UNIVERSITY OF MANITOBA

THE PARASITE FAUNA OF THE MUSKRAT, *ONDATRA ZIBETHICA* (LINNAEUS 1766) MILLER 1912, IN MANITOBA

by

CHRISTOPHER E. McKENZIE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF ZOOLOGY

WINNIPEG, MANITOBA

December, 1977.

THE PARASITE FAUNA OF THE MUSKRAT,

ONDATRA ZIBETHICA (LINNAEUS 1766) MILLER 1912, IN MANITOBA

BY

CHRISTOPHER E. MCKENZIE

A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

ABSTRACT

The parasites of 171 muskrats from four regions of Manitoba were examined to determine the prevalence and incidence of parasitism. Complete examinations for both endoparasites and ectoparasites were performed for 29 muskrats, while 31 were examined only for ectoparasites and 111 were necropsied only for endoparasites.

Seventeen species of parasites were recovered, including 7 trematodes, 3 nematodes, 2 cestodes, 1 acanthocephalan, 3 mites and a protozoan. Two new host records were recorded, the trematode *Plagiorchis noblei* and the nematode *Heligmosomum carolinensis*.

Capillaria michiganensis and *Hymenolepis* sp. were significantly more prevalent in female muskrats than in males. Young muskrats were found to be parasitized shortly after weaning, with the most prevalent forms being acquired first.

ACKNOWLEDGEMENTS

I wish to thank my supervisor, Dr. H.E. Welch for his advice, interest and support during this study. I also wish to thank Dr. L.C. Graham for his help as acting supervisor during the writing of this thesis, and his aid in identifying certain helminths. I thank Dr. T.A. Dick for criticizing the manuscript.

I extend thanks to the staff of the University Field Station for their aid, and the use of the facilities, and to the Department of Renewable Resources, particularly Mr. Dick Stardom, for supplying muskrat carcasses.

I thank Dr. J.C. Holmes of the University of Alberta, Barbara MacKinnon of the University of New Brunswick and Dr. L. Peters of Northern Michigan University for supplying unpublished survey data.

Len Brownlie and Brian O'Malley have my appreciation for their able field assistance.

This study was supported by a Canadian Wildlife Service grant and a University of Manitoba Fellowship to the author, and a National Research Council operating grant to Dr. Welch.

TABLE OF CONTENTS

PAGE

ABSTRACT. i

ACKNOWLEDGEMENTS. ii

LIST OF TABLES. iv

INTRODUCTION. 1

HOST BIOLOGY. 2

LITERATURE REVIEW 5

MATERIALS AND METHODS 20

RESULTS

I Parasites 25
II Geographic variation. 39
III Effect of host sex. 41
IV Effect of host age. 41
V Pathology 42

DISCUSSION

I Parasites 44
II Geographic variation. 53
III Effect of host sex. 54
IV Effect of host age. 55
V Pathology 56

CONCLUSIONS 58

LITERATURE CITED. 59

APPENDIX I. 79

APPENDIX II 80

APPENDIX III. 86

LIST OF TABLES

TABLE		PAGE
I	Parasites recorded from the muskrat *Ondatra zibethica* (L.) Miller, 1912 in North America.	7
II	Sampling areas, dates and numbers of muskrats taken in 1976-1977	24
III	Prevalence and intensity of endoparasites from the muskrat in Manitoba.	26
IV	Prevalence and intensity of ectoparasites from the muskrat in Manitoba	27
V	Occurrence of concurrent infections of endoparasites in the muskrat in Manitoba.	28
VI	Measurements of *P. noblei* from the present study compared with those of several other species in the literature.	30
VII	Measurements of *Notocotylus filamentis* compared to the original description, and measurements of *N. urbanensis* . .	33
VIII	Measurements of *Heligmosomum carolinensis* from this study and from Dikmans (1940)	37
IX	Prevalence of the seven most prevalent helminths at the four sample sites.	40
X	Comparison of the seven most prevalent species between young of the year and adult muskrats.	43
XI	Measurements of *Quinqueserialis quinqueserialis* in this study.	81

LIST OF TABLES CONT'D

TABLE PAGE

XII Measurement of *Alaria mustelae* in this study. 82

XIII Measurements of *Wardius zibethicus* in this study. 83

XIV Measurements of *Hydatigera taeniaformis* in this study 84

XV Measurements of *Capillaria michiganensis* in this study. . . . 85

INTRODUCTION

The economic importance of the muskrat, *Ondatra zibethica* (Linnaeus, 1766) Miller 1912, in North America is easily demonstrated. The fur industry, in which the muskrat ranks first amongst trapped pelts, supports a large number of trappers, many of whom are native people (Bondar, 1950). Economic damage from tunneling, to dykes and drainage systems, must also be considered. Any factor affecting the ecology and well-being of the muskrat is thus of great importance to a large number of people.

Notwithstanding the twenty-two published, and at least four unpublished surveys already made of muskrat parasites in North America, the central prairies have been largely ignored. One exception was an ecological study by Bondar (1950) in southern Manitoba, which briefly examined the parasitic fauna of the muskrat.

The muskrat is an excellent study animal, being numerous, easily secured and living a semi-aquatic mode of life with the resultant exposure to a large number of parasites species with aquatic intermediate hosts. This is particularly true of the digenetic trematodes.

The objectives of this study were: 1. to determine the parasites present in the muskrat and their prevalence; 2. to examine the effect of host sex and age on the parasitic fauna, and to observe any obvious pathology or apparent harm to the host.

HOST BIOLOGY

The muskrat is the largest member of the rodent family Cricetidae. It is stout-bodied, 25-35 cm long, with a tail of an additional 20-28 cm, and weighs between 0.5 and 1.5 kg (Burt and Grossenheider, 1964). The muskrat is primarily nocturnal and is well adapted to its semi-aquatic existence. The pelage is in two layers, an inner evenly distributed, soft under fur, and long, unevenly distributed guard hairs. The tail is relatively hairless and laterally compressed in aid of swimming. The hind feet are broad and provided with stiff hairs between the digits which spread to increase the surface area when swimming. A muskrat may remain submerged up to fifteen minutes (Bondar, 1950).

A female muskrat may have three or four litters per year, averaging five or six young per litter. Muskrats breed from April to August in Northern areas, and breed during the winter in the South (Burt and Grossenheider, 1964). Young usually reach sexual maturity in time to breed the following spring (Bondar, 1950).

Muskrats are omnivorous, though they can survive on a herbivorous diet. The preferred plant is cattail (*Typha* spp.) especially the lower stems, shoots and rhizomes. Muskrats eat a variety of other water plants, including bulrush (*Scirpus* spp.) and *Phragmites* spp. Crayfish, snails, frogs and fish are the usual animal supplements to the diet (Bondar, 1950). Muskrats may also scavenge. Smith (1938) reported that muskrats tested in captivity ate both fish and dead birds. Under severe conditions, muskrats may be cannibalistic, feeding on their neighbours' young (Errington, 1957).

Dispersal takes place during the autumn, at which time muskrats may be found travelling overland. Their behaviour is more aggressive while away from water, and they may attack without apparent provocation (Banfield, 1974).

During the winter muskrats remain active and swim under the ice, utilizing "push-ups" or openings through the ice which they themselves maintain. They feed on roots, and presumably predate or scavenge animal material as well. It is important that the water body not freeze to the bottom, as this exposes the muskrat to predation. This constitutes the greatest threat, as Seton (1909) observed, "There is yet another and still more dangerous enemy, that is, a severe winter following a dry fall. The ponds are then so shallow that they freeze to the bottom, the rats are either forced out to be at a helpless disadvantage among birds and beasts of prey, or are sealed in so that they prey on each other. It takes years for the species to recover from such a dire experience."

The main predators on muskrats in Southern Manitoba are mink (*Mustela vison* Schreber), owls and hawks (Bondar, 1950).

The muskrat is found over all of North America except for the far North, Florida and parts of Texas and California (Burt and Grossenheider, 1964). There are fifteen subspecies, seven in Canada and eight in the United States (Bondar, 1950). Three subspecies occur in Manitoba, though there has been much interbreeding (Banfield, 1974).

The muskrat has been introduced to Europe and has spread across the Ukraine.

According to Bondar (1950), the taxonomy of the muskrat has been repeatedly revised:

Castor zibethicus	Linnaeus 1766
Ondatra zibethicus	(L.) Link 1795
Fiber zibethicus	(L.) True 1885
Ondatra zibethica	(L.) Miller 1912

LITERATURE REVIEW

The first record of a muskrat parasite is that of Leidy (1858). He described a helminth, *Monostomum affine*, the correct identity of which is now uncertain. In another paper, Leidy (1888) reported *Distomum echinatum*, (Zeder 1803) Dietz 1910 and *Amphistomum subtriquetrum*, Reed, which are considered synonomous with *Echinostoma revolutum* (Froelich 1802) Dietz 1910 and *Wardius zibethicus* Barker and East 1915, respectively. Stiles and Hassall (1894) reported the presence of *Cysticercus fasciolaris* Rudolphi 1808 (larval *Hydatigera taeniaformis* (Batsch 1876) Lamarck 1816, in a muskrat.

Barker and Laughlin (1911) made the first survey of muskrat parasites and since then at least 25 additional surveys have been carried out, most of which consider only helminths. Penn (1942), Knight (1951a, 1951b) Grundmann and Tsai (1967) and Meyer and Reilly (1950) are the only four studies which deal with both endo and ecto-parasites. Ball (1952), Penn (1942) and Grundmann and Tsai (1967) were the only workers to examine the gut for protozoans. Bishop (1934) published the most comprehensive account of gut protozoans from muskrats in England. No blood protozoans are known from the muskrat, but only Grundmann and Tsai (1967) reported having looked for them. The recorded ectoparasites of muskrats are almost exclusively Acarina. Mites occur most frequently, both as commensal, and as lymph and blood feeding forms. Fox (1940) listed the muskrat as host to a flea, *Ctenophthalmus pseudagyrtes*, Baker 1904, in the Eastern

United States and Takos (1940) observed fleas on a muskrat, but the muskrat evaded capture. Ulbrich (1930) reported two species of *Haematopinus* (Anoplura) on a muskrat in Germany, *Haematopinus spininger* Denny, and *H. spinulosus* Denny.

Ticks are occasionally found on muskrats, possibly as incidental infestations. Kohls (1952) reported the tick *Ixodes muris* Bishopp and Smith, on 2 of 812 animals that he examined.

Larval dipterans, causing myiasis were reported by Penn (1942) and Arata (1959).

Literature on muskrat parasites from Europe and Asia indicates that some North American parasites, such as *Quinqueserialis quinqueserialis* (Barker and Laughlin 1911) Harwood 1939 have become established in their hosts' new range (Warwick, 1936; Sey, 1966; Gvozdev, 1966; Vaňatka, 1970), while other species such as *Wardius zibethicus* and *Notocotylus urbanensis* (Cort 1914) Herber 1955, have been lost. At the same time new species of parasites, closely related to North American forms, such as *Plagiorchis arvicolae* Schulz and Skvorzov 1931, and *Tetratirotaenia polyacantha* (Leuckart, 1856) Abuladze 1964, have been acquired from phylogenetically similar hosts (Sey, 1967; Gvozdev, 1966).

A list of the parasites of muskrats in North America (Table I) includes 37 trematodes, 18 cestodes, 21 nematodes, 2 acanthocephalans, 4 protozoans and 14 mites.

Table I. Parasites recorded from the muskrat, *Ondatra zibethica* (L.) Miller, 1912 in North America.

Parasite, Authority	Citation	Locality
HELMINTHS		
Phylum Platyhelminths		
Class Trematoda		
Family Brachylaimidae		
Ptyalincola ondatrae Wootton and Murrell 1967	Wootton and Murrell 1967	Michigan
Family Diplostomatidae		
Alaria mustelae Bosma 1931	Law and Kennedy 1932	Ontario
	Penner 1940	Minnesota
	Sweatman 1952	Ontario
	Dunagan 1957	Alaska
Fibricola cratera (Barker and Noll 1915) Dubois 1938	Barker 1915	Nebraska
	Penner 1940	Minnesota
	Gilford 1954	Illinois
	Beckett and Gallicchio 1967	Ohio
	Grundmann and Tsai 1967	Utah
	MacKinnon (pers. comm.)	New Brunswick
Family Echinostomatidae		
Echinochasmus schwartzi Price 1931	Price 1931	Maryland
	Law and Kennedy 1932	Ontario
	Penner 1940	Maryland
	Chandler 1941	Texas
	Penn 1942	Louisiana
	Byrd and Reiber 1942	Louisiana
	Abram 1969	Maryland
	Holmes (pers. comm.)	Alberta
Echinochasmus sp.	MacKinnon (pers. comm.)	New Brunswick
Echinoparyphium contiguum Barker and Bastron 1915	Barker 1915	Nebraska
	Law and Kennedy 1932	Ontario
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Knight 1951a	British Columbia
	Sweatman 1952	Ontario

	Burnett 1956	Colorado
	Gupta 1962 a	Quebec
	Grundmann and Tsai 1967	Utah
	Gash and Hanna 1972	Kansas
Echinoparyphium recurvatum (Linstow 1873) Dietz 1909	Penner 1940	Minnesota
	Meyer and Reilly 1950	Maine
	Beckett and Gallicchio 1967	Ohio
	Harley 1972	Kentucky
Echinostoma revolutum (Froelich 1802) Dietz 1910	Leidy 1888	U.S.A.
	Barker 1915	Nebraska
	Law and Kennedy 1932	Ontario
	Beaver 1937	Alberta
		Quebec
		Pennsylvania
		Maryland
		Colorado
		Illinois
	Penner 1940	Minnesota
	Leigh 1940	Illinois
	Ameel 1942	Michigan
	Rausch 1946	Ohio
	Rider and Macy 1947	Oregon
	Edwards 1949	New York
	Knight 1951a	British Columbia
	Sweatman 1952	Ontario
	Ball 1952	Colorado
	Gilford 1954	Illinois
	Senger and Neiland 1955	Oregon
	Burnett 1956	Colorado
	Dunagan 1957	Alaska
	Gupta 1962a	Quebec
	Anderson and Beaudoin 1966	Pennsylvania
	Beckett and Gallicchio 1967	Ohio
	Grundmann and Tsai 1967	Utah
	Abram 1969	Maryland
	Harley 1972	Kentucky
	Rice and Heck 1975	Ohio
	Peters (pers. comm.)	Michigan
	Holmes (pers. comm.)	Alberta
	MacKinnon (pers. comm.)	New Brunswick
Family Heterophyidae		
Apophallus brevis Ransom 1921	Penner 1940	Minnesota
Euryhelmis pacificus Senger and Macy 1952	Senger and Macy 1952	Oregon
	Senger and Neiland 1955	Oregon

