THE HELMINTHS IN THE DIGESTIVE TRACT

OF THE MALLARD AND PINTAIL

IN SOUTHERN MANITOBA

A Thesis

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ABSTRACT

This study was designed to identify the parasites of the mallard and pintail in southern Manitoba and to examine the role of these parasites in the regulation of the host populations.

The Delta marsh was the centre of the study during 1967-1968. One hundred and one mallards and 100 pintails were examined for helminths. The average helminth burden in the mallards was 243 per bird and 189 in the pintails. Mallards harboured an average difference of 56 helminths per bird more than pintails. The following kinds of helminths were recovered: Cestoda, five genera containing five species; Trematoda, seven genera with seven species; Nematoda, six genera with seven species; and Acanthocephala, two genera with two species. Both birds are host to a similar helminthfauna but the mallards have a greater intensity of infection than pintails. Similar foods were found in the crops of both species. The mallard may be more susceptible to parasitism than the pintail. The helminths in the host duck caused neither emaciation of the breast muscles nor a weight loss. The effects of the parasites in times of stress could be greater on mallards than pintails.

The parasite fauna of the canvasback was similar to that of mallards and pintails but the numbers were greater in the former.

The helminthfauna variability is just as great within each of these host species as between the two closely related hosts.

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INTRODUCTION

The decline in the number of mallard (*Anas platyrhynchos platyrhynchos* L.) and pintail (*Anas acuta* L.) ducks in Manitoba since 1957 has focused new attention on these once common species. This attention reveals a paucity of information on most aspects of their life history. Their parasitic fauna is relatively unknown and here may lie some factors that could contribute to the decline of these economically important birds.

Relatively little is known of the parasitic fauna of our wildlife and our knowledge is incomplete regarding the effects of almost all such parasites on wildlife. It is well known that few individual animals of any species are completely free from parasites. Some parasites produce abnormal conditions in the host animal though many others have not yet been linked with any diseased condition. Hosts in apparently good health usually have fewer parasites than those in a less healthy state. On the other hand, sick hosts may not support any helminths. A fundamental problem in parasitology is the accurate assessment of the physical condition of the bird. This is essential if any relationships are to be concluded concerning the effect of kinds and numbers of parasites on the health of the host.

The dabbling ducks, *Anas platyrhynchos platyrhynchos* and *Anas acuta*, occupy much the same habitat and have a number of similar habits. The canvasback, *Aythya valsineria* L. is a diving duck and is found primarily in the pothole country of southern Manitoba, a habitat which differs considerably from the area in which the mallards and pintails were collected. Cornwell (1966) investigated the parasite fauna of the canvasback.

A comparison of the helminth fauna of these birds therefore permits one to examine two reciprocal aspects of a principle enunciated by a current school of Russian helminthologists; namely, that the habitat and food habits of any species determine its parasitic fauna. These three ducks belong to two different genera. Two prime differences relative to this program are (i) the area inhabited by the mallards and pintails collected in this study differs considerably from the areas where Cornwell collected his canvasbacks in Manitoba and (ii) the mode of feeding of the canvasback is quite different from that of mallards and pintails. Since *A. platyrhynchos* and *A. acuta* occupy similar niches, the hypothesis that they will have a similar parasite fauna can be examined. The differences in the canvasback's habitat and method of feeding enables one to examine the hypothesis that the canvasbacks will have a dissimilar helminthfauna. This fauna could differ in two possible ways, (i) the number and types of species and (ii) the total helminth burden.

The objectives of this study are four-fold:

(i) to determine what helminths are present in the digestive tract of the mallard and pintail in southern Manitoba.

(ii) to determine whether helminths are causing any emaciation of the pectoral muscles.

(iii) to determine whether the helminthfauna of dabbling ducks is significantly different from that of diving ducks.

(iv) to determine whether the helminthfauna is of greater variability within a host species than between two closely related host species.

REVIEW OF LITERATURE

A Review of Helminths Found in the Anatidae

General

The published works on the helminths of waterfowl are too extensive to summarize here. Therefore, this review will be concerned solely with the parasites of the better known members of the family Anatidae. McDonald (1965a) presented a useful bibliography and a list of anatid hosts and their parasites (1965b). Examination of the literature revealed an emphasis on morphological descriptions of parasites (eg. Cannon, 1938) with little attention to incidence and to pathology of helminth infections.

More ecological studies have been conducted in eastern Europe and the U.S.S.R. than in the western hemisphere, especially North America. Cornwell (1966) attempted to elucidate some factors involved in host-parasite relationships of anatid helminths in a study on the canvasback, *Aythya valsineria* L. in Manitoba.

Kinds of Surveys

Helminth surveys of waterfowl vary; some deal with one particular species in a number of hosts, while others discuss a particular class of helminth and its occurrence in one or several host species. Still others deal with all classes of helminths in one, two or many hosts.

I believe that the last type of survey is the most informative, and also fulfills the responsibility of a researcher to obtain the most information from the least number of birds, especially in view of dwindling waterfowl numbers.

Incidence of Helminth Infections

The occurrence of parasites in waterfowl is expressed usually in one of three ways: (i) as a ratio of infected to non-infected in terms of either a numerical or a percentage ratio; (ii) as the total number of parasites in either a single host or a number of hosts; (iii) as the mean number of parasites per host. This is usually an arithmetic mean. Unfortunately, some authors have not presented their data clearly and interpretation of these data is difficult (eg. Morgan, 1939).

The chief objection to the first method is that if nearly all of the ducks are parasitized, then comparisons of the ratios are not productive. This has resulted in authors using either method (ii) or (iii). Method (iii) would be more valuable if an error were given as this would give a concept of the parasite distribution. Method (ii) is commonly known as extensity and method (iii) as intensity.

Most of the North American and European data which were reviewed are summarized in Tables I and II. Several observations can be made. Sample sizes vary considerably but are

TABLE I

NORTH AMERICAN SURVEYS OF HELMINTHS IN THE ANATIDAE

Author	Location	Host Types	No. Examined	Percentage Infected or (Av./Bird)	Percentage Birds Infected or (Av./Bird) Cestoda	Trematoda	Nematoda	Acanthocephala	Comments
O'Roke (1928)	California	M*	134	40.3	-	-	-	-	Extremely low percentage infected
Gower (1938)	Michigan	M	104	80.5	-	-	-	-	Gives seasonal percentages for 11 genera
Morgan (1939)	Oregon	M	140	-	-	-	-	-	Data cannot be summarized
McNeil (1948)	Washington	M	62	80.6	62.9	45.2	0	17.7	
Warren (1956)	Idaho	S	25	-	-	-	-	-	Gives percent infected for each helminth species
Town (1960	Michigan	M	100	100	88	99	90	4	Gives percent infected with each helminth species
Hanson and Gilford (1961)	Illinois	M	639						Viscera of Canada Geese only
Buscher (1965a)	Manitoba	M	500	94 in August	91% in August	56% in Spring	33% in August	65% in August	Does not give overall percent infected for each helminth class-just when maximums occurred
Cornwell (1966)	Manitoba	S	7	(1,322)	(1,202)	(83)	(37)	(<1)	Marshes
Cornwell (1966)	Manitoba	S	23	(715)	(525)	(176)	(19)	(<1)	Potholes
Cornwell (1966)	Manitoba	S	6	(85)	(21)	(16)	(48)	(1)	Moulting lakes
Cornwell (1966)	Manitoba	S	3	(12)	(5)	(2)	(6)	(0)	Migrating birds with different food habits
Cornwell (1966)	Manitoba	S	180	Of the 250,817 helminths recovered, 78% were cestodes, 18.3% trematodes, 3% nematodes, and 0.1% acanthocephalans.					

*M - many hosts
S - single host

TABLE II

EUROPEAN AND U.S.S.R. SURVEYS OF HELMINTHS IN THE ANATIDAE

Author	Location	Host Types	No. Examined	Percentage Infected Or (Av./Bird)	Percentage Birds Infected Or (Av./Bird) Cestoda	Trematoda	Nematoda	Acanthocephala	Comments
Bezubik (1956a)	Poland	M*	278	73	58	23	9.0	33.0	
Ryzhikov(1956a)	U.S.S.R.	M	44	100	90.7	83.7	79.1	7.0	Breeding Grounds
Ryzhikov(1956b)	U.S.S.R.	M	26	100	84.6	69.3	92.3	11.5	Wintering Grounds
Okorokov(1957)	U.S.S.R.	M	173	90.7	84.0	24.0	17.0	35.0	
Wiśniewski(1958)	Poland	M	277	<100	Most Characteristic Of Area	Second Most Characteristic Of Area			

*M - many hosts

usually more than 100 per species except in specialized studies. Where parasitism by helminth classes is given, most records reveal the presence of four classes: Cestoda, Trematoda, Nematoda and Acanthocephala. Approximately 80% of all birds harbour cestodes and 60% trematodes. Nematode infection rates vary, with some authors reporting low percents and others high ones. Generally, the acanthocephalans are found in approximately 30% of the anatids from North America and about 20% of those from Europe and Russia.

Extensity of Parasitism

Extensity is the percent of individuals infected with a particular helminth class or species (Buscher 1965b). It is often used to show differences in seasonal parasitism or in parasitism of various hosts. For example, Gower (1938), used extensity of infection to study the seasonal abundance of 11 genera of helminths from wild ducks (Table III) in Michigan.

TABLE III

SEASONAL AND TOTAL PERCENTAGES OF INFECTION
(Gower, 1938)

Genus	Spring	Summer	Fall	Winter	Total
Amphimerus	11.7	11.6	2.0	30.0	8.6
Cotylurus	5.9	27.0	41.0	10.0	28.0
Echinostoma	35.0	27.0	39.0	50.0	42.0
Maritrema	5.9	0	2.0	30.0	4.8
Prosthogonimus	17.5	0	27.0	20.0	18.3
Typhlocoelum	17.5	3.8	12.0	0	9.6
Zygocotyle	17.5	23.0	4.0	10.0	11.0
Fimbriaria	5.9	65.0	21.0	40.0	31.0
Hymenolepis	47.0	57.0	61.0	60.0	57.0
Tetrameres	11.7	31.0	4.0	10.0	12.5
Filicollis	5.9	3.8	12.0	0	7.7

As mentioned above extensity data are used to show differences in parasitism of various hosts. O'Roke (1928) examined 10 species of waterfowl from California and found only 40.3% parasitized (Table I). This low percentage does not agree with other studies. In one instance, he reported 42 of 43 ducks from one area to be free of helminths. This suggests either a nonrepresentative sample of hosts and/or inadequate necropsy procedures.

Another use is to show different rates of parasitism for different hosts. Table IV gives Town's (1960) extensity data for diving ducks on the Detroit River. No single parasite species was found in all the ducks. With the exception of a single bird which harboured only one species of parasite, several species were found in the hosts. Town's data as seen in Table I are unusual in that the extensity for cestodes ranked third after trematodes and nematodes.

Table V summarizes the extensity of helminth infections from Druzno Lake in Poland found by Wiśniewski (1958). This example shows little difference between host species.

Cornwell (1966) discussed the incidence of helminths in various organs of canvasbacks. His tabulated data show the percent infection and the mean difference in male and female birds: males harbour fewer parasite than females.

An obvious conclusion is that seasonal variations in extensity occur for both classes and species of parasites. Some species attain maximums in the spring, others in summer and

TABLE IV

PERCENTAGE AND NUMBER OF DIVING DUCKS
INFECTED WITH HELMINTHS FROM THE DETROIT RIVER
(TOWN, 1960)

(% Infected (No.))

Species	L	G	C	E	D	Total(%)
No. Examined	52	15	22	8	3	100
Echinostomidae	100(52)	86(13)	95(21)	75(6)	66(2)	94
<u>Zygocotyle lunatum</u>	86(45)	100(15)	68(15)	0(0)	0(0)	75
(Dies.,1836)	40(21)	40(6)	63(14)	37(3)	0(0)	44
Stunkard 1917						
<u>Cotylurus flabelliformis</u> (Faust 1917) Van Haitsma, 1931	40(21)	40(6)	63(14)	37(3)	0(0)	44
Schistosomidae	44(23)	33(5)	50(11)	50(4)	0(0)	43
<u>Typhocoelum cymbium</u> (Dies.,1850)	21(11)	40(6)	36(8)	12(1)	0(0)	26
<u>Eucotyle wehri</u> Price,1930	11(6)	6(1)	8(2)	50(4)	0(0)	13
<u>Notocotylus imbricatus</u> (Looss,1893) Szidat,1935	13(7)	0(0)	4(1)	25(2)	0(0)	10
<u>Amphimerus elongatus</u> Gower,1938	2(1)	0(0)	0(0)	62(5)	66(2)	5
<u>Ribeiroia ondatrae</u> (Price,1931)	0(0)	0(0)	0(0)	37(3)	66(2)	5
<u>Tetrameres crami</u> Swales,1933	78(41)	67(10)	63(14)	50(4)	33(1)	70
<u>Amidostomum</u> sp.	57(30)	67(10)	86(19)	75(6)	33(1)	66
<u>Capillaria</u> sp.	73(38)	60(9)	27(6)	12(1)	33(1)	55
Hymenolepididae	94(49)	73(11)	91(20)	12(1)	66(2)	83
<u>Hymenolepis</u> sp.	6(3)	13(2)	27(6)	25(2)	0(0)	13
<u>Fimbriaria</u> sp.	17(9)	0(0)	4(1)	0(0)	0(0)	10

L-lesser scaup, G-greater scaup, C-canvasback, E-common goldeneye, D-common merganser

TABLE V

EXTENSITY OF HELMINTH INFECTIONS IN ANATIDAE FROM POLAND (Wiśniewski, 1958)

Species	No. Examined	Percent Infected
Anas platyrhynchos	61	93
Aythya nyroca	23	100
Anas querquedula	14	100
Anas strepera	4	100
Aythya fuligula	1	100
Aythya ferina	6	100

autumn and some in the winter.

Intensity of Parasitism

Intensity is the number of helminths present in or the average number of helminths per individual (Buscher,1965b).

Cornwell (1966) discussed the intensity of helminth infections in the canvasback. He concluded that female canvasbacks carry greater helminth burdens than males. This is interesting in view of the fact that adult sex ratios among North American ducks usually favors the drake (Bellrose *et al*, 1961).

Table VI summarizes McNeil's (1948) work in Eastern Washington with regards to intensity. As most nematodes in waterfowl are tissue dwellers, McNeil's record of no nematodes suggests inadequate necropsy procedures. If mallards are excluded concrete conclusions are difficult because of the small sample sizes for the other species. In mallards, the higher cestode burden compared to other helminth classes agrees with the literature. McNeil found a maximum of 206 helminths in a given host.

TABLE VI

INTENSITY OF HELMINTH INFECTIONS IN ANATIDS FROM WASHINGTON (McNEIL,1948)

Host Species	No. Examined	Mean Trematodes per Bird	Mean Cestodes per Bird	Mean Acanths. per Bird
Mallard	38	8	11	1
Pintail	3	0	67	1
Redhead	3	9	13	0
Green Winged Teal	3	0	1	0
Baldpate	1	0	0	0
Gadwall	1	0	0	0
Canvasback	1	18	0	0
Teal*	2	38	22	14
Coot	4	1	0	4
Canada Goose	5	1	1	0

*immature male, either blue winged or cinamon teal

Wiśniewski (1958) found in Poland that approximately four times as many cestodes were recovered as trematodes. Table VII summarizes the intensity of infection of each helminth class from Wiśniewski's work. The relative frequencies of infection with all helminth classes agree with the literature.

From the literature discussed in this section it is apparent that the intensity of infection with cestodes generally exceeds that of any other helminth class.

<u>Special Parasite Surveys</u>

The types of parasite surveys conducted on waterfowl were

TABLE VII

INTENSITY OF HELMINTH INFECTIONS IN ANATIDS FROM POLAND (Wiśniewski, 1958)

Host Species	No. Examined	Cestoda av./bird	Trematoda av./bird	Nematoda av./bird	Acanthocephala av./bird
Anas platyrhynchos	61	406	19	0	5
Aythya nyroca	23	410	88	0	<1
Anas querquedula	14	79	1	0	0
Anas strepera	4	7	22	0	0
Aythya fuligula	1	888	10	0	6
Aythya ferina	6	90	15	0	1

discussed earlier. This section briefly reviews some of the more important studies on particular classes of parasites.

Cestoda: Table VIII summarizes some of the known data. In cestode surveys of waterfowl one would expect at least 50% of the birds examined to harbour cestodes. Members of the family Hymenolepididae are the most common cestodes. Within this family, the genus *Hymenolepis* is the most frequent one encountered.

Schiller (1951) examined 184 specimens (18 species) of Anseriformes collected in the North Central States for cestodes. Schiller's finding that over a thousand tapeworms in a single host was not unusual is significant as his observations were based on 18 host species. As many as six species of a genus occurred simultaneously in a given individual host.

Korpaczewska (1963) published one of the few papers giving extensity and intensity data for each tapeworm species encountered in waterfowl from three Polish lakes.

Town (1960) found that members of the family Hymenolepididae were predominant. The intensity of infection ranged from one to 38,000 with a mean of 6,431 for the Hymenolepididae excluding *Hymenolepis megalops* (Creplin, 1829). Twelve percent of eight common goldeneyes were infected with cestodes; much lower than the usual 66% of the other ducks.

Buscher's work (1965a) showed an extensity of 50% or greater in bluewinged teal, shovellers and pintails at three collecting sites (Table VIII). Juvenile birds were more heavily infected than adult birds. This agrees with the literature.

Cornwell (1966) found that 78.6% of all the helminths recovered from 180 canvasbacks were cestodes. Three quarters of these were found in the small intestine. Cornwell's data on location of parasites in the digestive tract are difficult to summarize, but cestodes comprised well over 50% of the total helminths found in the gizzard, duodenum and small intestine and approximately 50% of those in the cloaca.

