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METAZOAN PARASITES OF THE MUSKRAT,

<u>ONDATRA</u> <u>ZIBETHICA</u> <u>CINNAMOMINUS</u>,

FROM THE ENGLISH COULEE

GRAND FORKS COUNTY, NORTH DAKOTA

by

David A. Boyd IV

B. A. in Zoology, University of Minnesota, 1963

A Thesis

Submitted to the Faculty

of the

Graduate School

of the

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in partial fulfillment of the requirements

for the Degree of

Master of Science

Grand Forks, North Dakota

August

1967

This thesis submitted by David A. Boyd in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota is hereby approved by the Committee under whom the work has been done.

Chairman

Dean of the Graduate School

253376

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Appreciation for helpful services is extended to Dr. Vera Facey for help in composing the floral lists for the study area, and to the North Dakota Game and Fish Department for the loan of traps. I would also like to thank Dr. James Reilly for his assistance in proof-reading this thesis.

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ABSTRACT

During the fall of 1966 and the spring of 1967, 55 muskrats were trapped along the reaches of the English Coulee, Grand Forks County, North Dakota. These muskrats were necropsied and all ectoparasites and endoparasites collected. The parasites were stained and identified and the number of worms counted to discern the parasite burden.

Eight species of parasites were found. The only ectoparasite encountered was *Laelaps multispinosus* (89.09 per cent incidence). Four species of trematodes were identified as *Echinostoma revolutum* (34.54 per cent), *Quinqueserialis quinqueserialis* (47.27 per cent), *Notocotylus urbanensis* (41.81 per cent), and *Plagiorchis proximus* (14.54 per cent). Two species of cestodes were found. These were *Hymenolepis evaginata* (3.63 per cent) and the larval stage of *Hydatigera taeniaeformis* (16.36 per cent). Only one specimen of a nematode was found. This was *Trichuris opaca* (1.81 per cent).

It was concluded that the worm burden was not sufficient to cause disease, and no obvious pathology was found in any of the muskrats examined.