Phagicola lageniformis Chandler 1941	Chandler 1941	Texas
Phagicola nana Ransom 1921	Byrd and Reiber 1942	Louisiana
Family Lecithodenidriidae		
Allassogonoporus marginalis Olivier 1938	Olivier 1938	Michigan
Family Microphallidae		
Levinseniella brachysoma (Creplin 1878) Stiles and Hassall 1901	Penner 1940	Minnesota
Family Notocotylidae		
Notocotylus filamentis[1] (Barker 1915) Harwood 1939	Barker 1915	Nebraska
	Law and Kennedy 1932	Ontario
	Goble 1940	New York
	Ameel 1942	Michigan
	Meyer and Reilly 1950	Maine
	Sweatman 1952	Ontario
	Burnett 1956	Colorado
	Dunagan 1957	Alaska
	Holmes (pers. comm.)	Alberta
Notocotylus urbanensis[1] (Cort 1914) Herber 1955	Penner 1940	Minnesota
	Rider and Macy 1947	Oregon
	Edwards 1949	New York
	Bondar 1950	Manitoba
	Knight 1951a	British Columbia
	Beckett and Gallicchio 1967	Ohio
	Grundmann and Tsai 1967	Utah
	Harley 1972	Kentucky
	MacKinnon (pers. comm.)	New Brunswick
Notocotylus sp.	Stiles and Hassall 1894	Maryland
	Gilford 1954	Illinois
	Senger and Neiland 1955	Oregon
Nudacotyle novicia Barker 1916	Barker 1916	Minnesota
	Chandler 1941	Texas
	Ameel 1942	Michigan
	Penn 1942a	Louisiana
	Meyer and Reilly 1950	Maine
	Gilford 1954	Illinois
	Beckett and Gallicchio 1967	Ohio
	Abram 1969	Maryland
	Harley 1972	Kentucky
	MacKinnon (pers. comm.)	New Brunswick

Quinqueserialis quinqueserialis (Barker and Laughlin 1911) Harwood 1939	Barker and Laughlin 1911	Nebraska
	Barker 1915	Nebraska
	Law and Kennedy 1932	Ontario
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Rausch 1946	Ohio
	Edwards 1949	New York
	Bondar 1950	Manitoba
	Meyer and Reilly 1950	Maine
	Knight 1951a	British Columbia
	Ball 1952	Colorado
	Rausch 1952	Alaska
	Sweatman 1952	Ontario
	Gilford 1954	Illinois
	Senger and Neiland 1955	Oregon
	Burnett 1956	Colorado
	Dunagan 1957	Alaska
	Arata 1959	Illinois
	Gupta 1962b[2]	Quebec
	Anderson and Beaudoin 1966	Pennsylvania
	Beckett and Gallicchio 1967	Ohio
	Grundmann and Tsai 1967	Utah
	Abram 1969	Maryland
	Harley 1972	Kentucky
	Rice and Heck 1975	Ohio
	Holmes (pers. comm.)	Alberta
	MacKinnon (pers. comm.)	New Brunswick
	Peters (pers. comm.)	Michigan
Paramonostomum pseudalveatum Price 1931	Price 1931	Maryland
	Penn 1942	Louisiana
	Grundmann and Tsai 1967	Utah
Family Opisthorchiidae		
Amphimerus pseudofelineus (Ward 1901) Barker 1911	Gilford 1954	Illinois
Metorchis conjunctis Cobbald 1860	Sweatman 1952	Ontario
	Anderson and Bedouin 1966	Pennsylvania
Opisthorchis tonkae Wallace and Penner 1939	Wallace and Penner 1939	Minnesota
	Penner 1940	Minnesota
	Edwards 1949	New York
	MacKinnon (pers. comm.)	New Brunswick
Parametorchis sp.	Smith 1938	Maryland
	Penner 1940	Minnesota

Family Troglotrematidae		
Paragonimus kellicotti Ward 1908	Ameel 1932	Michigan
	Penner 1940	Michigan
	Harley 1972	Kentucky
Family Paramphistomatidae		
Wardius zibethicus Barker and East 1915	Leidy 1888	U.S.A.
	Barker 1915	Nebraska
	Law and Kennedy 1932	Ohio
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Rausch 1947	Ohio
	Edwards 1949	New York
	Bondar 1950	Manitoba
	Meyer and Reilly 1950	Maine
	Smith 1958	Michigan
	Murrell 1965	Michigan
	Anderson and Beaudoin 1966	Minnesota
	Beckett and Gallicchio 1967	Ohio
	Abram 1969	Maryland
	Harley 1972	Kentucky
	Rice and Heck 1976	Ohio
	MacKinnon (pers. comm.)	New Brunswick
Zygocotyle lunatum Diesing 1835	Holmes (pers. comm.)	Alberta
Family Plagiorchiidae		
Plagiorchis maculosus (Rudolphi 1802) Braun 1902	Penner 1940	Minnesota
Plagiorchis massino Petrov and Tikhonov 1927	Holmes (pers. comm.)	Alberta
Plagiorchis micracanthos Macy 1931	Penner 1940	Minnesota
Plagiorchis muris (Tanabe 1922) Yamaguti 1931	Penner 1940	Minnesota
Plagiorchis mustelae Petrov and Kadenatsii 1927	Holmes (pers. comm.)	Alberta
Plagiorchis proximus Barker 1915	Barker 1915	Nebraska
	Law and Kennedy 1932	Ontario
	Penner 1940	Minnesota
	Ameel 1946	Michigan
	Rausch 1946	Ohio
	Edwards 1949	New York
	Bondar 1950	Manitoba

	Meyer and Reilly 1950	Maine
	Knight 1951a	British Columbia
	Ball 1952	Colorado
	Rausch 1952	Alaska
	Sweatman 1952	Ontario
	Gilford 1954	Illinois
	Burnett 1956	Colorado
	Dunagan 1957	Alaska
	Anderson and Beaudoin 1966	Pennsylvania
	Beckett and Gallicchio 1967	Ohio
	Grundmann and Tsai 1967	Utah
	Harley 1972	Kentucky
	Holmes (pers. comm.)	Alberta
	MacKinnon (pers. comm.)	New Brunswick
Family Prosthogonimidae		
Mediogonimus ovilacus Woodhead and Malewity 1936	Penner 1940	Minnesota
	Beckett and Gallicchio 1967	Ohio
Family Psilostomatidae		
Ribeiroia ondatrae (Price 1931) Babero 1972	Price 1931	Oregon, Ontario
	Law and Kennedy 1932	Ontario
Family Schistosomatidae		
Schistosomatium douthitti (Cort 1914) Price 1929	Penner 1938	Minnesota and Michigan
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Gilford 1954	Illinois
	Beckett and Gallicchio 1967	Ohio
	MacKinnon (pers. comm.)	New Brunswick
Family Urotrematidae		
Urotrema shillinger Price 1931	Price 1931	Maryland
	Penner 1940	Minnesota
	Penner 1941	Maryland
Class Cestoda		
Family Anoplocephalidae		
Andrya macrocephala Douthitt 1915	Anderson and Beaudoin 1966	Pennsylvania
Andrya ondatrae Rausch 1948	Rausch 1948	Ohio
Andrya primordialis Douthitt 1915	MacKinnon (pers. comm.)	New Brunswick

Andrya sp.	Grundmann and Tsai 1967	Utah
Monoecocestus americanus (Stiles 1895) Beddard 1914	Olsen 1939	Minnesota
	Harley 1972	Kentucky
Monoecocestus variabilis (Douthitt) Beddard 1914	Olsen 1939	Minnesota
Monoecocestus sp.	Arata 1959	Illinois
Family Dilepididae		
Anomotaenia telescopica Barker and Andrews 1915	Barker 1915	Nebraska
Family Hymenolepididae		
Hymenolepis evaginata Barker and Andrews 1915	Barker 1915	Nebraska
	Law and Kennedy 1932	Ontario
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Penn 1942a	Louisiana
	Edwards 1949	New York
	Meyer and Reilly 1950	Maine
	Knight 1951a	British Columbia
	Ball 1952	Colorado
	Sweatman 1952	Ontario
	Gilford 1954	Illinois
	Dunagan 1957	Alaska
	Senger and Bates 1957	Utah
	Beckett and Gallicchio 1967	Ohio
	Grundmann and Tsai 1967	Utah
	Harley 1972	Kentucky
	Peters (pers. comm.)	Michigan
	Holmes (pers. comm.)	Alberta
	MacKinnon (pers. comm.)	New Brunswick
Hymenolepis octocoranata (von Listow) Fuhrmann 1924	Knight 1951a	British Columbia
Hymenolepis ondatrae Rider and Macy 1947	Rider and Macy 1947	Oregon
	Macy and Biggs 1953	Oregon
	Senger and Bates 1957	Utah
	Grundmann and Tsai 1967	Utah
Hymenolepis oregonensis Neiland and Senger 1952	Neiland and Senger 1952	Oregon
	Senger and Neiland 1955	Minnesota, Kentucky
Family Taeniidae		
Cladotaenia cerci Yamaguti 1935	Penner 1940	Minnesota

Cladotaenia sp.	Knight 1951a	British Columbia
Hydatigera taeniaformis (Batsch 1786) Lamarck 1816	Linton 1915	Pennsylvania
	Johnston 1925	New York
	Smith 1938	Maryland
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Kuntz 1943	Michigan
	Rausch 1946	Ohio
	Edwards 1949	New York
	Bondar 1950	Manitoba
	Knight 1951a	British Columbia
	Byrd 1952	Virginia
	Burnett 1956	Colorado
	Gallati 1956	Ohio
	Anderson and Beaudoin 1966	Pennsylvania
	Beckett and Gallicchio 1967	Ohio
	Harley 1972	Kentucky
	Holmes (pers. comm.)	Alberta
Taenia intermedia[3] Rodolphi 1810	Holmes (pers. comm.)	Alberta
Taenia tenuicollis Rudolphi 1819	Skinker 1935	Ontario
	Penner 1940	Minnesota
	Locker 1955	Alaska, Montana
	Dunagan 1957	Alaska
Taenia sp.	Peters (pers. comm.)	Michigan
Phylum Nematoda		
Family Ascaridae		
Ascaris lumbricoides Mérat 1821	Smith 1938	Maryland
	Tiner and Chin 1948	Illinois
	Anderson and Beaudoin 1966	Pennsylvania
	Harley 1972	Kentucky
Ascaris sp.	Barker 1916	Minnesota
	Burnett 1956	Colorado
	Grundmann and Tsai 1967	Utah
Family Capillariidae		
Capillaria hepatica (Bancroft 1893) Baylis 1931	Law and Kennedy 1932	Ontario
	Price 1932	Ontario
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Penn 1942a	Louisiana
	Meyer and Reilly 1950	Maine
	Knight 1951a	British Columbia

Capillaria michiganensis Read 1949	Read 1949a, 1949b	Wisconsin
	Burnett 1956	Colorado
	Webster 1966	Ontario
	Grundmann and Tsai 1967	Utah
Capillaria ransomia Barker and Noyes 1915	Barker 1915	Nebraska
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Knight 1951a	British Columbia
	Beckett and Gallicchio 1967	Ohio
Family Dioctophymidae		
Eustrongylides sp.	Gibson and McKiel 1972	Ontario
Family Dracunculidae		
Dracunculus insignis (Leidy 1858) Chandler 1942	Gibson and McKiel 1972	Ontario
	Gash and Hanna 1972	Kansas
	Crichton and Beverly-Burton 1974	Ontario
Family Filariidae		
Dirofilaria immitis (Leidy 1856) Railliet and Henry 1911	Goble 1942	New York
Dirofilaria sp.	Smith 1938	Maryland
	Harley 1972	Kentucky
Family Heligmosomatidae		
Heligmosomum longispiculatus (Dikmans 1940) Skrjabin 1971	Dikmans 1940	New Jersey
	Gilford 1954	Illinois
Longistriata adunca Chandler 1932	Penn 1942a	Louisiana
Longistriata dalrymplei Dikmans 1935	Chandler 1941	Texas
	Beckett and Gallicchio 1967	Ohio
	Harley 1972	Kentucky
Family Physalopteridae		
Physaloptera sp.	Penn 1942a	Louisiana
Family Rhabdiasidae		
Strongyloides ratti var. *ondatrae* Chandler 1941	Chandler 1941	Texas
Family Rictulariidae		
Rictularia ondatrae Chandler 1941	Chandler 1941	Texas

Rictularia sp.	Penn 1942a	Louisiana
Family Setariidae		
Litomosoides carinii Travassos 1919	Chandler 1941	Texas
Family Trichinellidae		
Trichinella spiralis Owen 1835	Rausch *et al.* 1956	Alaska
	Beckett and Gallicchio 1967	Ohio
	Harley 1972	Kentucky
Family Trichostrongylidae		
Trichostrongylus calcaratus Ransom 1911	Barker 1915	Nebraska
	Chandler 1950	Pennsylvania
	Beckett and Gallicchio 1967	Ohio
	Harley 1972	Kentucky
Trichostrongylus sp.	Rider and Macy 1947	Oregon
Family Trichuridae		
Trichuris opaca Barker and Noyes 1915	Barker 1915	Nebraska
	Penner 1940	Minnesota
	Ameel 1942	Michigan
	Rausch 1946	Ohio
	Edwards 1949	New York
	Tiner 1950	Wisconsin
	Knight 1951a	British Columbia
	Ball 1952	Colorado
	Sweatman 1952	Ontario
	Gilford 1954	Illinois
	Dunagan 1952	Alaska
	Anderson and Beaudoin 1966	Pennsylvania
	Beckett and Gallicchio 1967	Ohio
	Grundmann and Tsai 1967	Utah
	Abram 1969	Maryland
	Harley 1972	Kentucky
	Rice and Heck 1975	Ohio
	Holmes (pers. comm.)	Alberta
Phylum Acanthocephala		
Family Polymorphidae		
Corynosoma constrictum Van Cleave 1918	Holmes (pers. comm.)	Alberta
Corynosoma sp.	Beckett and Gallicchio 1967	Ohio
Polymorphus paradoxus Connell and Corner 1957	Connell and Corner 1957	Alberta
	Holmes (pers. comm.)	Alberta

