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SEASONAL DYNAMICS OF THE INTESTINAL HELMINTH FAUNA IN THREE SPECIES OF DUCKS.

The University of Oklahoma, Ph.D., 1965
Zoology

University Microfilms, Inc., Ann Arbor, Michigan

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

SEASONAL DYNAMICS OF THE INTESTINAL HELMINTH FAUNA IN THREE SPECIES OF DUCKS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

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Norman, Oklahoma

1965

SEASONAL DYNAMICS OF THE INTESTINAL HELMINTH

FAUNA IN THREE SPECIES OF DUCKS

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ACKNOWLEDGMENTS

I am grateful to Dr. J. Teague Self, my major professor, for his interest and guidance of this problem, and to Mr. H. A. Hochbaum, Director of the Delta Waterfowl Research Station at Delta, Manitoba, for the use of its facilities. Mr. Marvin Schwilling, Waterfowl Project Leader at the Cheyenne Bottoms Waterfowl Management Area in Barton County, Kansas made available the facilities of that agency. Mr. Lewis Oring gave invaluable time in assisting with host collections and Mr. Ronald Hoffman spent many hours collecting hosts and preparing helminths for study.

I would like to thank the United States Fish and Wildlife Service, the Parks and Wildlife Department of the state of Texas, and the Department of Northern Affairs and National Resources of Canada for extending me the courtesy of scientific collecting permits.

This study was supported in part by NIH Predoctoral Grant No. 5-F1-GM-19, 616-02, and by funds made available at the Delta Waterfowl Research Station.

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SEASONAL DYNAMICS OF THE INTESTINAL HELMINTH FAUNA IN THREE SPECIES OF DUCKS

CHAPTER I

INTRODUCTION

Anatid helminths have been studied by workers in many parts of the world and the published works are too extensive to review here except for those which apply to this work. Lapage (1961) presents a host-species list of anatid parasites known at that time and includes an extensive bibliography.

Several investigations have been conducted by various authors, especially in the Balkan countries, to determine the influence of various factors on the helminth fauna of migratory birds, especially waterfowl. The significance of seasonal migrations on the helminth fauna of birds was discussed by Dubinia (1937), Markov (1939), and Spasskaya (1954) with the conclusion that migrations play an important role in the maintenance and distribution of some helminths. Bezubik (1956a, 1956b) studied the helminth fauna of anatids in Poland and when interpreting the seasonal fluctuation in extensity and intensity of some of the more common helminths he postulated a certain dependence of parasitofauna (sic) on the host's food.

Extensive studies have been done on the dynamics and ecological distribution of avian trematodes in the USSR by Bykhovskaya-Pavlovskaya

(1952, 1954, 1955, 1957, 1959, 1962, 1964a, 1964b) and Kasimov *et al*. (1962). They found that the major portion of the avian trematode fauna in Russia is formed in the breeding areas and becomes greatly impoverished during and after migration. They also found that very few trematodes infect birds in their wintering areas.

The importance of food and the role of invertebrates in establishing an avian cestode fauna have been studied by Jarecka (1958a), Polozhentsev and Negrobov (1958), and Rysavy (1962, 1964), with the conclusion that the cestode fauna is directly related to the type of food ingested.

Studies to elucidate the factors involved in host-parasite relationships of anatid helminths have not been done in America. This investigation was undertaken to study the dynamics of the intestinal helminth fauna of some anatids along a North American migratory route and the factors contributing to it. "Migratory route" is used here because previous work discredits the use of the flyway theory as a biological concept (Van Tyne and Berger, 1961).

The Hosts

In selecting the hosts for this study the following points were kept in mind: the hosts' migrations should be of sufficient magnitude to effect a change of habitats; the hosts should be easily obtainable at all collecting sites along the migratory route; they should have similar, but not necessarily identical, habits (i.e., nest-site selection, feeding habits, etc.) which would facilitate data comparisons; and their parasite fauna should be fairly well known.

Three species of dabbling ducks, viz., *Anas acuta* L., the pintail, *Anas strepera* L., the gadwall, and *Spatula clypeata* L., the shoveller, were studied. They all nest commonly in Manitoba and are common central Kansas migrants on the southward journey to their wintering areas in the fresh-water marshes along the Gulf Coast of the United States.

For study purposes the ducks were divided into adult and juvenile categories. Although young ducks can fly by the 8th to 10th week, in this study they were considered to be juveniles through their first migration. Age determinations of non-flying juveniles were based on the condition of down and length of feathers, a system proposed by Southwick (1953). Flying juveniles were distinguished from adults by the condition of the feathers and the bursa of Fabricius. All ducks taken on the wintering grounds were classed as adults.

Collection Sites

Collections were made at three areas included in the migratory range of the hosts:

(1) Large marshes near Delta, Manitoba. Adults and juveniles were taken here during the months of April through August. These marshes provide nesting sites for many aquatic and semi-aquatic birds including several species of ducks (Hochbaum, 1944).

(2) Cheyenne Bottoms Waterfowl Management Area in Barton County, Kansas. Adults and juveniles were collected during the months of October and November. This area covers approximately 30 square miles, most of which is kept under one to three feet of water, and provides a resting site for ducks along the migratory route. Most of the food available to them in this area consists of grains and seeds of marsh plants

although some animal matter is available.

(3) Fresh-water marshes near Gilchrist in Galveston County, Texas. Adult birds were taken during the months of December and January in this area which constitutes their winter habitat. Wild rice and other marsh plants grow commonly in these extensive fresh-water marshes and along with available animal matter provide an adequate winter food supply.

CHAPTER II

MATERIALS AND METHODS

Helminths from the alimentary tracts of the three species of ducks were studied. These helminths were chosen for study because of the availability of alimentary tracts of ducks from hunters' bags, especially at the Cheyenne Bottoms Area and at the Gilchrist marshes. Ducks were collected at the Delta marsh by shooting or trapping.

Five hundred alimentary tracts were collected during the months of June, 1963, through August, 1964 (Table I). Some were autopsied immediately following collection while others were frozen and autopsied when time permitted.

Cestodes and trematodes were fixed with AFA and stained with Semichon's acetocarmine, Mayer's paracarmine, Harris's hematoxylin, or Hematein. They were cleared in beechwood creosote, and mounted in permount or piccolyte. Acanthocephalans were also fixed with AFA and studied after being cleared with 10% lactic acid or stained with Harris's hematoxylin or Semichon's acetocarmine and mounted in piccolyte. Nematodes were fixed in hot 70% ethanol and studied after being cleared in 10% lactic acid.

CHAPTER III

RESULTS

Thirty-four species of helminths were found in the alimentary tracts of the three species of hosts. Among those collected were eight genera and 20 species of Cestoidea, seven genera and eight species of Digenea, five species of Nematoda in as many genera, and one species of Acanthocephala.

Infections were recorded in extensity (i.e., per cent of ducks infected) and intensity (i.e., average number of helminths per infected duck) following the procedure of Czaplinski (1956). Those helminths occurring less than five times (in less than one per cent of the sample) were not included in this study. In this group were the following: *Hymenolepis simplex*, *Diploposthe laevis*, and *Drepanidotaenia bissaccata* (Cestoidea); *Leucochloridium* sp. (Trematoda); and *Capillaria* sp., *Tetrameres* sp., and *Echinuria uncinata* (Nematoda). Although found only a few times in this study, these helminths are common duck parasites and in some cases (e.g., *E. uncinata*) may cause extensive mortality in waterfowl populations (Cornwell, 1963).

