DIET OF NESTLING TREE SWALLOWS (*Tachycineta bicolor*) NEAR SUDBURY, ONTARIO, SUMMER 1986

Peter J. Blancher
Caren L. Furlonger
Donald K. McNicol

Technical Report Series No. 31
Ontario Region 1987
Canadian Wildlife Service

This series may be cited as:

Blancher, P.J.; Furlonger, C.L.; McNicol, D.K. 1987. Diet of nestling tree swallows (*Tachycineta bicolor*) near Sudbury, Ontario, summer 1986. Technical Report Series No. 31. Canadian Wildlife Service, Ontario Region.

Published by Authority of the
Minister of Environment
Canadian Wildlife Service

Catalogue No. CW69-5/31E
ISBN 0-662-15666-8
ISSN 0831-6481

Copies may be obtained from:

Donald K. McNicol
Canadian Wildlife Service
Ontario Region
1725 Woodward Drive
Ottawa, Ontario
K1A 0H3

ABSTRACT

We present some preliminary information on the diet of nestling Tree Swallows (Tachycineta bicolor) northeast of Sudbury, Ontario in 1986. Flies (Diptera) comprised nearly half of the diet items, but aphids (Aphididae), mayflies (Ephemeroptera), dragonflies and damselflies (Odonata), beetles (Coleoptera), and ants and wasps (Hymenoptera) were also important in the diet. Close to half of prey items were aquatic in origin. Of these, mayflies and mollusc shells were more prominent in the diet near wetlands of relatively high pH, than near wetlands of lower pH. Aquatic prey were of larger average size than terrestrial prey. The relative merits of several diet collection methods are discussed.

RESUMÉ

Nous présentons de l'information préliminaire sur l'alimentation des jeunes de L'Hirondelle bicolore (Tachycineta bicolor) au nord-est de Sudbury, Ontario, en 1986. Des mouches (Diptera) composaient presque la moitié des éléments trouvés dans leur régime alimentaire, mais des pucerons (Aphididae), des éphémères (Ephemeroptera), des libellules et des demoiselles (Odonata), des coléoptères (Coleoptera), des fourmis et des guêpes (Hymenoptera) étaient aussi importants à leur alimentation. Près de la moitié des espèces consommées étaient de provenance aquatique. De celles-ci, les éphémères et les coquilles de mollusques étaient plus en évidence dans les échantillons recueillis près de marécages avec un pH relativement élevé que dans les endroits où le pH était plus bas. La nourriture provenant de sources aquatiques avait en moyenne de plus grandes dimensions que celle provenant d'endroits terrestres. Nous discutons ici des mérites relatifs de plusieurs méthodes de collecte de données alimentaires.

TABLE OF CONTENTS

	PAGE
Abstract	i
Resumé	i
Table of Contents	ii
1. Introduction	1
2. Study Area	1
3. Methods	1
4. Results	2
4.1 Diet Samples	2
Table 1: Diet samples collected in 1986	3
4.2 Diet Composition	3
Table 2: Summary of nestling diet	4
Table 3: Aquatic prey in diet samples	5
Fig. 1: Mollusc shells in nests	7
4.3 Prey Size	5
Fig. 2: Size distribution of prey	7
5. Discussion	6
5.1 Evaluation of Diet Sampling Techniques	8
6. Acknowledgments	9
7. Literature Cited	9
8. Appendix 1: List of Prey Items	12

1. Introduction

We are studying the biology of Tree Swallows (*Tachycineta bicolor*) breeding near Sudbury, Ontario, as part of an investigation into the effects of acid precipitation on wetland-dwelling wildlife (Blancher and McNicol 1986, McNicol *et al*. 1987b). In 1986, reproduction was poorer for swallows breeding near low pH wetlands compared to swallows breeding near less acid wetlands (Blancher and McNicol 1988). We hypothesized that this difference might be related to a change in the quality or quantity of prey of aquatic origin available to swallows as wetland pH changes. A detailed study of swallow diet is planned for 1987 to test this hypothesis. Here we examine some preliminary diet data collected in 1986. Our objectives in this report are:

(1) to describe the importance of aquatic prey, particularly those organisms that are sensitive to pH, in the diet of nestling Tree Swallows near wetlands northeast of Sudbury; and

(2) to examine briefly the relative merits of several methods used to collect nestling diet information.