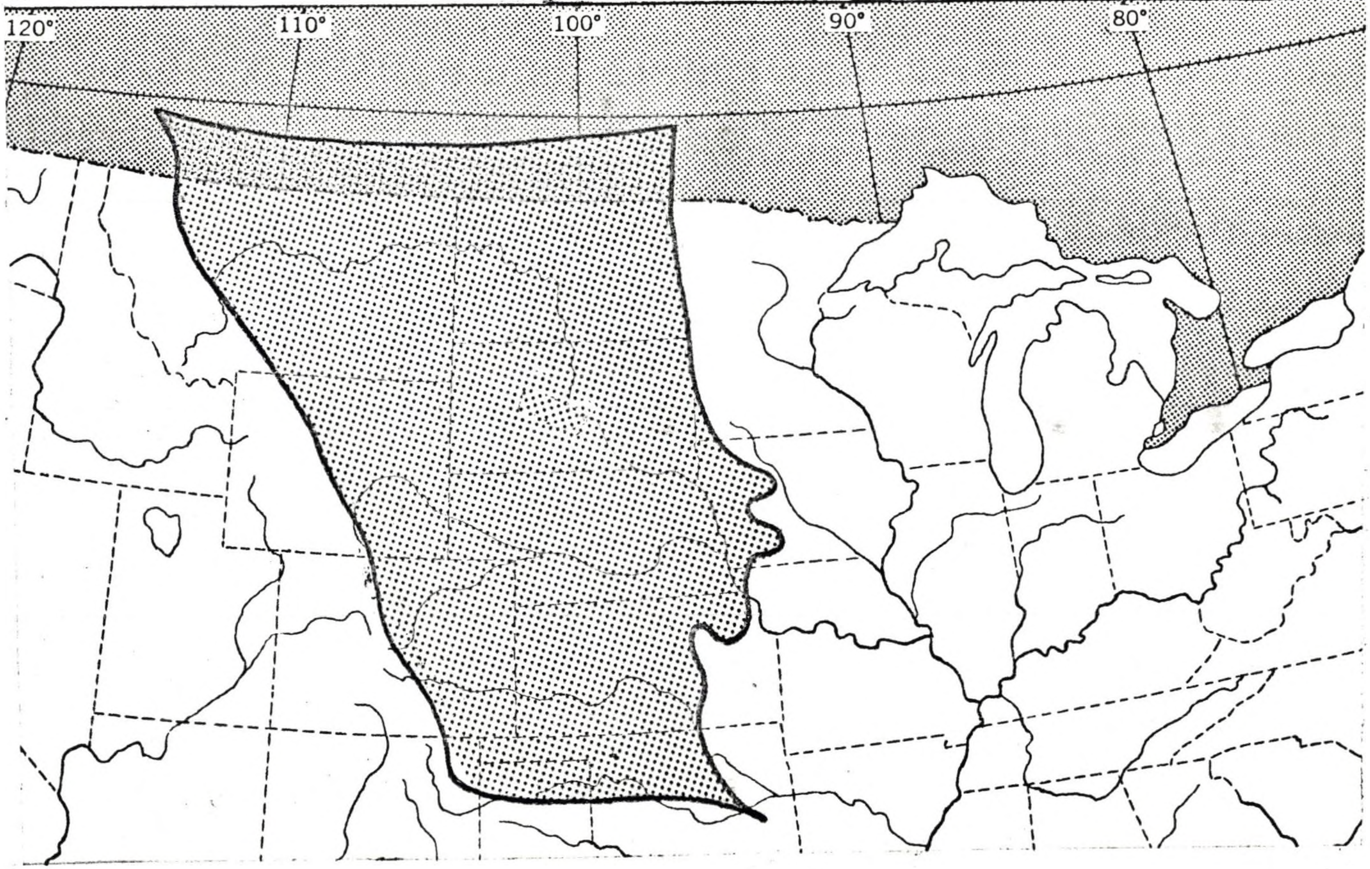
INTRODUCTION

The purpose of this study was to survey the metazoan parasites of the Great Plains muskrat (Ondatra zibethica cinnamominus Hollister, 1911) from the English Coulee in Grand Forks County, North Dakota. The only previous report of parasites of North Dakota muskrats is that of Goldsby and Johnston (1951) who examined a "large number" of muskrats in Lower Souris National Wildlife Refuge. Early distribution records and life history studies of North Dakota muskrats were presented by Bailey (1926). More recently Seabloom and Beer (1963) studied the population dynamics of this rodent in Towner County. According to Bailey (1926) and Hall and Kelson (1959), the muskrat subspecies in this state is Ondatra zibethica cinnamominus Hollister, 1911. Since the eastern boundary of O. z. cinnamominus overlaps the western range of O. z. zibethicus L., 1776 (See text figure 1), it seemed quite possible that both subspecies could occur in the English Coulee.

Since the study area is located in the ecotone between the Great Plains and the Northern Deciduous Hardwood Forest (Pitelka, 1941), the question arose whether the animals would possess parasites of either region or a mixture of both. While the parasites of muskrats have been studied in most of the major geographical and ecological subdivisions of North

FIGURE 1

DISTRIBUTION OF ONDATRA Z. CINNAMOMINUS



America, no study of possible ecological interactions from the ecotone has been reported. It was felt that a comparison with other surveys should indicate whether the parasitic fauna was typical of either biome, or unique to the ecotone.

To test the hypothesis of whether the ecotone might influence the abundance and types of parasites, a total of 55 muskrats were taken from the English Coulee in the fall of 1966 and spring of 1967. The main body of this thesis concerns the parasites recovered from these hosts.