Polymorphus sp.	Knight 1951a	Alberta
	Dunagan 1957	Alaska
Unidentified acanthocephala	Bondar 1950	Manitoba
Phylum Protozoa		
Sub-Phylum Sarcomastigophora		
Class Zoomastigophora		
Order Diplomonadida		
Giardia ondatrae Travis 1939	Travis 1939	Iowa
	Penn 1942	Louisiana
	Ball 1952	Colorado
	Grundmann and Tsai 1967	Utah
Order Trichomonadidae		
Trichomonas sp.	Penn 1942	Louisiana
	Grundmann and Tsai 1967	Utah
Sub-Phylum Apicomplexa		
Class Sporozasida		
Order Eucoccidiorida		
Eimeria stiedae Lindemann 1865	Allen 1933	North America
Toxoplasma microti	Karstad 1964	Ontario
Phylum Pentastomida		
Porocephalus crotali Humboldt	Penn 1942b	Louisiana
	Penn and Martin 1941	Louisiana
Phylum Arthropoda		
Class Arachnida		
Order Acarina		
Mites		
Family Labidophoridae		
Dermacarus hypudaei (Koch 1941)	Grundmann and Tsai 1967	Utah
Dermacarus ondatrae Rupes and Whitaker 1968	Rupes and Whitaker 1968	Indiana
	Whitaker and Wilson 1968	Indiana
	Fain 1969	Rhode Is.
	Rupes *et al.* 1971	Montana
	Fain *et al.* 1971	Ontario
	Fain and Whitaker 1973	Ohio
Family Laelapidae		
Androlaelaps fahrenholzi (Berlese 1911)	Lawrence 1965	Michigan

Laelaps alaskensis Grant 1947	Lawrence 1965	Michigan
Laelaps kochi Oudemans 1936	Harper 1961	U.S.A.
Laelaps multispinosus Banks 1909	Banks 1909	Ontario
	Ewing 1922	New York
	Sivhla and Sivhla 1931	Louisiana
	Smith 1938	Maryland
	Penn 1942a	Louisiana
	MacCreary 1945	Delaware
	Dozier 1947	Eastern U.S.A.
	Meyer and Reilly 1950	Maine
	Knight 1951b	British Columbia
	Keegan and Hedeen 1952	Alaska
	Hays and Guyton 1958	Alabama
	Harper 1961	U.S.A.
	Lawrence, Hays and Graham 1961	U.S.A.
	Lawrence 1965	Michigan
	Allred and Beck 1966	Utah
	Grundmann and Tsai 1967	Utah
	Whitaker and Wilson 1968	Indiana
Laelaps muris (Ljungh 1799)	Judd 1950	Ontario
Family Listrophoridae		
Listrophorus americanus Radford 1944	Radford 1944	Maryland
	Knight 1951b	British Columbia
	Lawrence 1965	Michigan
	Grundmann and Tsai 1967	Utah
Listrophorus dozieri Radford 1944	Radford 1944	Maryland
	Grundmann and Tsai 1967	Utah
Listrophorus kingstownensis Fain and Hyland 1973	Fain 1973	Rhode Is.
Listrophorus ondatrae Fain, Kok and Lukoschus 1970	Fain 1970	Ontario
Listrophorus validus Banks 1909	Banks 1909	Ontario
	Dozier 1947	Washington
	Knight 1951b	British Columbia
	Grundmann and Tsai 1967	Utah
Listrophorus sp.	Smith 1938	Maryland
Family Myobiidae		
Radfordia zibethicalis Radford 1936	Radford 1950	Texas

Radfordia sp.	Knight 1951b	British Columbia
Family Trombiculidae		
Eutrombicula harperi (Ewing)	Knight 1951b	British Columbia
Ticks		
Ixodes muris Bishopp and Smith 1937	Bishopp and Trembley 1945	Eastern U.S.A.
	Kohls 1952	Utah
Demacentor variabilis	Bishopp and Trembley 1945	North America
Class Insecta (Say)		
Order Diptera		
Sarcophaga sp.	Penn 1942	Louisiana
Unidentified larvae (myiasis)	Arata 1959	Illinois
Order Siphonaptera		
Ctenophthalmus pseudagyrtes Baker 1904	Fox 1940	Eastern U.S.A.

[1] Due to the uncertainty as to whether *Notocotylus filamentis* and *N. urbanensis* are one or two species, they are listed separately.

[2] original citation *Q. zibethica* Gupta 1962 now *species inquirenda* (Kinsella 1971).

[3] original citation *Taenia mustelae* Gmelin 1790.

MATERIALS AND METHODS

Winter samples (1975 - 1976) from several locations in Manitoba, and winter and summer samples (1976 - 1977) from Oak Hammock Marsh were obtained from trappers through the assistance of the Department of Renewable Resources (Table II). Muskrats were stored frozen until examination. Summer samples (1976 - 1977) from Delta Marsh were taken, under permit, with Tomahawk live traps (Tomahawk Trap Co., Tomahawk, Wisconsin).

Muskrats from Delta and Oak Hammock Marshes were examined for both endo- and ectoparasites; those from other sites were necropsied only for endoparasites. All internal organs, including the brain, were examined with a dissecting microscope. The contents of the caecum were strained through a series of screens (3, 2, 1 and 0.5 mm/mesh, in that order) prior to examination. Routine necropsy procedures were followed for all organs. Parasites were separated by general morphology into vials of 70% ethanol. Sections of diaphragm and liver were squashed for viewing under high power for encysted larvae of *Trichinella spiralis* and eggs of *Schistosomatium douthitti*.

Trematodes were stained in Van Cleave's haematoxylin, Harris' haematoxylin or Gower's carmine; some were counterstained with Fast Green. After dehydration through a series of alcohols, the specimens were cleared in xylene and mounted in permount. Cestodes were stained in Semichon's aceto-carmine and cleared with methyl salicylate.

Nematodes were processed through Baker's series and mounted in glycerin. Acanthocephala were stained with Semichon's aceto-carmine, cleared in methyl salicylate and mounted (Appendix I).

Specimens from Delta were live trapped. Captured muskrats were taken to the laboratory and immobilized by injecting three to four millilitres (10 mg/cc solution) of phencyclidine hydrochloride (Sernylan: Bio-ceutic Laboratories, Inc., St. Joseph, Missouri). Animals were then combed with a fine tooth comb. The comb was examined under a dissecting microscope and any ectoparasites killed and stored in 70% ethanol. This procedure continued until repeated combing revealed no further parasites.

The ears and nose were examined, and one ear tagged to facilitate identification upon recapture. Two blood smears were made from a tail snip and the faeces were examined and a faecal smear made. The following day, the muskrats were released at the capture site. Six were subsequently recaptured and examined a second time.

Specimens from Oak Hammock were etherized and the ectoparasites brushed off into plastic bags. Mites were rehydrated from 70% ethanol and mounted in Berlese fluid; some were mounted directly in Berlese without prior fixation.

A sample of Delta muskrats were killed and necropsied. The procedure was the same as for the frozen carcasses, except spleen impressions and gut content smears were taken for protozoans. The liver was shredded and placed in a side-arm flask in an attempt to collect miracidia of *S. douthitti* by the technique of Rau *et al.* (1972).

Live trematodes were fixed under slight coverslip pressure with AFA (alcohol-formalin-acetic acid) and stored in 70% ethanol. Live nematodes were relaxed in warm saline and fixed in 70% ethanol. Blood smears were air dried, then fixed in absolute methanol and stained with Giemsa in buffered, distilled water (pH 6.75). Stained smears were microscopically examined for microfilaria and protozoan parasites. Gut smears were fixed with Schaudinn's fixative and stained with Delafield's haematoxylin.

Lenses were collected and fixed in 10% formalin for the purpose of aging the host animals by the lens weight method (Lord, 1959). Due to the possibility of damage to the lens by freezing (Montgomery, 1963), a test series with 18 rats (*Rattus norvegicus* Linnaeus) was made. One lens of each pair was fixed fresh, and the other was frozen for 15 - 25 days before fixation. As an additional aging method, zygomatic arch breadths were also recorded (Alexander, 1951).

Differences between sites, in terms of number of species per host was analysed by a one-way analysis of variance (ANOVA). A similar procedure was employed on the data for males and females. The parasite intensity (numbers of individuals of a species) of the common species were compared between males and females by testing the means by a t-test, where the F-test on the variances was not significant. Differences in prevalence between male and female muskrats were tested with a G-test (Sokal and Rohlf, 1973 and Snedecor and Cochran, 1967).

There is some confusion in the literature as to the precise meaning of prevalence, intensity and abundance. For this study, the following definitions will be used: prevalence is the percentage of animals infected in a sample, and intensity refers to the number of parasites of a species per host. Abundance normally refers to an expression of the product of prevalence and intensity.

TABLE II

Sampling areas, dates and numbers of muskrats taken in 1975 - 1977.

	General Location	Dates	Number Examined for Parasites	
			Internal	External
Area I	Delta Marsh	May-Oct. 1976	17	45
		June 1977*	3	4
Area II	Oak Hammock Marsh	Winter 1976-1977	12	11
		June-Aug. 1976	34	0
Area III	Duck Mountain and vicinity	Winter 1975-1976	27	0
Area IV	The Pas and surrounding region	Winter 1975-1976	47	0

*The small sample size is due to winter kill (Appendix III).

RESULTS

I Parasites

A total of 17 parasite species was found which include 7 trematodes, 3 nematodes, 2 cestodes, 1 acanthocephalan, 3 mites and a protozoan. Table III lists the species of endoparasites and their prevalence and intensity, while Table IV provides the same information for the ectoparasites. Concurrent infections of endoparasites occurred in 88% of the muskrats examined (Table V), with 64% of the muskrats harbouring 2 or 3 species.

Parasites were identified using group monographs and keys such as Yorke and Maplestone (1926), Harwood (1939), Tipton (1960), Schell (1970), Schmidt (1970) and others, as well as papers on the morphology of individual species. A brief comment on the taxonomy of each species along with its status as a muskrat parasite in Manitoba is presented. Appendix II provides measurements, not given in the text, for several species of helminths recovered in this study.

HELMINTHS

Trematoda

Quinqueserialis quinqueserialis (Barker and Laughlin 1911) Harwood 1939

Synonomy: *Notocotylus quinqueserialis*, Barker and Laughlin 1911
Quinqueserialis hassalli (McIntosh and McIntosh 1934) Harwood 1939

TABLE III Prevalence and intensity of endoparasites from the muskrat in Manitoba.

	Prevalence			Intensity		
	male n=81	female n=59	Total n=140	mean	SE	Range
Trematoda						
Quinqueserialis quinqueserialis	93.8	91.5	92.9	121	±24.6	1-1856
Plagiorchis noblei	83.9	84.7	84.2	97	±17.7	1-880
Echinostoma revolutum	23.5	27.1	25.0	27	±10.5	1-264
Notocotylus filamentis	14.8	15.2	15.0	35	±12.9	1-232
Wardius zibethicus	16.0	6.8	12.1	8	± 1.6	1-29
Alaria mustelae	2.5	1.7	2.1	17	±15.3	2-48
Schistosomatium douthitti (eggs in liver)	1.2	0	.7	-	-	-
Schistosomatium douthitti (immature in spleen)	3.7	0	2.1	4	± 3.0	1-10
Cestoda						
Hymenolepis sp.	21.0	47.5	32.1	2	± 0.38	1-16
Hydatigera taeniaformis (cysticercus)	1.2	0	.7	27	-	27
Nematoda						
Capillaria michiganensis	4.9	8.5	6.4	11	± 4.7	1-38
Capillaria hepatica	1.2	0	.7	7	-	7
Heligmosomum carolinensis	0	1.7	.7	35	-	35
Acanthocephala						
Polymorphus sp.	2.5	3.4	2.9	13	± 9.1	1-40
Protozoa						
Unidentified	1.2	1.7	1.4	-	-	-

TABLE IV Prevalence and intensity of ectoparasites from the muskrat in Manitoba.

Total n = 60*	Prevalence			Intensity		
	males	females	total	mean	SE	range
Delta* n = 49						
Laelaps multispinosus	48.0	52.1	49.0	11	± 3.5	1-66
Listrophorus americanus	60.0	52.0	55.1	-	-	-
Dermacarus ondatrae	8	4	6	-	-	-
Oak Hammock n = 11						
Laelaps multispinosus	100	100	100	159	±68.6	1-811
Listrophorus americanus	20	50	36	-	-	-
Dermacarus ondatrae	40	33	27	-	-	-
Total Sample						
Laelaps multispinosus	54.8	60.7	56.7	59	±24.7	1-811
Listrophorus americanus	51.6	53.6	51.7	-	-	3-400+
Dermacarus ondatrae	12.9	7.1	10.0	-	-	1-25

*1 unsexed individual in the Δ sample - nil

TABLE V Occurrence of concurrent infections of endoparasites in the muskrat in Manitoba.

Number of species	0	1	2	3	4	5	6
Percentage of sample	.7	11.4	32.9	31.4	15.0	5.7	2.9

Measurements from the specimens in this study agreed with the original description (Barker and Laughlin 1911), and with Kinsella's (1971) paper on host-induced morphological variation in this species.

Quinqueserialis quinqueserialis was the most prevalent and abundant parasite found, occurring in 92.9% of the muskrats surveyed, and ranging up to 1856 individuals per muskrat. The normal site of infection is the caecum, but a few were found in the small and large intestines.