2. Study Area

The study area is located north of Lake Wanapitei, and is 40 to 65 km northeast of Sudbury. Fifty-one wetlands were selected to include a range of pH (4.05 to 7.60), water colour and the presence or absence of fish (see Blancher and McNicol 1988 for details). Wetlands ranged in size from 1.2 to 25.5 ha, and averaged 6.3 ha. Most wetlands had shorelines of ericaceous shrubs associated with a *Sphagnum* mat. However, wetlands ranged from clear, rocky headwater lakes to dark-coloured pools in well-developed peatland habitat. Wetlands were surrounded by mixed forest of the Great Lakes - St. Lawrence Forest Region (Rowe 1972). We placed two to four nest boxes at 1 to 2 m height around the edges of open water in each wetland.

3. Methods

Nestling diet information was collected in six ways:

(1) Food Boluses - Adults bringing food to nestlings were trapped inside boxes using automatic door traps described by Stutchbury and Robertson (1986). Food was removed from the mouth and throat of adults with the aid of forceps, and the nest box was checked for prey items that had been dropped.

(2) Neck Collars - Short pieces of black pipe-cleaner were wrapped around the throats of nestlings, loosely enough to allow normal breathing. Nestlings were left in this manner for 30 to 60 minutes while parent swallows continued to bring food to them. We removed food items from nestling throats, and checked the nest for regurgitated prey.

(3) Stomachs - Nestlings that died during inclement weather were collected for stomach contents analysis. Only those nestlings with identifiable prey remains are considered here.

(4) Regurgitations - Two pellets of digested insect parts were found in nest boxes and analyzed.

(5) Feces - Feces were collected opportunistically whenever nestling swallows were handled, from hatchday to sixteen days after hatch. A subsample of 32 fecal collections was analyzed for prey remains.

(6) Spillage in Nests - Undigested prey and prey remnants (e.g. mollusc shells, dragonfly head capsules, wings) were frequently found in nests that had fledged young. All nests were searched for prey items once swallows had left the box. Known nest parasites (flea larvae (Siphonaptera), larval blow flies (Calliphoridae)) were not included in analyses.

The six types of food samples listed above were placed into three groups for analysis: prey fed to nestlings (food boluses and neck collar samples), prey digested by nestlings (stomach samples, regurgitations, and fecal samples), and prey remains found in nests (spillage). Samples of food fed to nestlings were taken at the end of June and throughout July, and underrepresent the peak of nesting activity in June.

Prey items were identified to the level of Family whenever possible, and classed as terrestrial or aquatic based on larval habits. All intact prey items were measured to the nearest mm under a dissecting microscope. For digested samples we determined the minimum number of each prey type that could account for the prey remains observed.

Analysis of prey composition was based on the aggregate percent method (unless otherwise stated), which gives equal weight to each food sample regardless of the relative size of the sample (Swanson et al. 1974). Percents within each sample were calculated from the number of identified prey. This method removes the bias of a few samples with large numbers of one food type, but gives high weight to items from relatively small samples. Percent frequency of occurrence in diet samples was calculated for comparison. Analyses of prey composition should ideally be based on biomass rather than numbers of prey or frequency of occurrence, but we did not have dry weights for many of the prey taxa. To partially compensate, we present prey size information.

4. Results

4.1 Diet Samples

Neck collar samples and stomach samples usually included many more prey items than other types of diet samples (Table 1). A single sample of 3 nestling stomachs contained 278 identifiable prey items and

Table 1: Diet samples collected in 1986.

	Number of Samples	Number of Prey Items
Fed to Nestlings		
Food Boluses	25	319
Neck Collars	7	601
Digested Samples		
Stomach Samples	7[a]	461
Regurgitations	2	15
Fecal Samples	32	500
Spillage in Nest	66	857

[a] 7 samples from a total of 12 nestling stomachs

another stomach contained 105 items. Other stomachs contained few well-digested prey remains.