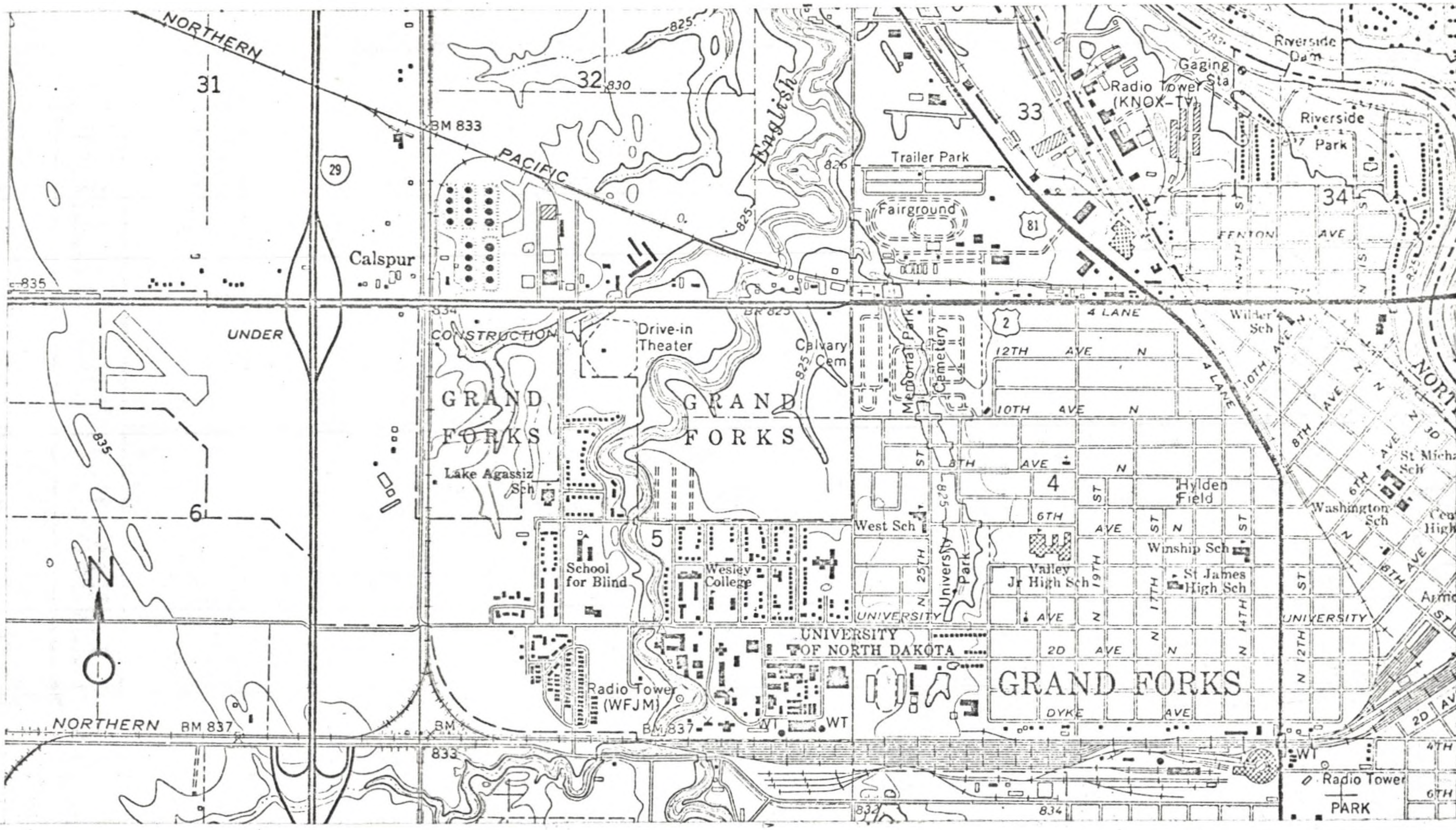
DESCRIPTION OF THE STUDY AREA

The study area was located on the western and northwestern edge of Grand Forks (Sec. 5, T. 151 N., R. 49 W.; Sec. 32 T. 152 N., R. 49 W.), Grand Forks County, North Dakota, and consisted of a three mile stretch of the English Coulee, a tributary of the Red River of the North (Text figure 2). The English Coulee is about eight miles in length, and meanders northward through the eastern edge of Grand Forks County. The banks are variable, ranging from steep slopes to level banks. The bottom is composed of muddy silt ranging from one to five feet in thickness. In addition to the mud, the detritus of civilization, namely beer cans, broken glass, concrete reinforcements, posts, and barbed wire litter the bottom.

Water for the English Coulee consists of rainfall, drainage from the surrounding land, and from ditches in adjacent areas. The English Coulee reaches its highest point immediately following the spring thaw (around April 15) and usually floods the surrounding land while reaching a depth of approximately nine feet. For this reason, no muskrat lodges are present in the water. The only signs of muskrat habitation are bank dens and feeding stations. The latter are mats of reeds upon which the muskrat sits while eating emergent vegetation. The low point of water is reached during August when its depth varies from three to seven feet.

FIGURE 2

STUDY AREA
SCALE 1:24000



During the winter, the muskrats migrate down the English Coulee to the Red River. According to Seabloom (personal communication), they may also migrate overland. Four visits after fresh snow falls failed to reveal tracks, signs, or holes in the ice typical of muskrat winter activity. Thaws during the winter yielded holes in the ice which gave off the heavy odor of hydrogen sulfide gas.

In addition to muskrats, the following mammals are found along the reaches of the Coulee: Microtus pennsylvanicus (Meadow Vole), Zapus hudsonius (Meadow Jumping Mouse), Peromyscus maniculatus (Deer Mouse), Mustela rixosa (Least Weasel), Mustela vison (Mink), Sorex arcticus (Arctic Shrew), Sorex cinereus (Masked Shrew), Blarina brevicauda (Shorttail Shrew), and Geomys bursarius (Plains Pocket Gopher). According to Seabloom (personal communication), raccoon (Procyon lotor), striped skunk (Mephitis mephitis), and fox (Vulpes fulva) also utilize the area.

