A-9a cow No. 1 has 4 records. The appropriate factor is 0.40. Multiplying 0.40 by the average deviation of -5.0 B.C.A. gives us the breeding value of -2.0 for cow No. 1. Note that the factors are larger for more records. This follows because we can put more confidence in the average deviation of five records from the herd average as an estimator of a cow's breeding value than we can in the average deviation of two records on a cow.

The chief advantage of the breeding value figures is that we can accurately compare the breeding value figures for cows with varying numbers of records and different ages. Selection among cows for milk yield is made by selecting those cows for breeding purposes with the highest plus breeding values and culling those with the largest negative breeding values.

CONVERSION FACTORS FOR METRIC SYSTEM

Imperial units	Approximate conversion factor	Results in:	
LINEAR			
inch	x 25	**millimetre**	**(mm)**
foot	x 30	**centimetre**	**(cm)**
yard	x 0.9	**metre**	**(m)**
mile	x 1.6	**kilometre**	**(km)**
AREA			
square inch	x 6.5	**square centimetre**	**(cm^2)**
square foot	x 0.09	**square metre**	**(m^2)**
acre	x 0.40	**hectare**	**(ha)**
VOLUME			
cubic inch	x 16	**cubic centimetre**	**(cm^3)**
cubic foot	x 28	**cubic decimetre**	**(dm^3)**
cubic yard	x 0.8	**cubic metre**	**(m^3)**
fluid ounce	x 28	**millilitre**	**(mL)**
pint	x 0.57	**litre**	**(L)**
quart	x 1.1	**litre**	**(L)**
gallon	x 4.5	**litre**	**(L)**
WEIGHT			
ounce	x 28	**gram**	**(g)**
pound	x 0.45	**kilogram**	**(kg)**
short ton (2000 lb)	x 0.9	**tonne**	**(t)**
TEMPERATURE			
degrees Fahrenheit	($^\circ$F-32) x 0.56 or ($^\circ$F-32) x 5/9	**degrees Celsius**	**($^\circ$C)**
PRESSURE			
pounds per square inch	x 6.9	**kilopascal**	**(kPa)**
POWER			
horsepower	x 746	**watt**	**(W)**
	x 0.75	**kilowatt**	**(kW)**
SPEED			
feet per second	x 0.30	**metres per second**	**(m/s)**
miles per hour	x 1.6	**kilometres per hour**	**(km/h)**
AGRICULTURE			
gallons per acre	x 11.23	**litres per hectare**	**(L/ha)**
quarts per acre	x 2.8	**litres per hectare**	**(L/ha)**
pints per acre	x 1.4	**litres per hectare**	**(L/ha)**
fluid ounces per acre	x 70	**millilitres per hectare**	**(mL/ha)**
tons per acre	x 2.24	**tonnes per hectare**	**(t/ha)**
pounds per acre	x 1.12	**kilograms per hectare**	**(kg/ha)**
ounces per acre	x 70	**grams per hectare**	**(g/ha)**
plants per acre	x 2.47	**plants per hectare**	**(plants/ha)**