The helminths studied are listed with their hosts in Table II. Ten of them were common in the three hosts; seven were found in two of the three hosts; and ten of them were found in only one of the three hosts examined.

The monthly extensity and intensity of helminth infections in the total sample are shown in Table III and for each host species in Tables IV, V, and VI. The overall infection rate of helminths reached a peak of 94% with an intensity of 308 worms per infected duck during the summer at Delta followed by a gradual tapering off during the fall to a low of 66% with an intensity of 12 worms per infected duck during the winter along the Gulf Coast (Fig. 8). Table VII shows the monthly infection rate for each helminth species in the total host sample. Monthly infection rates for each helminth species in each of the three hosts can be found in the attached Appendix.

Infection by Cestoidea

Cestodes reached a peak infection of 91% in August at Delta with an intensity of 294 worms per infected duck before dropping to a low of 50% with an intensity of four worms per infected duck during the winter along the Gulf Coast (Table III). Juveniles of all three hosts were more heavily infected with cestodes than the adults (Tables IV, V, and VI).

The genus Hymenolepis was represented by nine species (Table II), only three of which, viz., H. teresoides (Fig. 1), H. hopkinsi (Fig. 2), and H. megalops (Fig. 3), were found at all three collecting sites. All three had peak infections at Delta in August. Three other species of this genus were found only during the summer at Delta. These were: H. anatina, which had two peaks of infection — one in June and the other in August; H. macrocephala, which had one peak in July; and H. filumferens, which also reached a peak infection in July (Fig. 4). Hymenolepis stolli and H. gracilis, not found at Delta in the spring in these hosts, reached peaks of infection there in July (Fig. 5). Hymenolepis stolli then disappeared in August but was found again in the fall at the Cheyenne Bottoms and during the winter along the Gulf Coast. Hymenolepis gracilis, on the other hand, was not found at the Cheyenne Bottoms in the fall, but like H. stolli, was found in ducks collected during the winter along the Gulf Coast. Hymenolepis compressa reached a peak infection in June with a secondary peak in August before being lost during the fall (Fig. 6).

Three of the cestodes were of the genus Diorchis (Table II). Diorchis spinata was found at all three collecting sites with a peak infection occurring at Delta in August (Fig. 3). Although not found at Delta in the spring, D. bulbodes reached a peak infection there in August. The infection rate of D. bulbodes was considerably higher in ducks collected during the winter than during the fall (Fig. 5). Diorchis nyrocae, like D. bulbodes, was not found at Delta in the spring. This cestode had a peak infection at Delta in July while the infection rate was quite low during the fall at the Cheyenne Bottoms and along the Gulf Coast during the winter (Fig. 5).

The genus Aploparaksis was represented by two species, A. furcigera and A. veitchi (Table II). Aploparaksis furcigera had a peak infection rate in June at Delta, was at a low level during the fall at the Cheyenne Bottoms, and was not found during the winter along the Gulf Coast (Fig. 6). Aploparaksis veitchi, on the other hand, was found at all three collecting sites with infection peaks in the spring and in August at Delta and also during the winter along the Gulf Coast (Fig. 2).

One species of the genus Fimbriaria, viz., F. fasciolaris, was found (Table II). This cestode, although not found in ducks examined at Delta in the spring, reached a peak infection rate there in July (Fig. 4). It had a low infection rate at the Cheyenne Bottoms in the fall and was not found during the winter along the Gulf Coast.

The genus Echinocotyle was represented by one species, E. rossiteri (Table II). It had a peak infection in July at Delta and was not found at the Cheyenne Bottoms or at the Gulf Coast (Fig. 6).

The genus Anomotaenia, also represented by one species, A. ciliata (Table II), reached a peak infection (although low in extensity) in June at Delta (Fig. 3). Very low levels of infection were found at the Cheyenne Bottoms and along the Gulf Coast.

Infection by Trematoda

Trematodes were at a peak extensity of 56% in the spring at Delta although the intensity was highest in the early summer (Table III). The lowest rate of infection of 13% with an intensity of eight worms per infected bird occurred during the winter along the Gulf Coast.

Two species of the genus Echinoparyphium were found (Table II). Echinoparyphium baculus reached a peak infection rate of 44% in June at Delta (Fig. 7). Only one per cent of the ducks harbored this trematode at the Cheyenne Bottoms and it was not found along the Gulf Coast during the winter. Echinoparyphium flexum had a peak infection rate of 11% in June at Delta and had disappeared by August (Fig. 7). It was present in one per cent of the ducks at the Cheyenne Bottoms and in three per cent of the ducks collected along the Gulf Coast.

Echinostoma revolutum, the only species found of that genus (Table II), was present in 20 to 25 per cent of the ducks throughout the spring and summer at Delta (Fig. 3). Only four per cent harbored this worm at the Cheyenne Bottoms while at the Gulf Coast the infection rate was only two per cent.

Hypoderaeum, represented by one species, H. conoideum (Table II), showed two peaks at Delta — one of 16% in the spring and another of 16% in July (Fig. 7). At the Cheyenne Bottoms in the fall the infection rate was two per cent. It was not found in ducks collected during the winter along the Gulf Coast.

The genus Zygocotyle, the only amphistome reported from ducks, was represented by a single species, Z. lunata (Table II). Infections were highest in the spring at 19% and lowest in August at 5% (Fig. 2). Ten per cent of the ducks at the Cheyenne Bottoms and 11% of the ducks along the Gulf Coast harbored this worm.

The only strigeid found was Cotylurus flabelliformis (Table II). The infection rate ranged from six to ten per cent in the spring and summer at Delta to four per cent at the Cheyenne Bottoms (Fig. 7). It was not found in ducks collected during the winter along the Gulf Coast.

The genus Notocotylus, represented only by N. attenuatus (Table II), reached a peak infection rate of 39% in August and was present in five per cent of the ducks at the Cheyenne Bottoms and in three per cent of those collected along the Gulf Coast (Fig. 1).

Infection by Nematoda

Two species of nematodes were collected (Table II). Epomidiostomum uncinatum reached a peak infection rate of 33% at Delta in August, infected only 10% of the ducks at the Cheyenne Bottoms, and only five per cent of the ducks collected along the Gulf Coast (Fig. 1). Amidostomum sp. was not found in ducks examined during the spring at Delta but did reach a peak infection there of 50% in August (Fig. 4). Only four per cent of the ducks collected at the Cheyenne Bottoms harbored this worm and it was not found in ducks collected along the Gulf Coast.

Infection by Acanthocephala

The only acanthocephalan found in this study was *Corynosoma constrictum* (Table II). At Delta its infection rate ranged from 36% in the spring to 65% in August (Fig. 3). Thirty-five per cent of the ducks at the Cheyenne Bottoms and 14% of the ducks collected along the Gulf Coast harbored this worm.