According to Clements and Shelford (1939), the study area is within the ecotone of the true North American Grasslands Biome. Since most of the adjacent land is no longer virgin, this concept has little relevancy today. According to Facey (personal communication), various trees, shrubs, and woody vines occur along the English Coulee (Table 1).

Table 1

Woody Vegetation Along the English Coulee

Species	Common Name
TREES	
Acer negundo	Box Elder
Fraxinus pennsylvanicus	Green Ash
Populus deltoides	Cottonwood
Tilia americana	Basswood
Ulmus americana	American Elm
SHRUBS	
Amelanchier alnifolia	Juneberry
Artemisia frigida	Pasture Sage
Corylus americana	Hazelnut
Corylus cornuta	Beaked Hazel
Crataegus chrysocarpa	Hawthorn
Prunus americana	Wild Plum
Prunus virginiana	Chokecherry
Rhus radicans	Poison Ivy
Ribes americanum	Wild Black Currant
Ribes missouriense	Missouri Gooseberry
Rosa arkansana	Prairie Rose
Rosa blanda	Smooth Wild Rose
Rubus idaeus	Raspberry
Salix amygdaloides	Peach-leaved Willow
Spiraea alba	Wild Spiraea
Symphoricarpus occidentalis	Wolfberry
WOODY VINES	
Clematis virginiana	Virgin's Bower
Parthenocissus inserta	Woodbine

According to Halverson (unpublished checklist) the English Coulee possesses a varied assortment of emergent vegetation (Table 2).

Table 2

Emergent Vegetation in the English Coulee

Species	Common Name
Agropyron repens	Quackgrass
Alisma subcordatum	Water Plaintain
Anacharis occidentalis	Elodea
Apocynum sibiricum	Dogbane
Astragalus flexosus	Slender Milkvetch
Avena fatua	Wild Oat
Beckmannia syzigachne	Sloughgrass
Bromus inermis	Smooth Brome
Carex aquatilis++	Water sedge
Cicuta maculata	Water Hemlock
Cirsium vulgare	Bull Thistle
Convolvulus sepium	Large Bindweed
Elaegnus angustifolia	Russian Olive
Eleocharis calva	Spike rush
Elymus canadensis	Canada Wild-Rye
Elymus virginicus	Virginia Wild-Rye
Gallium boreale	Northern Bedstraw
Glyceria grandis	Tall Mannagrass
Hordeum jubatum	Wild Barley
Juncus balticus	Baltic Rush
Koeleria cristata	Prairie Junegrass
Lemna minor*	Duckweed
Lycopus americanus	Water Hoarhound
Myriophyllum exalbescens	Water Milfoil
Phaleris arundinacea	Reed-Canary Grass
Plantago major	Common Plaintain
Poa pratensis	Kentucky Bluegrass
Polygonum coccineum++	Long-rooted Smartweed
Potamogeton foliosus++	Leafy Pondweed
Potamogeton pectinatus++	Sago Pondweed
Potamogeton perfoliatus++	Clasping-leaved Pondweed
Potentilla anerina	Silvergrass
Ranunculus cymbalaria	Seaside Buttercup
Ratibida columnifera	Long-headed Coneflower
Ribes americanus	Wild Black Currant
Rosa blanda	Smooth Wild Rose
Rumex crispus	Curled Dock
Sagittaria cuneata++	Arrowhead
Salix amygdaloides++	Peach-leaved Willow

Table 2 - Continued

Species	Common Name
Salix petiolaris++	Slender Willow
Scirpus americanus++*	Chairmakers Rush
Scirpus atrovirens++*	Darkgreen Bulrush
Scirpus fluviatilis++*	River Bulrush
Scirpus validus++*	Common Bulrush
Solidago gigantea	Tall Smooth Goldenrod
Sonchus asper	Spiny Sow Thistle
Sparganium eurycarpum++*	Burreed
Spartina pectinata	Prairie Cordgrass
Symphoricarpos occidentalis	Wolfberry, Buckbrush
Taraxacum officinale	Common Dandelion
Typha latifolia++*	Broad-leaved Cattail
Vallisneria americana	Eelgrass
Zizania aquatica++	Wild Rice

++ Probable food plant utilized by muskrat (from Errington,1963)
* May be utilized in building bank den (from Errington, 1963)

An abundant invertebrate fauna is possessed by the English Coulee. Possible intermediate hosts include Lymnea stagnalis, Physa sp., Helisoma antrosa, Ferrisia sp., Gyraulus parvus, and Amnicola sp. among the Gastropods, and the finger-nail clams Pisidium sp. and Sphaerium sp. These were either identified by the author or taken from graduate student collections.