Schiller's data (1953) on Aleutian teal (*Anas crecca* L.) in Alaska showed cestode infections to be relatively light ranging from one to 25 per bird. His work on four species of eiders (1955) showed that the percent infection ranged from 58.4 to 86.6.

TABLE VIII

CESTODE SURVEYS OF THE ANATIDAE AS SUMMARIZED FROM THE LITERATURE

Author	Location	Host Types	No. Examined	Percent Parasitized with Cestodes	No. of Genera	Cestodes Species	Maximum No. of Parasites Per Host	Mean No. of Parasites Per Host	Range	Comments
Schiller (1951)	North Central States	M	184	63	5	34	1,680	-	-	Up to six species of same genus in one host
Korpaczewska (1963)	Poland	M	128	90	15	25	1,414	-	1-1,414	Gives extensive tables for intensity and extensity
Town (1960)	Michigan	M	100	88	2	Many	38,000	6,431 for Hymenolepididae	1-38,000	
Buscher (1965a)	Manitoba	M	278	91 (August)			-	294	-	
	Gulf Coast		82	50 (Winter)	16	27	-	4	-	
Cornwell (1966)	Manitoba	S	180	-						Percentages given for each area of host
	Michigan				4	?	-	-	-	
Neufeld (1954)	Manitoba	M	7 species	-	4	16	-	-	-	
Schiller (1953)	Alaska	S	20	80	3	4	-	-	1-25	Aleutian Teal
Schiller (1955a)	Alaska	S	116	59	3	5	-	-	-	Old Squaw Duck
Schiller (1955b)	Alaska	1 Genus 4 Species	93	68	6	13	-	-	-	Eider Ducks
Heck* (1958)	Washington	M	232	56	1	1	27	-	-	Interested in only one Cestode

*Study of Gastrotaenia cygni
M - many hosts
S - single host

Heck's (1958) data on *Gastrotaenia cygni* in nine anatid species in Washington are particularly interesting as this cestode lives under the koilin lining of the gizzard in association with Trichostrongylid nematodes.

Trematoda: Table IX summarizes some of the data on trematodes. Various authors (Cornwell, 1966; Buscher, 1965a; Town, 1960) whose works were mentioned previously also gave data on trematode infections.

Trematodes occur not only in the digestive tract and in the circulatory system, but also in various body organs. The intensities vary for different species. The genus *Zygocotyle* is usually present in small numbers whereas members of the genera *Echinoparyphium*, *Echinostoma* and *Notocotylus* often occur in large numbers.

Three factors regulate the occurence of flukes in the biocoenosis: (i) the degree of specificity of the mature and larval forms; (ii) the quantity and quality of food accessible to the host; and (iii) the season of the year when the birds become invaded (Sulgostowska, 1958).

Sulgostowska (*op. cit.*) conducted work on Lake Druzno in Poland to determine the dominant fluke species and their intensities of infection in waterfowl. For all hosts the intensity was greatest in *Larus ridibundus* (5,441 per individual), second in *Aythya nyroca* (2,012) and third in *Anas platyrhynchos* (1,175). The extensity of infection by flukes

TABLE IX

TREMATODE SURVEYS OF THE ANATIDAE AS SUMMARIZED FROM THE LITERATURE

Author	Location	Host Types	No. Examined	Trematode Extensity	No. of Genera	Trematode Species	Maximum No./Host	Mean No./Host
Sulgostowska (1958)	Poland	M	108	-	-	14	-	56
Bykhovskaya - Pavlovskaya (1962)	U.S.S.R.	M	Observed that of the 521 trematode species of the class Aves in the U.S.S.R., 145 (28%) were reported from Anseriformes					
Sulgostowska (1960)	Poland	M	108	95%		8		
Cannon (1938)	Canada	M				8		

M - many hosts

was variable. Some parasites occurred frequently in almost every specimen of a given host and were regarded as typical of the biocoenosis. On the other hand, some helminths were found in a few hosts and in small numbers; these are non-typical or accidental in the biocoenosis. The digeneans are highly specific to their first intermediate host but not to the definitive host. Thus, the type of trematodes present depends on the local mollusc fauna (Bykhovskaya-Pavlovskaya, 1964).

Sulgostowska (1960) determined the species composition and numbers of intestinal flukes of birds from Lakes Goldapiwo and Mamry Pólnocne in Poland. Trematodes were found more frequently in Anatidae than other families of waterfowl (Table X). Apparently more divers were infected than dabblers.

Nematoda: Most nematodes occurring in the Anatidae are tissue dwelling forms, either living in glands or forming cysts. The common sites of occurrence are the walls of the oesophagus, proventriculus, caecum and under the koilin lining of the ventriculus.

Czaplinski (1962a-c) in Poland necropsied 551 anseriforms belonging to 14 wild and two domestic species and found 17 species of nematodes. The commonest species was Tetrameres fissipina Travassos, 1914 which ranged in numbers from one to 189 in the domestic mallard.

Epizootics of amidostomiasis and epomidiostomiasis

TABLE X

TREMATODE INFECTIONS IN ANATIDAE

(SULGOSTOWSKA, 1960)

Species	Lake Goldapiwo		Lake Mamry Północne		Total		
	No. Examined	No. Infected	No. Examined	No. Infected	No. Examined	No. Infected	% Infected
Anas crecca	1	1	1	1	2	2	100
A. platyrhynchos	37	37	7	6	44	43	98
A. strepera	-	-	4	4	4	4	100
A. querquedula	10	9	4	4	14	13	93
Aythya ferrina	5	5	13	13	18	18	100
A. fuligula	6	6	1	1	7	7	100
A. marila	5	5	-	-	5	5	100
A. nyroca	8	7	2	2	10	9	90
Anser anser	2	0	-	-	2	0	0
Bucephala clangula	-	-	1	0	1	0	0
Mergus merganser	-	-	1	1	1	0	0

were reported as the cause of losses among waterfowl populations in the United States, Canada and Europe (Cram, 1925; 1926; Jerstad, 1936; Alder and Moore, 1948; Herman and Wehr, 1954; McCraw, 1952). Leiby and Olsen (1965) pointed out the need for detailed study of these parasites because of their importance to waterfowl. They studied the developmental and morphological features of two species of *Amidostomum* and one species of *Epomidiostomum.* Herman and Wehr (1954) assessed the occurrence of gizzard worms in Canada geese *Branta canadensis* L.. The percentage of infected hosts ranged from 28 to 100. The largest number examined, 329, were collected in North Carolina; of these, 318 (98%) were infected. The heaviest infection was 1,537 worms while the means for three years were 80, 64 and 78. *Amidostomum* sp. was the cause of poor condition in only a single bird which harboured over 1,500 worms. Hanson and Gilford (1961) examined 639 Canada geese from Illinois. Of the 14 helminth species present, the commonest was *A. anseris* (Zeder, 1800).

Echinuria sp. is one of the most pathogenic parasites of Anatidae. Cornwell (1963) reported an outbreak of echinuriasis in the ducks and swans of southern Manitoba. Gibson and Barnes (1957) stated that in Britain this parasite is rare among domestic birds but may cause considerable economic loss. Buxton *et al.* (1952) recorded a striking example of echinuriasis in which 85% (213) of a flock of ducks died within an eight week period.

Acanthocephala: Most studies are concerned with taxonomy, but one by Van Cleave and Starrett (1940) reported on the examination of 56 ducks (eight species) in central Illinois. Twenty-one (38%) of these birds were infected with spinyheaded worms which ranged from one to about 200 per bird. Four species of Polymorphus were encountered along with Corynosoma constrictum (Van Cleave, 1918).

Ecology of Helminth Infections

A number of factors determine the relationship between an Anatid host and its helminthfauna. A discussion of the more important factors follows.

Host Age

Variations of the helminthfauna with the age of the host are predictable, but their dynamics are not well understood (Cornwell, 1966). In some hosts (eg.fish), as the individual ages, parasites, especially tissue dwelling forms accumulate. This is not so in waterfowl in which the intensity of infections decrease with age.

The difference in diets of young and adult birds probably is the most important single factor controlling parasites variations (quantitative and qualitative). The work of Bykhovskaya-Pavlovskaya (1962) and Cornwell (1966) support this view. The former author observed that young waterfowl carry greater trematode infections than adults. She believed that this resulted from the greater quantity of animal food consumed by ducklings in their first weeks of life. The intensity of these infections diminishes with age so that at the time of migration both juveniles and adults have essentially the same trematode fauna. Cornwell (1966) found that canvasback ducklings were more heavily parasitized than adults, with a mean total helminth population in ducklings of 2,478 per bird compared to 519 per bird in adults.

Host Food Habits

Most helminths are ingested with food. Therefore, factors that influence the kinds and amounts of food eaten by the host will determine the host's exposure to helminths. An important factor according to Gower (1938) is the way in which the infective stages of the parasite reaches the final host. For example, the larval stages of parasites may encyst on vegetation, in crustaceans, in snails, in the larvae of aquatic insects, and in fishes. Thus, the biology of the intermediate host will regulate infection of the definitive host.

As most parasites utilize invertebrates as intermediate hosts the assumption arose that birds will be more heavily infected when they have an animal rather than a plant diet.

A Czechoslovakian, Rysavy (1964), stated that the composition of cestode fauna parasitizing various orders or families of hosts depends not only on the phylogenetic relationship of the host but also on their ecology and the composition of their food. To the contrary, Korpaczewska (1963) affirmed that the cestode fauna does not depend on the systematic position of the host but is conditioned to a great extent by ecological factors and mainly by the kind of food. Rysavy (1964) stated that similar food habits may result in the formation of a similar or even identical fauna of cestodes in phylogenetically remote hosts. The cestodes of Anseriformes resemble those of Ralliformes (Rysavy, op.cit.). Both orders are aquatic. His investigations proved that the food composition is an important factor determining the cestode fauna of birds.

Ingested foods may scour the alimentary canal and thereby remove helminths. Madon (1931) reported that Great-crested Grebes (Podiceps cristatus) eat large amounts of feathers which may entangle and thus remove tapeworms while passing through the gut. Components of the ingested foods could have pharmacological effects on the parasites of the host (Rogers, 1962). Cornwell (1966) reported that the guts of three adult canvasbacks were filled with muskgrass (Chara sp.) and that these hosts had less helminths than the three immature ducks without muskgrass in their gut. The difference may stem from food differences or time of exposure but the observation is sufficiently interesting to merit re-examination.

Environmental Stresses

Hosts may experience stress by extreme fluctuations of environmental factors. Cornwell (1966) stated that any upset in the energy relationships or physiological homeostasis of the host will be reflected in the bionomics of the helminthocoenosis.

Physiological stress of egg laying, rearing young and post nuptial moult may influence the helminth populations of female birds. Clapham (1961) observed that birds infected by *Syngamus trachea* (Montagu, 1811) frequently died when exposed to the added stress of physical handling. The physiological stress of migration may have an accompanying effect on the helminthfauna.

The stress of disease may alter the helminths in a given host. Clapham (1937) found that chickens suffering from leukemia invariably were heavily infected with *Heterakis gallinae*, Gmelin, 1790, *Capillaria* sp. and *Ascaris lineata* (Schneider, 1866). She suggested that the leukemia lowered the resistance of the host to the helminth.

Cornwell (1966) concluded from his study on canvasbacks of the Detroit River that the severe helminth infections of dead and dying waterfowl probably weakened the host. This weakening would be most critical during periods of low temperature that require increased metabolism, and when food is restricted by ice cover (Longcore and Cornwell, 1964). This prolonged, extensive and largely unnoticed mortality, is the result of parasitism, other diseases, low temperature and diminished food supplies interacting to cause the death of the duck.

Migration

A full study of the parasites of a particular migratory host requires sampling the host population in a great many environments throughout the year.

Migrating hosts experience extreme changes in macro-environments which result in exposure to a greater variety of helminth species. Migrating birds must be opportunists in their selection of food to survive and the resulting variations in food habits influence the helminthfauna.

The effects of migration upon the helminths of birds are difficult to ascertain. Dubinina (1937) studied the parasite fauna of the far migrating black-crowned night heron (Nycticorax nycticorax). Spasskaya (1954) who also worked on migrating birds in the U.S.S.R., along with Dubinina pointed out that migration deeply affects the parasite fauna of the host.

Rausch (1951) found that cestodes are the most abundant and varied group of parasites in both migratory and non-migratory birds of Alaska. This work suggests that the parasite fauna is related to latitude. Trematodes are relatively uncommon. The scarcity of intermediate snail hosts in the northern regions may contribute to this restricted trematode fauna. Here one rarely finds these parasites in loons and ducks which are usually heavily infected with trematodes further south. Parasitic nematodes are often abundant, but the number of species is relatively small. In both arctic and subarctic regions the diversity of species is less than that at lower latitudes. Certain genera are completely lacking though they may comprise the major part of the helminthfauna of the same host farther south. Rausch (op. cit.) stated that the helminthfauna of the northern nesting birds is obtained before the northward migration.

Sulgostowska (1958, 1960) found that the seasonal changes in the parasitic fauna of Anatidae at two Polish lakes depended on the migratory habits of the birds. Bykhovskaya-Pavlovskaya (1962) stated that some trematodes brought to the breeding areas from the wintering sites remain in the host and return to the wintering grounds during the autumnal migration, others are gradually lost and are not reestablished until the host returns to the source of infection. Many of the northern species of parasites acquired on the breeding grounds have a short life cycle and are lost before the host migrates, while others are carried to the wintering grounds. The migrating birds usually have a reduced trematode fauna on the migration journey and it may change as they visit various habitats.

Ryzhikov (1956a,b) found that all of the 26 ducks (5 dabblers, 3 divers) from the wintering grounds in the U.S.S.R.

and 43 (97.7%) of 44 ducks (6 dabblers, 1 diver) from the breeding grounds were infected. More birds were infected with nematodes on the wintering than on the breeding grounds. The percentage infection with trematodes was greater on the breeding than on the wintering grounds. The reverse was true for cestodes.

Migrating birds assist in the distribution of helminths from one place to another by creating new foci of infections in environments having the appropriate intermediate hosts and climate. Parasites are carried both internally and externally by waterfowl from one area to another (Schlichting, 1958). The importance of birds in distributing intermediate hosts during migration needs attention.

Waterfowl could establish possible new foci of infections by depositing both helminth eggs and intermediate hosts at the same site. On three occasions I found *Gammarus lacustris* clinging to the breast feathers of a ruddy duck and two whistling swans in the Delta marsh.

Host Habitat

If a helminth is to reach its definitive host, this host, the intermediate host, and the parasite must simultaneously occur in the same biotope. The host's feeding behaviour is usually the ecological factor linking host and parasite.

Saline water may limit free-living stages of parasites or the activity of intermediate hosts. Dogiel and Bykhovski (1934) found that parasite populations were reduced in the saline areas of the Aral Sea. This may be a significant factor in determining the helminthfauna of waterfowl which reside for long periods in coastal marshes, marine estuaries, or in the large saline, western marshes of North America.

Korpaczewska (1963) showed that the qualitative and quantitative composition of the cestode fauna in birds was related to the limnological type of lake. Mesotrophic lakes will probably contain a richer qualitative composition of bird cestodes than eutrophic lakes.

Davies (1938) observed that domestic ducks reared on stagnant water were parasitized heavier than those reared on streams. Cornwell (1966) observed that adult canvasbacks from marshes carried the heaviest helminth burden with a mean population of 1,322, those from potholes averaging 715 and those from moulting areas only 85 (Table XI). Ducklings hatched and reared on marshes carried a mean total helminth burden of 3,129, nearly twice that of ducklings reared on potholes which had 1,658. Cestodes were the dominant helminth class in ducks from marshes and potholes, but nematodes were dominant in the moulting areas. This is probably due to the fact that most nematodes in the digestive tract of birds are tissue dwellers and are not as easily removed from the host as cestodes and trematodes. This parasite fauna is not replaced as readily on the large moulting lakes as it would be in the marsh and pothole areas where the birds probably feed more on animal matter.

TABLE XI

HELMINTHFAUNA OF ADULT CANVASBACKS

Geographic Location	Marsh	Pothole	Moulting Lakes
No. Examined	7	23	6
Mean No. of Helminths	1,322±1,017*	715±243	85±24
Mean No. of Cestodes	1,202±1,002	525±206	21± 8
Mean No. of Trematodes	83± 43	176± 13	16
Mean No. of Nematodes	37± 7	19± 5	48
Mean No. of Acanthocephalans	<1	<1	1

*Standard Error of the Mean

Bykhovskaya-Pavlovskaya (1962) reported from the U.S.S.R. that aquatic birds are more heavily infected with trematodes than terrestrial ones. In all the biotopes studied by this author, trematode species were more numerous in aquatic hosts.

Sulgostowska (1963) stated that lakes lacking a littoral zone have a smaller trematode fauna because they have fewer intermediate hosts. She also found that the incidence of infection by trematodes, the number of species present and their intensity of infection did not vary between lakes.

Seasonal Fluctuations

Most helminthological studies have been conducted in the temperate regions of the world. The seasonal variations of the helminthfauna described in the literature are not surprising because of the seasonal climatic changes.

The diversity of the parasite fauna of most hosts generally reaches a peak in summer and a low in late winter and early spring. Bezubik (1956a) showed that the extensity of invasion was maximum for nematodes (17%) in May, for flukes (33%) and acanthocephalans (67%) in July, and for cestodes (76%) in August. He found that the extensity for all helminths was lowest in the spring-time and greatest (89%) in July. This maximum extensity decreased in the autumn. He found that the mallard was invaded by flukes to the same degree of intensity during the spring, summer and fall, but that a peak extensity of 100% was reached in May.