Plagiorchis noblei Park 1936

Synonomy: *Neolepoderma noblei* (Park 1936) Mehra 1937

Plagiochoides noblei (Park 1936) Olsen 1937

The species of *Plagiorchis* commonly reported from the muskrat is *Plagiorchis proximus* Barker 1915, but measurements taken in the present study closely approximate those of *P. noblei* as described by Blankespoor (1974) (Table VI). *Plagiorchis noblei* is a normal parasite of the blackbird in this area (Hood 1977), but in laborabory infection Blankespoor (1974) was able to infect a wide range of avian and mammalian hosts.

There is some question as to the correct identity of *P. noblei*. Fedorova (1969) synonomized five species with *P. maculosus* (Rudolphi 1802) Braun 1902. Sharpilo and Sharpilo (1972) synonomized 12 species with *Plagiorchis elegans* (Rudolphi 1802) Braun 1902 including *P. proximus*, *P. muris* Tanabe 1922 and *P. maculosus*. Park (1936) noted that *P. noblei* and *P. maculosus* differed mainly in the extent of the vitelline follicles. Blankespoor (1974) showed considerable variation

TABLE VI Measurements of Plagiorchis noblei from the present study compared with those of several other species in the literature. All measurements in micrometers.

Character	Present Study n=20 range (mean)	P. proximus in Barker 1915	P. muris in McMullen 1937	P. micracanthos in Macy 1931	P. noblei in Blankespoor 1974 Range of Means in 4 Species	Age range in Pigeon	P. elegans in Skrjabin 1958
length	950-3168(1772)	1320-1980	2670	2200	-	(665)+ 1812-3328	3140
width	403-749(531)	490- 660	520	800	-	(242) 561-1131	710 max
oral sucker:							
length	164-281(207)	85-125	213	190	-	(99) 167-260	266
width	117-281(198)	45-55	dia.	170	-	(102) 172-249	dia.
pharynx:							
length	59-140 (92)	-	-	96	-	120-148	129
width	70-152 (96)	-	107	82	-	127-155	154
acetabulum:							
length	117-257 (160)	65-110	144	150	-	143-237	206
width	94-269 (159)	75-105	dia.	150	-	155-213	189
cirrus sac	351-655(480)*	-	-	340	-	342-739	-
ovary:							
length	99-211 (165)	95-145	196	220	156-232	156-281	257
width	123-257 (168)	100-110	dia.	160	136-233	137-272	dia.
anterior testes:							
length	94-468 (274)	-	231	230	143-328	259-334	386
width	140-328 (255)	-	dia.	280	121-261	197-343	300
posterior testes:							
length	129-445 (291)	-	252	260	150-403	284-357	394
width	129-328 (252)	-	dia.	320	146-267	178-341	324
testes: combined							
length	-	125-160	-	-	-	-	
width	-	120-150	-	-	-	-	
egg length	32-43.5(35.6)†	32-37.8	38	37	33-42	35-40	34.5-37.2(41)
egg width	18.9-24.7(20.8)	20-24	19	18	18-24	19-21	17.9-20.7

* 7 measurements
† 45 measurements
\+ immature specimens

in the extent of the vitelline follicles in *P. noblei* in different hosts. Blankespoor thus suggested that *P. noblei* may be synonomous with *P. maculosus*. *Plagiorchis proximus* and *P. noblei* may therefore be synonomous, but pending further work on life-cycles and morphological variation of *P. proximus* the specimens in the present collection are regarded as *Plagiorchis noblei*.

Plagiorchis noblei was second only to *Quinqueserialis quinqueserialis* in prevalence and intensity in this survey.

Echinostoma revolutum (Froelich 1802) Dietz 1910

Synonomy of species

reported from the muskrat: *Distomum echinatum* (Zedar 1803) Dietz 1910

Echinostomum coalitum Barker and Beaver 1915

Echinostomum armigerum Barker and Irvine 1915

Echinostomum callawayensis Barker and Bastron 1915

For a complete list of synonyms see Beaver (1937)

Identification was based on general morphology and the presence and arrangement of 37 cephalic or collar spines in four groups. Two are corner groups of 5 spines each. There are two lateral groups of 6 spines, and a single dorsal group of 15 spines, arranged in two alternating rows. The anterior row has 7 spines and the posterior 8. According to Beaver (1937) measurements are unreliable due to allometric growth.

Echinostoma revolutum was the third most prevalent trematode, but occurred in fewer numbers than *Quinqueserialis quinqueserialis* or *Plagiorchis noblei*.

Notocotylus filamentis (Barker 1915) Harwood 1939

Synonomy: *Catatropis filamentis* Barker 1915

Catatropis fimbriata Barker 1915

(?) *Notocotylus urbanensis* (Cort 1914) Herber 1955

Paramonostomum echium Harrah 1922

The taxonomic status of this trematode is uncertain. There is a question as to whether *N. filamentis* and *N. urbanensis* are one or two species (Holmes, pers. comm.). If they are synonomous, *N. urbanensis* would be the correct name, by the rule of priority. The specimens recovered in this study have been identified as *N. filamentis* since they more closely resemble the original description of *N. filamentis* (Barker, 1915) than that of *N. urbanensis*, as given by Herber (1955) and Acholonu and Olsen (1973) (Table VII).

This species was moderately prevalent (15%) and fairly intense.

Wardius zibethicus Barker and East 1915

Synonomy: *Amphistomum subtriquetrum* Reed

Pseudodiscus zibethicus (Barker and East 1915) Fukui 1929

Measurements of the specimens in the present study agreed with the original description given in Barker (1915).

Wardius zibethicus was moderately prevalent (12%) but low in intensity.

TABLE VII Measurements of *Notocotylus filamentis* compared to the original description, and measurements of *N. urbanensis*.

Character	*N. filamentis* Present study n=12 range (mean)	*N. filamentis* in Barker 1915 range	*N. urbanensis* in Herber 1955 range (mean)
length	1627-3514(2570)	2200-3300	2670-3620(311)
width	311-720(580)	560-700	730-920(800)
ratio of body width to length	.23	.23	.25
oral sucker length	81-110(106)	66-92	110-130(120)
width	84-113(112)	79-99	diameter
ratio of oral sucker to body length	.04	.03	.04
max. width of uterine coils	164-527(336)	-	-
ovary length	90-290(135)	132	160-210(180)
width	75-223(113)	105-112	130-210(150)
ratio of ovary length to body length	.05	.05	.06
testes length	164-527(276)	198-257	270-350(320)
width	49-246(117	132-151	170-230(200)
egg length	17.4-20.9*(19.9)	20-22	21-24

All measurements in µm.

*n = 35.

Alaria mustelae, Bosma 1931

Synonomy: *Alaria freundi* Sprehn 1932

Alaria intermedia (Olivier and Odlaug, 1938)

Alaria dubia Chandler and Rausch 1946

Alaria minuta Chandler and Rausch 1946

Measurements of specimens agreed with those given by Bosma (1931 and 1934).

Alaria mustelae was not very prevalent occurring in three hosts in low numbers.

Schistosomatium douthitti (Cort 1914) Price 1929

Synonomy: *Cercariae douthitti* Cort 1914

Schistosomatium pathlocopticum Tanabe 1923

Eggs which matched the characteristics of those of *S. douthitti* were found in the liver of one muskrat. What appear to be immature *S. douthitti* were recovered from the spleens of three other animals.

Cestoda

Hymenolepis sp. Weinland 1858

The structure of the proglottids corresponded to those described in Schmidt (1970) and in Hughes (1941). As most of the specimens were recovered from frozen carcasses, and had been damaged by decay and/or freezing, it was not possible to make a specific identification. Proglottid morphology was quite consistent, suggesting that only a single species was present.

This was the more prevalent cestode and third most prevalent helminth. It was not present in high intensity.

Hydatigera taeniaformis (Batsch 1786) Lamarck 1816

Synonomy of species

reported from the muskrat: *Taenia taeniaformis* Batsch 1786

Taenia crassicolis Rudolphi 1808

Cysticercus fasciolaris Rudolphi 1808

There are at least 55 synonyms in the literature (see Abuladze, 1964).

Identification was based on the shape and size of scolex hooks, which were in agreement with values given by Penner (1940).

Twenty-seven cysticerci were recovered from the liver of one muskrat taken at Delta Marsh.

Nematoda

Capillaria michiganensis Read 1949

The measurements of the specimens recovered in this study match those given by Read (1949a) for the females and Webster (1966) for the males. The eggs were rough-shelled, which agrees with Webster (1966), though Read (1949a) originally described them as being smooth-shelled.

Capillaria michiganensis was the most prevalent nematode in this survey, occurring in nine muskrats with low intensity.

Capillaria hepatica (Bancroft 1893) Baylis 1931

Synonomy: *Trichocephalus hepaticus* Bancroft 1893

Terichosoma tennuissinum Leidy 1891

Terichosoma hepaticum Railliet 1898

Hepaticola hepatica (Bancroft 1893) Hall 1916

Measurements of one intact worm and fragments of at least six others agree with values given by Baylis (1931) for *C. hepatica*.

Heligmosomum carolinensis (Dikmans 1940) Skrjabin 1971

Synonomy: *Nematospiroides carolinensis* Dikmans 1940

Table VIII compares measurements of *H. carolinensis* from the present study with those of Dikmans (1940). These measurements are provided to further define this species.

Heligmosomum carolinensis was recovered only once at Delta Marsh and it represents the first report of this parasite from muskrats.

Acanthocephala

Polymorphus sp. Lühe 1911

Specific identification is impossible due to the small number of specimens and their immaturity. In general morphology these specimens were assigned to the genus *Polymorphus* as described by Petrochenko (1971).

Polymorphus sp. was rare and not abundant.

TABLE VIII Measurements of *Heligmosomum carolinensis* from this study and from Dikmans (1940).

Character	Present Study (7 male 3 female)	Dikmans, 1940
length		
male	4.92 (3.90 - 6.15)mm	4 mm
female	7.65 (6.43 - 8.86)mm	uncertain
head width		
with inflation		
male	48.9 µm	-
female	43.5 µm	-
without inflation		
male	27.3 µm	-
female	29.7 µm	-
spike on tail of female	14.1 µm	≈15 µm
spicules	1.94 (1.73-2.2) mm	1.8-1.9 mm
eggs		
length	none	60-65 µm
width	none	40-45 µm
distance from anus to vulva	-	95-110 µm

Protozoa

Fifty-three animals were examined for blood and gut protozoa. No blood forms were found, however, two hosts were found to harbour very small numbers of a gut protozoan which appeared to be a flagellate. Attempts to obtain permanent stained specimens from gut smears failed, making further identification impossible.

Ectoparasites

Acarina

Laelaps multispinosus Banks 1909

Synonomy: *Tetragonyssus spininger* Ewing and Stover

Liponyssus spininger Ewing and Stover 1915

Specimens of this mite agree with the descriptions of the species as given by Banks (1909) and Tipton (1960).

Laelaps multispinosus was the most prevalent of the three mites found, but occurred in slightly less intensity than *Listrophorus americanus*.

Listrophorus americanus Radford 1944

Specimens of *L. americanus* match the original description as given by Radford (1944).

Listrophorus americanus was nearly as prevalent as *Laelaps multispinosus*, and more numerous. Concurrent infections of *Laelaps multispinosus* and *Listrophorus americanus* were common.

Dermacarus ondatrae Rupes and Whitaker 1968

Synonomy: *Zibethicarus ondatrae* (Rupes and WHitaker 1968) Rupes, Yunkers and Wilson 1971.

These phoretic hypopi were identified from the original description. They did not appear until late in the season (October) at Delta Marsh, and were found during the winter on muskrats from Oak Hammock. What appear to be adults were collected from one muskrat at Oak Hammock. The specimens had been damaged by freezing and were difficult to identify.

Recapture Studies

Six released muskrats were recaptured. Five of these were found to be infested with *Laelaps multispinosus* and/or *Listrophorus americanus* upon recapture. The minimum time elapsed between recapture was two weeks, while the maximum was four weeks.

II Sampling Areas

Analysis of variance (ANOVA) of the number of helminth species per host between the four sampling areas was not significant.

There were no major differences in the prevalence and intensity of the most prevalent species of helminths between the four areas (Table IX), though *Plagiorchis noblei* was somewhat less prevalent in the Duck Mountain region (Area III). Some of the less prevalent species were not recovered from all areas. *Wardius zibethicus* was found only in the two western regions sampled (Areas III and IV). *Notocotylus filamentis* was not found at Delta Marsh (Area I), and *Capillaria michiganensis* was not recovered from Oak Hammock Marsh. Muskrats

TABLE IX Prevalence of the seven most prevalent helminths at the four sample sites.

Helminth / Site	I Delta (n=20)	II Oak Hammock (n=46)	III Duck Mountain (n=27)	IV The Pas (n=47)	Total (n=140)
Trematoda					
Quinqueserialis quinqueserialis	95	96	93	89	93
Plagiorchis noblei	80	83	63	96	84
Echinostoma revolutum	10	46	19	17	25
Notocotylus filamentis	0	17	11	23	15
Wardius zibethicus	0	0	15	30	12
Cestoda					
Hymenolepis sp.	35	41	11	36	32
Nematoda					
Capillaria michiganensis	5	0	4	15	6

harbouring *Polymorphus* sp. were all from Area IV.

III Effect of Host Sex

Analysis of variance of the number of helminth species per host between male and female muskrats was not significant. The t-tests on parasite intensity were performed only for *Quinqueserialis quinqueserialis* and *Capillaria michiganensis,* as all the other species had dissimilar variances, generally due to the sample size being too small for a parametric test. The t-tests for both *Q. quinqueseralis* and *michiganensis* were not significant, indicating no differences in the numbers of these species occurring in male and female muskrats.

Tests for goodness of fit (G-test) indicated that the higher prevalence of *Hymenolepis* sp. in females was very significant ($P \leq .005$) and that the higher prevalence of *C. michiganensis* in female muskrats was significant ($P \leq .05$). Though *Wardius zibethicus* appeared to be more prevalent in males, the G-test was not significant.