LITERATURE REVIEW

Food and Building Habits of the Muskrat

Food habits

In any consideration of parasitism, it is important to determine how the parasite enters the host. With a knowledge of the food habits of the host, one can better understand the life history of the parasite. Muskrats use their environment to obtain two essential things: nutrition and shelter.

Although, primarily herbivorous, muskrats may be carnivorous, omnivorous, or at high population levels, cannibalistic (Errington, 1963). They possess the large caecum of herbivores, and according to Luppa (1956), they do not possess any morphological adaptations for a carnivorous diet. They also use the most available vegetation for the construction of bank dens and open water lodges. Errington (1963) in an extensive review presents the food habits of the muskrat and defines the optimum environment for muskrats as fresh to moderately brackish water with a large amount of cattails, bulrushes, and other edible emergent vegetation.

The principal food plants that may predispose an area for a heavy concentration of muskrats are burreed (Sparganum), duck potato (Sagittaria), sago pondweed (Potamogeton), wild rice (Zizania), willows (Salix), sedges (Carex), smartweeds (Polygonum), assorted legumes and composites. Of lesser importance are the reeds (Phragmites) and the yellow water lily (Nuphar) (Errington, 1941a; BellRose, 1950). The bulrush, Scirpus olneyi is preferred by Northern Plains muskrats (Lay, 1945; Lynch, O'Neil, and Lay, 1947; O'Neil, 1949). However, in the far North, goose grass (Equisetum fluviatile) becomes the food of choice. The most preferred foods, when available, are cultivated ear corn along with soybeans (Errington, 1963).

During periods of low water or freeze-up, muskrats may use two sources of food. If the vegetation is merely frozen, they may utilize cattails, bulrushes, caches of ear corn, and tubers of duck potato, If sufficient vegetation is not available, they may become carnivorous. Merriam (1884) found that muskrats ate such fish as carp, sucker, and trout. Lantz (1910) observed that muskrats had been seen feeding on bodies of dead and wounded ducks, and Hollister (1911) cited evidence that muskrats eat mussels, fish, dead birds, and amphibians. Barker and Laughlin (1911) record the finding of large numbers of snails in the stomachs of muskrats. Johnson (1925) found that muskrats would feed on their own dead as well as on insects, crayfish, snails, fish, young birds, amphibians, and reptiles. Evermann and Clark (1920) reported that muskrats would feed on dead coots and ducks, turtles, fish crayfish, and frogs. Smith (1938) found that muskrats would utilize the blue crab (Callinectes sapidius) and salt water mussels, and on the basis of feeding experiments would also eat fish and small birds. Sather (1950) reported that black bullheads (*Ictalurus melas*) were also a dietary item for muskrats. Glass (1956) presented evidence that after the heads and limbs of hibernating turtles (*Pseudemys scripta troosti*) had been gnawed off and abandoned by raccoons (*Procyon lotor*), the carapaces were gnawed open and the carcasses consumed by muskrats. According to Errington (1963), fish congregated at the entrances and channels of the muskrat lodges during freeze-up. If the water in these entrances freezes, the muskrats may gnaw on the frozen mass and derive nourishment from this frozen cache.

Building habits

In lodge building, the muskrat utilizes emergent vegetation such as hardstem bulrush, river bulrush, cattail, reed grass, smartweed, and various sedges. Preferred submergent plants are coontail, bladderwort, duckweed, and various pondweeds (Sather, 1950). Errington (1963) reported the use of algae for filler and lining material. Buckley and Hicks (1962) gave information on the plant materials used in muskrat lodges on Goose Lake in Iowa. They found that the muskrat utilized *Lemna minor* (lesser duckweed), *Scirpus acutus* (hard-stemmed bulrush), *Scirpus fluviatilis* (river bulrush), *Sparganium eurycarpum* (large burreed), Spirodela polyrhiza (greater duckweed), Typha angustifolia (narrow-leaved cattail), and Wolffia punctata (dotted wolffia).

Diseases of the Muskrat

Epizootics among muskrats may be caused by pathogenic fungi, bacteria, viruses, protozoa, neoplasms, and metazoan parasites. Each of these etiological groups is reviewed below.

Fungal infections

Errington (1942b) and Dozier (1943) found outbreaks of the "ring worm" fungus, *Trichophyton mentagrophytes*, in muskrats from Iowa and Maryland. The former author specified that this epizootic was chiefly confined to very young muskrats.