Bezubik (*op.cit.*) pointed out that the composition of the parasite fauna and its relation to the food habits cannot be discussed without reference to the season of the year. His data appear to contradict the assumption that animal feeders are more parasitized than plant feeders. He found that the ducks *Nyroca nyroca* and *Chauliodus streperus*, which live mostly on vegetable food were heavily parasitized, 100% and 60% respectively, while *Querquedula querquedula* and *Nettion crecca* living chiefly on animal food were lightly invaded, 37% and 48% respectively. This depended on the fact that *Nyroca nyroca* and *Chauliodus streperus* were examined in summer and autumn, when small crustaceans and molluscs (intermediate hosts of tapeworms, acanthocephalans and flukes) constituted much of their food while *Querquedula querquedula* and *Nettion crecca* were examined early in the spring, when their food consisted mainly of plants.

Bezubik (op.cit.) also found that birds examined in early spring or late autumn were often free of parasites or had only a few. Gower (1938) studied the seasonal abundance of helminths in 12 species of ducks from Michigan and found little variation. The percent infection ranged from 76 in the spring to 84 in the summer and dropped to 80 in the winter. Buscher (1965a) found greater fluctuations in the three species of ducks (pintail, shoveller and blue-winged teal) which he examined from Delta, Manitoba, Cheyenne Bottoms, Kansas and Gilchrist, Texas. The extensity of infection was 88% in the spring, 94% in August and 66% in December and January in Texas.

Thus, seasonal variations are extremely common, and are best discussed on an individual species basis. The extensity of infection of hosts with helminths in temperate areas is greatest in mid summer and early autumn and lowest in mid winter and early spring.

It was suggested that the seasonal nature of helminth infections may be caused by a synchronous periodicity in the intermediate host fauna. *Daphnia* sp. reached a peak population at the Delta marsh in July, 1955 (Collias and Collias, 1963). As cladocerans are important hosts for certain nematodes and cestodes, this peak of *Daphnia* as a food source could have preceded peaks of certain helminth species in the intermediate and definitive hosts.

Environmental factors such as temperature may be the cause of seasonal infection. Johnson (1920), in California reported that eggs of the trematode *Echinostoma revolutum* (Froelich, 1802), passed in the fall and winter do not hatch until they have been exposed for a month to a temperature of 25°C.. Following the parasite's development, most ducks will not be exposed to a large population of infected snails until mid August, leading to large infections with *Echinostoma revolutum*. This life cycle demonstrates the precise coincidence required between the migratory habits of the final waterfowl hosts, peak populations of infective intermediate hosts and reproductive synchrony of the parasite.

The influence of seasonal changes on helminth infections is regulated by the solitary or combined action of variations (i) in the availability of intermediate hosts, (ii) in the presence and activity of the final host, and (iii) intrinsic periodicity in the life cycle of the helminths concerned.

Pathology and Mortality Associated with Helminth Infections

General

Cornwell (1966) pointed out that of the approximately 2,600 published papers dealing with waterfowl helminths, less than 100 discuss mortality and associated pathology. Relatively little information is available regarding the epidemiology of parasitic diseases and their significance as factors controlling wild populations though increasing attention has recently been paid to these problems.

Cornwell (1966) provided a partial listing of fatal helminth infections in waterfowl adopted from an original listing given by McDonald (1965a,b). He listed 19 trematode, six cestode, 14 nematode and five acanthocephalan infections as causes of host mortality.

Pathogenicity of Helminths to Individual Hosts.

Many factors influence the pathogenicity of helminths. Some depend on the worms - their virulence, number, size, the host biotope normally infected, the way in which they move through the host and their manner of feeding. The effects of tissue feeders are different from those which live on the contents of the gut. Some other factors are the physical condition of the host, its age, sex, diet, previous history of infection and variation in host susceptibility.

An examination of the literature reveals nine principal effects of the parasite on Anatidae. These major effects will be briefly discussed in relation to waterfowl parasitism.

Tissue Destruction: The tissues of the host may be mechanically destroyed by the parasite's movement or feeding behaviour.

Various types of lesions such as cysts and swellings usually occur at the site of infection. Town (1960) noted a thinning and weakening of the walls of the small intestine in heavy cestode infections. Harrison (1955) reported nodular lesions due to *Filicollis anatis* (Lühe, 1911) in an eider duck. Both enteritis and colitis were caused by these worms. The attachment organs of various gut parasites damage the intestinal wall and in some cases perforate it.

Obstruction: Any helminth which inhabits the lymph ducts, blood vessels and tubules can impede the flow of fluids. Cestodes and acanthocephalans can partially or completely block the digestive tract (Bezubik, 1956a). Parasite eggs and granulomata caused by their presence may result in occlusion, especially at points anatomically susceptible to blockage. Kidney parasites found in waterfowl can obstruct blood vessels and renal tubules (Cornwell, 1966).

Pressure Effects: Mechanical pressure resulting from the presence of parasites may cause tissue rupture, haemorrhage, necrosis, hypertrophy and inflammation often leading to the formation of granulomata.

The effects of pressure resulting from helminth infections on waterfowl have not been reported. This effect should not be overlooked where helminths illicit severe host reactions.

Blood Change: As is the case with pressure effects, nothing has been written about the effects of parasites on the blood of waterfowl, However, the loss of blood resulting in anemia is a common effect of parasitism, especially of intestinal parasites.

Consumption of Host Food: It is well known that all intestinal parasites cause partial loss of various components of the host's food, but the results of that loss are not always clearly discernible and apparent in the general state of the host. Bezubik (1956a) was the only researcher working on waterfowl to definitely state that helminths were consuming food from the digestive tract of the anatid host.

Emaciation: It has been stated that deterioration of the breast muscles occurs early in the onset of most avian diseases (Cornwell, 1966). He measured this deterioration with his emaciation index (see p. 51).

Bezubik (1956a) described the pathological changes caused by parasites on the basis of examining 278 wild ducks. He stated that all these effects resulted in emaciation. All the diving ducks examined by Town (1960) were emaciated. A minimal amount of food was present in the crop, gizzard and intestinal tract of all birds. No fat was found in the mesenteries or around the heart. Other authors have observed that accumulation of parasites in the intestine can on occasion lead to general emaciation of the host.

McNeil (1948) observed the opposite effect. Ducks with the heaviest worm burden were in excellent condition and he was unable to distinguish between infected and uninfected birds. One point to be recognized is that he was dealing with small numbers of worms. Of the 40 individuals examined, only five had more than 100 parasites (maximum of 206 in one host). He found an average of 27 helminths per individual.

Schiller (1951) stated that the effect of heavy helminth infections upon the well being of the anseriform host is hardly known. The relationship between the host and the cestodes that it harbours usually reaches a state of equilibrium without serious consequences to the host.

The influence of a single parasite may be so slight that no pathological symptoms or signs can be detected. However, a large single parasite may sometimes elicit a serious reaction.

Mortality: Jennings (1961) examined 38 Anatids in Britain and attributed 12 deaths to parasites. He did not indicate the helminths involved, pathology, or how he determined the cause of death. He stated that the anseriforms harbour a large number of parasites but usually an equilibrium develops and the parasite does little harm to the host. Keymer et al (1962) examined 2,044 British birds, 100 of which were waterfowl. Helminths were found in 338 (16%) birds and mortality was attributed to helminths in 64 cases. It was not always easy to determine the significance of these parasites with regard to mortality when other pathogenic organisms were present. Mortality was attributed to helminths when these were numerous and caused lesions, and when death could not be attributed to any other cause.

Pathogenicity of Helminths to Duck Populations

As early as 1937, Clapham formulated the two questions that still confront wildlife biologists and parasitologists; namely, the importance of helminths as a mortality factor of waterfowl and their effect on Anatid populations.

Schiller (1951) stressed the scarcity of information concerning the duck population as a whole, or the effects of helminth infections upon young birds. He also pointed out that potential pathogenicity may be a factor of considerable importance, especially in the analysis of population fluctuations.

Cornwell (1966) showed the difference in helminth burdens between normal and diseased canvasbacks from the Detroit River (Table XII). He classed birds as normal on the basis of weight, fat accumulation, ability to fly, and the fact that they were actively feeding when live-trapped.

TABLE XII

HELMINTH BURDENS OF NORMAL AND DISEASED CANVASBACKS (Cornwell, 1966)

	Normal		Diseased	
	Mean	Range	Mean	Range
No. Examined	43		16	
Mean Weight (gms)	1141	917-1,391	873	708-1,027
Total Helminths	194±67*	4-2,114	912±380	22-4,707
Total Cestodes	69±42	0-1,830	22± 13	0-208
Total Trematodes	113±53	0-2,106	874±383	0-4,695
Total Nematodes	15±3	1-219	16±4	1-452

* Standard Error of the Mean

The diseased birds were either dead when collected or in a moribund condition. The mean total helminth burden in the diseased group was approximately five times that in the normal group. The difference lies primarily in the intestinal trematode populations. I believe that the diseased birds were in this condition as a result of the pollution situation which exists in the Detroit River. It is impossible to draw conclusions from these data on the effect of helminths on the population of canvasbacks in this geographical location.

Helminths can and do destroy the host sometimes causing epizootics. Clark *et al* (1958) reported an epizootic among eider ducks caused by *Polymorphus botulus* (Van Cleave, 1916) in Massachusetts. A number of dead eiders were examined and approximately 200 birds were observed in a weakened condition. All the birds examined were heavily infected with *P. botulus* in the lower small intestine. Their findings indicate that *P. botulus* could be a major factor contributing to epizootics among eider ducks. *Echinuria uncinata* (Rud., 1819) caused an epizootic in seven species of waterfowl from Manitoba (Cornwell, 1963).

McDonald (pers.comm.) stated that the possibility of parasitism acting as a population control of waterfowl varies with locality; in Utah there seems to be little effect but it is probably important in Montana and perhaps also in Manitoba.

A Review of Helminths Found in the Mallard and Pintail

I found records of 46 genera and 104 species of helminths infecting the mallard and pintail. The number of genera and species of each class are given in Table XIII

TABLE XIII

NUMBER OF GENERA AND SPECIES OF HELMINTHS FROM THE MALLARD AND PINTAIL

Class	Genera	Species
Cestoda	14	39
Trematoda	15	20
Nematoda	13	38
Acanthocephala	4	7

LaPage (1961) recorded a list of helminths from Anatidae. Table XIV gives the number of genera and species that he encountered.

TABLE XIV

NUMBER OF GENERA AND SPECIES OF HELMINTHS FROM THE MALLARD AND PINTAIL (LaPage, 1961)

Anas platyrhynchos	Genera	Species and Subspecies
Cestoda	22	96
Trematoda	40	96
Nematoda	19	38
Acanthocephala	5	16
Anas acuta		
Cestoda	7	26
Trematoda	22	31
Nematoda	7	8
Acanthocephala	4	6

Certain difficulties are encountered in the interpretation of LaPage's list. One of the most important is that LaPage made no reference to synonyms, even though they do occur in his listing.

Only one study dealing exclusively with the mallard, that by Warren (1956), was found in the literature. He studied the helminths of the mallard in Idaho. No detailed study of the helminths of Anas acuta was found. Buscher (1965a) studied the helminths of three species of ducks from Manitoba, one of which was the pintail.

The parasites found by Warren in the mallard were as follows: Hymenolepis collaris (Batsch, 1786); H. megalops (Nitzsch, 1829); Hymenolepis sp.; Diorchis bulbodes Mayhew, 1929; Typhlocoelum cymbium (Diesing, 1850); Zygocotyle lunatum; Riberoira ondatrae (Price, 1931); Orchipedum tracheicola Braun, 1901; Cotylurus flabelliformis; Echinoparyphium recurvatum (Linstow, 1873); Hypoderaeum conoideum (Bloch, 1782) Dietz, 1909; Echinostoma revolutum; Notocotylus urbanensis (Cort, 1914); Eucotyle renalis (Warren, 1956); Capillaria sp.; Echinuria uncinata; Tetrameres crami; Polymorphus botulus; and Corynosoma constrictum.

Cestoda

Avery (1966a) examined a large number of Anatids from Slimbridge, England. The following tapeworms were found in the mallard; Fimbriaria fasciolaris (Pallas, 1781) Wolffhügel, 1900; Sphenacanthus sp., Sobolevicanthus gracilis

(Zeder, 1803) Spassky and Spasskaya, 1954, Orlovilepis megalops (Nitsch in Creplin, 1829) Spasskaya and Spasskaya, 1954 and Dicrotaenia coronula (Dujardin, 1845) Railliet, 1892 in mallards and a pintail.

Polk (1942a,b) described two new cestode species in pintails from Oklahoma; namely, Hymenolepis dafilae and H. parvisaccata.

Morgan (1939) found six species of cestodes in mallards from Oregon: Metroliasthes lucida Ransom, 1900, Choanotaenia infundibulum (Bloch, 1779), Raillietina cesticillus (Lolin, 1858) and Hymenolepis carioca (de Magelhaes, 1898) Ransom, 1902, H. megalops, and H. canatiniana (Polonio, 1860) Ransom, 1909.

Table XV shows the cestodes fround in mallards and pintails from Ohio, Michigan and Wisconsin (Schiller, 1951).

TABLE XV

CESTODES FROM MALLARDS AND PINTAILS
(Schiller, 1951)

Species	Mallard	Pintail
Diorchis flavescens (Kreft, 1871)	-	x
D. bulbodes	x	-
F. fasciolaris	x	x
Hymenolepis echinocotyle Fuhrmann, 1907	x	-
H. fausti (Shen Tseng, 1932) Fuhrmann, 1932	x	x
H. gracilis Railliet, 1899	x	-
H. introversa (Mayhew, 1925) Fuhrmann, 1932	x	-
H. macrostrobilodes (Mayhew, 1925)	x	-
H. megalops	x	x
H. nyrocae Yamaguti, 1935	x	-
H. coronula (Dujardin, 1845) Cohn, 1901	-	x
H. simplex Fuhrmann, 1906	-	x

Table XVI shows the cestodes that Czaplinski (1956) found in mallards and pintails from Poland.

TABLE XVI

CESTODES FROM MALLARDS AND PINTAILS IN POLAND (Czaplinski, 1956)

Species	Mallard	Pintail
Aploparaksis furcigera (Rudolphi, 1814)	x	x
Diorchis nyrocae	x	x
D. parvogenitalis Skrjabin et Mathevossian, 1945.	x	-
Dicrotaenia coronula (Dujardin, 1845) Railliet, 1892.	x	x
Drepanidotaenia lanceolata (Bloch, 1782) Railliet, 1892.	x	-
Echinocotyle rosseteri Blanchard, 1891.	x	-
Hymenolepis abortiva (von Linstow, 1904) von Linstow, 1905	x	-
H. anatina (Krabbe, 1865) Cohn, 1901	x	x
H. compressa (Linton, 1892) Kowalewski, 1904	x	x
H. paracompressa Czaplinski, 1956	x	-
H. teresoides Fuhrmann, 1906	x	x
H. megalops	x	x
H. gracilis	x	x
H. fragilis Lühe, 1910	x	-
H. octacantha Railliet, 1899	x	x
H. macrocephala Fuhrmann, 1913	x	-
Fimbriaria fasciolaris	x	x
Diploposthe laevis (Bloch, 1782) Jacobi, 1897	x	-

Trematoda

Avery (1966a) recovered *Echinoparyphium recurvatum*, *Hypoderaeum conoideum* and *Notocotylus attenuatus* (Rud., 1809) from the mallard in England.

Bezubik (1956a) recorded *Echinoparyphium nordiana*

Baschkirova, 1941, *Tylodelphys* sp. and *Orchipedum tracheicola* for the first time in the mallard.

Beverley-Burton (1958) described *Uniserialis gippyensis*, a new genus and species from mallards in England.

Morgan (1939) recovered three species of trematodes from mallards in Oregon: *Echinoparyphium recurvatum*, *Hypoderaeum conoideum* and *Sphaeridotrema globulus* (Rud.,1814) Odhner, 1913.

Table XVII shows the trematodes that Sulgostowska (1958) found in mallards and pintails from Lakes Goldapiwo and Mamry Polnocne in Poland.

TABLE XVII

TREMATODES FROM MALLARDS AND PINTAILS IN POLAND
(Sulgostowska, 1958)

Species	Mallard	Pintail
Echinochasmum beleocephalus (Linstow, 1873).	x	-
E. coaxatus Dietz, 1909.	x	-
Echinoparyphium clerci Skrjabin, 1915	x	x
E. recurvatum	x	x
Echinostoma revolutum	x	-
Hypoderaeum conoideum	x	x
Maliniella anceps (Molin, 1859) Hübner, 1939.	x	-
Prosthogonimus cuneatus (Rud., 1803)	x	x
Schistogonimus rarus (Braun, 1901)	x	x
Psilochasmus oxyurus (Creplin, 1825)	x	x
Psilotrema spiculigerum Mühling, 1898	x	-
Catatropis verrucosa (Fröhlich, 1789) Odhner, 1905.	x	-
Notocotylus attenuatus	x	x

Nematoda

Avery (1966a,b) recovered a number of nematodes from mallards in England; Hystrichis tricolor Duj., 1845, E. uncinata, Amidostomum acutum (Lindahl, 1848) Seurat, 1918, A. anseris, Epomidiostomum sp., Porrocaecum crassum (Deslongchamps, 1824) and Capillaria anatis (Schrank, 1790).

Czaplinski (1962a,b) found 11 species of nematodes in mallards from Poland: A. anseris, E. uncinatum, P. crassum, Ascaridia galli (Schrank, 1788) Freeborn, 1923, Heterakis gallinarum (Schrank, 1788), Streptocara crassicauda (Crepl., 1829), E. uncinata, T. fissipina, C. anatis, Capillaria contorta (Crepl., 1839) and Hystrichis tricolor.