4.2 Diet Composition

A detailed list of prey types, number of prey items, and prey sizes is given in Appendix 1 and summarized in Table 2. Flies (Diptera) were by far the most numerous prey items, comprising almost half of the nestling diet. Flies belonging to thirty families were identified in the diet, with dance flies (Empididae), midges (Chironomidae) and muscid flies (Muscidae) being most predominant (Appendix 1). Horse flies (Tabanidae - genus Tabanus) were not as numerous but were an important diet item because of their relatively large size.

Homopterans, particularly aphids (Aphididae), were also abundant in the food fed to nestlings (i.e. food boluses and neck collar samples). Together, Diptera and Homoptera comprised 72% of the food items fed to nestlings. Mayflies (Ephemeroptera), dragonflies and damselflies (Odonata), beetles (Coleoptera), and ants and wasps (Hymenoptera) were also important in the diet (Table 2).

Sphaeriid clam shells were fed to nestlings occasionally, perhaps as grit or as a source of calcium. Other calcium-rich items such as snails (Gastropoda), crayfish (Decapoda) chelipeds, bones, and pieces of eggshell were also found in the diet samples, mostly in the "in nest"

Table 2: Summary of nestling diet.

	% of Food Items			% Occurrence		
Taxonomic Category	Fed to Nestlings	Digested Samples	In Nest	Fed to Nestlings	Digested Samples	In Nest
Mollusca	3.8	2.2	6.5	6.3	17.1	36.4
Araneae	1.7	0.02	0.1	21.9	2.4	4.5
Decapoda			0.1			1.5
Ephemeroptera	10.7	0.2	3.2	21.9	4.9	12.1
Odonata	4.5	6.1	17.8	18.8	48.8	68.2
Psocoptera	1.3	1.2	0.8	28.1	12.2	7.6
Hemiptera	0.4	1.2	0.4	9.4	17.1	7.6
Homoptera	26.1	5.7	4.4	75.0	36.6	21.2
Neuroptera	0.2	0.02		3.1	2.4	
Coleoptera	3.9	16.6	7.7	12.5	63.4	40.9
Trichoptera	0.02	1.5	3.7	3.1	17.1	12.1
Lepidoptera	0.2	4.3	2.1	6.3	22.0	21.2
Diptera	46.3	49.3	43.2	81.3	90.2	77.3
Hymenoptera	1.0	8.9	2.3	21.9	53.7	18.2
Chordata			1.2			9.1
Grit		2.9	6.6		12.2	25.8
Aquatic	46.0	37.3	53.6	87.5	85.4	90.0
Terrestrial	54.0	62.7	46.4	84.4	90.2	83.3

material. Stones and glass were present in a few stomach samples and feces, and in several nests. No vegetable material was observed in any of the diet samples.

There were conspicuous differences in diet composition between food fed to nestlings and food in digested samples. Spiders (Araneae) mayflies and aphids are all soft-bodied prey that were found less frequently in digested samples than in food fed to nestlings (Table 2). Mollusc shells, dragonflies, beetles and wasps tended to be found more frequently in digested samples, primarily because hard parts of these prey were not fully digested. Relatively high proportions of mollusc shells, dragonfly head capules and wings, beetles parts, and grit were also present in "in nest" samples, possibly indicating a tendency for

Table 3: Aggregate percent of aquatic prey items in diet samples (only samples with aquatic prey are included).

Taxonomic Category	Fed to Nestlings	Digested Samples	In Nest
Mollusca	5.4	6.9	12.0
Decapoda			0.3
Ephemeroptera	15.7	1.6	4.7
Odonata	8.9	28.4	33.2
Hemiptera	0.5	0.7	0.3
Coleoptera		2.4	0.1
Trichoptera	0.03	4.7	5.3
Diptera	69.6	55.4	44.1
# of Samples	28	35	60

nestlings to reject the least digestible parts of prey items. A relatively large number of mosquitoes (Culicidae) were found in "in nest" samples, but it is likely that many of these were attracted to the nest box environment, and were not brought as nestling food.

Close to half of the prey fed to nestlings were aquatic in origin (Table 2). Flies with aquatic or semi-aquatic larval stages accounted for as much as 70% of aquatic prey (Table 3). Mayflies, odonates (primarily small Libellulid dragonflies), and mollusc shells were other important aquatic prey items. Mayflies and molluscs are known to be highly sensitive to wetland pH (Eilers et al. 1984), so we examined their prevalance in the diet in relation to pH of the nearby wetland.