Jellison (1950a) found extensive growths in the lungs of 18 per cent of 126 animals studied in Montana, and was able to identify the etiological agent as *Haplosporangium* sp. Knight (1951a) found four muskrats with a fungal infection of the lungs in British Columbia. She was unable to identify the fungus, but was able to pass the infection in rats, but not in rabbits. Her description is similar to that of Jellison, and it is probable that the infection was caused by *Haplosporangium* sp.. Rider and Macy (1947) found *Haplosporangium* sp. in the lungs of Oregon muskrats.

Dowding (1948) identified spores of *Emmonsia crescens* in the lungs of muskrats taken from British Columbia, and Grundmann and Tsai (1967) found the same fungus in the lungs of a single muskrat from Utah. Dozier (1943) reported that "lumpy jaw" in Maryland muskrats was caused by Blastomyces sp..

Bacterial infections

Errington (1963) and Armstrong (1942) have isolated Salmonella typhimurium from muskrats during population die-offs in Maryland.

Pasteurella pestis has never been reported as a cause for epizootics of muskrats. P. tularensis, on the other hand, does sweep through and decimate populations. In an extensive literature review, Parker, et al., (1951) recorded epidemics in Maine, New York, Ontario, Indiana, Michigan, Wisconsin, Iowa, Minnesota, Manitoba, Alaska, Montana, Idaho, Wyoming, Washington, Oregon, Utah, and Nevada.

Rausch (1946) in Ohio found a subcutaneous abscess that probably arose from fighting. Another muskrat had signs of "croupous pneumonia."

Viral infections

Errington's (1963) review of hemorrhagic disease of muskrats reveals an epizootic of uncertain etiology, but highly suggestive of a viral disease. Necropsies revealed a multiplicity of hemorrhagic areas in the lungs, liver, and intestine of the muskrat. Errington reported that outbreaks of this disease have occurred in Oregon, Montana, Idaho, British Columbia, Saskatchewan, Manitoba, North Dakota, South Dakota, Nebraska, Minnesota, Wisconsin, Michigan, Ontario, Ohio, New York, Pennsylvania, Maryland, New Jersey, and Delaware.

Protozoan infections

Shillinger (1938) speculated that massive infections of coccidia occur during low water due to the buildup of infective cysts in the muskrat's waterways. He further felt that significant mortality could occur from such hyperinfection.

Other protozoan parasites such as Trichomonas and Giardia apparently do not cause disease in muskrats.

Malignant neoplasms

Rausch (1946), working with parasites of muskrats in Ohio, reported adenocarcinoma of the lung in one muskrat. Gallati (1956) described a fibrosarcoma of a muskrat liver associated with three strobilocerci of Hydatigera taeniaeformis. Knight (1951a) reported tumor-like masses, two of which occurred in the axillary regions, and one on the side of the neck. Due to the extreme post-mortem decomposition, she was unable to determine the effect of this pathology, but she considered them to be encapsulated abscesses. She also described a proliferative osteitis of the bones of the forelimbs following the loss of limbs through trapping.

Metazoan parasite infections

The only mention in the literature of disease associated with parasitic infections was that of an epizootic occurring in Oregon (Macy and Biggs, 1953). In this case the disease was associated with and presumably caused by *Hymenolepis ondatrae*. All other authors, if they consider the health of the host at all, report that muskrats seem to tolerate their parasitic infections, be it heavy or light, with no sign of discomfort or disease.

REVIEW OF THE LITERATURE OF METAZOAN PARASITES

The literature on muskrat parasites is quite extensive and dates back over a century. Leidy (1858) described Monostomum affine from the bile duct and gall bladder of a Pennsylvania muskrat. Since the description is such that the worm can not be recognized, it usually is omitted by taxonomists from parasite keys and historical checklists. In 1888, the same author mentioned two other species, Echinostomum echinatum (= E. revolutum) and another which he identified as Amphistomum subtriquetrum. Barker (1915b) felt that the latter species was probably Wardius zibethicus. It should be noted that from 1911 through 1916, Barker and his co-workers published a number of papers on muskrat parasites from Nebraska. These publications were based on the first comprehensive parasite survey to be conducted on North American muskrats.

Other early North American records include Bank's (1909) description of the mite, Laelaps multispinosus, the most common ectoparasite of muskrats. Linton (1915) reported Cysticercus fasciolaris (the larva of Hydatigera taeniaeformis) from the livers of Pennsylvania muskrats.

Apparently the earliest European record is that of Beddard (1912) who found a cestode in the bile duct of a muskrat from the London Zoological Gardens. Yamaguti (1959) believed that the parasite was actually the larva of H. taeniaeformis.

It should be noted that since the muskrat is not native to Europe (yet has done very well there), the parasites are of special interest. The retention of North American parasites and the acquisition of European species raise interesting questions concerning zoogeography, life cycles, and the adaptive capabilities of parasites to cope with new environments.