Hymenolepis sp. also appeared to be more abundant in female muskrats (mean 2.7) as opposed to male muskrats (mean 1.5). This cannot be tested statistically, due to the reason given above.

IV Effect of Host Age

Rat Lens Experiment

The mean difference in weight between frozen and fresh fixed lenses was 4.2%, with a range of 1.1 to 8.5%. In view of these results and those of Montgomery (1963), the aging of muskrats via the lens weight technique was abandoned. It was noted that increased handling of the treated lenses caused a further loss of weight and increased error.

Using a combination of zygomatic arch breadth and body weight to separate young from adults resulted in too few animals that were definitely young of the year (10), as opposed to definite adults (113) for statistical analysis.

Table X compares the seven most prevalent helminths in young and adults. Four of these seven species occurred in the young. The only noticeable changes in prevalence of a parasite were an increase in *Plagiorchis noblei* and *Hymenolepis* sp. Young muskrats had a maximum of three concurrent helminth infections. The youngest muskrat necropsied, at two months old, was parasitized only by *Q. quinqueserialis*.

V Pathology

No signs of parasite-related pathology were observed in any of the frozen sample (120 animals). However, damage to the carcasses by decay or freezing may have obscurred such pathology.

One fresh muskrat displayed minor hemorrhaging of the gut mucosa associated with a large number of immature *Quinqueserialis quinqueserialis*.

TABLE X Comparison of the seven most prevalent species between young of the year and adult muskrats.

Helminth	Young n=10	Adult n=113
Trematoda		
Quinqueserialis quinqueserialis	90%	93%
Plagiorchis noblei	30%	86%
Echinostoma revolutum	30%	25%
Notocotylus filamentis	30%	17%
Wardius zibethicus	0	13%
Cestode		
Hymenolepis sp.	0	36%
Nematoda		
Capillaria michiganensis	0	7%

DISCUSSION

The majority of surveys on muskrat parasites (15 of 26) have been done in the Great Lakes region and eastern United States. Ten were conducted in southern and western areas of the muskrat's range, and one in Alaska. In his study of muskrat biology, Bondar (1950) mentions parasites, and even though his identifications were incomplete, they represent the only known report on muskrat parasites for central North America.

The diversity of parasite species recovered in this study was comparable to that found in other surveys of a similar sample size. Penner (1940) found the greatest diversity, 27 helminth species from approximately 500 muskrats. It is difficult to compare the species diversity of larger samples with some of the smaller surveys ($n < 60$) since less prevalent species may have been missed.

Quinqueserialis quinqueserialis, Plagiochis proximus, Echinostoma revolutum, Notocotylus spp., *Hymenolepis evaginata* and *Trichuris opaca* are the most commonly reported helminth species from the muskrat. Three of these (*Q. quinqueserialis, E. revolutum* and *N. filamentis*) were found in this study (Table III) and are widely distributed throughout the range of the muskrat. The paramphistome trematode *Wardius zibethicus*, another commonly reported muskrat parasite is notably absent from muskrats in the western half of the continent, though it is frequently reported from eastern areas. The presence of

W. zibethicus in Manitoba reported in this study and by Bondar (1950), along with its presence in Nebraska (Barker, 1915) represents the most western reports of this species to date. Less commonly recorded parasites appear localized, but this would be expected on the basis of their low prevalence.

The present study extends the ranges of *Capillaria michiganensis* and *Heligmosomum carolinensis*, the latter also being a new host record.

In the present study the trematodes showed the greatest diversity (7 species) and were the most prevalent and intense parasites. *Quinqueserialis quinqueserialis*, the most abundant parasite recovered (Table III), has been reported from muskrats in virtually all surveys in North America including Alaska. The life cycle involves the planorbid snail *Gyraulus parvus* Say, from which cercariae emerge and encyst on vegetation (Kinsella, 1971). Muskrats become infected when they ingest the metacercariae along with their food.

Kinsella (1967) reported *Q. quinqueserialis* from the meadow vole (*Microtus pennsylvanicus*, Ord). Rausch (1952) reported the species from voles (*Microtus* spp.) in Alaska. In 1971 Kinsella demonstrated in laboratory experiments that *Q. quinqueserialis* would develop in several other rodent species. It is apparent from the literature and this study that the muskrat is the main host in nature.

Notocotylus filamentis, the second member of the family Notocotylidae found in this survey has also been reported from most of North America, including Ontario (Law and Kennedy, 1932) and Alberta (Holmes, pers. comm.). Bondar (1950) reported both *Q. quinqueserialis* and *N. urbanensis* in Manitoba, though their combined prevalence was only 48.7% compared to the present 92.9% for *Q. quinqueserialis* and 15.0% for *N. filamentis*. It is probable that Bondar's *N. urbanensis* is the same as the present *N. filamentis*. The life-cycle is basically the same as that of *Q. quinqueserialis*, though it utilizes different snail intermediates (Harwood, 1939). The muskrat is the main host for this species.

Plagiochis noblei utilizes a lymnaeid snail as its first intermediate (Blankespoor, 1977). Cercaria penetrate and encyst within an arthropod (Odonata, Diptera, Trichoptera, Ephemeroptera and Amphipoda). The definitive host acquires the trematode when it ingests the metacercariae with the second host (Blankespoor, 1977). Various species of blackbirds are the most frequently recorded hosts though Blankespoor (1974) was able to infect a wide range of avian and mammalian species. Compared to the present 84.2% prevalence, Bondar (1950) found only 66.6% of his sample infected with a species of *Plagiorchis*. *Plagiorchis noblei* has not been previously reported from the muskrat.

Echinostoma revolutum is probably the least host-specific trematode recovered, developing to maturity in at least 23 species of birds and nine different mammals. In addition, at least four genera of gastropods (*Helisoma, Pseudosuccinea, Physa* and *Stagnicola*) have been implicated as first intermediate hosts. Sixteen species of snails, 2 species of clam, 7 tadpoles and bullhead fry can serve as the second intermediate host (Olsen, 1974). Definitive hosts are infected by the metacercariae when they eat the second intermediate host. The muskrat is an auxillary host for *E. revolutum*. Bondar (1950) found 48.7% of his sample infected by a species in the family Echinostomatidae, which is nearly double the present 25%.

Cercariae of *Wardius zibethicus* encyst on various substrates, including rocks, vegetation and crayfish exo-skeletons (Murrell, 1965). Muskrats are probably most often infected by those on vegetation. The prevalence in this study (12%) was much lower than the 83.3% reported by Bondar (1950).

Adult *Alaria mustelae* have been previously reported in muskrats from Alaska (Bunagan, 1957), Ontario (Law and Kennedy, 1932; Sweatman 1952) and Minnesota (Penner, 1940). Bosma (1934) described the life-cycle, which is unusual in requiring four hosts. Cercariae leave the first intermediate (*Planorbula armigera,* Say) and develop to the mesocercarial stage in a second host (usually frogs). The third intermediate host, normally a small mammal, becomes infected upon eating the second host, or a paratenic host, such as a snake. Carnivores (usually mink and weasel) serve as the definitive host, and are infected when they eat the third host and the metacercariae.

Johnson (1968) experimentally infected a cat with adult worms by feeding it mesocercariae, thus showing that there is the potential to skip the metacercarial stage. There are thus two ways that a muskrat could be infected. First, by eating the second or paratenic host (frog or snake) and ingesting mesocercariae, which could result in metacercariae in the lungs or adults in the gut. The second route of infection is by eating the third host and acquiring the metacercariae which would develop to adult flukes in the intestine. Muskrats are probably most often infected by mesocercariae from frogs, though they may be predating or scavenging small mammals. Considering their cannibalistic tendencies (Errington, 1957), they may even be acquiring metacercariae from other muskrats. Muskrats can serve as either third or fourth (definitive) hosts for *Alaria mustelae,* though they are only accidental hosts.

Schistosomatium douthitti was rare and found only in areas III and IV. Farley (1969) failed to find any *S. douthitti* in muskrats in Manitoba. Malek (1977) examined the geographical distribution of *S. douthitti* in North America, and concluded that it was related to the distribution of its normal snail hosts, *Lymnaea* spp. and *Stagnicola* spp. Cercariae penetrate the definitive host directly. Pathology may occur due to the accumulation of eggs in the liver, and resultant fibrosis. In the case of the three muskrats with immature flukes, no eggs were found, and in the muskrat with eggs in the liver, there was no appreciable damage.

Hydatigera taeniaformis was recovered from only one muskrat. The muskrat is an intermediate host in this case, the cysticerci develop in the liver after the muskrat ingests the eggs. The definitive host is a carnivore, usually a feline (Penner, 1940). In areas where there are few cats (wild or domestic), the prevalence of *H. taeniaformis* is expected to be low. Bondar (1950). found taeniid cysticerci in the liver of 1.3% of the muskrats he examined.

Hymenolepis sp. was the more prevalent cestode recovered in this study. Four species in this genus have been previously reported from the muskrat across North America. The life-cycle of species in the genus involves an arthropod intermediate in which cysticercoids develop after ingestion of oncospheres. Definitive hosts are infected by ingestion of the intermediate (Olsen, 1974). Whether the infection of muskrats is accidental, or though consuming invertebrates is unknown. Considering the prevalence of *Hymenolepis* sp. in this survey (32%) it is probably due to predation. Bondar (1950) found 2.6% of his sample infected with an adult cestode.

Two of the three nematodes recovered were of the genus *Capillaria*. *Capillaria michiganensis* was the most prevalent nematode. Its life-cycle has not been described, but is presumably similar to those of other species in the genus, which either use a single intermediate host or are direct.

Capillaria michiganensis has been reported only four times, always from the muskrat, in Utah (Grundmann and Tsai, 1967), Wisconsin (Read, 1949b), Colorado (Burnett, 1956) and Ontario (Webster, 1966). Bondar (1950) found no nematodes in his study in Manitoba.

The muskrat is not a usual host for *Capillaria hepatica*, and it was recovered from only one muskrat in this survey. Jacobsen (1967) reported it from three other rodents in Manitoba. It is widely distributed globally, and is known from a variety of hosts, including man (Baylis, 1931; Lubinsky, 1956). The life-cycle is direct, with the definitive host accidentally ingesting the eggs (Freeman and Wright, 1960).

Heligmosomum carolinensis may be considered an accidental parasite of the muskrat since only one animal was infected, and the only previously known host was *Clethrionomys gapperi* (Vigors), in New Jersey (Dikmans, 1940). Although its life cycle has not been determined, it is probably similar to that of *Heligmosomum skrjabini* (Baylis 1926) Skrjabin and Schikhobalova 1952, which Bryant (1973) described as direct, with free-living larvae and an infective third stage larvae.

Jacobsen (1967) reported two other species of *Heligmosomum* in Manitoba rodents, *H. costellatum* (Dujardin 1845) and *H. microti* (Kuns and Rausch 1950).

Members of the genus *Polymorphus* utilize an arthropod intermediate, usually a crustacean, which is eaten by the definitive host (Petrochenko, 1971). As muskrats eat crustaceans when available, a route of infection is present (Bondar, 1950). Bondar (1950) reported one muskrat infected with Acanthocephala. Based on the literature and this study, the muskrat is an accidental host for these helminths.

Intestinal protozoa were of minor importance, being of very low prevalence and abundance. This is surprising since Bishop (1934) found four genera represented in muskrats in England.

The absence of blood protozoa is hardly conclusive. Samples were generally taken from the peripheral blood, and many parasites are cyclic in their presence in the peripheral circulation (James and Harwood, 1969; Hawking, 1975). Grundmann and Tsai (1967) examined muskrat blood, also with negative results.

It is apparent, that with the exception of *S. douthitti,* all the helminths reported in this study are acquired by the muskrat by ingestion. Although two species, *Q. quinqueserialis* and *N. filamentis* are acquired only from plants, *W. zibethicus* may be on plants or animals, and *Plagiochis noblei, E. revolutum, A. mustelae, C. michiganensis, Hymenolepis* sp. and *Polymorphus* sp. are all contracted with the ingestion of an animal intermediate. In the cases of *P. noblei, W. zibethicus, Hymenolepis* sp. and *C. michiganensis* the ingestion of the intermediate may be accidental. Infection with *E. revolutum* or *A. mustelae* requires either predation or scavenging of the animal intermediate. Metacercariae of *E. revolutum* were found in the kidneys of young frogs (*Rana pipiens*) at Delta Marsh during the summer of 1975. Muskrats regularly eat frogs (Errington, 1939) so a route of infection is readily available.

Some workers believed the muskrat to be primarily herbivorous (Svihla and Svihla, 1931; Butler, 1940; Arata, 1959) but other studies indicated that the muskrat is omnivorous (Smith, 1938; Errington, 1957; Bondar, 1950) or even carnivorous in some regions (Errington, 1939). To date, no one has suggested that muskrats feed on insects, but the high prevalence of *Plagiorchis noblei* in this study (84%) coupled with the probable short life span (Blankespoor, 1977) suggests that the muskrat is feeding on one or more of the infected arthropod intermediates, possibly larger forms, such as dragonfly naiads or amphipods.

The overall abundance of several helminths (*P. noblei, E. revolutum, Hymenolepis* sp.) indicates that the muskrat may have a more varied diet than the literature indicates, and that animal food, including some insects, forms a substantial part of this diet.

Ectoparasites recovered were all Acarina (mites). *Laelaps multispinosus* has been widely reported from the muskrat (Table I), and is by far the most prevalent mite on the rodent. Although a blood feeder, it appears to do no harm to the host at the levels of infestation observed. Very little work has been done on the ecology or life-cycles of *Laelaps* species. The larval (6-legged) stage was observed on the muskrat, so it is possible that all stages in the life-cycle occur on the same host. The muskrat appears to be the main host.

Listrophorus americanus is a small commensal mite, feeding on skin detritus, and possibly skin secretions. Unless extremely numerous, they are harmless to the host (Sweatman, 1971). In very heavy infections they may cause mange. Little is known of their life-cycle, and it is assumed to be similar to that of other mites. No immature stages were observed on the muskrats, and none have been reported elsewhere.