Mayflies were absent from all eleven samples of food fed to nestlings at pH < 5.0, but were 8.3% of aquatic food at pH 5.0 - 6.0 (n = 6), and 29.9% at pH > 6.0 (n = 13). Mollusc shells showed a similar increased occurrence in "in nest" samples as wetland pH increased (Fig. 1). Snail shells, in particular, were found primarily in nests near wetlands with pH > 6.0. The three low pH (< 5.0) wetlands where Sphaeriid clams were found in nests did not have known clam populations, so shells must have been obtained by swallows from wetlands farther away (minimum distances to wetlands with higher pH were 0.6, 1.1, and 1.3 km).

4.3 Prey Size

Prey items ranged in length from 1 mm for an aphid to 35 mm for several Libellulid dragonflies, and averaged 6.0 mm (n = 1856). Terrestrial food items were smaller on average (4.7 mm, n = 1070) than aquatic prey (7.6 mm, n = 786), with 71% of terrestrial items 5 mm or less in length (Fig. 2). Items greater than 10 mm long made up 16% of aquatic prey vs. 3% of terrestrial prey (8.2% of all prey). Thus, aquatic prey may be more important than was indicated by prey numbers alone. This is especially true of odonates, which averaged 29.2 mm in length (n = 27), but also applies to tabanid flies (12.4 mm, n = 52), mayflies (10.6 mm, n = 62), and caddisflies (Trichoptera: 10.0 mm, n = 17). In contrast, aphids averaged only 2.9 mm in length (n = 222), so their importance as nestling food is much less than indicated by their abundance in the diet.

The average length of prey items was similar at wetlands with pH < 5.0 (6.2 mm, n = 709) and wetlands with pH > 6.0 (6.2 mm, n = 749), but was smaller at wetlands with pH 5.0 - 6.0 (5.3 mm, n = 398) because few dragonflies and mayflies were included in the diet there.

5. Discussion

The small number of samples analyzed in this study does not allow any firm conclusions about Tree Swallow diets. Nevertheless, it is useful to compare our results with other reports in the literature.

The high percentage of flies observed in the diet of nestling Tree Swallows is consistent with other studies of Tree Swallow diet. Beal (1918) reported 40.5% Diptera in adult stomach samples from across North America. Holroyd (1972) found 96.9% Diptera in food fed to nestlings at Long Point, Ontario, including more than 80% chironomid midges. Quinney and Ankney (1985) reported 74% and 94% Diptera in food brought to nestlings in two populations near Port Rowan, Ontario. Quinney and Ankney (1985) also reported that homopterans were a frequent diet item, as observed in the present study. The bias towards hard-bodied prey in stomach samples is evident in Beal's (1918) study, as beetles, ants and wasps were important prey items of Tree Swallows. The present study differs from that of Quinney and Ankney (1985) in that a greater proportion of large insects were included in nestling diets. Quinney and Ankney found less than 0.7% of insects were longer than 10 mm (compared to 8.2% near Sudbury), and did not observe many mayflies or odonates in the diet, two of the largest insects eaten by swallows near Sudbury. Holroyd (1972) found 5.5% of prey items were longer than 10 mm, primarily midges 12 mm in length. Midges 8-12 mm in length were a very important food of Tree Swallows at Long Point (Holroyd 1983), but were scarce or absent at the wetlands we studied (unpublished emergence trap data).

Insects of aquatic origin are an important source of food for swallows breeding near Sudbury wetlands, particularly when the size of aquatic prey items is compared to the smaller terrestrial prey. Wetland acidity may influence the availability of prey for swallows by changing the species composition of aquatic invertebrates present. The sensitivity of mayflies to low pH (Eilers et al. 1984) is consistent with their absence in Tree Swallow (this study) and waterfowl duckling (McNicol et al. 1987a) diets on acid wetlands near Sudbury. The absence