Since the purpose of this thesis is to report a parasite survey, the remainder of this review is restricted to the major surveys of muskrat parasites reported for North America. These include Canadian surveys by Law and Kennedy (1932), Swales (1933), Allen (1934), Knight (1951a), and Sweatman (1952). In the United States similar work has been reported from Maine (Meyer and Reilly, 1950), New York (Edwards, 1949), Ohio (Rausch, 1946), Michigan (Ameel, 1942), Illinois (Gilford, 1954), Nebraska (Barker, 1915b), Louisiana (Penn, 1942b), Texas (Chandler, 1941), Colorado (Ball, 1952), Utah (Senger and Bates, 1957; Grundmann and Tsai, 1967), Oregon (Rider and Macy, 1947), and Alaska (Dunagan, 1957). All parasites reported from these surveys and other pertinent literature are presented in tabular form in Appendix 2.

METHODS AND MATERIALS

Examination of the Host

Fifty muskrats were trapped in the fall of 1966 and another five in the spring of 1967. They were trapped using number 1 and 1.5 steel-traps. If the animal was not dead in the trap, it was killed by collapsing its rib cage. The dead animals were transported to the laboratory and immediately examined. When several muskrats were taken at one time, the carcasses awaiting necropsy were refrigerated until they could be examined. In addition to the pelt, the following organs were examined: eyes, trachea, heart, esophagus, stomach, intestinal tract, liver, gall bladder and ducts, kidneys, and urinary bladder. Standard weights and measurements were taken for all hosts.

Examination of the pelt involved holding the animal by the tail over a piece of white paper. A coarse toothbrush was then run briskly through the fur to dislodge any possible ectoparasites. Those which dislodged were removed from the paper with forceps and fixed.

Internal tissues and organs were exposed by an incision at the ventral midline of the animal. The pleural and peritoneal cavities were examined for parasites and necrotic areas or petechial hemorrhages. The bottom of the heart was then cut off and duplicate blood smears were made for microfilariae examinations. Sections of the diaphragm were excised and press preparations were checked for the presence of *Trichinella spiralis*. The stomach was removed after clamping a hemostat at the pyloric valve. The organ was then slit along its greater curvature and dropped into a gallon jar filled with cold tap water. It was found that less damage was done to the parasites if the contents were stirred vigorously rather than shaken. After the suspension had settled for about five minutes, the tap water with its mucous and debris was carefully decanted, and the jar refilled and stirred again. The process was repeated until the remaining sediment was sufficiently clear to be poured into a shallow dish for examination under a binocular microscope.

The small intestine, caecum, large intestine, and colon were examined separately. These areas were judged by Knight (1951a) as most significant in localizing the residence of parasites. The emptied sections of gut were then everted by means of a hemostat and examined after washing. Pigmented areas occurring along the gut were removed and preserved for future examination for coccideans. All other organs were teased apart, and after washing to remove blood, were examined for parasites with a binocular microscope. The musculature of five animals was teased apart and incubated in warm physiological saline (0.9 per cent NaCl) overnight in an attempt to recover adult filarid worms.

Fixation and Preservation

Helminths were washed free of mucous and fecal material and placed in deep-well dishes for preservation. Trematodes were placed between slides and fixed with AFA by flooding the interstitial space. When fixation was complete (as judged by whitening of the parasite) they were placed in AFA overnight, followed by storage in 70 per cent ethanol. Cestodes were dropped into 60 C. tap water so that they died in an expanded state, placed in AFA overnight, and then stored in 70 per cent ethanol. This heat killing technique also worked very well with the larger worms, such as Echinostoma revolutum. Nematodes were fixed and stored in buffered 5 per cent formalin. Ectoparasites were fixed in AFA for 24 hours, followed by storage in 70 per cent ethanol.

Staining and Mounting

Trematodes were removed from their storage alcohol and stained with Semichon's Aceto-Carmine for 30 minutes. They were destained in 70 per cent acid alcohol (1 per cent HCl in 70 per cent ethanol), and dehydrated through the ethanol series, cleared in carbol-xylol and xylol, and mounted in balsam.

Cestodes were rehydrated overnight in distilled water to remove all traces of alcohol. Specimens were then stained in freshly filtered Delafield's Hematoxylin (1 part stain: 20 parts water) for 8 to 12 hours. Following staining, they were dehydrated up to 70 per cent ethanol, destained in acid alcohol until light pink, and neutralized in basic alcohol (0.5 per cent $NaHCO_3$ in 70 per cent alcohol) until blue. After a rinse in 70 per cent ethanol, they were dehydrated, cleared, and mounted in the same manner as were trematodes. Supports were used under the coverslip when necessary.