Dermacarus ondatrae is the most interesting of the three mites recovered, the stage found being a phoretic hypopus. This is a non-feeding stage, lacking mouth parts and being high specialized for adhering to the host. Dorsal-ventrally compressed, the mite has specialized claws, suckers and ventral claspers. The first report of this species was by Rupes and Whitaker (1968). It has been reported five times since, always from the muskrat. Virtually nothing is known of the adult or larval stages, with the adult being first described by Rupes *et al.* in 1971.

Muskrats which were released and recaptured were found with *Laelaps multispinosus* and *Listrophorus americanus*. In the case of *L. multispinosus* it may represent reinfection by adult mites, though the minimum time for reinfection of two weeks could be sufficient for eggs to hatch and develop to mature mites (James and Harwood, 1969). In the case of reinfection this may indicate either the lodge or other muskrats as the source of reinfection. Muskrats are known to carry tularemia (*Francisella tularensis*) and Errington's viral enteritis (Bondar, 1950). It has been suggested that mites may be involved in the transmission of these diseases between muskrats, or even to man (Tipton, 1960). The observation of apparent reinfection supports the hypothesis that *L. multispinosus* moves from host to host, and therefore may be involved in transmission of disease.

II Geographical Variation in Manitoba

There was no major differences in the parasite fauna in muskrats examined from the four sites. The absence of *Wardius zibethicus* from Delta and Oak Hammock Marshes is not conclusive in view of its relatively low prevalence (12%) and the rather small size of the Delta sample (20). Within the two regions where it was found, *W. zibethicus* tended to be localized at specific sites within the larger area. This could reflect local distribution of the snail intermediate, though

Clarke (1973) shows the snail to be distributed across Manitoba, and reported that it occurred in a variety of permanent aquatic environments.

The similarity of the parasitic fauna in the muskrat across Manitoba is proably the result of widespread drainage networks, abundant habitat and autumn dispersal of the host.

Anderson and Beaudoin (1966) showed a difference in parasite fauna between habitats; stream muskrats had a greater species diversity and higher intensity than marsh or river muskrats. Rice and Heck (1975) reported differences in prevalence of three species of parasites between marsh and pond muskrats. Such differences between habitats would be masked in the present study by pooling of data within each of the four regions.

III Effect of Host Sex

The very significant result of the G-test with respect to *Hymenolepis* sp. indicates that there is a definite tendency for females to be more readily infected or to maintain infections longer than males. *Capillaria michiganensis* was also significantly more prevalent in female muskrats. As there is no logical reason to postulate a difference in behaviour, and thus exposure, the difference must be due to host factors.

Studies by various researchers have shown a relationship between host sex and levels of infection. These differences are often hormonally determined. Cook and Beer (1958) studied lice on voles and mice, and found female voles had significantly fewer lice than male voles, while mice showed no difference. Dobson (1961b) working with *Heligmosomum dubius* found male rats were more susceptible than female rats, which agreed with his earlier work in mice (Dobson, 1961a). The conclusion reached from these studies was that estrogen provided some protection against parasites, while testosterone had little or no effect (Dobson 1961b). Further studies by Dobson (1964, 1966a, b, c) corroborate his earlier work.

Studies by Haley (1958) and Dunsmore (1966) also show host sex as an important influence on parasitic infections. Esch (1967) demonstrated that experimentally infected female mice, and naturally infected female jackrabbits (*Lepus californicus*, Gray 1837) were more susceptible to *Taenia multiceps* Leske 1780, than males. These studies show that the prevalence and intensity of parasite infections may be affected by the host's hormones.

There are no published records on differences between the parasitic fuana of male and female muskrats. In the present study, species other than *Hymenolepis* sp. and *C. michiganensis* showed no differences in prevalence between male and female hosts.

IV Effect of Host Age

Muskrats in their first summer had concurrent infections to a maximum of three species, as opposed to adults which had up to six. The four species found in young muskrats were amongst the most prevalent parasites in the adults. The exception was the absence of *Hymenolepis* sp. in young muskrats. The youngest muskrat (2 months) was infected with *Q. quinqueserialis* which appears to be the first helminth acquired. One young muskrat was uninfected by any parasite, the only uninfected muskrat in the sample of 140 examined for endoparasites. These observations suggest that young muskrats acquire the most prevalent parasites first, and continue to gain new species as they age. These conclusions are based on a young muskrat sample of ten animals, which is not large enough for statistical analysis.

Anderson and Beaudoin (1966) examined the effect of host age on parasites in the muskrat in Pennsylvania. They found an increase in abundance of *Q. quinqueserialis* in adults over its abundance in young. They interpreted this as indicating a constant rate of exposure with a fluke longevity of over one year. *Wardius zibethicus* and *E. revolutum* remained at constant levels which Anderson and Bedouin concluded to be due to a constant rate of infection and a longevity of less than one year. *Hydatigera taeniaformis* exhibited a significant rise in prevalence in adult muskrats, while abundance remained constant, which was attributed to the muskrat developing immunity.

V Pathology

The lack of gross pathology suggests that under normal conditions muskrats can support a large number of their normal parasites without appreciable harm. One muskrat had over 2000 trematodes (1856 *Q. quinqueserialis*) but showed no adverse effects.

Bondar (1950) found a dead muskrat with 24 Acanthocephala, to which he attributed the muskrat's death. Acanthocephala in large numbers are pathological due to damage to the gut wall by the probocis hooks, but the number found by Bondar (1950) seems very low for this.

Several other potentially pathogenic parasites were recovered. *Schistosomatium douthitti* and *C. hepatica* can both cause fibrosis of the liver due to a build-up of eggs. *Schistosomatium douthitti* is one of the species responsible for "swimmer's itch" (cercarial dermatitis) in humans, and *C. hepatica* infections in humans can cause liver cirrhosis (Lubinsky, 1956). *Hydatigera taeniaformis* may also be extremely damaging. Bullock *et al.* (1920) produced sarcoma of the liver in rats infected with *H. taeniaformis,* but like *S. douthitti* and *C. hepatica,* larval cestodes are rare in muskrats in Manitoba.

The fur trade is primarily concerned with the pelt, which mites in sufficient numbers can damage by mange (Sweatman, 1971). None of the animals observed showed any sign of mange. Neither mites nor helminths appear to be a problem to muskrats in Manitoba.

CONCLUSIONS

1. Thirteen species of helminths, one protozoan and three Acarina were found to parasitize muskrats in Manitoba. Two new host records are reported, *Plagiorchis noblei* and *Heligmosomum carolinensis*. Muskrats were taken from four general regions, totaling 171 animals, of which 111 were necropsied for endoparasites, 31 were examined for ectoparasites and 29 examined for both.

2. Variation of the parasite fauna between the four sample areas was minimal, probably due to the ease of dispersal of the host.

3. *Hymenolepis* sp. and *Capillaria michiganensis* were both significantly more prevalent in female muskrats.

4. Young muskrats appear to acquire the most prevalent helminths first.

LITERATURE CITED

Abram, J.B. 1969. Some gastrointestinal helminths of *Ondatra zibethicus* L., the muskrat in Maryland. Proc. Helminthol. Soc. Wash. 36(1):93-95.

Abuladze, K.I. 1964. Taeniata of Animals and Man and Diseases Caused by Them [Transl. from Russian]. Keter Press, Jerusalem.

Acholonu, A.D. and O. Wilford Olsen. 1966. Studies on the life history of two Notocotylids (Trematoda). Proc. Helminthol. Soc. Wash. 34(1):43-50.

Alexander, M.M. 1951. The aging of muskrats on the Montezuma National Wildlife refuge. J. Wildl. Manag. 15:175-186.

Allen, J.A. 1933. Parasites of fur-bearing animals. Pacific Sci, Congr. Proc. 5th Congr. 2981-2989.

Allred, D.M. and D.E. Beck. 1966. Mites of Utah mammals. Brigham Young Univ. Sci. Bull. Biol. Ser. 8:1-123 *cited in* Whitaker, J.O. Jr. and N. Wilson. 1974. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Ameel, D.J. 1932. The muskrat, a new host for *Paragonimus*. Science 75:382.

Ameel, D.J. 1942. Two larval cestodes from the muskrat. Trans. Am. Microsc. Soc. 61:267-271.

Anderson, D.R. and R.L. Beaudoin. 1966. Host habitat and age as factors in the prevalence of intestinal parasites of the muskrat. Wildl. Dis. Assc. Bull. 2(3):70-77.

Arata, A.A. 1959. Ecology of muskrats in strip-mine ponds in southern Illinois. J. Wildl. Manag. 23:177-186.

Ball, L. 1952. Notes on helminth parasites of muskrats from western Colorado. J. Parasitol. 38:83-84.

Banfield, A.W.F. 1974. The Mammals of Canada. Univ. of Toronto Press, Toronto.

Banks, N. 1909. New Canadian mites. Proc. Entomol. Soc. Wash. 11:133-143.

Barker, F.D. 1915. Parasites of the American muskrat (*Fiber zibethicus*). J. Parasitol. 1:184-197.

Barker, F.D. 1916. A new monostome trematode parasitic in the muskrat with a key to the parasites of the American muskrat. Trans. Am. Microsc. Soc. 35:175-184.

Barker, F.D. and J.W. Laughlin. 1911. A new species of trematode from the muskrat, *Fiber zibethicus*. Trans. Am. Microsc. Soc. 30:261-274.

Baylis, H.A. 1931. On the structure and relationships of the nematode *Capillaria* [*Hepaticola*] *hepatica* (Bancroft). Parasitology 25:533-543.

Beaver, P.C. 1937. Experimental studies on *Echinostoma revolutum* (Froelich) a fluke from birds and mammals. Ill. Biol. Monogr. 15(1).

Beckett, J.V. and V. Gallicchio. 1967. A survey of helminths of the muskrat, *Ondatra z. zibethica* Miller, 1912, in Portage County, Ohio. J. Parasitol. 53(6):1169-1172.

Bishop, A. 1934. The intestinal protozoa of a muskrat, *Fiber* (=*Ondatra*) *zibethica*, with a note upon *Retortamonas* sp. from the guinea pig. Parasitology 26:578-581.

Bishopp, F.C. and H.L. Trembley. 1945. Distribution and hosts of certain North American ticks. J. Parasitol. 31(1):1-54.

Blankespoor, H.D. 1974. Host-induced variation in *Plagiorchis noblei* Park, 1936 (Plagiorchiidae:Trematoda). Am. Midl. Nat. 92(2):415-433.

Blankespoor, H.D. 1977. Notes on the biology of *Plagiorchis noblei* Park, 1936 (Trematoda:Plagiorchiidae). Proc. Helminthol. Soc. Wash. 44(1):44-50.

Bondar, G.F. 1950. A biological survey of the muskrat, (*Ondatra zibethica alba*) (Sabine) Miller, 1912, in Manitoba. Master's thesis, University of Manitoba.

Bosma, Nelly J. 1934. The life history of the trematode *Alaria mustelae*, Bosma, 1931. Trans. Am. Microsc. Soc. 53:116-148.

Bryant, V. 1973. The life cycle of *Nematospiroides dubius*, Baylis, 1926 (Nematoda:Heligmosomidae). J. Helminthol. 47(3):263-268.

Bullock, F.D., N.R. Curtis and G.L. Rohdenburg 1920. Tapeworm sarcoma of the rat's liver. Proc. Soc. Exp. Biol. Med. 18:29 *cited in* Penner 1940.

Burnett, M.P. 1956. A preliminary report on the helminth parasites from muskrats collected in the vicinity of Fort Collins, Colorado. J. Co.-Wyo. Acad. Sci. 4(8):45.

Burt, W.H. and R.P. Grossenheider 1964. A Field Guide to Mammals. Houghton Mifflin Co., Boston.

Butler, L. 1940. A quantitative study of muskrat food. Can. Field-Nat. 54:37-40.

Byrd, M.A. 1952. High occurrence of *Taenia taeniaformis* in the muskrat. Va. J. Sci. 3(4):298.

Byrd, E.E. and R.J. Reiber 1942. Mammalian trematodes. II. Three flukes from small mammals. Tenn. Acad. Sci. J. 17:143-148.

Chandler, A.C. 1941. Helminths of muskrats in southeast Texas. J. Parasitol. 27:175-181.

Chandler, A.C. 1950. *Trichostrongylus calcaratus* in muskrat. J. Parasitol. 36:87.

Clarke, A.H. 1973. The freshwater molluses of the Canadian interior basin. Malacologia 13(1-2):1-509.

Connell, R. and A.H. Corner 1957. *Polymorphus paradoxus* sp. nov. (Acanthocephala) parasitizing beavers and muskrats in Alberta, Canada. Can. J. Zool. 35:525-533.

Cook, E.F. and J.R. Beer 1958. A study of louse populations on the meadow vole and deer mouse. Ecology: 39(4):645-659.

Crichton, V.F.J. and M.B. Burton 1974. Distribution and prevalence of *Dracunculus* spp. (Nematoda:Dracunculoidea) in mammals in Ontario. Can. J. Zool. 1974. 52:163-167.

Dikmans, G. 1940. A note on the genera *Nematospiroides* Baylis, 1926, and *Sincosta* Roe, 1929 (Nematoda, Heligmosomatidae), with descriptions of two new species of *Nematospiroides*. Pro. Helminthol. Soc. Wash. 7(2):79-82.

Dobson, C. 1961a. Certain aspects of the host-parasite relationship of *Nematospiroides dubius* (Baylis). I The effect of sex on experimental infections in the mouse. Parasitology 51:173-179.

Dobson, C. 1961b. Certain aspects of the host-parasite relationship of *Nematospiroides dubius* (Baylis). II The effect of sex on experimental infections in the rat (an abnormal host). Parasitology 51:499-510.

Dobson, C. 1964. Host endocrine interactions with Nematode infections. I Effects of sex, gonadectomy, and thyroidectomy on experimental infections in lambs. Exp. Parasit. 15:200-212.

Dobson, C. 1966a. The age and sex of the host as factors affecting the host-parasite relationship of the third-stage larva of *Amplicaecum robertsi* Sprent and Mines, 1960, in the laboratory mouse. Parasitology 56:399-406.