Hobmaier (1932) reported the finding of Capillaria contorta in the pintail. Swales (1936) found Tetrameres crami in mallards and pintails from Alberta.

Morgan (1939) in his work in Oregon found Capillaria sp., A. anseris, Epomidiostomum sp., T. crami and T. fissipina in mallards and pintails.

Acanthocephala

Avery (1966a) found Polymorphus minutus (Goeze, 1728) Lühe, 1911 in mallards from southern England. Bezubik (1956a) in Poland reported Acanthocephalus ranae (Schrank, 1788) from the mallard.

Czaplinski (1962c) examined 141 mallards from Poland and found Filicollis anatis and P. minutus.

Van Cleave and Starrett (1940) reported P. minutus and C. constrictum in both mallards and pintails while Polymorphus *marilis* Van Cleave, 1939 was found in mallards.

This literature survey shows that more parasites have been reported from the mallard than the pintail. This could stem from the fact either that the mallard harbours a wider variety of parasites than the pintail or that more mallards were examined for helminths than pintails. The latter is more probable.

BIONOMICS OF THE MALLARD AND PINTAIL

It was stated in the introduction that the mallard, *Anas platyrhynchos platyrhynchos* L., and the pintail, *Anas acuta* L., are two closely related species and occupy similar niches. This section will briefly indicate some similar habits of both species which are related to this study.

McGraw (domestic) mallards were released at Delta in the early 1950's. The possibility exists that some of the birds collected during my study had McGraw characteristics. These individuals are far enough removed from the original parental McGraws through crossing with true wild birds (at least 12 generations) that they can be considered as true wild birds for the purposes of this study.

Mallards and pintails can be found along marsh borders, open meadows, small potholes, roadside ditches and wherever dry land and water meet in the Delta region. Kortright (1943) stated that the principal feeding grounds of the mallard are the shallow waters of sloughs, ponds, lakes, rivers as well as wheat, barley, corn and buckwheat fields. The feeding habits and feeding areas of the pintail are similar to those of the mallard, except that the pintail spends less of its time feeding on dry land remote from water. He found that nine-tenths of the diet of both species was vegetable matter.

Hochbaum (1955) has seen pintails turn sharply toward the feeding call of a female mallard. Such individuals no doubt have lived with mallards and may have learned to associate this call with a favorable situation. Kortright (1943) reported that mallard-pintail hybrids occur readily and repeatedly but that they are rarely fertile.

The first mallards and pintails arrive at Delta late in March during an early spring and the middle of April in a late spring. The species migrating together most frequently at Delta in the spring are mallards and pintails (Sowls, 1955). He stated that the time of day of migration, loafing areas, and feeding areas were generally the same. Observations made at Delta in 1967 and 1968 showed that throughout the spring and summer mallards and pintails were closely associated at feeding and loafing areas and stubble flights of mallards and pintails were common. In the autumn, the pintails left the marsh earlier and consequently few were seen with the large autumn flights of mallards. Sowls (*op. cit.*) stated that in the spring and in late August until freeze up, daily stubble flights of mallards and pintails occurred.

MATERIALS AND METHODS

Study Area

This study was conducted on the marshes surrounding the Delta Waterfowl Research Station at Delta, Manitoba. The Delta marshes lie at the southern end of Lake Manitoba.

The northern edge of this marsh is a sand ridge covered with trees, shrubs and herbs. South of the ridge the marsh extends about 30 kilometres east and west, and about eight kilometres southward, covering an area of almost 15,000 hectares (Hochbaum, 1944). South of the marsh lies the rich farmland of the Portage Plains. The marsh is an intricate system of large and small bays and lagoons some covering several hundred hectares, others only a few. The lagoons are never more than three metres deep, usually less than one, and their bottom is covered by a thick layer of detritus (Walker, 1965). *Phragmites communis* Trin. var *berlandieri* (Fourn) and *Scolochloa festucacea* (Willd) Link. are normally the most prevalent vegetation species (Walker, *op. cit.*).

The collecting areas were located at the following places: Twp. 13 R6 S36 SE8; Twp. 13 R6 S29 NE9,16; Twp. 13 R7 S24 NE15; Twp. 14 R7 S1 NW12,13; Twp. 14 R7 S11 NE10,15; Twp. 14 R7 S8 SW 3,4,5,6; and Twp. 14 R7 S8 SE1,2,7,8. The areas in township 14 were easily accessible both by car and foot, but township 13 was more difficult to traverse.

Dr. M. Levin, Department of Botany, surveyed the vegetation at the collecting areas. The predominant water plants found were: _Ranunculus_ _aquatilis_ L., _R._ _scleratus_ L., _Potamogeton_ _pectinatus_ L., _P._ _vaginatus_ Turcz., _Sagittaria_ sp. L., _Lemna_ _trisulca_ L. and the algae _Cladophora_ L., and _Enteromorpha_ (Hudson) Kutzing. The terrestrial vegetation surrounding the collecting areas was: _Phragmites_ _communis_ var _berlandieri_, _Scirpus_ _acutus_ Muhl., _Scolochloa_ _festucacea_, _Typha_ _latifolia_ L,, _Atriplex_ sp. L., _Puccinellia_ _nuttaliana_ (Schultes) Hitchc., _Melilotus_ sp. Mill., _Hordeum_ _jubatum_ L., and _Sonchus_ sp. L., Fig. 1 shows the vegetation found at one of the preferred collecting areas.

Field Procedure

Collection

Attempts were made to collect five mallards and five pintails each week throughout the spring, summer and fall using a 12 gauge shotgun. A well trained Chesapeake retriever reduced the loss of crippled birds and minimized the amount of time spent in the field.

Examination Procedure

Each bird was assigned a number, weighed, sexed and records made of plumage condition and any other external abnormalities. The presence or absence of sarcocysts in the breast, leg and neck muscles was noted when the skin was removed. The relative size of the subcutaneous and visceral

Fig. 1: Vegetation surrounding a preferred feeding area of mallards and pintails.

fat deposits was recorded.

The pleuroperitoneal and pericardial cavities were exposed next by severing the sternum from the keel along its entire length. Two blood smears were made with blood drawn by syringe from the heart. The entire digestive tract (upper oesophagus to cloaca) was then removed and slowly injected with a 10% solution of $MgCl_2$. The entire tract was then placed for 3-4 hours in a labelled jar filled with $MgCl_2$. This solution relaxes and kills the helminths. The gut was then placed in F.A.A.,

The juvenile birds were sexed on the basis of their gonads. The weight and volume of the gonads of all ducks was measured to the nearest gram and millilitre respectively. The volume was determined using a graduated cylinder filled with water.

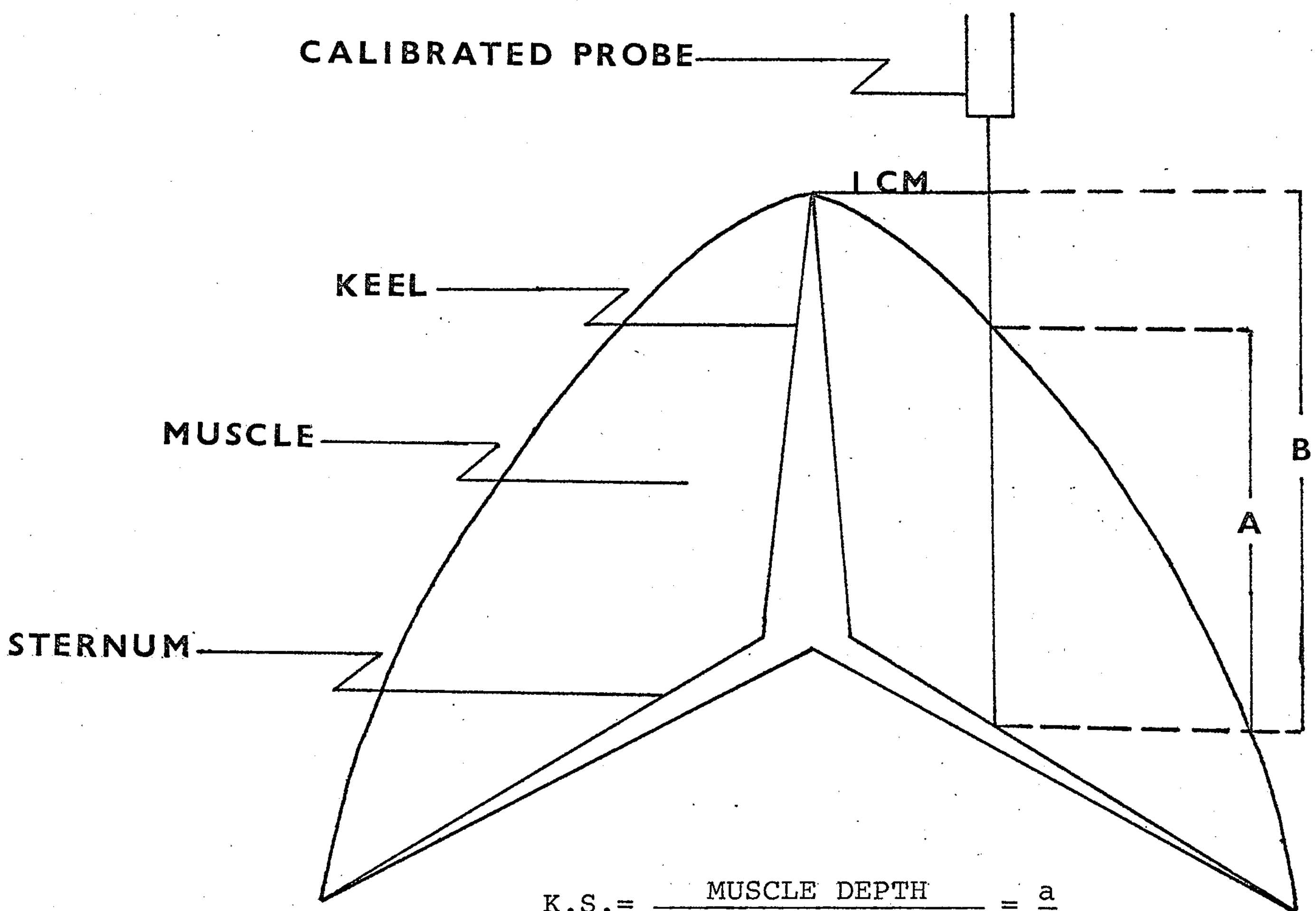
Keel-Sternum Ratio

Cornwell (1966) stated that variations in body weight with sex, age and body size limit the usefulness of weight as a sole indicator of the individual's physical condition. A decrease in the volume of the pectoral muscles is an indication of poor physical condition and appears early in the onset of most avian diseases. Cornwell (*op. cit.*) developed a technique to quantify the degree of emaciation by measuring the depth of the breast muscles relative to the depth of the keel. He selected a standard point 2.5 cm. from the anterior end and 1.0 cm. to the right of the keel (Fig. 2). At this point, the perpendicular distance from the ventral edge of the keel to the sternum was measured in millimetres with a calibrated probe. This measurement serves as the denominator of a fraction whose numerator is the depth of the muscle at the same point. Cornwell referred to the quotient as the Emaciation Index. A more appropriate term would be keel-sternum ratio, henceforth referred to as the K.S. ratio. Figs. 3 and 4 show hosts with high and low K.S. ratios respectively. This ratio is measured before the body cavity is exposed.

The height of the keel varies within a species with sex, age and skeletal characters. The K.S. ratio is not distorted by this variation as it is only a measurement of the pectoral muscle depth relative to the keel height.

Laboratory Procedure

During the first summer, the gut was placed in F.A.A. after 3-4 hours in $MgCl_2$ and stored until time permitted a detailed helminthological examination, but in the second summer the examination was carried out before fixation. Cestodes, trematodes and acanthocephalans were killed in $MgCl_2$ and then fixed in F.A.A.. The nematodes were heat relaxed and killed in hot 0.5% acetic acid and then fixed in T.A.F. (triethanolamine, formalin, distilled water). This method produced much better specimens than when the entire gut was



$$K.S. = \frac{\text{MUSCLE DEPTH}}{\text{KEEL-STERNUM DEPTH}} = \frac{a}{b}$$

CROSS SECTION OF DUCK BREAST 2.5cm. FROM THE ANTERIOR TIP OF THE KEEL, SHOWING THE POINT OF MEASUREMENT FOR THE KEEL-STERNUM RATIO AND HOW IT IS OBTAINED.

Fig. 2: Measuring the keel-sternum ratio.

Fig. 3: Mallard with K.S. ratio of 1.0.

Fig. 4: Mallard with K.S. ratio of 0.45.

fixed and the parasites removed later. It was found that the hooks of acanthocephalans were retained if the tissue they were attached to was fixed with the worm and the worm was then easily removed with fine forceps.

A 10 power zoom Olympus dissecting microscope was used for all necropsies along with a direct source of lighting to illuminate the material being examined. A piece of black cardboard was placed under the stage of the microscope to give a dark background.

The digestive tract was divided into eight regions: the oesophagus, proventriculus, ventriculus, duodenum, intestinal coils, caeca, rectum and cloaca. The helminths from each area were counted and recorded on necropsy sheets (Appendix 1 & 2).

The oesophagus was slit open with a scalpel and its inner surface searched for capillarid nematodes. These were removed with fine forceps. The food contents and mucous from the lumen of the oesophagus were examined for helminths. The food present in the oesaphagus and crop was preserved in 10% formalin. It was studied by Mr. N. Seymour, Department of Zoology, and its identification will be published separately (1969).

The proventriculus was also slit open, scraped in water and then pressed between two pieces of 1/4 inch glass plate. A strong light was passed through the tissue to locate the parasites in the crypts of Lieberkühn. Nematodes found in the glands were removed with fine forceps. Cysts of Echinuria uncinata were carefully opened and the number of nematodes counted.

The ventriculus was cut between the cranial and caudal grinding plates (Bradley and Grahame, 1951) and the contents washed into a petri dish. The inner surface was examined under the microscope for lesions, erosion of the koilin lining and discoloration. The koilin lining was then removed and its inner surface examined for helminths. The gizzard contents were examined for both helminths and lead shot.

The duodenum was cut from the remainder of the small intestine at the point where the common bile duct enters the intestine. It was slit open with a scalpel. Caution must be used to avoid cutting the helminths present. The contents were carefully removed to avoid losing the scolices of cestodes and then examined under the dissecting microscope. It was possible to examine thoroughly about four inches of intestine at a time.

The remainder of the small intestine, caeca, rectum and cloaca were examined in the same manner as the duodenum.

Helminth Preparation

The helminths from each area of the gut were placed in a vial, labelled and stored in fixative for identification

Cestodes and trematodes were washed in tap water and stained in Ehrlich's acid alum hematoxylin for 24 hours. They were then destained using 70% alcohol with hydrochloric acid, blued in running water, and then dehydrated in a series of 70, 85, 95 and 100% alcohol. The helminths were cleared in a 50-50 xylene-alcohol mixture for two hours, transferred to pure xylene for 2-3 hours, and mounted in permount. Small, fragile cestodes and trematodes were moved from one mixture to another using small baskets made out of fine nylon mesh. The hooks of cestodes were counted and measured by removing the scolex and placing it in a small drop of Berlese's fluid. A cover slip was placed on the scolex and gently agitated with a probe over the scolex to squash it and spread the hooks. The slide was allowed to dry and then sealed with clear nail polish.

The nematodes when removed from T.A.F. were processed by the rapid Baker's method (Goodey, 1963), mounted in glycerine and sealed with glyceel.

The acanthocephalans were not identified to species; consequently they were not mounted on slides.

Parasite Identification

The helminths were identified by using Yamaguti's Systema Helminthum (1958, 1959, 1961), Wardle and McLeod (1952), Yorke and Maplestone (1926), Fuhrmann (1932) and other pertinent papers published in journals.

Some identified specimens were compared with named specimens in Dr. M. McDonald's collection at the Research Station, Bear River, Utah. Dr. McDonald confirmed the identification of some of the helminths collected. With the exception of _H. megalops_, the hymenolepids were not identified to species. Two reasons for this were the taxonomic confusion existing in the Hymenolepididae and the time involved in mounting these specimens on slides. Blood parasites were not identified further than microfilaria (Class: Nematoda).

It was not practical to mount all specimens collected. However, approximately 1,000 cestodes, 400 trematodes and 1,200 nematodes were mounted. After examining a large number of mounted nematodes and trematodes, unmounted ones could be identified by studying them under the microscope. All cestodes except those of the genus _Hymenolepis_ were identified to species along with nematodes and trematodes.

Data Tabulation

All the information pertaining to each specimen was recorded on the form shown in Appendix 1. During the necropsy, the location of parasites, their numbers and the class were recorded on the diagram shown in Appendix 2. The number of individuals of each species identified was recorded on the form shown in Appendix 1. When all identifications were completed the data for each group of ducks (eg. adult male mallards) were tabulated on the form shown in Appendix 3.

RESULTS

Data on Hosts Examined

Sex and Age

A total of 101 mallards and 101 pintails were examined in the course of this investigation. Table XVIII gives the sex and age of all these ducks. An attempt to collect broods was unsuccessful and no comparisons could be made of the helminthfauna of broods with that of the female parent. All juvenile birds examined were capable of flight.

TABLE XVIII

SEX AND AGE OF 202 DUCKS EXAMINED

No. Examined		Mallard 101		Percent of Total	Pintails 101		Percent of Total
Sex		M	F		M	F	
Age	A	68	19	86.1	56	24	79.2
	J	7	7	13.9	7	14	20.8
Total		75	26	100	63	38	100

A - adult
J - juvenile
M - male
F - female

Weight

The average weights in grams for the four groups of ducks of each species are given in Table XIX.

Physical Condition

Table XX gives the average K.S. ratio for the birds examined.