CHAPTER IV

DISCUSSION

The intestinal helminths studied can be grouped into the following categories:

(1) Those helminths brought into the breeding area by the ducks. Group A includes those helminths not found at the wintering grounds but found in ducks arriving at the breeding area near Delta in the spring (i.e., they were probably obtained during spring migration). This group includes *A. furcigera*, *E. rossiteri*, *H. compressa*, *E. baculus*, *H. conoideum*, and *C. flabelliformis* (Figs. 6 and 7).

Activities of the intermediate hosts for these helminths might account for infections occurring at that time. In Poland, Jarecka (1958a) found that *E. rossiteri* utilized an ostracod, *Cypridopsis vidua*, as an intermediate host and in 1960, found that *H. compressa* used the copepods, *Macrocyclops albidus* and *Mesocyclops leuckarti*, while *A. furcigera* was found in an oligochaete, *Limnodrilus* sp. The three trematodes, *E. baculus*, *H. conoideum*, and *C. flabelliformis*, all utilize lymneid snails and possibly physids or planorbids as intermediate hosts (Van Haitsma, 1931; Cort, *et al.*, 1941; Ginetzinskaya, 1949; Wikgren, 1956; and Ulmer, 1956, 1957).

Ferguson (1944), working in Missouri, found that *Cypridopsis vidua* becomes active in February. Copepods and cladocera also begin active reproduction when the water temperature reaches 6 to 12° C

(Pennak, 1953). Pennak also indicates that snails generally become active in the early spring. Assuming that helminths of this group utilize these invertebrates as intermediate hosts along this migratory route, one can easily see how ducks, migrating northward in the spring, could become infected with these parasites.

Group B of this category includes those helminths found in ducks at the wintering grounds along the Gulf Coast and also in ducks arriving at the breeding area near Delta in the spring (i.e., they were possibly carried over from the wintering grounds to the breeding area). This group includes A. ciliata, A. veitchi, D. spinata, H. megalops, H. teresoides, H. hopkinsi, E. revolutum, N. attenuatus, Z. lunata, E. uncinatum, and C. constrictum (Figs. 1, 2, and 3).

Six of the 11 species of this group were found in protected areas of the intestinal tract. Epomidiostomum uncinatum was found beneath the gizzard lining and A. veitchi, H. teresoides, H. hopkinsi, N. attenuatus, and Z. lunata, in the caecum. Being inhabitants of protected areas like these might allow these parasites to remain with their hosts for prolonged periods. Individuals of Zygocotyle lunata have been found to survive in a host for two or more years (Willey, 1941). Figures 1, 2, and 3 show that the infection rates for these helminths were higher in the spring than during the winter. This indicates that additional infections probably occurred during the spring migration. This seems likely when one realizes that H. teresoides has been found to utilize the copepod, Cypridopsis vidua (Jarecka, 1958a), and Notocotylus spp. utilize lymneid snails (Wikgren, 1956), while Z. lunata can utilize Helisoma spp. (Willey, 1941), as intermediate hosts. One might assume that A. veitchi and H. hopkinsi also use comparable hosts.

Four of the five remaining species of this group, E. revolutum, C. constrictum, A. ciliata, and D. spinata, were intestinal forms while the fifth, H. megalops, was found exclusively in the cloaca. Echinostoma revolutum is a widespread parasite inhabiting many types of hosts, both intermediate and definitive (Beaver, 1937). It is probable that this worm infects ducks all along the migratory route although some rather large specimens were found indicating that they might remain with the host for some time. The intermediate hosts for C. constrictum and D. spinata are not known although it is thought that C. constrictum might utilize a crustacean, possibly an amphipod (Van Cleave, 1945). The ability of these two forms to remain with the host for prolonged periods could be due to the fact that they attach quite firmly to the mucosal lining of the intestine and become quite difficult to dislodge. Hymenolepis megalops, with its scolex firmly wedged into a pocket of the cloacal lining, appears to remain with the definitive host for prolonged periods. As seen in Figure 3, A. ciliata was found at all three collecting sites although at very low levels of infection except during the spring. Jarecka (1958b) found that A. ciliata utilizes the cladoceran, Simocephalus exspinosus, as an intermediate host. According to Pennak (1953), Simocephalus is monocyclic, producing large populations only in the spring. Thus, the extensity of A. ciliata infections in ducks seems to correspond with the availability of its intermediate host as food for the ducks.

(2) Those helminths obtained by the ducks at the breeding area. Adult ducks, in addition to bringing seventeen species of helminths into the breeding area, acquired 10 others, viz., D. bulbodes, D. nyrocae, H. stolli, H. gracilis, H. anatina, H. macrocephala, H.

filumferens, F. fasciolaris, E. flexum, and Amidostomum sp. (Figs. 4, 5, and 7). Seven of the 10 species were found in only one of the three hosts (Table II). Life cycle studies (Jarecka, 1958a, 1960) indicate that H. gracilis utilizes the ostracod, Cypridopsis vidua, and F. fasciolaris uses the copepod, Macrocyclops albidus, as intermediate hosts. One can assume that the other hymenolepids of this group probably utilize intermediate hosts similar to those of H. gracilis and F. fasciolaris. It seems doubtful that more than a few of these invertebrate hosts survive the winter in Manitoba. Although it is possible that the helminths could survive in limited numbers in those invertebrates that do last out the winter, this limited population could not account for the extensive infections indicated in Figures 4, 5, and 7. It seems more likely that these helminths are brought into the breeding area during the spring by other species of ducks not included in this study.

Echinoparyphium flexum and Amidostomum sp., on the other hand, could quite likely survive the winter conditions. Echinoparyphium flexum utilizes a variety of snails as intermediate hosts (Najarian, 1953), which are quite capable of surviving through the winter. Amidostomum spp. have direct life cycles according to Leiby and Olsen (1965). They observed that eggs of A. raillieti and A. skrjabini kept at low temperatures for long periods failed to hatch until warmed for various lengths of time, depending on the species. Cowan (1955), however, found that survival and infectivity of infective larvae of A. anseris decreased greatly when kept at 6°C for longer than ten days. Thus, it appears that freshly passed eggs would have greater viability than eggs that have overwintered. This could account for the peak infection of <u>Amidostomum</u> sp. occurring in August instead of in the early spring. Leiby and Olsen (1965) also point out that the major infections probably occur in young ducklings on the breeding grounds and as seen in Table VI, this seems to be the case.

Juvenile ducks were invaded by all 27 of the helminth species found in this study while at the breeding area. Although adults and juveniles harbor essentially the same helminths during the summer, the extensity and intensity of invasion is much greater in juveniles (Tables IV, V, and VI). It is during this time that the newly hatched ducklings begin to fend for themselves. Young ducks probably do not acquire an age-immunity to parasitic infections for some time and thus are more susceptible to invasion than adults. At the same time, these ducklings take a greater variety of food than the adults including all types of invertebrates (Cottam, 1939; Mendall, 1949). Since these very likely include the intermediate hosts for these parasites, they enhance the probability of infection.

The incidence of helminths in adult ducks of all three species was greatly reduced when the ducks were flightless during the moulting period. This reduction may be due to a change in the physiological state of the moulting host or to a change in the host's diet, for it is during this time that the ducks move into deeper water and feed almost exclusively on vegetation.