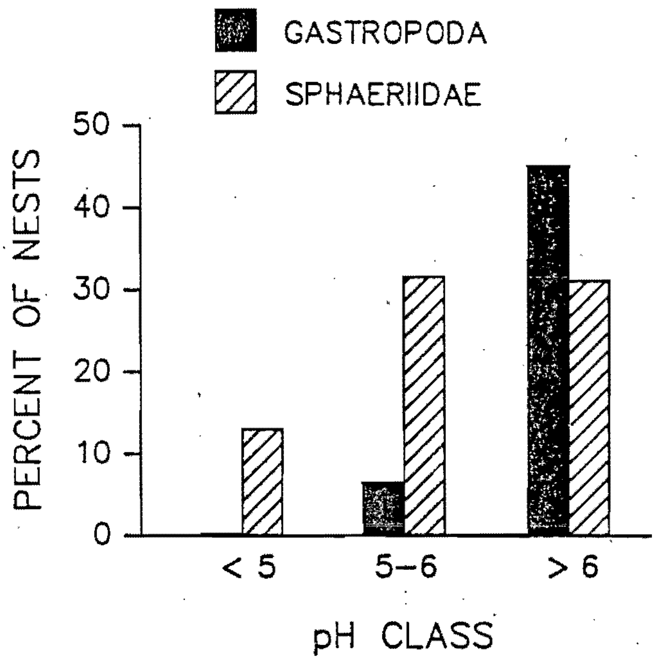

Figure 1: Percent frequency of mollusc shells in nests near wetlands differing in pH.

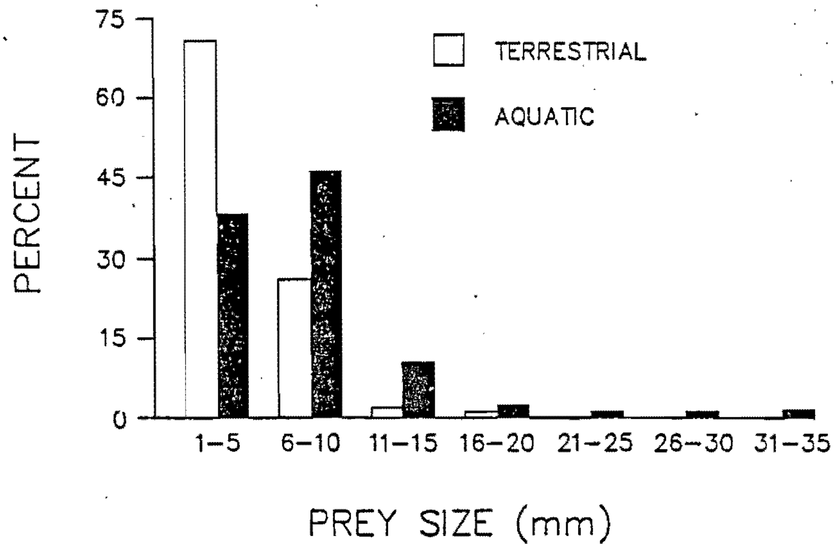

Figure 2: Comparison of the size distribution of aquatic vs. terrestrial prey in diet samples.

of molluscs in low pH waters was reflected in the low frequency of these shells in Tree Swallow nests near low pH wetlands.

While mollusc shells were not abundant in food samples brought to swallow nestlings, they may be important nutritionally. Calcium-rich prey such as mollusc shells appear to be important to egg-laying birds (e.g. Krapu and Swanson 1975, Jones 1976, Ankney and Scott 1980) and to growing young (e.g. Betts 1955, MacLean 1974, Barrentine 1980). Shells were frequently present in nestling Tree Swallow stomachs in Manitoba (Mayoh and Zach 1986), and were fed to nestling Tree Swallows at Long Point (Holroyd 1983). Low availability of shells to swallows breeding near acid wetlands may therefore affect the nutrition of growing nestlings.

The presence of shells, bones, crayfish parts and grit in diet samples shows that some food of swallows is not taken in the air. Even winged dragonflies were occasionally gleaned from shrubs soon after emergence (P. Blancher, pers. obs.). Ground feeding is increasingly being recognized as a mode of foraging used by swallows (Elliot 1939, Barlow and Klaas 1963, Erskine 1984, Cohen and Dymerski 1986, Hobson and Sealy 1987).