TABLE XIX

AVERAGE WEIGHTS OF 202 DUCKS EXAMINED
(In grams)

Species	Age	Sex	Average	Range
Mallard	A	M	1,244 ± 17*	1,034 - 1846
Mallard	A	F	1,099 ± 26	902 - 1293
Mallard	J	M	1,019 ± 51	850 - 1204
Mallard	J	F	902 ± 46	799 - 1085
Pintail	A	M	924 ± 9	790 - 1065
Pintail	A	F	836 ± 18	707 - 1067
Pintail	J	M	903 ± 41	697 - 1049
Pintail	J	F	723 ± 42	222 - 851

A - adult M - male
J - juvenile F - female
*Standard error of the mean

TABLE XX

AVERAGE K.S. RATIO OF 202 DUCKS EXAMINED

Species	Age	Sex	Average	Range
Mallard	A	M	0.90 ± 0.01*	0.62 - 1.10
Mallard	A	F	0.93 ± 0.03	0.58 - 1.10
Mallard	J	M	0.91 ± 0.04	0.73 - 1.00
Mallard	J	F	0.96 ± 0.04	0.78 - 1.10
Pintail	A	M	0.86 ± 0.02	0.59 - 1.20
Pintail	A	F	0.89 ± 0.02	0.68 - 1.00
Pintail	J	M	0.86 ± 0.02	0.80 - 0.98
Pintail	J	F	0.93 ± 0.02	0.80 - 1.10

A - adult M - male
J - juvenile F - female
*Standard error of the mean.

Parasites Collected

Incidence

Helminths Recovered: Helminths were found in all of the ducks. No single species of helminth was common to all of the ducks examined. All ducks had multiple infections except for two individuals each of which harboured only a single specimen. The number of helminths per host ranged from one to 4,223.

The number of genera and species of each class of helminths were as follows: Cestoda, five genera containing five species; Trematoda, seven genera with seven species; Nematoda, six genera with seven species; and Acanthocephala, two genera of two species. Table XXI lists the parasites and the ages and sexes of their hosts. Tables XXII and XXIII give the total number of helminths recovered from each species of duck and the total for each sex and age group (eg. adult male mallards).

The number of helminths recovered from the mallards and the pintails was 24,567 and 18,948 respectively. Thus, 5,619 more helminths were recovered from the mallards, an average difference of 56 per bird. If the juvenile pintail which harboured 4,223 helminths is excluded, 9,842 more helminths were recovered from the mallards, an average difference of 98 helminths per bird. Table XXIV shows the extensity of invasion for both duck species over the entire collecting period.

TABLE XXI

HELMINTHS FOUND IN MALLARDS AND PINTAILS

Helminth Species	Mallard				Pintail			
	AM	AF	JM	JF	AM	AF	JM	JF
Cestoda								
Hymenolepis spp.	x	x	x	x	x	x	x	x
Hymenolepis megalops	x	x	x	x	x	x	x	x
Diorchis nyrocae	x	x	x	x	x	x	x	x
Gastrotaenia cygni	x	x	x	x	x	x	x	x
Fimbriaria fasciolaris	x	x	x	x	x	x	x	x
Ligula intestinalis	x							
Trematoda								
Echinostoma revolutum	x	x	x	x	x	x		x
Echinoparyphium sp.	x	x	x	x	x	x	x	x
Zygocotyle lunatum	x	x	x	x	x	x	x	x
Cotylurus flabelliformis	x		x	x	x	x	x	x
Notocotylus attenuatus	x	x	x	x	x	x	x	x
Hypoderaeum conoideum	x	x	x	x	x	x	x	x
Lyperorchis sp.					x			
Nematoda								
Echinuria uncinata	x		x	x	x	x		x
Capillaria sp.	x	x	x	x	x	x	x	x
Capillaria contorta	x	x		x	x	x		
Amidostomum anseris	x	x	x	x	x	x	x	x
Epomidiostomum uncinatum	x	x	x	x	x	x		
Streptocara crassicauda		x	x		x	x		
Tetrameres crami	x	x	x	x	x	x	x	x
Acanthocephala	x	x	x	x	x	x	x	x

x - present
A - adult
J - juvenile
M - male
F - female

TABLE XXII

TOTAL NUMBER OF HELMINTHS RECOVERED

Sex	Species	No. Examined	Cestoda	Trematoda	Nematoda	Acanthocephala	Total
A	Mallard	87	14,144	1,393	582	473	16,592
J	Mallard	14	6,667	464	812	32	7,975
A	Pintail	80	4,670	1,086	313	357	6,426
J	Pintail	20	11,412	662	144	334	12,552
	Total	201	36,893	3,605	1,851	1,196	43,545

A - adult
J - juvenile

TABLE XXIII

TOTAL NUMBER OF HELMINTHS RECOVERED
FROM EACH GROUP AND AVERAGE PER BIRD

Sex	Species	No. Examined	Cestoda Total	Cestoda Av.	Trematoda Total	Trematoda Av.	Nematoda Total	Nematoda Av.	Acanthocephala Total	Acanthocephala Av.	Total Total	Total Av.
AM	Mallard	68	9,543	140	800	12	424	6	266	4	11,031	162
AF	Mallard	19	4,601	242	593	31	158	8	207	11	5,559	293
JM	Mallard	7	2,611	373	234	33	617	88	22	3	3,484	498
JF	Mallard	7	4,056	579	230	33	195	28	10	1	4,491	642
AM	Pintail	56	1,523	27	383	68	206	4	199	4	2,311	41
AF	Pintail	24	3,147	131	703	29	107	5	158	7	4,115	171
JM	Pintail	7	6,093	870	312	45	26	4	319	46	6,750	964
JF	Pintail	13	5,902	409	350	27	118	9	15	1	5,902	454

A - adult
J - juvenile
M - male
F - female

TABLE XXIV

EXTENSITY OF INVASION IN MALLARDS AND PINTAILS

% INFECTED (NUMBER)

Age	Species	No. Examined	Cestoda	Trematoda	Nematoda	Acanthocephala
A	Mallard	87	77(67)	80.5(70)	71.3(62)	39.1(34)
J	Mallard	14	100(14)	85.7(12)	100 (14)	57.1(8)
A	Pintail	80	67.5(54)	66.3(53)	80 (64)	45.0(36)
J	Pintail	20	100(20)	55.0(11)	85 (17)	55.0(11)

A - adult
J - juvenile

Each group of birds and its parasites are treated individually.

<u>Juvenile Male Mallards</u>: In these, helminths averaged 498 per bird and ranged from 46-658.

Cestodes were the most common parasites in these hosts. Four genera were identified (Table XXV). Cestodes comprised 75% of the 3,484 helminths recovered.

Six species of trematodes were recovered from the juvenile male mallards examined (Table XXVI). Trematodes comprised 6.7% of the total number of helminths recovered.

All birds in this group were infected with nematodes. Six hundred and seventeen specimens were collected belonging to six species (Table XXVII). Nematodes comprised 17.7% of all the helminths found.

Six of the seven ducks examined harboured acanthocephalans. The average per bird was three with a maximum of six. This group comprised 0.6% of all helminths recovered from juvenile male mallards.

<u>Juvenile Female Mallards</u>: A total of 4,491 helminths were recovered from this group of ducks with an average of 642 per bird and a range of 88 to 1,368.

All hosts harboured cestodes belonging to four genera (Table XXVIII). Tapeworms comprised 90.3% of the total number of worms collected.

Six species of trematodes were recovered from six out of seven birds (Table XXIX). This class accounted for 5.1% of the helminths collected.

Nematodes comprised 4.3% of all the helminths recovered, belonging to six species (Table XXX).

Acanthocephalans were found in two of the seven birds examined. The average per bird was one with a maximum of seven. These worms comprised 0.2% of the total number of helminths from this group of ducks.

Juvenile Male Pintails: This group of ducks harboured 6,750 helminths with an average of 964 per bird and a range of 140-4,223. If the single individual which contained the exceedingly large number of helminths is deleted, 2,527 worms were found with an average of 421 per bird and a range of 140-1,028. This is more in agreement with the usual data.

The unusually large number of 4,159 cestodes were found in one individual and this distorted the average. The usual cestode fauna was encountered (Table XXXI). This table shows in brackets the corrected average, range and percent of total cestodes were applicable when the heavily infected bird is removed. Cestodes comprised 90.3% (76.5%) of all helminths collected from this group.

Five species of trematodes were encountered in juvenile male pintails (Table XXXII). These worms comprised 5.1% of all helminths collected from this group of ducks.

Three species of nematodes (Table XXXIII) were recovered

TABLE XXV

CESTODES FROM 7 JUVENILE MALE MALLARDS

Species	No. Infected	Av./Bird	Range	% of Total Cestodes
Hymenolepis spp.	7	282	46-589	75.7
H. megalops	4	5	0-24	1.5
D. nyrocae	6	63	0-223	16.9
G. cygni	1	<1	0-1	0.04
F. fasciolaris	6	22	0-84	5.9
Total Cestodes	7	373	46-658	

TABLE XXVI

TREMATODES FROM 7 JUVENILE MALE MALLARDS

Species	No. Infected	Av./Bird	Range	% of Total Trematodes
E. revolutum	3	282	0-3	3.0
Echinoparyphium sp.	3	5	0-82	63.7
Z. lunatum	5	63	0-4	3.9
H. conoideum	1	<1	0-1	0.4
C. flabelliformis	3	1	0-5	3.9
N. attenuatus	1	8	0-57	24.4
Total Trematodes	7	33	1-88	

TABLE XXVII

NEMATODES FROM 7 JUVENILE MALE MALLARDS

Species	No. Infected	Av./Bird	Range	% of Total Nematodes
E. uncinata	4	63	0-205	72.0
Capillaria sp.	5	4	0-10	4.4
A. anseris	7	11	0-39	12.2
E. uncinatum	5	7	0-19	7.5
S. crassicauda	1	2	0-9	1.8
T. crami	5	5	0-16	5.8
Total Nematodes	7	88	12-217	

TABLE XXVIII

CESTODES FROM 7 JUVENILE FEMALE MALLARDS

Species	No. Infected	Av./Bird	Range	% of Total Cestodes
Hymenolepis spp.	7	527	10-1,311	90.9
H. megalops	2	4	0-22	0.6
D. nyrocae	5	36	0-225	6.3
G. cygni	1	<1	0-2	0.1
F. fasciolaris	3	12	0-40	2.1
Total Cestodes	7	279	10-1,335	

TABLE XXIX

TREMATODES FROM 7 JUVENILE FEMALE MALLARDS

Species	No. Infected	Av./Bird	Range	% of Total Trematodes
E. revolutum	5	6	0-17	19.1
Echinoparyphium sp.	4	5	0-16	14.4
Z. lunatum	3	2	0-8	6.1
H. conoideum	1	1	0-10	4.4
C. flabelliformis	2	9	0-65	28.7
N. attenuatus	5	8	0-43	25.2
Total trematodes	6	33	0-77	

TABLE XXX

NEMATODES FROM 7 JUVENILE FEMALE MALLARDS

Species	No. Infected	Av./Bird	Range	% of Total Nematodes
E. uncinata	4	16	0-86	58.5
Capillaria sp.	3	1	0-4	4.1
C. contorta	1	<1	0-2	1.0
A. anseris	7	5	1-10	18.5
E. uncinatum	5	4	0-10	13.9
T. crami	3	1	0-5	4.1
Total Nematodes	7	28	3-92	

TABLE XXXI

CESTODES FROM 7 JUVENILE MALE PINTAILS

Species	No. Infected	Av./Bird	Range	% of Total Cestodes
Hymenolepis spp.	7	801(253*)	1-4,090(1-841)	92.0(78.3)
H. megalops	5	3(3)	0-7	0.3(0.8)
D. nyrocae	6	66(66)	0-189	7.6(20.5)
G. cygni	2	<1(<1)	0-2	0.1(0.05)
F. fasciolaris	3	1	0-5	0.1
Total Cestodes	7	870(322)	24-4,159(24-843)	

TABLE XXXII

TREMATODES FROM 7 JUVENILE MALE PINTAILS

Species	No. Infected	Av./Bird	Range	% of Total Trematodes
Echinoparyphium sp.	4	24	0-145	54.8
Z. lunatum	1	<1	0-1	0.3
H. conoideum	2	1	0-3	1.3
C. flabelliformis	3	1	0-7	2.9
N. attenuatus	7	18	5-45	40.7
Total Trematodes	7	454	5-167	

TABLE XXXIII

NEMATODES FROM 7 JUVENILE MALE PINTAILS

Species	No. Infected	Av./Bird	Range	% of Total Nematodes
Capillaria sp.	3	2	0-7	50.0
A. anseris	2	1	0-4	19.2
T. crami	4	1	0-5	30.8
Total Nematodes	5	4	0-9	

from five of the ducks. These worms represented 0.4% of all helminths recovered.

All juvenile male pintails harboured acanthocephalans. The average per bird was 46 with a range of 3-114. These parasites accounted for 4.7% of the total number recovered.

Juvenile Female Pintails: The 13 ducks from this group contained an average of 454 helminths per bird with a range of 119-1,172.

These ducks had the usual fauna of cestodes in the digestive tract (Table XXXIV). These helminths represented 90.1% of the 5,902 helminths collected from this group.

Eleven ducks contained trematodes belonging to six species (Table XXXV). This class of helminths accounted for 5.9% of the total recovered from this group.

Nematodes were recovered from 12 of the 13 individuals (Table XXXVI). They comprised 2% of all the helminths collected.

Four (30.8%) of the birds carried acanthocephalans with an average of one per bird and a maximum of five. These worms represented 0.3% of all the worms recovered from juvenile female pintails.

Adult Male Mallards: Five genera of cestodes were found in 67 (98.5%) of the birds (Table XXXVII). A single specimen of *Ligula intestinalis* (linnaeus, 1758) was found in the small intestine. This was the sole specimen of this

TABLE XXXIV

CESTODES FROM 13 JUVENILE FEMALE PINTAILS

Species	No. Infected	Av./Bird	Range	% of Total Cestodes
Hymenolepis spp.	13	343	69-1,026	83.7
H. megalops	7	3	0-13	0.7
D. nyrocae	12	49	0-119	11.9
G. cygni	5	1	0-3	0.2
F. fasciolaris	6	22	0-249	5.5
Total Cestodes	13	409	117-1,078	

TABLE XXXV

TREMATODES FROM 13 JUVENILE FEMALE PINTAILS

Species	No. Infected	Av./Bird	Range	% of Total Trematodes
E. revolutum	2	1	0-4	2.0
Echinoparyphium sp.	7	8	0-74	28.0
Z. lunatum	1	<1	0-2	0.6
H. conoideum	3	2	0-23	8.3
C. flabelliformis	4	5	0-62	19.7
N. attenuatus	8	11	0-85	41.4
Total Trematodes	11	27	0-87	

TABLE XXXVI

NEMATODES FROM 13 JUVENILE FEMALE PINTAILS

Species	No. Infected	Av./Bird	Range	% of Total Nematodes
E. uncinata	2	1	0-5	7.6
Capillaria sp.	10	2	0-5	17.0
A. anseris	5	1	0-10	15.3
T. crami	9	6	0-45	60.2
Total Nematodes	12	9	0-47	

genus found in the present survey. Cestodes represented 86.5% of the total helminthfauna recovered from these ducks.

Six trematode species were found in 52(76.5%) of the male mallards (Table XXXVIII), comprising 7.3% of the total number of helminths collected.

Seven species of nematodes were present in 62(91.2%) of the ducks (Table XXXIX). They represented 3.8% of the parasites recovered.

Acanthocephalans were found in 27(39.7%) of the 68 birds. The average per bird was four with a range of 0-57. This class of helminths comprised 2.4% of all worms collected.

Adult Female Mallards: In all, 5,559 worms were recovered from 19 adult female mallards. The average per bird was 293 with a range of 7-851.

The usual fauna of cestodes was found (Table XL). They represented 82.8% of all helminths recovered.

Six species of trematodes were encountered in 18(94.7%) of the birds (Table XLI). This class comprised 10.7% of the total number of helminths collected.

Seven nematode species were recovered from 100% of the adult female mallards (Table XLII). This class represented 2.8% of all parasites recovered.

Acanthocephalans were found in seven (36.8%) birds, with an average of 11 per bird and a maximum of 120. These worms represented 3.7% of all those collected from this group of ducks.