(3) Those helminths not found at the Cheyenne Bottoms in the fall collections (i.e., they were probably lost during the fall migration from late August through November). This group included: <u>E</u>. <u>rossiteri</u>, <u>H</u>. <u>compressa</u>, <u>H</u>. <u>gracilis</u>, <u>H</u>. <u>anatina</u>, and <u>H</u>. <u>macrocephala</u>. These helminths are all intestinal forms living in an environment

directly related to the host's diet. Accompanying a change in diet as a result of migration is a change in the physiology of the host, which might account for the loss of these helminths. Figures 4, 5, and 6 indicate that these worms have a life cycle in which the infection is acute, i.e., involving a build-up of the helminths but followed by their rapid disappearance.

(4) Those helminths found at the Cheyenne Bottoms in the fall but not found during the winter along the Gulf Coast. This group included the intestinal forms *A. furcigera*, *H. filumferens*, *F. fasciolaris*, *E. baculus*, *H. conoideum*, and *C. flabelliformis*, and the gizzard worm, *Amidostomum* sp. It seems likely that these helminths are similar to those of the last group, except that they are capable of remaining with the host for longer periods.

(5) Those helminths found at the wintering grounds along the Gulf Coast but not in ducks arriving at Delta in the spring (i.e., they were probably lost during spring migration). In this group were *D. bulbodes*, *D. nyrocae*, *H. stolli*, *H. gracilis*, and *E. flexum*. The data indicate that these helminths may infect the ducks at the wintering grounds, at least to some extent. However, it appears that they cannot withstand the rigors of the spring migration if one assumes that the duck population sampled at the wintering grounds was the same as that sampled at the breeding grounds at Delta.

That the helminth fauna of the three species of ducks studied was similar but not identical even though the ducks occupied the same habitats can probably be explained by their feeding habits. Collias and Collias (1963) demonstrated that young ducklings of different species show a definite food preference which may be correlated with abundance of the invertebrates serving as food. Pintails, in addition to dabbling along the surface of the water for invertebrates also dive to some extent, which probably increases the variety of food taken and consequently the variety of helminths acquired. Shovellers, on the other hand, are almost exclusively dabblers, straining food from the surface of the water. This reduces the variety of invertebrates taken as compared to that of the pintail, and consequently the kinds of helminths being harbored. Gadwalls, especially adults, feed more on vegetation which further reduces the invertebrates taken and likewise the helminth fauna.

CHAPTER V

SUMMARY

Helminths and the degree of their infection varied greatly in different hosts in the same area, in young and adult ducks of the same species, and in ducks during different seasons. Factors influencing the composition of the helminth fauna include migration of the host, age of the host, and feeding habits of the host resulting directly from a change in climatic conditions and available food (all of which probably result in important changes in the physiology of the host), and the complexity and duration of the parasites' life cycles.

The greatest invasion of helminths occurred in young ducks at the breeding area and was probably the result of their feeding habits and general lack of immunity. Adult ducks showed a greatly reduced helminth fauna during the moulting period.

The intensity of helminth infections was greatly reduced during the fall migration. In addition, several species of helminths were lost entirely. This reduction of fauna was probably due to several factors including: (1) the natural loss of helminths because of unfavorable conditions of migration; (2) the disappearance of species with short life cycles; and (3) the absence or limitations on the possibility of new infections.

The geographical distribution of helminths found in migratory birds such as ducks, then, is dependent upon the relationships of the helminths with both the definitive and intermediate hosts. Those helminths remaining with the definitive hosts for but a short time such as *C. flabelliformis* probably do not extend their range as fast as those helminths remaining for longer periods. Although some helminths can utilize several definitive hosts, the intermediate hosts are usually more specific. Therefore, the helminths found established in any area are dependent upon the composition of the intermediate hosts and the presence of the definitive hosts.

A posteriori, ducks spending about six months of every year on the breeding grounds at a time when the populations of the intermediate hosts for the helminths are at their highest have a greater invasion of helminths than ducks at other times of the year in areas where the invertebrate intermediate host populations are lowest.

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Table I. Number of Alimentary Tracts Taken at the Three Collecting Sites

Collection Site	Pintail		Shoveller		Gadwall		Total	
	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile	Adult	Juvenile
Delta Marsh	46	37	42	37	80	36	168	110
Cheyenne Bottoms	24	26	12	25	18	35	54	86
Gilchrist Marshes	17	--	54	--	11	--	82	--
Total	87	63	108	62	109	71	304	196

Table II. List of Helminth Species Studied

Species of Helminth	Hosts		
	Pintail	Gadwall	Shoveller
TREMATODA			
Notocotylus attenuatus (Rudolphi, 1809)	X	X	X
Hypoderaeum conoideum (Bloch, 1782)	X		X
Zygocotyle lunata (Diesing, 1836)	X	X	
Cotylurus flabelliformis (Faust, 1917)	X	X	X
Echinostoma revolutum (Frölich, 1802)	X	X	X
Echinoparyphium baculus (Diesing, 1850)	X	X	X
Echinoparyphium flexum (Linton, 1892)	X	X	X
CESTOIDEA			
Hymenolepis megalops (Creplin, 1829)	X	X	X
Hymenolepis teresoides Fuhrmann, 1906		X	
Hymenolepis macrocephala Fuhrmann, 1913			X
Hymenolepis filumferens Brock, 1942			X
Hymenolepis stolli Brock, 1941	X		
Hymenolepis gracilis (Zeder, 1803)	X		

Table II (cont'd.)

Species of Helminth	Pintail	Gadwall	Shoveller
CESTOIDEA (cont'd.)			
Hymenolepis compressa (Linton, 1892)	X		
Hymenolepis hopkinsi Schiller, 1951	X	X	
Hymenolepis anatina (Krabbe, 1869)	X		
Diorchis spinata Mayhew, 1929		X	
Diorchis bulbodes Mayhew, 1929	X		
Aploparaksis furcigera (Rudolphi, 1819)	X	X	
Aploparaksis veitchi Baylis, 1933		X	X
Diorchis nyrocae Yamaguti, 1935	X		X
Fimbriaria fasciolaris (Pallas, 1781)	X	X	X
Anomotaenia ciliata Fuhrmann, 1913	X	X	X
Echinocotyle rossiteri Blanchard, 1891	X		X
NEMATODA			
Epomidiostomum uncinatum (Lundahl, 1848)	X	X	X
Amidostomum sp.			X
ACANTHOCEPHALA			
Corynosoma constrictum Van Cleave, 1918	X	X	X

Table III. Monthly Extensity and Intensity of Helminth Infections in Total Sample

		Apr.-May	June	July	Aug.	Oct.-Nov.	Dec.-Jan.
Total Helminths	Ext.-%	88	81	93	94	86	66
	Int. (Av.)	25	107	121	308	19	12
Total Cestodes	Ext.-%	71	77	90	91	75	50
	Int. (Av.)	10	88	104	294	14	4
Total Trematodes	Ext.-%	56	47	55	53	22	13
	Int. (Av.)	13	33	30	26	10	8
Total Acanthocephala	Ext.-%	32	36	48	64	36	22
	Int. (Av.)	19	9	6	15	10	9
Total Nematodes	Ext.-%	29	24	27	36	11	2
	Int. (Av.)	4	4	3	4	2	1

Table IV. Monthly Extensity and Intensity of Helminth Infections in the Pintail.