5.1 Evaluation of Diet Sampling Techniques

Four criteria can be used to evaluate the usefulness of our six diet sampling techniques: (1) the degree of bias in the composition of the sample, (2) the amount of disturbance caused to the nesting birds, (3) the number of prey items collected per unit effort, and (4) the ease of identification of collected prey. The degree of bias is particularly important for obtaining an accurate indication of the importance of different prey items. The least bias is associated with collections of food as it is fed to nestlings, since digested samples underrepresent soft-bodied prey. Digested prey is also more difficult to identify, particularly the prey remains found in fecal samples. Food collected by neck collars potentially underrepresent the largest prey items when these items are disgorged by collared nestlings (Johnson et al. 1980), but for birds such as swallows that nest in boxes, disgorged prey are easily recovered by checking the nest box (Moore 1983, this study). Samples of food taken when cleaning out nest boxes appeared to be biased towards prey items not easily digested by nestlings. An additional source of bias associated with "in nest" samples is that insects attracted to the nest box can not always be distinguished from insects brought as nestling food. The relatively large number of mosquitoes in the nest compared to other diet samples (see Appendix 1) may indicate that mosquitoes are attracted to the nest box environment. "In nest" samples are useful for supplementing data on mollusc shells and dragonflies taken to nests, especially since the availability of these items may change with wetland pH.

Collection of feces, regurgitations and "in nest" samples are easily obtained with little disturbance to the breeding birds. Food bolus and neck collar collections cause some temporary disturbance, but are preferable to killing nestlings for stomach analysis for ethical reasons and when other facets of reproduction are being studied.

The neck collar technique produced several boluses per sample and thus greater numbers of prey than individual food boluses. Numbers of prey were also large in stomach samples but were not as easily identified, and in most instances prey size could not be measured.

There is no ideal technique for sampling Tree Swallow diet, but a combination of neck collar sampling for relatively unbiased and easily identifiable prey, with "in nest" samples, regurgitation and stomachs from dead nestlings to supplement the data, may be the most efficient strategy. Fecal samples contain a wealth of information for studies that can afford the time to analyze them and do not have access to other food samples.

In this report we have used numbers of prey, and frequency of occurrence in diet samples, as our measures of the importance of various prey in swallow diets. However, these measures do not take into account the size of prey, which is very important from an energetic standpoint. Future analyses of swallow diet will be based on biomass of prey items, which is a more realistic measure of the relative importance of individual swallow foods.

6. Acknowledgments

We thank Mark Mallory, Janette Perkins, and Daniel Carrière for helping to collect the diet samples. We would also like to thank Barry Bendell and Janette Perkins for aid in the identification of many of the invertebrates. Helpful comments on the manuscript were received from Barry Bendell, Steve Curtis, Ken Ross, and G.L. Holroyd.

7. Literature Cited

Ankney, C.D. and D.M. Scott. 1980. Changes in nutrient reserves and diet of breeding Brown-headed Cowbirds. Auk 97: 684-696.

Barlow, J.C. and E.E. Klaas. 1963. Sunning of Bank and Cliff Swallows. Condor 65: 438-440.

Barrentine, C.D. 1980. The ingestion of grit by nestling Barn Swallows. J. Field Ornithol. 51: 368-371.

Beal, F.E.L. 1918. Food habits of the swallows, a family of valuable native birds. U.S. Dept. Agr. Bull. 619.

Betts, M.M. 1955. The food of titmice in oak woodland. J. Anim. Ecol. 24: 282-323.

Blancher, P.J. and D.K. McNicol. 1986. Investigations into the effects of acid precipitation on wetland-dwelling wildlife in northeastern Ontario. Can. Wildl. Serv. Tech. Rpt. Ser. No. 2, Ontario Region, Ottawa, Canada.

Blancher, P.J. and D.K. McNicol. 1988. Breeding biology of Tree Swallows in relation to wetland acidity. Can. J. Zool. (in press).

Cohen, R.R. and M.L. Dymerski. 1986. Swallows taking insects from pond surfaces. Wilson Bull. 98: 483-484.