TABLE XXXVII

CESTODES FROM 68 ADULT MALE MALLARDS

Species	No. Infected (%)	Av./Bird	Range	% of Total Cestodes
Hymenolepis spp.	60(88.2)	97	0-2,024	70.8
H. megalops	34(50.0)	2	0-14	1.4
D. nyrocae	44(64.7)	36	0-325	25.8
G. cygni	39(57.4)	2	0-21	1.5
F. fasciolaris	29(42.7)	3	0-27	2.5
L. intestinalis	1(1.5)	<1	0-1	0.01
Total Cestodes	67(98.5)	140	0-2,123	

TABLE XXXVIII

TREMATODES FROM 68 ADULT MALE MALLARDS

Species	No. Infected(%)	Av./Bird	Range	% of Total Trematodes
E. revolutum	16(23.5)	1	0-20	7.1
Echinoparyphium sp.	26(38.2)	5	0-56	46.1
Z. lunatum	25(36.8)	1	0-11	6.4
H. conoideum	9(13.2)	1	0-34	7.1
C. flabelliformis	9(13.2)	2	0-40	14.9
N. attenuatus	12(17.7)	2	0-67	18.4
Total Trematodes	52(76.5)	12	0-78	

TABLE XXXIX

NEMATODES FROM 68 ADULT MALLARDS

Species	No. Infected (%)	Av./Bird	Range	% of Total Nematodes
E. uncinata	2(2.9)	<1	0-2	0.7
Capillaria sp.	15(22.1)	1	0-16	9.4
C. contorta	13(19.1)	1	0-12	12.3
A. anseris	48(70.6)	2	0-11	35.4
E. uncinatum	24(35.3)	1	0-6	10.1
S. crassicauda	6(8.8)	<1	0-2	1.7
T. crami	29(42.7)	2	0-22	30.4
Total Nematodes	62(91.2)	6	0-31	

TABLE XL

CESTODES FROM 19 ADULT FEMALE MALLARDS

Species	No. Infected (%)	Av./Bird	Range	% of Total Cestodes
Hymenolepis spp.	17(89.5)	144	0-643	59.5
H. megalops	7(36.8)	2	0-23	0.9
D. nyrocae	11(57.9)	89	0-500	36.5
G. cygni	8(42.1)	2	0-13	0.7
F. fasciolaris	9(47.4)	6	0-62	2.4
Total Cestodes	19(100)	242	4-737	

TABLE XLI

TREMATODES FROM 19 ADULT FEMALE MALLARDS

Species	No. Infected (%)	Av./Bird	Range	% of Total Trematodes
E. revolutum	4(21.1)	1	0-8	2.9
Echinoparyphium sp.	12(63.2)	16	0-87	51.8
Z. lunatum	10(52.6)	1	0-4	2.7
H. conoideum	4(21.1)	4	0-63	11.5
C. flabelliformis	4(21.1)	3	0-31	11.0
N. attenuatus	5(26.3)	6	0-96	20.4
Total Trematodes	18(94.7)	31	0-121	

TABLE XLII

NEMATODES FROM 19 ADULT FEMALE MALLARDS

Species	No. Infected (%)	Av./Bird	Range	% of Total Nematodes
E. uncinata	1(5.3)	<1	0-3	1.9
Capillaria sp.	5(26.3)	1	0-11	12.0
C. contorta	2(10.5)	<1	0-3	3.8
A. anseris	17(89.5)	3	0-8	33.5
E. uncinatum	7(36.8)	1	0-8	14.6
S. crassicauda	3(15.8)	<1	0-3	3.2
T. crami	12(63.2)	3	0-19	31.0
Total Nematodes	19(100)	8	1-32	

Adult Male Pintails: A total of 2,311 helminths were recovered from the 56 adult male pintails. The average was 42 per bird with a range of 1-188.

The usual fauna of cestodes was found in 54(96.4%) of the birds (Table XLIII). These worms represented 65.9% of all the parasites recovered.

Seven trematode species were recovered from 41(73.2%) of the birds (Table XLIV). A single specimen belonging to the family Psilostomidae was found in the small intestine of one bird. Trematodes represented 16.6% of the total helminthfauna collected.

Six species of nematodes were encountered in 41(73.2%) of the birds (Table XLV). They represented 8.9% of the total number of parasites collected.

Acanthocephalans were found in 25(44.6%) of the adult male pintails with an average of four per bird and a maximum of 47. These worms comprised 8.6% of all helminths collected.

Adult Female Pintails: A total of 4,115 helminths were recovered from this group of hosts. The average per individual was 172 with a range of 6-1,264.

Cestodes comprised 76.5% of the total helminthfauna collected. The usual cestode fauna was encountered in 23(95.8%) of the hosts (Table XLVI).

Five trematode species were recovered from 21(87.5%) of these ducks (Table XLVII) and represented 17.1% of the total number of helminths recovered.

TABLE XLIII

CESTODES FROM 56 ADULT MALE PINTAILS

Species	No. Infected (%)	Av./Bird	Range	% of Total Cestodes
Hymenolepis spp.	47(83.9)	21	0-146	77.8
H. megalops	31(55.4)	1	0-6	4.9
D. nyrocae	5(8.9)	2	0-40	6.2
G. cygni	33(58.9)	1	0-6	4.4
F. fasciolaris	18(32.1)	2	0-49	6.6
Total Cestodes	54(96.4)	27	0-178	

TABLE XLIV

TREMATODES FROM 56 ADULT MALE PINTAILS

Species	No. Infected (%)	Av./Bird	Range	% of Total Trematodes
E. revolutum	11(19.6)	1	0-55	20.6
Echinoparyphium sp.	6(10.7)	<1	0-9	4.7
Z. lunatum	15(26.8)	<1	0-4	5.0
H. conoideum	3(5.4)	<1	0-2	1.0
C. flabelliformis	9(16.1)	1	0-32	19.8
N. attenuatus	16(28.6)	3	0-63	48.0
Lyperorchis sp.	1(1.8)	<1	0-1	0.3
Total Trematodes	40(71.4)	7	0-68	

TABLE XLV

NEMATODES FROM 56 ADULT MALE PINTAILS

Species	No. Infected (%)	Av./Bird	Range	% of Total Nematodes
E. uncinata	1(1.8)	1	0-1	0.5
Capillaria sp.	6(10.7)	<1	0-3	3.9
C. contorta	9(16.1)	<1	0-4	7.8
A. anseris	15(26.8)	1	0-9	17.5
E. uncinatum	14)25.0)	<1	0-4	10.2
T. crami	30(53.6)	2	0-14	60.2
Total Nematodes	42(75.0)	4	0-16	

TABLE XLVI

CESTODES FROM 24 ADULT FEMALE PINTAILS

Species	No. Infected (%)	Av./Bird	Range	% of Total Cestodes
Hymenolepis spp.	19 (79.2)	120	0-902	91.7
H. megalops	14 (58.3)	2	0-7	1.1
D. nyrocae	5 (20.9)	7	0-150	5.2
G. cygni	13 (54.2)	1	0-6	1.0
F. fasciolaris	9 (37.5)	1	0-16	0.9
Total Cestodes	23 (95.8)	131	1-904	

TABLE XLVII

TREMATODES FROM 24 ADULT FEMALE PINTAILS

Species	No. Infected (%)	Av./Bird	Range	% of Total Trematodes
E. revolutum	8 (33.3)	1	0-6	3.4
Echinoparyphium sp.	6 (25.0)	2	0-21	7.3
Z. lunatum	6 (25.0)	<1	0-3	1.1
H. conoideum	4 (16.7)	<1	0-6	1.3
N. attenuatus	12 (50.0)	26	0-310	86.9
Total Trematodes	21 (87.5)	29	0-334	

TABLE XLVIII

NEMATODES FROM 24 ADULT FEMALE PINTAILS

Species	No. Infected (%)	Av./Bird	Range	% of Total Nematodes
Capillaria sp.	4 (16.7)	<1	0-1	3.7
C. contorta	6 (25.0)	1	0-5	15.9
A. anseris	5 (20.8)	<1	0-1	4.7
E. uncinatum	2 (8.3)	<1	0-2	2.8
S. crassicauda	1 (4.2)	<1	0-1	0.9
T. crami	17 (70.8)	3	0-26	72.0
Total Nematodes	22 (91.7)	5	0-26	

Six species of nematodes were encountered in 22(91.7%) of the birds (Table XLVIII). This helminth class comprised 2.6% of the total number of helminths collected.

Eleven (45.8%) birds carried acanthocephalans with an average of seven per bird and a maximum of 94. These worms represented 3.8% of the total number obtained from adult female pintails.

Seasonal Variation of Helminth Numbers

Tables XLIX, L and LI show the seasonal variation (1967-68) of occurrence of each helminth class in the various groups of ducks. In the tabulation of this data, the helminth burdens of males and females have been combined.

Spring-Autumn Variability of Numbers and Species of Helminths

In order to determine what helminths the birds were bringing in and taking out of the marsh in the spring and fall, Tables LII, LIII and LIV were compiled to show what worms were found during the first five collecting weeks of 1968 and the last four of 1967 in the two host species.

Echinuriasis in Juvenile Birds

Table LV gives the data on the presence of *Echinuria uncinata* and scars indicating that the birds had been infected with these worms.

Sarcosporidiosis

Sarcosporidiosis was often found in the breast, neck,

TABLE XLIX

SEASONAL VARIATION OF HELMINTH NUMBERS IN
IN JUVENILE MALLARDS AND PINTAILS
(1967)
(av./Bird)

Month	Mallard (M&F) August	Mallard (M&F) September	Pintail (M&F) July	Pintail (M&F) August	Pintail (M&F) September
No. examined	5	9	3	11	7
Cestoda	300	574	214	863	182
Trematoda	57	20	16	39	27
Nematoda	49	20	5	8	6
Acanthocephala	2	3	0	8	35
Total	408	657	236	918	250

M-male, F-female.

TABLE L

SEASONAL VARIATION OF HELMINTH NUMBERS
IN ADULT MALLARDS
(1967-68)
(av./Bird)

Month	April 1968	May 1968	June 67-68	July 1967	August 1967	September 1967
No. examined	8	19	22	19	14	5
Cestoda	23	118	191	176	314	158
Trematoda	5	11	22	20	18	7
Nematoda	6	11	7	5	5	2
Acanthocephala	0	3	3	14	5	7
Total	34	143	222	214	340	175

TABLE LI

SEASONAL VARIATION OF HELMINTH NUMBERS
IN ADULT PINTAILS
(1967-68)
(av./Bird)

Month	April 1968	May 1968	June 67-68	July 1967	August 1967	September 1967
No. examined	9	20	22	13	14	1
Cestoda	6	25	33	152	64	3
Trematoda	<1	5	6	45	15	1
Nematoda	1	6	5	4	2	6
Acanthocephala	<1	3	<1	4	10	94
Total	8	38	44	204	91	104

TABLE LII

HELMINTHS FROM ADULT MALE MALLARDS AND PINTAILS IN FIRST MONTH OF COLLECTION (1968)

Host	Ap.22-26 M	Ap.22-26 P	Ap.29-May3 M	Ap.29-May3 P	May6-10 M	May6-10 P	May13-17 M	May13-17 P	May20-24 M	May20-24 P
No. Examined	4	2	3	3	4	3	5	4	3	4
Helminths Recovered	No.		No.		No.		No.		No.	
Hymenolepis spp.	7	2	31	-	95	28	32	22	179	32
H. megalops	2	3	6	2	7	-	-	7	6	-
D. nyrocae	21	-	76	-	126	-	102	-	185	-
G. cygni	8	1	9	3	3	3	9	9	6	4
F. fasciolaris	9	-	20	-	46	6	36	-	1	3
E. revolutum	3	-	-	-	-	2	9	-	1	55
Echinoparyphium sp.	28	-	1	-	8	-	9	7	1	-
Z. lunatum	-	-	2	2	3	1	1	1	3	-
H. conoideum	-	-	4	-	8	-	-	-	-	-
C. flabelliformis	-	-	-	-	66	-	-	-	-	-
N. attenuatus	-	-	-	-	-	-	12	1	-	8
Capillaria sp.	2	-	1	-	-	1	-	-	-	-
A. anseris	5	-	1	1	5	2	26	1	16	7
E. uncinatum	1	-	-	1	2	1	6	3	8	1
T. crami	3	3	25	-	15	8	6	11	10	18
C. contorta	-	-	14	-	14	1	8	5	6	3
S. crassicauda	-	-	-	-	2	-	-	-	-	-
Acanthocephala	-	-	3	8	12	2	4	15	-	8

Ap. - April
M - mallard
P - pintail

TABLE LIII

HELMINTHS FROM ADULT MALE MALLARDS AND PINTAILS IN LAST MONTH OF COLLECTION (1967)

Host	August 21-25		August 28 - September 1		September 11-15	
	M	P	M	P	M	P
No. Examined	2	0	4	3	3	0
Helminths Recovered	No.		No.		No.	
Hymenolepis spp.	518	-	75	271	5	-
H. megalops	23	-	18	0	9	-
D. nyrocae	106	-	13	7	31	-
G. cygni	9	-	4	9	3	-
F. fasciolaris	-	-	15	-	-	-
Z. lunatum	1	-	5	1	5	-
N. attenuatus	1	-	3	-	-	-
E. revolutum	-	-	3	-	1	-
Echinoparyphium sp.	-	-	47	10	-	-
C. flabelliformis	-	-	3	-	-	-
H. conoideum	-	-	-	-	3	-
T. crami	4	-	1	2	1	-
Capillaria sp.	-	-	2	3	2	-
A. anseris	-	-	5	-	4	-
S. crassicauda	-	-	-	-	1	-
Acanthocephala	1	-	4	20	5	-

M - mallard
P - pintail

TABLE LIV

HELMINTHS FROM JUVENILE MALLARDS AND PINTAILS IN SEPTEMBER, 1967

Host	Sept. 4-8 M	Sept. 4-8 P	Sept. 11-15 M	Sept. 11-15 P	Sept. 18-22 M	Sept. 18-22 P	Sept. 25-29. M	Sept. 25-29. P
No. Examined	2	3	4	1	2	1	1	2
Helminths Recovered	No.		No.		No.		No.	
Hymenolepis spp.	1,876	759	727	52	686	69	1,311	7
H. megalops	4	9	24	7	3	–	–	5
D. nyrocae	69	70	304	36	–	49	10	212
F. fasciolaris	44	–	109	–	–	–	–	–
G. cygni	–	1	1	–	–	–	–	–
E. revolutum	12	–	2	–	10	–	4	–
Echinoparyphium sp.	87	77	1	–	6	–	6	–
Z. lunatum	2	2	7	–	9	–	4	–
C. flabelliformis	2	64	2	–	–	–	–	–
N. attenuatus	2	1	–	30	4	–	3	10
H. conoideum	–	–	–	–	10	2	–	–
Capillaria sp.	10	7	11	–	4	–	4	5
A. anseris	45	5	21	–	11	10	8	4
E. uncinatum	20	–	17	–	14	–	10	–
T. crami	16	5	10	–	–	–	5	–
E. uncinata	–	5	212	–	137	–	–	–
Acanthocephala	5	–	11	15	4	3	3	227

M – mallard
P – pintail

head and leg muscles of adult birds (Fig. 5). It is possible that some juvenile birds were infected, but the cysts were small and therefore overlooked. Table LVI shows the occurrence of Sarcocystis sp. together with the average K.S. ratios and weights of the hosts.

TABLE LV

ECHINURIASIS IN JUVENILE MALLARDS AND PINTAILS

Host	Mallard	Pintail
No. Examined	14	20
No. Infected	8	3
No. with Scars	0	7
No. Echinuria Recovered	572	11
Average/Bird	41	1

TABLE LVI

EXTENSITY OF SARCOSPORIDIOSIS

Age Sex Species	No. Examined	No. Infected (%)	Average No. Parasites	Average K.S. Ratio	Average Weight (gms)
A M Mallards	68	8 (11.8)	139±37*	0.88±0.04*	1211±17
A F Mallards	19	1 (5.3)	7	1.00	1231
A M&F Mallards	87	9 (10.3)	124±36	0.90±0.04	1213±15
A M Pintails	56	12 (21.4)	42±14	0.89±0.05	972±19
A F Pintails	24	2 (8.3)	51±44	0.84±0.16	798±91
A M&F Pintails	80	14 (17.5)	43±12	0.88±0.05	947±25

A - adult, M - male, F - female
*Standard error.

Lead Poisoning

Five typical cases of lead poisoning were encountered in juvenile male mallards (Fig. 6). The lead shot found was in various stages of erosion and a bright silver colour caused by the grinding action of the gizzard. Table LVII gives the pertinent data for each case. These birds were collected in September, 1967.

TABLE LVII

LEAD POISONING IN JUVENILE MALE MALLARDS

	Weight (gms)	K.S. Ratio	No. of Pellets	Cause of Death
1	1,013	0.74	33	shot
2	730	0.45	26	shot
3	868	0.77	42	shot
4	1,044	0.65	19	shot
5	-	0.35	50	lead poisoning

<u>Microfilariae</u>

Microfilariae (nematodes) were the only parasites found in the blood smears (Table LVIII).

TABLE LVIII

MICROFILARIAE IN MALLARDS AND PINTAILS

Host	Mallard	Pintail
No. Examined	80	88
No. Infected	11	3
Percent Infected	13.8	3.4

Fig. 5: Sarcosporidiosis in adult pintail (June, 1967).

Fig. 6: Lead shot in gizzard of juvenile male mallard(#3)
(September, 1967).

DISCUSSION

General

Wild ducks are infected by many types of helminths. The majority of these show little host specificity. Where specificity exists it is probably ecological and can be explained by the feeding habits of the hosts which exposes them to different intermediate hosts of parasites.

Incidence

Helminths Recovered

A minimum of one and a maximum of 4,223 parasites were found in the hosts necropsied during this study. The fauna which I found in the mallards was similar to that found by Warren (1956). The trematode and acanthocephalan faunae were identical but that of the cestodes differed slightly. I found *G. cygni* and *F. fasciolaris* but Warren did not. The nematode fauna differed in both studies. I found seven species (Table XXI) but Warren found only three (*Capillaria* sp., *E. uncinata* and *T. crami*). In my study, the hymenolepids were the commonest cestodes, *Echinoparyphium* sp. and *Notocotylus attenuatus* the commonest trematodes, and *Amidostomum anseris* the commonest nematode.

The helminthfauna of each individual host duck was usually composed of many species. In mallards and pintails the minimum number of helminth species was two and one respectively while in both hosts the maximum was 12.

Table LIX gives the percentage of the birds that were infected with the various parasite classes. These percentages are higher than those reported for North America, the U.S.S.R. and eastern Europe.