		Adult						Juvenile			
		Apr.-May	June	July	Aug.	Oct.-Nov.	Dec.-Jan.	June	July	Aug.	Oct.-Nov.
Total Helminths	Ext.-%	91	93	90	81	54	65	100	100	100	85
	Int. (Av.)	6	84	28	23	11	2	257	207	244	4
Total Cestodes	Ext.-%	55	86	60	73	46	59	100	100	100	85
	Int. (Av.)	2	73	19	18	12	2	170	152	189	4
Total Trematodes	Ext.-%	73	79	40	18	9	12	100	95	60	23
	Int. (Av.)	6	17	31	20	2	1	86	52	63	2
Total Acanthocephala	Ext.-%	0	14	60	27	0	0	83	81	90	15
	Int. (Av.)	0	6	3	4	0	0	2	5	19	1
Total Nematodes	Ext.-%	18	29	20	18	9	6	17	19	10	12
	Int. (Av.)	2	2	2	4	2	1	1	4	2	1

Table V. Monthly Extensity and Intensity of Helminth Infections in the Shoveller.

		Adult						Juvenile			
		Apr.-May	June	July	Aug.*	Oct.-Nov.	Dec.-Jan.	June	July	Aug.	Oct.-Nov.
Total Helminths	Ext.-%	88	81	100	—	92	67	100	100	100	100
	Int. (Av.)	57	50	57	—	3	15	434	199	177	21
Total Cestodes	Ext.-%	75	67	100	—	75	44	100	100	100	89
	Int. (Av.)	11	22	31	—	2	4	398	178	146	9
Total Trematodes	Ext.-%	50	33	79	—	8	13	67	80	90	27
	Int. (Av.)	35	27	28	—	1	16	47	16	8	11
Total Acanthocephala	Ext.-%	75	57	50	—	33	32	0	72	100	73
	Int. (Av.)	26	14	4	—	3	20	0	10	21	12
Total Nematodes	Ext.-%	0	19	36	—	8	0	33	36	70	15
	Int. (Av.)	0	1	3	—	1	0	15	3	6	2

* Indicates no adult hosts were collected during this time.

Table VI. Monthly Extensity and Intensity of Helminth Infections in the Gadwall.

		Adult						Juvenile		
		Apr.-May	June	July	Aug.	Oct.-Nov.	Dec.-Jan.	July	Aug.	Oct.-Nov.
Total Helminths	Ext.-%	93	78	87	100	89	64	91	92	94
	Int. (Av.)	22	40	39	34	8	7	153	969	42
Total Cestodes	Ext.-%	87	72	84	90	61	64	87	92	83
	Int. (Av.)	12	35	38	33	7	6	144	941	32
Total Trematodes	Ext.-%	47	17	19	0	17	18	39	92	34
	Int. (Av.)	8	12	4	0	4	1	26	22	20
Total Acanthocephala	Ext.-%	33	17	24	60	39	9	22	50	49
	Int. (Av.)	10	3	2	4	7	2	1	15	13
Total Nematodes	Ext.-%	53	28	41	70	11	9	0	17	9
	Int. (Av.)	5	6	2	3	2	1	0	2	2

Table VII. Monthly Extensity of Infection for Each Helminth Species in the Total Host Sample.

Species of Helminth	Apr.-May	June	July	Aug.	Oct.-Nov.	Dec.-Jan.
CESTOIDEA						
Anomotaenia ciliata	5	17	10	4	2	3
Aploparaksis furcigera	8	18	5	5	4	0
Aploparaksis veitchi	19	5	11	22	5	16
Diorchis spinata	13	39	45	51	12	27
Diorchis bulbodes	0	11	12	20	4	18
Diorchis nyrocae	0	32	37	30	3	1
Echinocotyle rossiteri	7	4	25	20	0	0
Hymenolepis compressa	9	62	29	35	0	0
Hymenolepis stolli	0	15	34	0	10	6
Hymenolepis gracilis	0	27	46	14	0	6
Hymenolepis anatina	0	16	5	15	0	0
Hymenolepis megalops	48	28	43	69	56	32
Hymenolepis teresoides	33	11	40	77	20	27
Hymenolepis macrocephala	0	7	12	0	0	0
Hymenolepis filumferens	0	60	67	20	2	0
Hymenolepis hopkinsi	20	21	32	33	8	14
Fimbriaria fasciolaris	0	24	36	26	3	0
TREMATODA						
Echinoparyphium baculus	19	44	17	8	1	0
Echinoparyphium flexum	0	11	2	0	1	3
Echinostoma revolutum	26	20	24	25	4	2
Hypoderaeum conoideum	16	7	16	10	2	0

Table VII. (cont'd.)

Species of Helminth	Apr.-May	June	July	Aug.	Oct.-Nov.	Dec.-Jan.
TREMATODA (cont'd.)						
Notocotylus attenuatus	20	38	32	39	5	3
Cotylurus flabelliformis	7	10	6	9	4	0
Zygocotyle lunata	19	8	11	5	10	11
NEMATODA						
Epomidiostomum uncinatum	24	23	21	33	10	5
Amidostomum sp.	0	22	24	50	4	0
ACANTHOCEPHALA						
Corynosoma constrictum	36	34	52	65	35	14

EXPLANATION OF FIGURES

Figure

1. Monthly Extensity of Infection by *H. teresoides*, *N. attenuatus*, and *E. uncinatum* in the Total Host Sample.
2. Monthly Extensity of Infection by *A. veitchi*, *H. hopkinsi*, and *Z. lunata* in the Total Host Sample.
3. Monthly Extensity of Infection by *C. constrictum*, *E. revolutum*, *H. megalops*, *D. spinata*, and *A. ciliata* in the Total Host Sample.
4. Monthly Extensity of Infection by *H. anatina*, *H. macrocephala*, *H. filumferens*, *F. fasciolaris*, and *Amidostomum* sp. in the Total Host Sample.