Eilers, J.M., G.J. Lein and R.G. Berg. 1984. Aquatic organisms in acidic environments: a literature review. Tech. Bull. No. 150, Dept. Nat. Res., Madison, Wisconsin.

Elliot, J.J. 1939. Wintering Tree Swallows at Jones Beach fall and winter of 1937 and 1938. Bird-Lore 41: 11-16.

Erskine, A.J. 1984. Swallows foraging on the ground. Wilson Bull. 96: 136-137.

Hobson, K.A. and S.G. Sealy. 1987. Foraging, scavenging, and other behavior of swallows on the ground. Wilson Bull. 99: 111-116.

Holroyd, G.L. 1972. Resource use by four avian species of aerial insect feeders. M.Sc. Thesis, Univ. of Toronto.

Holroyd, G.L. 1983. Foraging strategies and food of a swallow guild. Ph.D. Thesis, Univ. of Toronto.

Johnson, E.J., L.B. Best and P.A. Heagy. 1980. Food sampling biases associated with the "ligature method". Condor 82: 186-192.

Jones, P.J. 1976. The utilization of calcareous grit by laying Quelea quelea. Ibis 118: 575-576.

Krapu, G.L. and G.A. Swanson. 1975. Some nutritional aspects of reproduction in prairie nesting Pintails. J. Wildl. Manage. 39: 156-162.

MacLean, S.F., Jr. 1974. Lemming bones as a source of calcium for arctic sandpipers (Calidris spp.). Ibis 116: 552-557.

Mayoh, K.R. and R. Zach. 1986. Grit ingestion by nestling Tree Swallows and House Wrens. Can. J. Zool. 64: 2090-2093.

McNicol, D.K., B.E. Bendell and D.G. McAuley. 1987a. Avian trophic relationships and wetland acidity. Trans. N. Amer. Wildl. Nat. Res. Conf. 52: 619-627.

McNicol, D.K., B.E. Bendell and R.K. Ross. 1987b. Studies of the effects of acidification on aquatic wildlife in Canada: waterfowl and trophic relationships in small lakes in northern Ontario. Can. Wildl. Serv. Occas. Paper Ser. No. 62, Ottawa, Canada.

Moore, J. 1983. Responses of an avian predator and its isopod prey to an acanthocephalan parasite. Ecology 64: 1000-1015.

Quinney, T.E. and C.D. Ankney. 1985. Prey size selection by Tree Swallows. Auk 102: 245-250.

Rowe, J.S. 1972. Forest regions of Canada. Dept. Env., Can. For. Serv. Publ. No. 1300, Ottawa, Canada.

Stutchbury, B.J. and R.J. Robertson. 1986. A simple trap for catching birds in nest boxes. J. Field Ornithol. 57: 64-65.

Swanson, G.A., G.L. Krapu, J.C. Bartonek, J.R. Serie and D.H. Johnson. 1974. Advantages in mathematically weighting waterfowl food habits data. J. Wildl. Manage. 38: 302-307.

8. APPENDIX 1: Detailed list of prey items identified and their body lengths.

	Number of Prey Items				
	Fed to Nestlings	Digested Samples	In Nests	Mean Length mm	(n)
MOLLUSCA - unidentified	1	6	3	8.3	(3)
Sphaeriidae	2	1	41	9.7	(43)
GASTROPODA - unid.		1	1	4	(1)
Physidae			1	14	(1)
Planorbiidae			13	6.5	(13)
ARANEAE*	15	1	4	3.6	(20)
DECAPODA - chelipeds			4	10.8	(4)
EPHEMEROPTERA - unid.	1	1	11	13.2	(9)
Siphlonuridae	6	1	10	9.4	(16)
Baetidae	23			7.4	(23)
Ephemeridae	7	2	2	19.2	(10)
Ephemerellidae	3		1	6.8	(4)
ODONATA - unidentified		13		-	
ANISOPTERA - unid.		5	35	30	(1)
Gomphidae			1	-	
Corduliidae		1		-	
Libellulidae	3		45	31.3	(16)
ZYGOPTERA - unid.		2	3	15	(1)
Lestidae	1		1	27.5	(2)
Coenagrionidae	3	2	6	26.9	(7)
PSOCOPTERA*	20	47	11	3.0	(75)
HEMIPTERA - unid.*		4	2	5.0	(2)
Pentatomidae*		2	1	5	(1)
Miridae*	3	1	2	4.2	(6)
Saldidae	1			3	(1)
Corixidae		1	1	8	(1)
HOMOPTERA - unid.*	3	85	4	2.7	(3)
Cercopidae*	3	1	1	4.6	(5)
Cicadellidae*	25	28	17	4.6	(70)
Delphacidae*	1			4	(1)
Fulgoridae*	1			9	(1)
Aphididae*	210	38	4	2.9	(222)
NEUROPTERA - unid.*		1		-	
Hemerobiidae*	1	1		4	(1)