Dobson, C. 1966b. Certain aspects of the host-parasite relationship of *Nematospiroides dubius* (Baylis). Parasitology 56:407-416.

Dobson, C. 1966c. The effects of pregnancy and treatment with progesterone on the host-parasite relationship of *Amplicaecum robersi* Sprent and Mines, 1960, in the mouse. Parasitology 56:417-424.

Dozier, H.L. 1947. Salinity as a factor in Atlantic Coast tidewater muskrat production. Trans. N. Am. Wildl. Conf. 12:398-420 *cited in* Whitaker, J.O. Jr. and N. Wilson (1974). Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Dunagun, T.T. 1957. Helminth parasites of Alaskan muskrats. Trans. Am. Microsc. Soc. 76:318-320.

Dunsmore, J.D. 1966. Influence of host reporduction on numbers of Trichostrongylid nematodes in the European rabbit, *Oryctolagus cuniculus* (L.). J. Parasitol. 52(6):1129-1133.

Edwards, R.L. 1949. Internal parasites of central New York muskrats. J. Parasitol. 35:547-548.

Errington, P.L. 1939. Reactions of muskrat populations to drought. Ecology 20:168-186.

Errington, P.L. 1957. Of Men and Marshes. Iowa State Univ. Press, Ames, Iowa.

Esch, G.W. 1967. Some effects of cortisone and sex on the biology of coenuriasis in laboratory mice and jackrabbits. Parasitology 57:175-179.

Ewing, H.E. 1922. The Dermanyssid mites of North America. Proc. U.S. Nat. Mus. 62, art. 13.

Fain, A. 1969. Les deutonymphes hypopiales vivant en association phoretique sur les mammiferes (Acarina:Sarcoptiformes). Rev. Zool. Bot. Afr. 79:409-412 *cited in* Whitaker, J.O. Jr. and N. Wilson. 1974. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Fain, A. 1970. Rediscription du type de *Listrophorus validus* Banks, 1910 (Acarina:Sarcoptiformes). Rev. Zool. Bot. Afr. 81:125-132 *cited in* Whitaker, J.O. Jr. and N. Wilson (1974). Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Fain, A. 1973. Diagnosis d'Acariens nouveaux (Listrophoroidea et Myobiidae). Rev. Zool. Bot. Afr. 87:330-332 *cited in* Whitaker, J.O. Jr. and N. Wilson. 1974. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Fain, A., N.J.J. Kok, F.S. Lukoschus, and F.V. Clulow. 1971. Notes on the hypopial nymphs phoretic on mammals in Canada with a description of a new species (Acarina:Sarcoptiformes). Can. J. Zool. 49:15-18.

Fain, A. and J.O. Whitaker, Jr. 1973. Phoretic hypopi of North American mammals (Acarina:Sarcoptiformes, Glycyphagidae). Acarologia 15(1):144-170.

Farley, J. 1964. A survey of the Schistosome fauna of southern Manitoba and a monograph on the Schistosomatidae of the world. Ph.D. thesis, University of Manitoba.

Fedorova, O.E. 1969. Analysis of morph variability in *Plagiorchis maculosis* and its importance to systematics [in Russian]. Voprosy Zoologii. Chelyabinsk Gosudarstvennyi Pedagogichesii Institut. 1:76-86 *cited in* Helminthol. Abstr. 1973. 42(5): No. 1904.

Fox, I. 1940. Fleas of Eastern United States. Iowa State College Press, Ames, Iowa.

Freeman, R.S. and K.A. Wright 1960. Factors concerned with the epizootiology of *Capillaria hepatica* (Bancroft, 1893) (Nematoda) in a population of *Peromyscus maniculatus* in Algonquin park, Canada. J. Parasitol 46:373-382.

Gallati, W.W. 1956. Fibrosarcoma associated with the cysticercus of *Taenia taeniaformis* in the liver of muskrat. Ohio J. Sci. 56:71-75.

Gash, S.L. and W.L. Hanna 1972. Occurrence of some Helminth parasites in the muskrat, *Ondatra zibethicus,* from Crawford County, Kansas. Trans. Kans. Acad. Sci. 75(3):251-254.

Gibson, G.G. and D.A. McKiel 1972. *Dracunculus insignis* (Leidy, 1858) and larval *Eustrongylides* spp. in a muskrat from Ontario, Canada. Can. J. Zool. 50(6):897-901.

Gilford, J.H. 1954. A survey of muskrat helminths in Illinois. J. Parasitol. 40:702-703.

Goble, F.C. 1942. Dog heartworm in the muskrat in New York. J. Mammal. 23:346.

Grundmann, A.W. and Y.H. Tsai 1967. Some parasites of the muskrat, *Ondatra zibethicus osoyoosensis,* (Lord, 1863) Miller, 1912 from the Salt Lake valley, Utah. Trans. Am. Microsc. Soc. 86(2): 139-144.

Gupta, S.P. 1962a. A redescription of *Euparyphium melis* (Schrank, 1788) Dietz 1909 and *Echinostoma revolutum* (Froelich, 1802) Looss, 1899 parasitic in the intestine of mink (*Mustela vison*) and muskrat (*Ondatra zibethica*) from Canada. Indian J. Helminthol. 14(2):77-85.

Gupta, S.P. 1962b. On a new trematode, *Quinqueserialis zibethica* sp. nov., of the sub-family Notocotylinae from the duodenum of the muskrat (*Ondatra zibethica*) from Canada. Indian J. Helminthol. 14:66-70.

Gvozdev, E.V. 1966. Properties of the helminth fauna of muskrats acclimatized in Kazakhstan [transl. from Russian] *in* Proc. Conf. Acclimatization Anim. USSR. A.I. Yanushenich (Ed.) Israel Prog. Sci. Transl.

Haley, A.J. 1958. Sex difference in the resistence of hamsters to infection with the rat nematode *Nippostrongylus muris*. Exp. Parasitol. 7:338-348.

Harley, J.P. 1972, A survey of the helminths of the muskrat, *Ondatra z. zibethica* Miller, 1912, in Madison county, Kentucky. Trans. Ky. Acad. Sci. 33(½):13-15.

Harper, F. 1961. Land and fresh-water mammals of the Ungava peninsula. Univ. Kans. Mus. Nat. Hist. Misc. Publ. No. 12 94p. *cited in* Whitaker, J.O. Jr. and N. Wilson. 1974. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Harwood, P.D. 1939. Notes of Tennessee helminths. IV. North American trematodes of the sub-family Notocotylinae. J. Tenn. Acad. Sci. 14:332-340, 421-437.

Hawking, F. 1975. Circadian and other rhythms of parasites. Adv. in Parasitol. 13:123-182.

Hays, K.L. and F.E. Guyton. 1958. Parasitic mites (Acarina:Mesostigmata) from Alabama mammals. J. Econ. Entomol. 51:259-260.

Herber, E.C. 1955. Life history studies on *Notocotylus urbanensis* (Trematoda: Notocotylinae). Penn. Acad. Sci. Proc. 29:267-275.

Hood, D.E. 1977. A study of the parasites, nest fauna and selected endocrine parameters of the redwinged blackbird *Agelaius phoeniceus* L. Master's thesis, Univ. of Manitoba.

Hughes, R.C. 1941. A key to the species of tapeworms in *Hymenolepis*. Trans. Am. Microsc. Soc. 60:378-414.

Jacobsen, B.R. 1967. The helminthofauna of small rodents in southern Manitoba. Master's thesis, Univ. of Manitoba.

James, M.T. and R.F. Harwood. 1969. Herms's Medical Entomology. Sixth Ed. MacMillan Pub. Co., New York.

Johnson, A.D. 1968. Life history of *Alaria marcianae* (La Rue, 1917) Walton, 1949 (Trematoda:Diplostomatidae). J. Parasitol. 54(2):324-332.

Johnson, C.E. 1925. The muskrat in New York; its natural history and economics. Roosevelt Wildl. Life Forest Exp. Sta. 3:205-320 *cited in* Penner, 1940.

Judd, W.W. 1950. Mammal host records of Acarina and Insecta from the vicinity of Hamilton, Ontario. J. Mammal. 31:357-358.

Karstad, L. 1964. Studies on Toxoplasmosis in muskrats and mink. Ont. Dept. Agric. Ann. Report Agr. Res. Inst. Apr. 1, 1963 to Mar. 31, 1964. p. 192.

Keegan, H.L. and R.A. Hedeen 1952. Collection of ectoparasitic mites from Alaska. J. Parasitol 38:360-361.

Kinsella, J.M. 1967. Helminths of microtinae in western Montana. Can. J. Zool. 45:269-274.

Kinsella, J.M. 1971. Growth, development, and intraspecific variation of *Quinqueserialis quinqueserialis* (Trematoda:Notocotylidae) in rodent hosts. J. Parasitol. 57(1):62-70.

Knight, I.M. 1951a. Diseases and parasites of the muskrat (*Ondatra zibethica*) in British COlumbia. Can. J. Zool. 29:184-215.

Knight, I.M. 1951b. A report on mites infesting the muskrat (*Ondatra zibethica osoyoosensis*) in British Columbia. Can. Entomol. 83:279-280.

Kohls, G.M. 1952. A record of the occurrence of the tick *Ixodes muris* Bishopp and Smith on muskrats in Utah. Great Basin Natural. 12:65-66.

Kuntz, R.E. 1943. Cysticercus of *Taenia taeniaformis* with two strobilae. J. Parasitol. 29:424-425.

Law, R.G. and A.H. Kennedy 1932. Parasites of fur-bearing animals. Ont. Govern. Exp. Fur Farm Bull. No. 4. 30p.

Lawrence, W.H. 1965. Arthropodous ectoparasites from some northern Michigan mammals. Occas. Pap. Univ. Mich. Mus. Zool., No. 639. 7p. *cited in* Whitaker, J.O. Jr. and N. Wilson. 1974. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Lawrence, W.H., K.L. Hays and S.A. Graham. 1961. Ectoparasites of the beaver (*Castor canadensis* Kuhl). Wildl. Dis. No. 12. 13p. *cited in* Whitaker, J.O. Jr. and N. Wilson. 1974. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Leidy, J. 1858. Contributions to Helminthology. Proc. Acad. Nat. Sci. 10:110-112.

Leidy, J. 1888. Trematodes of the muskrat. Acad. Nat. Sci. of Philadelphia, Proc. 40:126-128.

Leigh, W.H. 1940. Preliminary studies on parasites of upland game birds and fur-bearing mammals in Illinois. Bull. Ill. Nat. Hist. Survey 21(5):185-194.

Linton, E. 1915. Cestode cysts from the muskrat. J. Parasitol. 2:46-47.

Locker, B. 1955. The identification of *Taenia tenuicollis* Rudolphi, 1819, in North America. J. Parasitol. 41:51-56.

Lord, R.D. Jr. 1959. The lens as an indicator of age in cottontail rabbits. J. Wildl. Manag. 23(3):358-360.

Lubinsky, G. 1956. On the probable presence of parasitic liver cirrhosis in Canada. Can. J. Comp. Med. 20(12):457-465.

MacCreary, D. 1945. Some ectoparasites, excluding Ixodoidea, of Delaware mammals. J. Econ. Entomol. 38(1):126-127.

Macy, R.W. 1931. New bat trematodes of the genera *Plagiorchis, Limatulum* and *Dicrocoelium*. J. Parasitol. 18:28-33.

Macy, R.W. and J.A. Biggs. 1953. Epizootic in eastern Oregon muskrats associated with massive infection of *Hymenolepis ondatrae* Rider and Macy. J. Parasitol. 39:570.

Malek, E.A. 1977. Geographical distribution, hosts, and biology of *Schistosomatium douthitti* (Cort, 1914) Price, 1931. Can. J. Zool. 55(4):661-671.

McMullen, D.B. 1937. The life histories of three trematodes, parasitic in birds and mammals, belonging to the genus *Plagiorchis*. J. Parasitol. 23(3):235-243.

Meyer, M.C. and J.R. Reilly. 1950. Parasites of muskrats in Maine. Am. Midl. Nat. 44:467-477.

Montgomery, G.G. 1963. Freezing, decomposition, and raccoon lens weight. J. Wildl. Manag. 27(3):481-483.

Murrell, K.D. 1965. Stages in the life cycle of *Wardius zibethicus* Barker, 1915. J. Parasitol. 51(4):600-604.

Neiland, K.A. and C.M. Senger 1952. Helminths of northwestern mammals. Part I. Two new species of *Hymenolepis*. J. Parasitol 38:409-414.

Olivier, L. 1938. A new trematode, *Allassogonoporus marginalis*, from the muskrat. J. Parasitol 24:155-160.

Olsen, O. W. 1939. Schizotaeniasis in muskrats. J. Parasitol. 25:279.

Olsen, O.W. 1974. Animal Parasites. Univ. Park Press, Baltimore.

Park, J.T. 1936. New trematodes from birds, *Plagiorchis noblei* sp. nov. (Plagiorchidae) and *Galactosomum humbargari* sp. nov. (Heterophyidae). Trans. Am. Microsc. Soc. 55:360-365.

Penn. G.H. Jr. 1942a. Parasitological survey of Louisiana muskrats. J. Parasitol. 28:348-349.

Penn, G.H. Jr. 1942b. The life history of *Porocephalus crotali* a parasite of the Louisiana muskrat. J. Parasitol. 28:277-283.

Penn, G.H. Jr. and E.C. Martin 1941. The occurrence of Porocephaliasis in the Louisiana muskrat. J. WIldl. Manag. 5(1):13-14.

Penner, L.R. 1938. Schistosomatium from the muskrat, *Ondatra zibethica,* in Minnesota and Michigan. J. Parasitol. 24(Abstr. Suppl.) #59.

Penner, L.R. 1940. Morphological and biological studies on certain Helminths of the muskrat. Ph.D. thesis, Univ. of Minnesota.

Penner, L.R. 1941. The status of *Urotrema shillingeri* Price, 1931 (Trematoda:Urotrematidae). Trans. Am. Microsc. Soc. 60:359-364.

Petrochenko, V.I. 1971. Acanthocephala of Domestic and Wild Animals. [Transl. from Russian] Keter Press, Jerusalem.