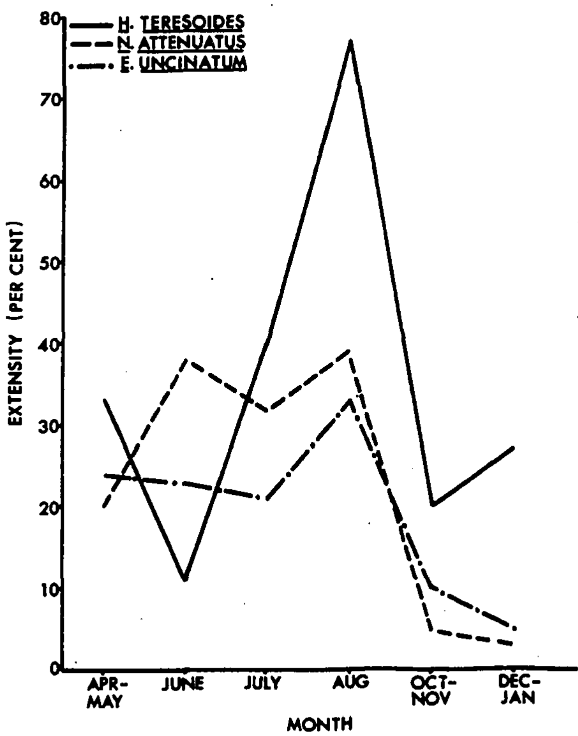

FIG 1

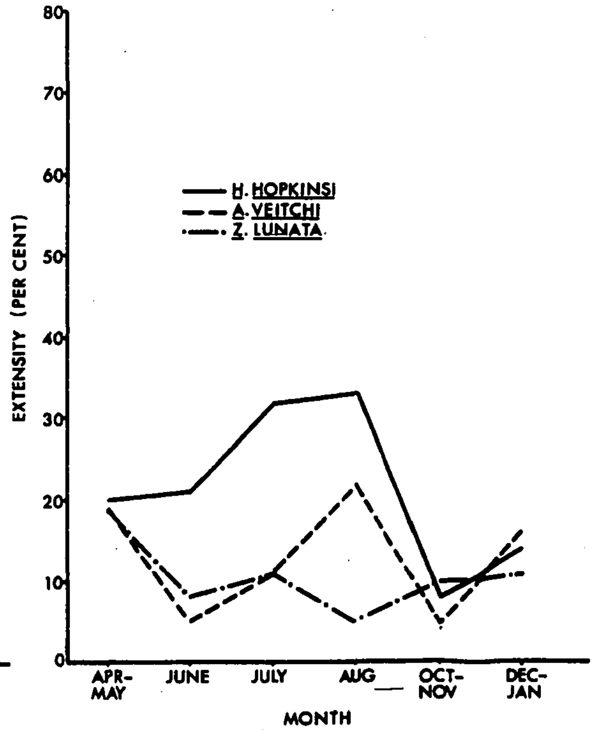

FIG 2

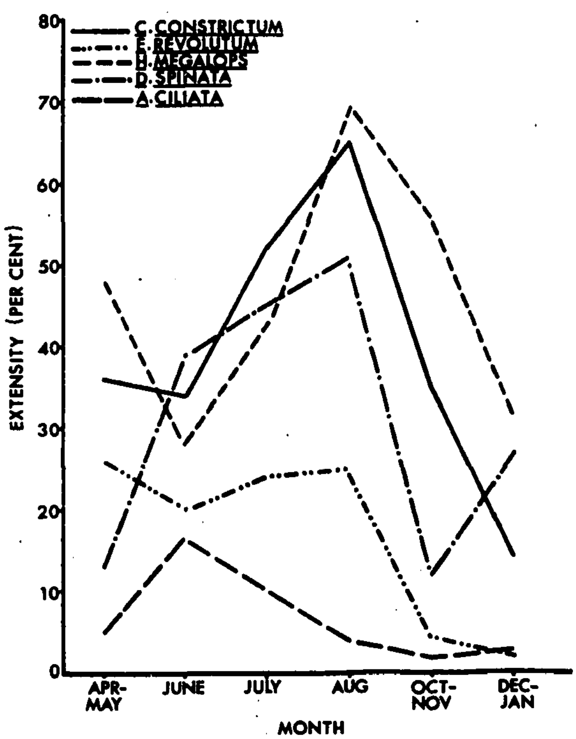

FIG 3

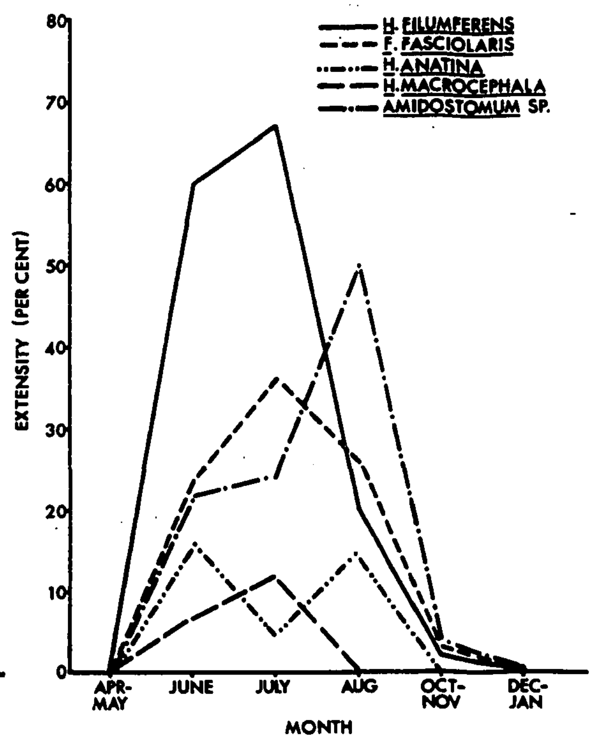

FIG 4

EXPLANATION OF FIGURES (cont'd)

Figure

5. Monthly Extensity of Infection by D. bulbodes, D. nyrocae, H. stolli, and H. gracilis in the Total Host Sample.
6. Monthly Extensity of Infection by A. furcigera, E. rossiteri, and H. compressa in the Total Host Sample.
7. Monthly Extensity of Infection by E. baculus, E. flexum, H. conoideum, and C. flabelliformis in the Total Host Sample.
8. Monthly Extensity of Infection by All Helminths, All Cestodes, All Trematodes, All Acanthocephala, and All Nematodes in the Total Host Sample.