TABLE LIX

PERCENT OF BIRDS INFECTED WITH HELMINTHS OF DIFFERENT CLASSES

	No. examined	Cestoda	Trematoda	Nematoda	Acanthocephala
AMMa	68	98.5	76.5	91.2	39.7
AFMa	19	100	94.7	100	36.8
JMMa	7	100	85.7	100	85.7
JFMa	7	100	85.7	100	28.6
AMP	56	96.4	57.1	75	44.6
AFP	24	100	87.5	91.7	45.8
JMP	7	100	100	71.4	100
JFP	13	100	84.6	92.3	30.8

A - adult, J - juvenile
F - female M - male
Ma - mallard, P - pintail

Two unusual findings of helminths were made: a specimen of L. intestinalis in the small intestine of an adult male mallard in June, 1968. Dr. M. McDonald from the Bear River Research Station, Bear River, Utah, stated that this parasite was never reported before from dabbling ducks in North America; and, a single specimen of psilostomid fluke was found in the rectum of an adult male pintail in June, 1967. This specimen was tentatively identified as Lyperorchis sp.. Yamaguti (1958) reported that Lyperorchis lyperorchis was described by Travassos, 1921, from the rectum and cloaca of the limpkin, Aramus escolipoceus in Brazil. This bird is a wader occurring in South and Central America. Pintails are known to migrate to Brazil so it is not surprising to find that they harbour some species of helminths from this area.

Seasonal Variation

The seasonal variation of waterfowl helminths numbers is well studied. My observations (Tables L and LI) basically agree with the literature.

In adult birds, cestodes reached maximum numbers in mallards during August and in pintails during July. Trematodes occurred in nearly equal numbers in mallards during, June, July and August while the peak in pintails occurred during July. Nematodes reached maximum numbers in both duck hosts during May and acanthocephalans during July in mallards and August in pintails. A single pintail collected in September contained 94 spiny headed worms but was not considered to be the peak. Generally speaking, the cestodes, trematodes and acanthocephalans reached maximum numbers in the warm summer months while nematodes peaked in May. If individual helminth species were examined seasonal variations would also be evident.

Table XLIX shows that the numbers of trematodes and nematodes decreased in juvenile mallards in September, those of the acanthocephalans remained almost unchanged while those of the cestodes increased. If the two juvenile mallards which harboured over 1,300 worms each in September are omitted, the average for September is close to that for August. The juvenile pintails showed almost a four fold decrease in parasite numbers in September from that in August. This decrease was evident in all classes except the Acanthocephala.

This general reduction in parasite numbers in September may be attributable to the change in the diet of the hosts. At this time of year, both species of ducks regularly feed in stubble fields and do not eat large amounts of aquatic plant and animal matter.

Spring-Autumn Variability

Tables LII, LIII and LIV were constructed in order to determine which helminths the ducks bring to the breeding grounds in the spring and carry away in the autumn and differences that exist between the two hosts.

In 1967 the last adult male pintails were collected in the week of August 28 - September 1. These birds harboured nine helminth species while the adult male mallards had 14. The last mallards collected in September were host to 12 helminth species (Table LIII). Eight and fourteen species respectively were found in juvenile pintails and mallards during the last two collecting weeks of 1967.

In the first two collecting weeks of 1968, the pintails harboured three cestode species, one trematode, three nematode and two acanthocephalan. Four more helminth species were found in the second week than in the first (Table LII). Over this period mallards had five cestode species, five trematode, four nematode and two acanthocephalan. Of the 16 parasite species recovered from mallards, 12 were found during the first week and four more in the second (Table LII). As the season progresses the pintails acquire the helminths that the mallards had initially.

Summarizing, the pintails brought nine helminth species into the Delta marsh in 1968 and the mallards 16. In the previous fall (1967), the pintails left the breeding area with nine species and the mallards 15. With few exceptions, both species return to the marsh with the same parasites with which they left in the autumn.

As will be discussed in the next section, the greater species variety and greater number of helminths in the mallard than pintail is probably attributable to a greater susceptibility.

Comparison of Helminthfauna Between Mallards and Pintails

One would expect that *A. platyrhynchos platyrhynchos* and *A. acuta*, so closely related phylogenetically and ecologically, would have similar helminthfaunae. The species of helminths are similar in both hosts but the numbers are greater in the mallard (Table XXI).

It should be noted that the food analysis done by Mr. N. Seymour showed that both host species (juvenile and adult) were consuming similar types of invertebrates. The percentage of the total bulk that is comprised of invertebrates was almost the same for both species. The only noticeable differences were the occurrence of chironomids and *Limnophilus* sp. which were found almost twice as often in pintails as mallards.

To determine if a significant difference existed between species, sex and age, a 3-way analysis of variance was used. The average number of helminths per bird, variance and standard errors were computed for each of the eight groups of birds. It was found that the variances were proportional to the square of the mean. Log transformations were then done to stabilize these variances. This test on the transformed data showed that no significant difference existed between the three categories. This non-significance is probably the result of grouping and not the situation as it exists in nature. It was decided to use Student's t-test on these species, sex and age data. Initially, it was determined that the sample variances were not equal so the appropriate t-test formula was used (reject hypothesis if

$$t' > \frac{\left(\frac{S_1^2}{n_1}\right)t_1 + \left(\frac{S_2^2}{n_2}\right)t_2}{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}};\ t' = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}})$$

At the 5% level of significance, a difference in parasite burdens was observed between juvenile mallards and pintails, between adult males of both species and between adult females of both species. In all cases, the mallards had significantly more worms than the pintails.

The difference between species must be large before a significant difference will be found using the 3-way analysis of variance test. This is necessary because the degrees of freedom are greatly reduced. The greater the error degrees of freedom, the greater is the precision. The probability of rejecting the null hypothesis increases with a high number of error degrees of freedom.

An examination of the mean parasite burdens of adult birds reveals not only a species difference but also a sex difference. In both host species, females harboured approximately 140 more helminths per bird than males. This sex difference probably depends on feeding habits. Both sexes have the same feeding habits for the first 10 to 14 days after arrival on the breeding grounds, but as soon as the hen starts to incubate, the male leaves her and the feeding habits of both change. Hochbaum (pers. comm.) stated that females require a diet rich in protein during the nesting and rearing periods and therefore consume larger numbers of invertebrates, some of which are intermediate hosts for parasites. The end result is that females have more parasites than males.

When the mean parasite burdens of juvenile birds are examined, there is practically no sex difference in pintails if the bird with over 4,000 helminths is omitted. The juvenile female mallards harboured approximately 150 more worms than in males. Thus juvenile mallards have more helminths than pintails and in one case (juvenile mallards) there is a sex difference. If a larger sample of each sex of juvenile mallards and pintails had been examined, the mean helminth burdens would be nearly of the same relative magnitude, and no sex difference would be found within a species.

The differences and similarities of the helminthfauna of the two species are summarized by saying that a difference between birds of the same sex of these two species exists and the mallards harbour more worms. In adult birds, the difference of the mean parasite burdens may indicate a sex difference, females having more helminths. The juvenile birds show a species difference but no sex difference.

It is not surprising to find that juvenile birds have more parasites than adults, nor that there is a sex difference. However, the interesting question is why two birds so closely related and from the same area differ so much in their parasite burdens. This difference is pronounced when one examines the mean number of parasites from males of both species. The mean burden of the 68 male mallards was 162 ± 39 while that of the 56 male pintails was 41 ± 6. As both species consumed approximately equal quantities of the same invertebrate species, this difference cannot be attributed to feeding habits. It is possible that mallards are more susceptible to parasitism than pintails. McDonald (pers. comm.) believes that the mallard is much more susceptible to parasitism than the pintail. I think that this statement is supported when one considers the infections with Echinuria in juvenile birds ranging in age from six to 13 weeks. Three cases exist concerning echinuriasis: (1) Echinuria are present in cysts; (ii) scars are present indicating that the birds had been infected; and (iii) no worms or scars are present. Of the eighteen juvenile mallards examined, *Echinuria* was found in eight, and 10 were free of scars and worms. In the 22 pintails examined, two had worms, nine had scars and 11 were free of both scars and worms. The average number of *Echinuria* per mallard was 32 and per pintail approximately one. One would suspect that as birds get older they would lose the infection. The six youngest pintails collected in July and August had less than one worm per bird but had scars indicative of previous infection. The average number of *Echinuria* in the five youngest mallards was 38.

The fact that mallards both leave the marsh and return to the marsh with greater numbers and species of helminths than pintails also supports this argument of greater susceptibility of the former species.

The Helminthfauna of Dabbling Ducks Compared to that of Diving Ducks in Manitoba.

A common diving duck in Manitoba is the canvasback (*Aythya valisineria*). Cornwell (1966) studied their parasites and it is of interest to compare his data with my data on mallards and pintails. The canvasbacks were collected from four different environments (marsh, potholes, moulting lakes and the Detroit River). Cornwell's Detroit River data will not be used in this comparison. My birds were collected only in the marshes which include the moulting areas for both mallards and pintails.

Canvasbacks had almost the same intestinal helminths in the digestive tract as mallards and pintails, but in addition to that small numbers of Tetrameres spinosus, (Maplestone, 1931) Amidostomum skrjabini Boulenger, 1926, Ribeiroia sp. and Sphaeridiotrema globulus (Rud., 1814) Odhner, 1913. Table LX shows the percentage that each helminth class comprised of the total number of helminths collected. Generally, the percentages are the same except that canvasbacks carry more trematodes and fewer acanthocephalans.

TABLE LX

PERCENTAGE OF EACH HELMINTH CLASS
OF TOTAL NUMBER OF HELMINTHS COLLECTED

	Canvasback	Mallard	Pintail
No. Examined	121*	101	99
No. of Helminths Recovered	250,817	24,565	14,865
Cestoda	78.6	84.3	80.4
Trematoda	18.3	7.6	11.8
Nematoda	3.0	2.0	4.7
Acanthocephala	0.1	6.1	3.1

* 85 ducklings, 36 adults

Adult canvasbacks from the marshes had a mean helminth burden of 1,322 ± 1,017, whereas mallards and pintails had 191 ± 34 and 80 ± 20 respectively. Thus, canvasbacks from marshes have larger helminth burdens than mallards and pintails.

Cornwell found that female canvasbacks carry greater helminth burdens than males. My data show that adult females carry more parasites than males, but in juveniles there is no sex difference.

Both my study and Cornwell's show that the parasite numbers are greater in juveniles than in adults. Adult canvasbacks from marshes had a mean burden of 1,322 ± 1,017 per bird while those from potholes had 715 ± 243 per bird. Marsh juveniles contained 3,129 ± 619 helminths per bird while those from potholes had 2,265 ± 657. In my study, the average burden of adult mallards and pintails was 191 ± 34 and 80 ± 20 respectively. Juvenile mallards contained 570 ± 107 helminths per bird and pintails 444 ± 70.

Both studies showed that cestodes live primarily in the duodenum, small intestine, caeca, rectum and cloaca; trematodes in the duodenum, small intestine, caeca and rectum; nematodes in the oesophagus, proventriculus, ventriculus and caeca; and acanthocephalans in the lower small intestine and rectum. Some helminths were found only in specific areas, eg. H. megalops in the cloaca, G. cygni under the koilin lining of the ventriculus, N. attenuatus and Z. lunatum in the caeca, C. contorta in the walls of oesophagus and crop, E. uncinata in cysts in the proventriculus, A. anseris and E. uncinatum under the koilin lining of the ventriculus.

It is well documented in the literature that waterfowl parasites undergo seasonal fluctuations. Cornwell found a decline in the number of helminths in the autumn and this was also observed in my study. This decline is attributed to a change in feeding habits. Mallards and pintails become gregarious in the late summer and autumn and feed on stubble fields surrounding the marsh whereas earlier they fed more on aquatic plants and animals. It would not be surprising to find that the parasite numbers in juveniles and adults of each of the three species are the same at migration time in late September and October. Bykhovskaya - Pavlovskaya (1962) noted this to be the situation concerning flukes from waterfowl in Poland.

From this comparison between mallards, pintails and canvasbacks it can be seen that:

(i) in Manitoba, these three species of ducks harbour nearly the same species of intestinal helminths.

(ii) the total number of helminths from canvasbacks is greater than that from mallards and pintails in Manitoba.

(iii) a seasonal variation exists in all three species.

(iv) females of all species carry greater helminth numbers than males.

(v) juveniles of all species harbour more helminths than adults.

Pathology

One of the objectives of this study was to determine what effect the helminths were having on the physical condition of mallards and pintails in Manitoba.

To determine the effects of parasites on the duck host, it is essential to accurately measure the physical condition of the bird. Poor physical condition or sickness in waterfowl is reflected in deterioration of the pectoral muscles. Using Cornwell's method of measuring this physical condition (K.S. ratio) I made an attempt to determine if a correlation existed between the K.S. ratio and the helminths present.

Correlation tests on the two largest groups of birds i.e. male mallards and pintails, were performed using the chi-square test. These correlations were made between the K.S. ratio and total cestodes, total trematodes, total nematodes, total acanthocephalans and total helminths. The null hypothesis of no correlation can be accepted at the 5% level of significance. That is, the K.S. ratio is independent of the helminths present. It should be noted that a great deal of variation existed between individual birds. For example, one adult male mallard had a K.S. ratio of 0.88 and 1,450 parasites whereas another bird had a K.S. of 0.80 and 10 parasites. Only in a few cases did the K.S. ratio reflect the parasite load. One adult mallard had a K.S. of 0.62 and 2,188 worms. In this case, a heavy helminth load was associated with a low K.S. ratio.

Town (1960) used a Spearman Rank Correlation Coefficient test to determine if a correlation existed between cestode numbers and the weights of the ducks. In his material a positive correlation existed i.e. the greater the weight, the greater the number of cestodes, but the r_s value was much too small to say that the correlation is conclusive. One would expect a negative correlation i.e. as the weights increase the cestode numbers decrease. This test was used in my study to determine if a correlation existed between host weight and total cestode and total helminth numbers for each collecting month. No correlation was found.

Cornwell (1966) stated that atrophy of the breast muscles appears early in the onset of most avian diseases. My data do not support this statement at least in respect of intestinal helminth infections. No atrophy was associated with helminthiasis except in a few cases. Lead poisoning, however, causes a definite atrophy (Table LVII). Sarcosporidiosis did not cause a reduction of the K.S. ratio. Thus, Cornwell's statement is hardly applicable to parasitic diseases in mallards and pintails. However, atrophy of the breast muscles develops slowly and does not appear in a few days.

No obvious abnormalities or variations of the plumage of the ducks was found. Moynihan and Stovell (1955) reported that ruffled feathers were a sign of infections with *Echinuria uncinata*. This was not observed in the present study.

Cornwell (1966) saw blood in various stages of decomposition in the intestinal and caecal lumens of diseased specimens. This was not observed in my study.

The two most common effects of parasites were tissue destruction and partial or complete blockage of the intestinal lumen. *E. uncinata* caused the formation of large cysts in the zone between the proventriculus and gizzard (Fig. 7). These

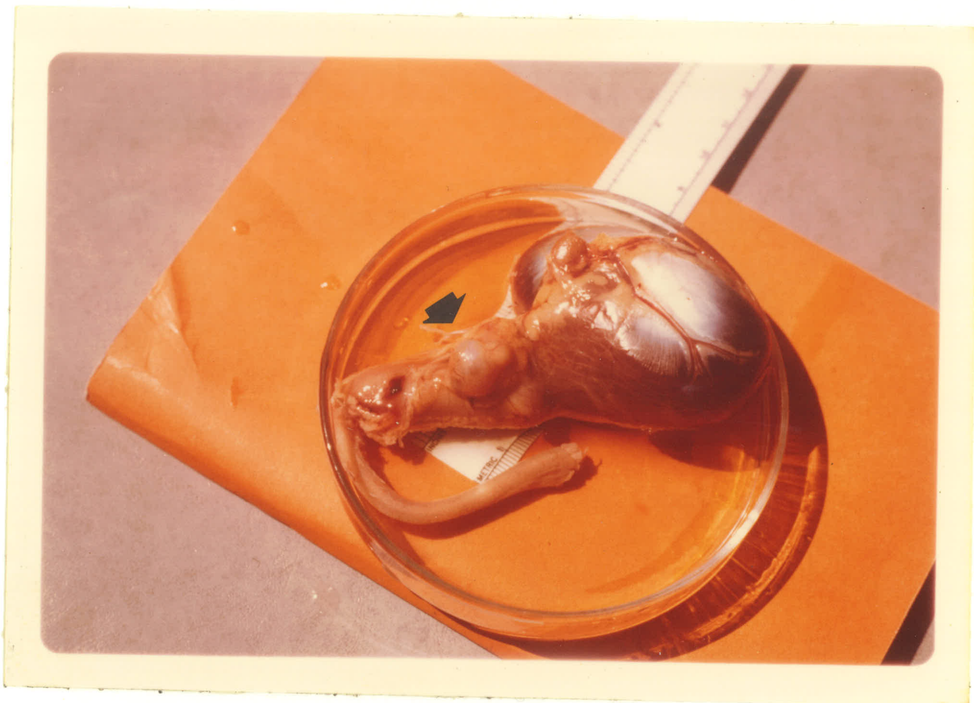


Fig. 7: *Echinuria uncinata* cysts at junction of proventriculus and ventriculus in juvenile mallard.

may cause some blockage of this passage and exert pressure on the surrounding organs. In some cases, the cysts had almost perforated the proventricular wall. _A_. _anseris_, _E_. _uncinatum_ and _G_. _cygni_ caused necrosis of the koilin lining of the gizzard and occasionally a severe inflammation of the gizzard wall. In some cases, the embedded probosci of acanthocephalans caused nodules to form on the external surface of the small intestine and in a few instances the probosci had completely perforated the intestinal wall and penetrated into the body cavity. Situations like this greatly enhance the danger of peritonitis. Fig. 8 shows acanthocephalans attached to the wall of the small intestine. Acanthocephalans may cause partial and complete blockage of the digestive tract at the junction of the caeca, rectum and small intestine (Fig. 9). Large numbers of cestodes also may cause blockage at places in the gut anatomically susceptible to it.

It is the opinion of this author that these parasitic diseases may have varied effects on the duck host at times of the year when the birds are subject to natural, annual or non-annual stresses. An example of a non-annual stress is the lack of water during the breeding season in dry years resulting in crowding on the available nesting and feeding areas and this causes stress to develop between the birds.