8. APPENDIX 1: (Cont.)

	Number of Prey Items				
	Fed to Nestlings	Digested Samples	In Nests	Mean Length mm	(n)
COLEOPTERA - unid.*		42	18	9.0	(3)
Cicindelidae*		1		-	
Dytiscidae		3	1	12	(1)
Staphylinidae*	2		2	5.7	(3)
Scarabaeidae*	1	2	5	11.8	(6)
Elateridae*		7	7	10.0	(6)
Anobiidae*			1	7	(1)
Mycetophagidae*		2		3.5	(2)
Tenebrionidae*			1	-	
Alleculidae*			1	6	(1)
Meloidae*			9	9.4	(8)
Cerambycidae*			3	10.3	(3)
Scolytidae*	2	3		3.5	(2)
TRICHOPTERA - unid.		15	2	7.8	(4)
Limnephilidae		5	4	13.6	(7)
Phryganeidae	1		5	7.3	(6)
LEPIDOPTERA - unid.*	1	11	15	8.4	(12)
Saturniidae*	2	3	2	17.0	(5)
DIPTERA - unid.*		118	3	-	
Tipulidae	6	10	1	7.2	(17)
Chaoboridae	12	2		3.7	(12)
Culicidae	2	8	98	5.8	(90)
Ceratopogonidae	1	2		3.0	(3)
Chironomidae	104	20	2	4.7	(126)
unid. midges	11	73		3.4	(12)
Simuliidae	17	7		3.0	(23)
Bibionidae			4	6.3	(4)
Mycetophilidae*	2	1		4.3	(3)
Sciaridae*	3			2.7	(3)
Cecidomyiidae*	1		1	2	(1)
Xylophagidae*	1	1		8.0	(2)
Stratiomyidae	1		2	4.7	(3)
Tabanidae	28	5	30	12.4	(52)
Rhagionidae*	1			7	(1)
Therevidae*			2	11.5	(2)
Empididae	165	124	45	6.3	(247)
Dolichopodidae	11	4	8	5.1	(21)
Lonchopteridae*	2			3.0	(2)

8. APPENDIX 1: (Cont.)

	Number of Prey Items				
	Fed to Nestlings	Digested Samples	In Nests	Mean Length mm	(n)
Phoridae*	32	3		2.1	(34)
Syrphidae*	8	2	14	8.3	(20)
unid. acalyptrate muscoids*	10	13	5	4.3	(24)
Otitidae*		5	1	2.8	(6)
Tephritidae*	2			4.5	(2)
Sciomyzidae	1	1	1	5.0	(2)
Drosophilidae*	1			3	(1)
Heleomyzidae*	1			5	(1)
unid. calyptrate muscoids*		86	28	6.0	(2)
Anthomyiidae*	12	20	22	5.4	(50)
Muscidae*	85	27	117	5.6	(216)
Calliphoridae*		2	2	7.0	(3)
Sarcophagidae*	2			7.0	(2)
Tachinidae*	32		24	6.4	(56)
HYMENOPTERA - unid.*		53	5	-	
Braconidae*	5			3.0	(5)
Ichneumonidae*	4	5	1	4.7	(7)
Chalcidoidea*	4	2	2	2.8	(6)
Formicidae*	11	8	13	6.7	(15)
CHORDATA - bones*			4	11.5	(4)
eggshell pcs.*			4	12.0	(3)
GRIT - stones*		34	69	4.2	(92)
glass*		1	48	5.8	(48)
TOTALS	920	976	857	6.0	(1856)

* terrestrial prey items