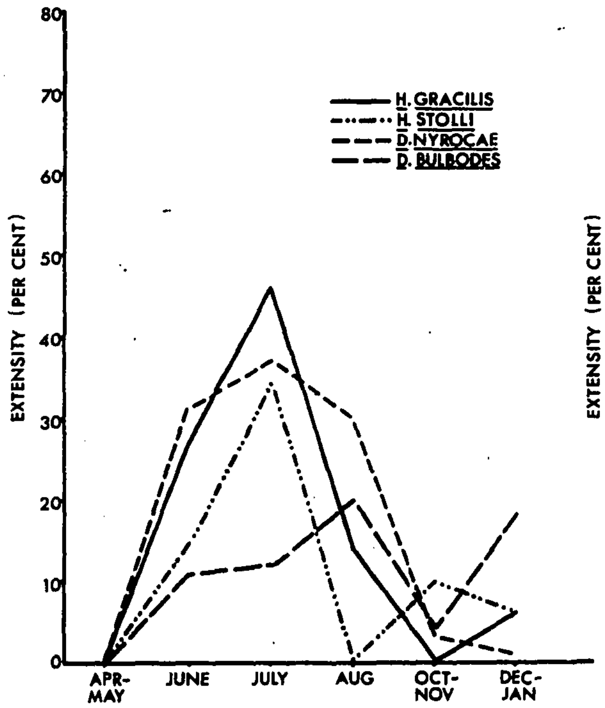

FIG 5

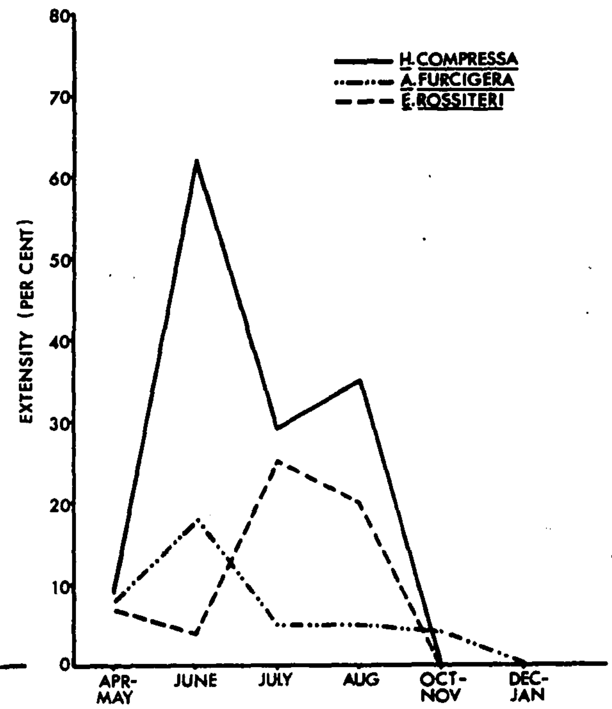

FIG 6

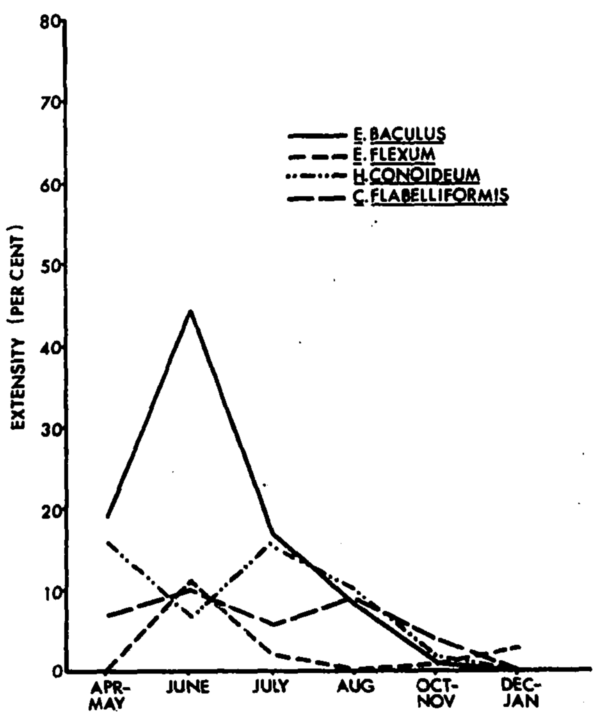

FIG 7

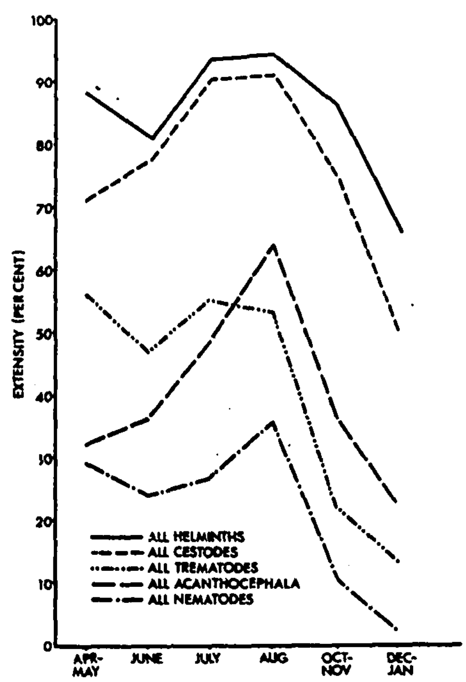

FIG 8

APPENDIX

Table VIII. Monthly Extensity and Intensity of Infection for Each Helminth Species in the Pintail.

Species of Helminth		Adults						Juveniles			
		Apr.- May	June	July	Aug.	Oct.- Nov.	Dec.- Jan.	June	July	Aug.	Oct.- Nov.
<u>Anomotaenia ciliata</u>	Ext. (%)	9	7	0	0	4	0	67	29	10	4
	Int. (Av.)	2	3	0	0	4	0	232	15	11	1
<u>Aploparaksis furcigera</u>	Ext. (%)	9	14	0	0	13	0	17	19	20	4
	Int. (Av.)	2	4	0	0	13	0	1	2	7	2
<u>Diorchis bulbodes</u>	Ext. (%)	0	21	10	9	4	18	0	14	30	4
	Int. (Av.)	0	2	7	3	1	2	0	5	10	1
<u>Diorchis nyrocae</u>	Ext. (%)	0	21	0	0	0	0	0	52	0	0
	Int. (Av.)	0	4	0	0	0	0	0	9	0	0
<u>Echinocotyle rossiteri</u>	Ext. (%)	0	0	0	0	0	0	0	19	0	0
	Int. (Av.)	0	0	0	0	0	0	0	29	0	0
<u>Hymenolepis compressa</u>	Ext. (%)	9	57	10	9	0	0	67	48	60	0
	Int. (Av.)	2	83	36	6	0	0	12	100	152	0
<u>Hymenolepis stolli</u>	Ext. (%)	0	29	10	0	4	6	0	57	0	15
	Int. (Av.)	0	12	18	0	55	1	0	45	0	4
<u>Hymenolepis gracilis</u>	Ext. (%)	0	21	40	27	0	6	33	52	0	0
	Int. (Av.)	0	7	9	19	0	1	9	13	0	0

Table VIII (cont'd.)

Species of Helminth		Adults						Juveniles			
		Apr.-May	June	July	Aug.	Oct.-Nov.	Dec.-Jan.	June	July	Aug.	Oct.-Nov.
Hymenolepis anatina	Ext. (%)	0	14	0	9	0	0	17	10	20	0
	Int. (Av.)	0	8	0	2	0	0	6	5	3	0
Hymenolepis megalops	Ext. (%)	46	21	40	64	33	41	0	48	90	46
	Int. (Av.)	2	2	2	2	2	1	0	2	14	2
Hymenolepis hopkinsi	Ext. (%)	0	7	0	9	0	0	17	57	30	0
	Int. (Av.)	0	73	0	23	0	0	7	81	237	0
Fimbriaria fasciolaris	Ext. (%)	0	50	40	27	4	0	50	67	20	15
	Int. (Av.)	0	3	1	13	11	0	8	18	13	1
Echinoparyphium baculus	Ext. (%)	18	21	10	9	0	0	100	33	30	4
	Int. (Av.)	8	5	28	2	0	0	26	17	70	3
Echinoparyphium flexum	Ext. (%)	0	0	0	0	0	0	33	5	0	0
	Int. (Av.)	0	0	0	0	0	0	56	11	0	0
Echinostoma revolutum	Ext. (%)	27	7	0	0	0	0	83	71	40	0
	Int. (Av.)	5	1	0	0	0	0	7	10	10	0
Hypoderaeum conoideum	Ext. (%)	18	21	10	0	4	0	0	5	30	4
	Int. (Av.)	2	9	83	0	1	0	0	1	2	1

Table VIII (cont'd.)