The possibility that the stress imposed on adult ducks during the moult might affect the K.S. ratio is reflected in the values of seven flightless adult male pintails. The

Fig. 8: Acanthocephalans attached to the wall of small intestine of juvenile pintail.

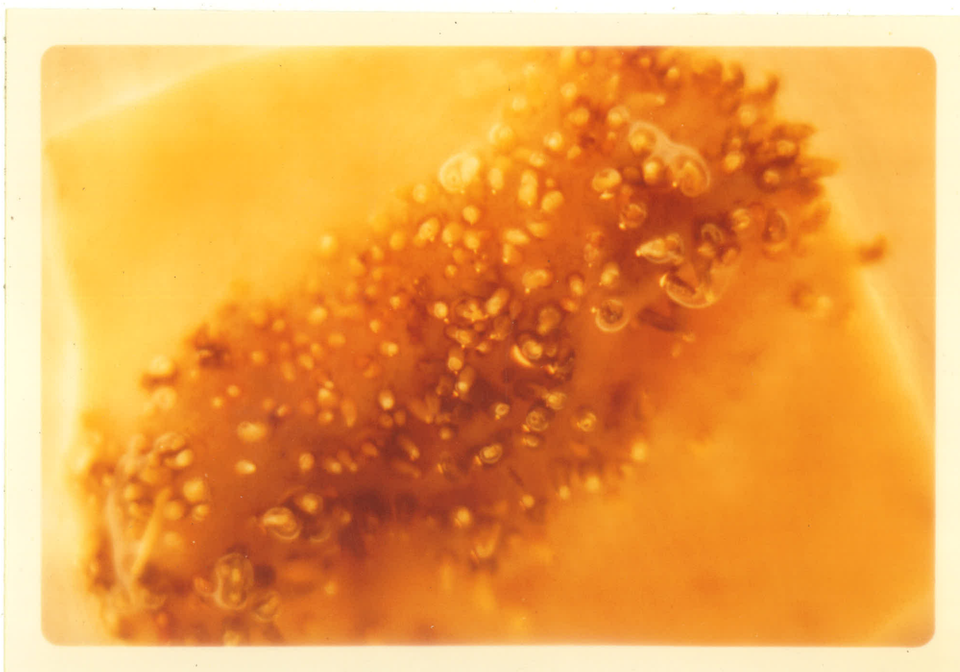


Fig. 9: Acanthocephalans attached to tissue at junction of small intestine, caeca and rectum of adult mallard.

average K.S. ratio was 0.68 ± 0.03 with a range of 0.59 to 0.80. The K.S. ratio and corresponding parasite burdens were variable as seen below:

0.62	30
0.59	87
0.80	56
0.68	13
0.71	30
0.64	8
0.75	157

One should remember, that sick birds do not necessarily have large numbers of parasites. Conversely, healthy birds often have large parasite loads.

Gower (1938) stated that only a few of the large variety of helminths in ducks are important pathogens. Others may become pathogenic under certain conditions and have to be regarded as potential pathogens. I think that my findings support this view of Gower and other authors. The helminths could have disastrous effects on waterfowl populations in Manitoba as well as other areas in times of adverse environmental stress.

<u>Echinuriasis</u>

In addition to the foregoing comments made throughout the discussion on this disease in mallards and pintails, a few other remarks are appropriate.

<u>Echinuria</u> was seen in only one adult bird that returned to the marsh in the spring of 1968. If yearling birds which were infected as ducklings return to their natal marsh still harbouring these helminths they act as a source of infection

to other birds.

Juveniles become infected at an early age. Scar tissue in the ecotone between the proventriculus and ventriculus indicate some of the birds which were infected as juveniles. Only in one duck was *E. uncinata* found in the glands of the proventriculus, the infection usually being at the junction between the proventriculus and ventriculus.

The ducks examined during this study were not collected in the close vicinity of the 'pond' at the Delta Waterfowl Research Station. However, during the summer of 1968 some juvenile mallards from the 'pond' were necropsied and each one harboured large numbers of *E. uncinata*. A maximum of 350 worms was recovered from one bird.

Yearling ducks infected with *Echinuria* and living in the 'pond' fly to and from the surrounding marsh and disseminate the infection in the area of the Waterfowl Station.

In years of adverse environmental conditions, echinuriasis may have a devastating effect on young ducklings in the marsh and the control of this disease at the Waterfowl Station may be of considerable practical importance.

Sarcosporidiosis

Sarcosporidiosis is caused by a protozoan of the genus *Sarcocystis*. Its life history and method of transmission are not yet fully understood.

In my study pintails were more frequently infected than mallards (Table LVI) and this disease was never observed in juveniles.

The most common sites of infection were the breast and leg muscles but it was also found in those of the neck and skull as well as in the subcutaneous fascia. The number of cysts ranged from light (six cysts in one bird) to extremely heavy (Fig. 5).

As stated previously, sarcosporidiosis did not affect the K.S. ratio. Some heavily infected individuals had high K.S. ratios and large fat deposits.

Lead Poisoning

This disease was observed in five juvenile male mallards (Table LVII). Eleven other birds of both species had lead shot in the digestive tract but no signs of lead poisoning and the shot was not worn.

The affected birds had typical signs of this disease: compacted proventriculus, ventricular lining hard, easily peeled, small lesions present and stained a deep green, brown stained areas beneath the lining, contents of ventriculus and fecal material in the lower rectum and cloaca stained a deep green. Cestodes and acanthocephalans in the lower digestive tract were also stained various shades of green.

Most of the shot was found in the gizzard (Fig. 6) and in various stages of attrition. Some pellets were flattened, others small, spherical and silvery.

Lead poisoning caused reduction of the K.S. ratio. It was assumed that the lower the K.S. ratio, the longer the bird had been suffering from this disease. The bird with the lowest K.S. ratio was the one found dead.

CONCLUSIONS

1. The species of helminths in mallards in Manitoba closely resembles that in pintails. The only parasite found exclusively in mallards was one specimen of *Ligula intestinalis* and in pintails one specimen of *Lyperorchis* sp.. The following helminths were found in both mallards and pintails: *Hymenolepis* spp., *Hymenolepis megalops*, *Diorchis nyrocae*, *Gastrotaenia cygni*, *Fimbriaria fasciolaris*, *Echinostoma revolutum*, *Echinoparyphium* sp., *Zygocotyle lunatum*, *Cotylurus flabelliformis*, *Notocotylus attenuatus*, *Hypoderaeum conoideum*, *Echinuria uncinata*, *Capillaria* sp., *Capillaria contorta*, *Amidostomum anseris*, *Epomidiostomum uncinatum*, *Streptocara crassicauda*, *Tetrameres crami*, *Polymorphus* sp. and *Corynosoma* sp..

A comparison of the number of helminths in similar groups (eg. adult male mallards and adult male pintails) showed that mallards harboured significantly more helminths than pintails and that in both hosts the percent infected with helminths is greater than that generally reported in the literature.

Adult females carried more helminths than males of the same species. There was no sex difference in juvenile birds.

Seasonal variation in helminth numbers was observed in both hosts with the largest burdens being reached in July and August and the smallest in the spring.

Mallards brought greater numbers and more species of helminths into the marsh in the spring and took out greater numbers and more species in autumn than pintails. As the season progressed, the pintails acquired the helminths which the mallards had initially in the spring only in smaller numbers.

2. The helminth burden does not affect the keel-sternum ratio nor the weight of the host. The commonest effects of the parasites were local inflammation, production of granulomata and blockage of the digestive tract.

3. The helminth species found in the dabbling ducks, mallards and pintails, in Manitoba are nearly identical with that of the canvasback, a diver. However, the divers carry larger parasite loads than the dabblers.

The adult females of all three species had more parasites than adult males. Juvenile birds carried greater parasite burdens than adults.

A seasonal variation of helminth numbers existed in all three species with the maximum burdens occurring in the warm summer months.

4. The helminthfauna variability is just as great within mallards and pintails as between the two species.

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APPENDICES

APPENDIX 1

Form Used in Recording Field Information and Helminths Recovered

PARASITES IN AVIAN SPECIES

Bird No.

Bird Type

Locality

Date

Physical Condition of Bird

Age

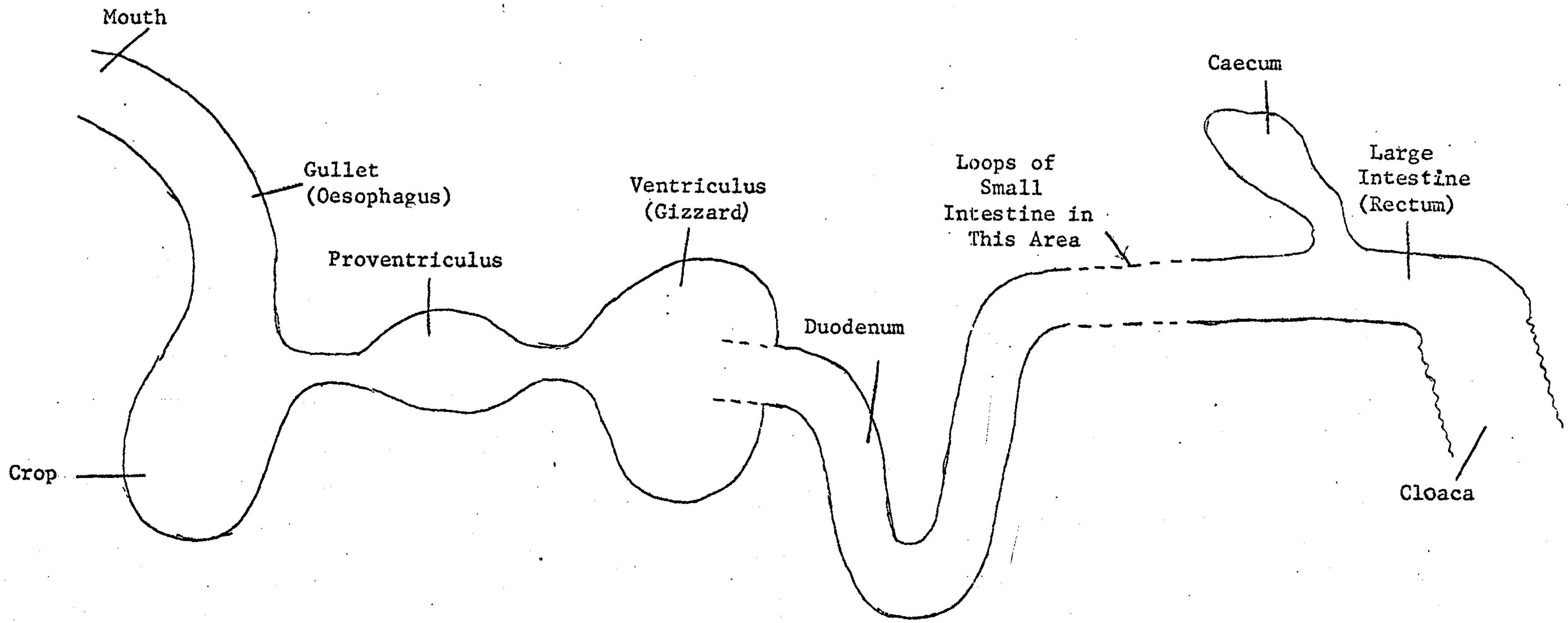
Parasite	BODY AREA																							
	Mouth No(M)		Gullet No. (G)		Crop No. (C)		Proventriculus No. (P)		Gizzard No. (Z)		Duodenum No. (D)		Small Intestine No. (S)		Rectum No. (R)		Caecum No. (A)		Cloaca No. (L)		Others No. (D)		Total No.	
	Sex		Sex		Sex		Sex		Sex		Sex		Sex		Sex		Sex		Sex		Sex		Sex	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M

Additional Information

APPENDIX 2

Form Used to Record Helminths Found During Necropsy of Host

BIRD ALIMENTARY SYSTEM

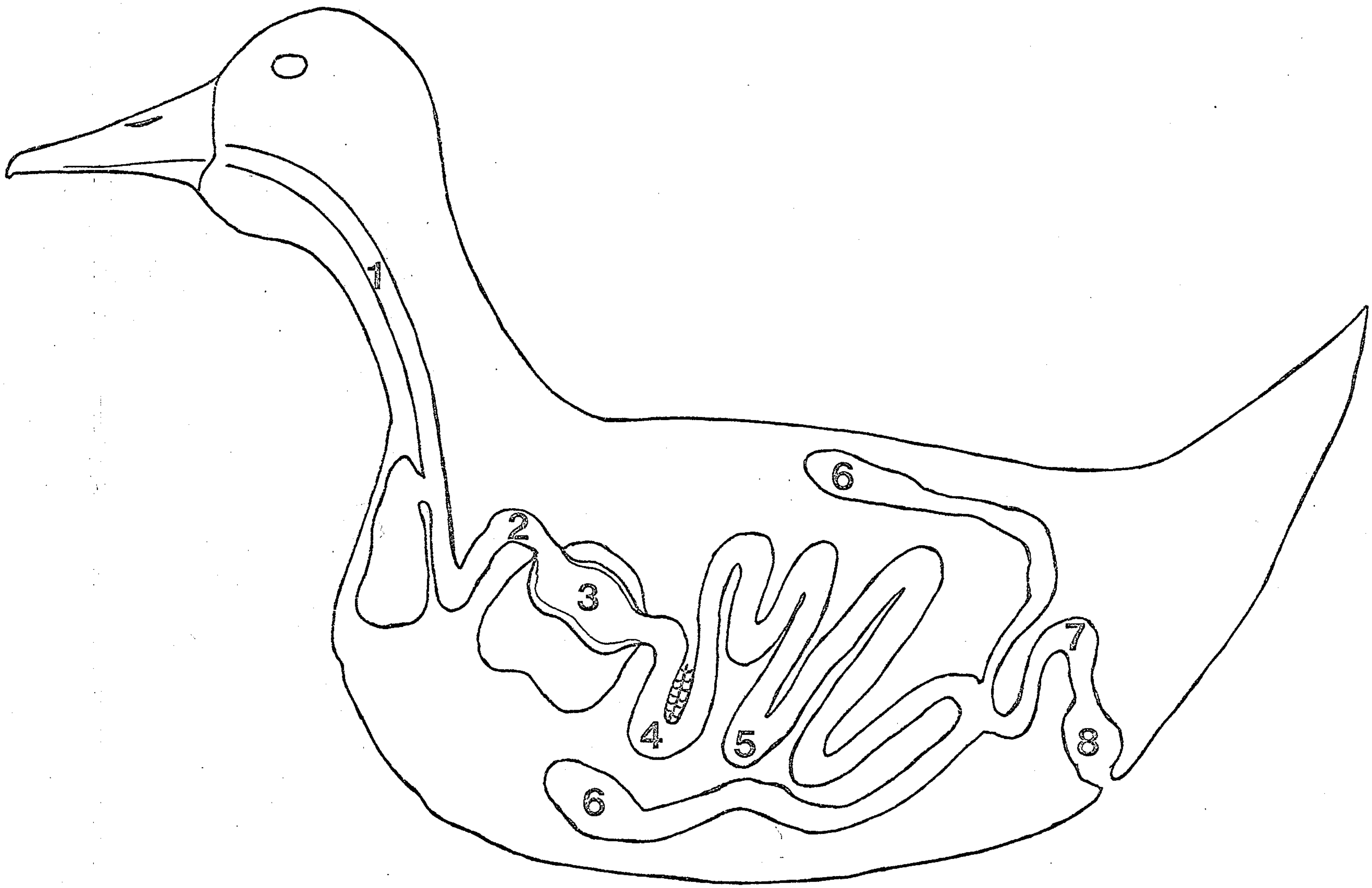


APPENDIX 3

Form Used in Recording Helminths from Various Host Groups

AGE, SEX, SPECIES –

			NEMATODES									ACANTHS	TREMATODES								CESTODES							TOTAL			
No.	DATE	KS	WT (gms)	ECH. unc.	CAP. sp.	CAP. cont.	AMID. ans.	EPO. unci.	STRE. cras.	TET. cran.	TOT. NEM.	TOTAL ACANTH	ECH. rev.	ECHIN. sp.	ZYG. lun.	Hyp. con.	COT. flab.	NOT. atti.	Lyp. lyn.	TOT. TREM.	HYM. sp.	HYM. meg.	DIO. nyro.	GAST. cyg.	FIM. fasc.	LIG. int.	TOT. CEST.	HELS.		REMARKS	



Areas of the Digestive Tract of the Duck Host
(see legend, page 121).

APPENDIX 5

Areas of the Digestive Tract and Parasites From these Areas

No.	Area	Usual Parasites
1	Oesophagus	*Capillaria contorta*
2	Proventriculus	*Tetrameres crami* *Echinuria uncinata* at junction with ventriculus
3.	Ventriculus (under koilin lining)	*Amidostomum anseris* *Epomidiostomum uncinatum* *Streptocara crassicauda* *Gastrotaenia cygni*
4	Duodenum	*Echinoparyphium* sp. *Hypoderaeum conoideum* *Cotylurus flabelliformis* *Hymenolepis* spp. *Fimbriaria fasciolaris*
5	Small Intestine	*Echinoparyphium* sp. *Echinostoma revolutum* *Hypoderaeum conoideum* *Cotylurus flabelliformis* *Hymenolepis* spp. *Fimbriaria fasciolaris* Acanthocephala
6	Caeca	*Diorchis nyrocae* *Notocotylus attenuatus* *Zygocotyle lunatum* *Capillaria* sp.
7	Rectum	*Echinostoma revolutum* *Hymenolepis* spp. *Fimbriaria fasciolaris* Acanthocephala
8	Cloaca	*Hymenolepis megalops*