Price, E.W. 1931. Four new species of trematode worms from the muskrat, *Ondatra zibethica* with a key to the trematode parasites of the muskrat. Proc. U.S. Nat. Mus. 79(4):1-13.

Price, E.W. 1932. *Hepaticola hepatica* in the liver of *Ondatra zibethica*. J. Parasitol. 18:51.

Radford, C.D. 1944. New Parasitic mites (Acarina) from rodents. Parasitology 35(4):161-166.

Radford, C.D. 1950. A revision of the fur mites Myobiidae (Acarina). Bull. Mus. Hist. Natur. Paris (2nd Ser.) 22:462-469, 582-586 *cited in* Whitaker, J.O. Jr. and N. Wilson. 1974. Host and distribution lists of mites (Acari), parasitic and phoretic, in the hair of wild mammals of North America, north of Mexico. Am. Midl. Nat. 91(1):1-67.

Rau, M.E., T.K.R. Bourns and J.C. Ellis. 1972. An improved method for collecting Schistosome miracidia. Int. J. Parasitol. (1972) 2pp : 279-280.

Rausch, R.L. 1946. Parasites of Ohio muskrats. J. Wildl. Manag. 10:70.

Rausch, R.L. 1948. Notes on the cestode genus *Andrya* Railliet, 1883, with the description of *A. ondatrae* n.sp. (Cestoda:Anoplocephalidae). Trans. Am. Microsc. Soc. 67:187-191.

Rausch, R. 1952. Studies on the helminth fauna of Alaska. XI. Helminth parasites of microtine rodents -- taxonomic considerations. J. Parasitol. 38:415-444.

Rausch, R., B.B. Babero, R.V. Rausch and E.L. Schiller. 1956. Studies on the helminth fauna of Alaska. XXVII. The occurrence of larvae of *Trichinella spiralis* in Alaskan mammals. J. Parasitol. 42:259-315.

Read, C.P. 1949a. Studies on North American helminths of the genus *Capillaria* Zeder, 1800 (Nematoda):I. Capillarids from mammals. J. Parasitol. 35(3):223-230.

Read, C.P. 1949b. Studies on North American helminths of the genus *Capillaria* Zeder, 1800 (Nematoda): II. Additional Capillarids from mammals with keys to the North American species. J. Parasitol.35(3):231-239.

Rice, E.W. and O.B. Heck. 1975. A survey of the gastrointestinal helminths of the muskrat, *Ondatra zibethicus,* collected from two localities in Ohio. Ohio J. Sci. 75(5):263-264.

Rider, C.L. and R.W. Macy. 1947. Preliminary survey of the helminth parasites of muskrats in northwestern Oregon, with description of *Hymenolepis ondatrae* n. sp. Trans. Am. Microsc. Soc. 66:176-181.

Rupes, V. and J.O. Whitaker, Jr. 1968. Mites of the subfamily Labidophorinae (Acaridae, Acarina) in North America. Acarologica 10(3):493-499.

Rupes, V., C.E. Yunker and N. Wilson. 1971. *Zibethicarus,* N. Gen., and three new species of *Dermacarus* (Acari:Labidophoridae). J. Med. Entomol. 8(1):17-22.

Schell, S.C. 1970. The Trematodes. Wm. C. Brown Co., Pub., Dubáque, Iowa.

Schmidt, G.D. The Tapeworms. Wm. C. Brown Co., Pub., Dubaque, Iowa.

Senger, C.M. and R.W. Macy. 1952. Helminths of northwest mammals. Part III. The description of *Euryhelmis pacificus* n.sp. and notes on its life cycle. J. Parasitol. 38:481-487.

Senger, C. and K.A. Neiland. 1955. Helminth parasites of some fur-bearers of Oregon. J. Parasitol. 41:637-638.

Senger, C.M. and J.W. Bates. 1957. The occurrence of *Hymenolepis evanginata* and *H. ondatrae* in Utah muskrats. Proc. Helminthol. Soc. Wash. 24:141-142.

Seton, E.T. 1909. Life Histories of Northern Animals. An account of the Mammals of Manitoba. Vol. 1 Arno Press, New York.

Sey, O. 1966. Contributions to knowledge of internal parasites of muskrats (*Ondatra zibethica*) living along the river Tisza [in Russian]. Tiscia 2:89-95 *cited in* Biol. Abstr. 49 no. 31762.

Sey, O. 1967. Modifications of the American muskrat's (*Ondatra zibethica)* parasitic fauna due to acclimatisation [in Russian]. Acta. Zool. Acad. Sci. Hung. (13 (3/4):409-416 *cited in* Biol. Abstr. 49 no. 31761.

Sharpilo, L.D. and V.P. Sharpilo. 1972. Relation of certain forms of the genus *Plagiorchis*, parasites of reptiles and rodents, to the species *Plagiorchis elegans* (Trematoda:Plagiorchiidae). Problemy parazitologia 425-427 *in* Helminthol. Abstr. 45a (3): 208 No. 1196.

Skinker, M.S. 1935. A redescription of *Taenia tenuicollis* Rudolphi, 1819, and its larva, *Cysticercus talpae* Rudolphi, 1819. Parasitology. 27:175-185.

Skrjabin, K.I. 1958. The Trematode Parasites of Animals and Man. Vol. 14. [in Russian]. Academy of Science USSR, Moscow.

Smith, F.R. 1938. Muskrat investigations in Dorchester county, Md. 1930-1934. U.S. Dept. Agriculture: circular no. 474.

Smith, R.J. 1958. The miracidium of *Wardius zibethicus* (Trematoda: Paramphistomatidae). J. Parasitol. 44:195.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical Methods. Sixth Ed. Iowa State Univ. Press. Ames, Iowa.

Sokal, R.R. and F.J. Rohlf. 1973. Introduction to Biostatistics. W.H. Freeman and Co., San Francisco.

Stiles, C.W. and A. Hassall. 1894. A preliminary catalogue of the parasites contained in the collection of the U.S. bureau of animal industry, U.S. Army Med. Mus., Biol. Dept. of the Univ. of Penn. and in collections Stiles and Hassall. Vet. Mag. 1894:245-253, 331-354 *cited in* Penner, 1940.

Svihla, A. and R.D. Svihla. 1931. The Louisiana muskrat. J. Mammal. 12:12-18.

Sweatman, G.K. 1952. Endoparasites of muskrats in the vicinity of Hamilton, Ontario. J. Mammal. 33:248-249.

Sweatman, G.K. 1971. Mites and pentastomes *in* Parasitic Diseases of Wild Mammals. J.W. Davies and R.C. Anderson, Ed. Iowa State Univ. Press, Ames, Iowa.

Takoš, M.J. 1940. A review of literature on disease and parasites of the muskrat. Maine Coop. Wildl. Res. Unit, 14p.

Tiner, J.D. 1950. Two new species of *Trichuris* from North America, with redescriptions of *Trichuris opaca* and *Trichuris leporis* (Nematoda:Aphasmidia). J. Parasitol. 36:350-355.

Tiner, J.D. and T.H. Chin. 1948. The occurrence of *Ascaris lumbricoides* L. 1758 in the muskrat *Ondatra zibethica* L. J. Parasitol. 34:253.

Tipton, V.J. 1960. The genus *Laelaps*. Univ. Calif. Pub. Entomol. 16(6):233-356.

Travis, B.V. 1939. Descriptions of five new species of flagellate protozoa of the genus *Giardia*. J. Parsitol. 25:11-17.

Ulbrich, J. 1930. Die Bisamratte. Verlag und Druck von C. Heinrich, Dresdan.

Vaňatka, F. 1970. Endoparasites in muskrats (*Ondatra zibethica*). Acta Veterinaria 38(3):381-389.

Wallace, F.G. and L.W. Penner. 1939. A new liver fluke of the genus *Opisthorchis*. J. Parasitol. 25:437-440.

Warwick, T. 1936. The parasites of the muskrat (*Ondatra zibethica* L.) in the British Isles. Parasitology 28:395-402.

Webster, W.A. 1966. A morphological description of *Capillaria michiganensis* Read 1949: male and female. Can. J. Zool. 44:982-983.

Whitaker, J.O. Jr. and N. Wilson. 1968. Mites of small mammals of Vigo County, Indiana. Am. Midl. Nat. 80:537-542.

Wootton, D.M. and K.D. Murrell. 1967. *Ptyalincola ondatrae,* Gen. and Sp. N. (Trematoda:Brachylaimidae) a fluke inhabiting the salivary glands of muskrats. J. Parasitol. 53(4):739-742.

Yorke, W. and P.A. Maplestone 1962 The Nematode Parasites of Vertebrates. Hafner Pub. Co., New York.

APPENDIX I

Technique for Staining and Clearing of Acanthocephala.

1. From 70% ethanol (storage) transfer specimens to 35% ethanol for 5 minutes.
2. Transfer to water for 5 minutes.
3. Transfer to 0.25% trisodium phosphate* for 20 to 30 minutes at 55°C.
4. Return to water for 5 minutes.
5. Transfer to 35% ethanol for 5 minutes.
6. Transfer to 70% ethanol and brush off mucous and debris.
7. Stain for 0.5 hour or longer as required. Stain consists of 1 part Semichon's aceto-carmine to 2 parts 70% ethanol.
8. Destain in acid 70% ethanol for a few seconds.
9. Rinse specimens in 70% ethanol and flatten between coverslips. Use paper clips as carriers.
10. Transfer to 85% ethanol for 5 to 10 minutes.
11. Transfer to 95% ethanol for 5 to 10 minutes.
12. Transfer to 100% ethanol (absolute) for 5 to 10 minutes.
13. Transfer to a second change of 100% ethanol for 5 to 10 minutes and remove cover slips. Add a drop of methyl salicylate (2 to 5 times) at 2 minute intervals.
15. Transfer to methyl salicylate to clar; when the specimens sink they are cleared.
16. Mount in permount, or other mountant.

* 0.25% trisodium phosphate: Dissolve 28.3 g in 100 ml of water; dilute 1 in 50 with water for use. Filter. This is approximately 0.25%.

APPENDIX II

Measurements of *Quinqueserialis quinqueserialis*, *Alaria mustelae*, *Wardius zibethicus*, *Hydatigera taeniaformis* and *Capillaria michiganensis* recovered in this study.

TABLE XI Measurements of *Quinqueserialis quinqueserialis* in this study.

n = 15

Character	Measurements (μm) range	(mean)
length	2506-3917	(3160)
width (at post. testes)	778-1627	(1264)
oral sucker (width)	269.1-397.8	(345.9)
right testes length	292.5-538.2	(420.4)
left testes length	304.2-549.9	(411.2)
ovary length	198.9-444.6	(286.3)
uterine coil (max. width)	351.0-819.0	(595.1)
egg length*	17.4-20.3	(19.0)

*n = 45

TABLE XII Measurements of *Alaria mustelae* in this study.

n = 10.

Character			Measurement (μm) range	(mean)
length	forebody		527-991	(667)
	hindbody		456-702	(581)
	overall		1083-1793	(1248)
width	forebody		281-433	(372)
	hindbody		281-468	(356)
oral sucker*		length	63.8	-
		width	40.6	-
ovary†	length		95.7-102	(99)
	width		90-116	(105)
anterior testes		length	117-222	(156)
		width	176-293	(241)
posterior testes		length	117-175	(159)
		width	210-316	(268)
eggs¶	length		104-128	(119)
	width		58-75	(69)

*measurements of oral sucker generally impossible to make

†n = 3

¶n = 20

TABLE XIII Measurements of *Wardius zibethicus* in this study.

n = 12

Character	Measurements (μm) range	(mean)
length	10-14 mm	(11.8 mm)
width	2016-3168	(2630)
oral sucker length	720-1008	(833)
width	622-950	(811)
diverticula* length	331-634	(520)
width	259-432	(364)
posterior sucker length	1440-2505	(2244)
width	1152-2275	(2026)
ovary diamter†	461-634	(528)
testes∏ (averaged) length	-	(1051)
width	-	(1258)
egg length¶	164-199	(181)

Measurements in μm unless otherwide noted.

*n=8

†n=3

∏n=6

¶n=40

TABLE XIV Measurements of *Hydatigera taeniaformis* in this study.

Character	Measurements (μm) range	(mean)
first row hooks* (anterior)	380-420	(397)
second row hooks*	234-269	(250)

*n = 10

TABLE XV Measurements of *Capillaria michiganensis* in this study.

n = 14

Character	Male measurements (n = 6) range	(mean)	Female measurements (n = 8) range	(mean)
length	12.1-23.4mm	(16.2mm)	15.7-30mm	(21.0mm)
width at vulva*	-	-	-	(34.8)
spicule length	1.591-1.838mm	(1.658mm)	-	-
distance of vulva to anterior	-	-	6.6-9.5mm	(8.11mm)
egg† length	-	-	49.3-58.0	(52.0)

Measurements in μm unless otherwise noted.

*n = 1

†n = 24

APPENDIX III

Unprovoked Attack by a Muskrat

In July 1976, a researcher at the University Field Station was attacked, without provocation, by a muskrat, which then escaped. Subsequent capture and examination of four muskrats from the immediate area for rabies proved negative. Also in July and early August, muskrats were dying at Delta and other marshes in Manitoba for no apparent reason. Two animals were autopsied by the Provincial Veterinary laboratory, but the cause of death was not ascertained.

Winter Kill

The 1976-1977 winter was particularly hard on muskrats in southern Manitoba. Low rainfall resulted in very low water levels which in Delta Marsh at least, meant many of the areas of the marsh freezing to the bottom, with the end result being the situation described by Seton (1909), quoted under Host Biology. Estimates for winter kill at Oak Hammock Marsh were 80-90% (Stardom, pers. comm.), while at Delta the estimate was between 60 and 80% (Jones, pers. comm.). This reduction in muskrat numbers was apparent in the spring of 1977 when attempts to trap muskrats proved extremely difficult. It also prevented a winter sample of Delta muskrats which interfered with an evaluation of seasonal variation of ectoparasites, beyond the observation that the intensity of infections increased over the summer months.