Species of Helminth		Adults						Juveniles			
		Apr.-May	June	July	Aug.	Oct.-Nov.	Dec.-Jan.	June	July	Aug.	Oct.-Nov.
<u>Notocotylus attenuatus</u>	Ext. (%)	27	64	20	18	0	0	100	67	36	0
	Int. (Av.)	3	16	5	17	0	0	31	54	25	0
<u>Cotylurus flabelliformis</u>	Ext. (%)	0	0	0	9	0	0	33	19	20	0
	Int. (Av.)	0	0	0	5	0	0	13	2	4	0
<u>Zygocotyle lunata</u>	Ext. (%)	18	14	30	0	4	12	0	10	10	12
	Int. (Av.)	2	1	1	0	2	1	0	2	5	2

Table IX. Monthly Extensity and Intensity of Infection for Each Helminth Species in the Shoveller

Species of Helminth		Adults						Juveniles			
		Apr.-May	June	July	Aug.*	Oct.-Nov.	Dec.-Jan.	June	July	Aug.	Oct.-Nov.
<u>Anomotaenia ciliata</u>	Ext. (%)	0	10	8	—	0	0	0	13	0	4
	Int. (Av.)	0	1	1	—	0	0	0	2	0	1
<u>Aploparaksis veitchi</u>	Ext. (%)	38	10	23	—	0	22	0	21	0	0
	Int. (Av.)	15	10	8	—	0	4	0	4	0	0
<u>Diorchis nyrocae</u>	Ext. (%)	0	5	39	—	0	2	100	58	90	12
	Int. (Av.)	0	17	64	—	0	11	131	23	64	1
<u>Echinocotyle rossiteri</u>	Ext. (%)	13	14	8	—	0	0	0	71	60	0
	Int. (Av.)	13	29	10	—	0	0	0	207	124	0
<u>Hymenolepis megalops</u>	Ext. (%)	50	48	62	—	75	28	33	21	80	92
	Int. (Av.)	2	5	4	—	2	2	5	3	17	9
<u>Hymenolepis macrocephala</u>	Ext. (%)	0	14	15	—	0	0	0	8	0	0
	Int. (Av.)	0	11	2	—	0	0	0	3	0	0
<u>Hymenolepis filumferens</u>	Ext. (%)	0	19	54	—	0	0	100	79	20	4
	Int. (Av.)	0	6	6	—	0	0	265	20	3	1
<u>Fimbriaria fasciolaris</u>	Ext. (%)	0	5	8	—	0	0	0	21	0	0
	Int. (Av.)	0	1	2	—	0	0	0	3	0	0

Table IX (cont'd.)

Species of Helminth		Adults						Juveniles			
		Apr.-May	June	July	Aug.*	Oct.-Nov.	Dec.-Jan.	June	July	Aug.	Oct.-Nov.
Echinoparyphium baculus	Ext. (%)	38	19	23	--	0	0	67	29	0	0
	Int. (Av.)	41	27	44	--	0	0	47	16	0	0
Echinoparyphium flexum	Ext. (%)	0	5	0	--	0	0	0	0	0	0
	Int. (Av.)	0	82	0	--	0	0	0	0	0	0
Echinostoma revolutum	Ext. (%)	25	5	15	--	0	6	0	42	60	8
	Int. (Av.)	3	1	1	--	0	2	0	4	2	2
Hypoderaeum conoideum	Ext. (%)	13	5	2	--	0	0	0	46	0	0
	Int. (Av.)	2	4	2	--	0	0	0	6	0	0
Notocotylus attenuatus	Ext. (%)	13	24	62	--	8	9	0	13	50	20
	Int. (Av.)	13	8	13	--	3	20	0	2	11	16
Cotylurus flabelliformis	Ext. (%)	13	0	0	--	0	0	0	17	10	0
	Int. (Av.)	37	0	0	--	0	0	0	16	1	0
Amidostomum sp.	Ext. (%)	0	10	23	--	0	0	33	25	50	8
	Int. (Av.)	0	1	2	--	0	0	13	2	3	2
Epomidiostomum uncinatum	Ext. (%)	0	10	31	--	8	0	33	13	50	8
	Int. (Av.)	0	2	2	--	1	0	2	4	4	4

*Indicates that no adult hosts were collected during this time.

Table X. Monthly Extensity and Intensity of Infection for each Helminth Species in the Gadwall.

Species of Helminth		Adults						Juveniles		
		Apr.- May	June	July	Aug.	Oct.- Nov.	Dec.- Jan	July	Aug.	Oct.- Nov.
<u>Anomotaenia ciliata</u>	Ext. (%)	7	0	3	0	0	9	4	8	0
	Int. (Av.)	2	0	25	0	0	2	62	2	0
<u>Aploparaksis furcigera</u>	Ext. (%)	7	22	0	0	0	0	0	0	0
	Int. (Av.)	1	6	0	0	0	0	0	0	0
<u>Aploparaksis veitchi</u>	Ext. (%)	0	6	0	0	0	9	0	67	20
	Int. (Av.)	0	12	0	0	0	3	0	5	22
<u>Diorchis spinata</u>	Ext. (%)	13	39	22	10	6	27	67	92	17
	Int. (Av.)	3	3	35	8	19	2	46	668	36
<u>Hymenolepis megalops</u>	Ext. (%)	47	39	43	70	44	27	0	42	46
	Int. (Av.)	2	2	3	5	4	4	0	2	6
<u>Hymenolepis teresoides</u>	Ext. (%)	33	11	46	70	2	27	33	83	37
	Int. (Av.)	6	3	3	7	6	4	7	14	13
<u>Hymenolepis hopkinsi</u>	Ext. (%)	40	39	14	10	6	27	58	83	26
	Int. (Av.)	17	49	150	204	5	3	65	302	17

Table X (cont'd)

Species of Helminth		Adults						Juveniles		
		Apr.-May	June	July	Aug.	Oct.-Nov.	Dec.-Jan.	July	Aug.	Oct.-Nov.
<u>Fimbriaria fasciolaris</u>	Ext. (%)	0	17	5	10	0	0	75	75	0
	Int. (Av.)	0	10	3	3	0	0	41	14	0
<u>Echinoparyphium baculus</u>	Ext. (%)	0	11	0	0	0	0	4	0	0
	Int. (Av.)	0	4	0	0	0	0	1	0	0
<u>Echinoparyphium flexum</u>	Ext. (%)	0	17	5	0	0	9	0	0	3
	Int. (Av.)	0	3	4	0	0	1	0	0	5
<u>Echinostoma revolutum</u>	Ext. (%)	27	6	14	0	6	0	4	25	11
	Int. (Av.)	4	1	4	0	1	0	1	3	8
<u>Notocotylus attenuatus</u>	Ext. (%)	20	0	0	0	0	0	29	92	0
	Int. (Av.)	10	0	0	0	0	0	33	19	0
<u>Cotylurus flabelliformis</u>	Ext. (%)	7	17	0	0	6	0	0	8	20
	Int. (Av.)	14	14	0	0	8	0	0	1	23
<u>Zygocotyle lunata</u>	Ext. (%)	20	11	3	0	11	9	0	8	14
	Int. (Av.)	1	1	1	0	2	1	0	1	9