Nematodes were dehydrated through successive alcohols, cleared in lacto-phenol, and examined unmounted and unstained.

Ectoparasites were dehydrated through successive alcohols, cleared, and mounted in balsam with a slight pressure maintained on the coverslip to insure that the appendages would remain outstretched.

Blood smears were stained with Wright's stain for two minutes, flooded with pH 7.0 bicarbonate buffer for five minutes, and rinsed in tap water.

RESULTS

Forty-nine of the 55 muskrats collected possessed one or more species of parasites. These included one species of mite, four of trematodes, two of cestodes, and one of nematodes. The parasites, their incidence, and relative abundance are presented in Table 3.

The frequency of uninfected, singly infected, and multiple infected juvenile and adult muskrats is presented in Tables 4 and 5. Following Table 5 is a brief consideration of each species of parasite found in this survey. These comments include synonyms, site and incidence of infection, historical review, geographical distribution, diagnostic and morphological features, aspects of the life cycle, and disease caused by the parasite.

Although the scope of this study did not include protozoan parasites, at least one species of coccidia was seen in pigmented areas of the small intestine. Intestinal scrapings revealed the presence of oocysts of the genus Eimeria. Stained, duplicate blood smears from each animal failed to reveal any protozoans or microfilariae.

One muskrat of the fall sample and four of the five animals in the spring sample possessed massive infestations with the amphipod Hyalella azteca. All animals were found dead in the water. Several hundred of these amphipods were localized chiefly in the pelt on the back an under the legs. Since these animals are not parasitic, they must have been scavenging on detritus between the hairs of the pelt. This condition was also found on four mallard ducks, one lesser yellow-legs, and on mink.

TABLE 3

PARASITES TAKEN FROM ENGLISH COULEE MUSKRATS

Parasite	Hosts		Parasites	
	Number infected	Per cent infected	Average number parasites/infected host	Range
ARACHNIDA				
Laelaps multispinosus	49	89.09	*	*
TREMATODA				
Echinostoma revolutum	19	34.54	3.88	1-28
Notocotylus urbanensis	23	41.81	11.1	1-134
Quinqueserialis quinqueserialis	26	47.27	5.1	1-44
Plagiorchis proximus	8	14.54	8.0	1-94
CESTODA				
Hymenolepis evaginata	2	3.63	1.0	1
Hydatigera taeniaeformis	9	16.36	1.33	1-3
NEMATODA				
Trichuris opaca	1	1.81	1	1

*Sample was impossible to quantitate due to collecting procedure.

TABLE 4

PERCENTAGE OF PARASITIC INFECTIONS
WITH PARASITIC HELMINTHS BY AGE GROUP OF MUSKRATS

Age Group	Sample Size	Per cent of Group Having Number of Species						
		0	1	2	3	4	5	6
Adult	37	21.62	24.32	24.32	18.91	8.10	2.70	0
Young	18	33.33	38.88	16.66	11.11	0	0	0
Total	55	25.45	29.09	21.81	16.36	5.45	1.81	0

TABLE 5

PERCENTAGE OF PARASITIC INFECTIONS
BY AGE GROUP OF MUSKRATS INCLUDING ECTOPARASITES

Age Group	Sample Size	Per cent of Group Having Number of Species						
		0	1	2	3	4	5	6
Adult	37	10.81	10.81	24.32	24.32	19.91	8.10	2.70
Young	18	11.11	22.22	38.88	16.66	11.11	0	0
Total	55	10.90	14.54	29.09	21.81	16.36	5.45	1.81

PHYLUM ARTHROPODA

CLASS ARACHNIDA

ORDER ACARINA

FAMILY LAELAPTIDAE

Laelaps multispinosus Banks, 1909

Synonym: *Tetragonussus spiniger* Ewing and Stover, 1915

Site of Infection: Pelt

Incidence of Infection: 49 of 55 animals (89.09 per cent).

History: Banks (1909) described this mite as *Laelaps multispinosus* from muskrats near Guelph, Ontario. Ewing and Stover (1915) and Ewing (1923) found parasitic mites infesting muskrats at Ithaca, New York. They believed it to be a new species, and named it *Tetragonyssus spiniger*. Additional specimens were collected from muskrats from Montana and Massachusetts (Ewing, 1923). Svihla and Svihla (1931) in their ecological study of the Louisiana muskrat reported this mite concentrated primarily around the eyelids. Warwick (1937) found *Laelaps multispinosus* on muskrats collected from several regions of England, Scotland, and Ireland. Smith (1938) found *Tetragonyssus spiniger* infesting muskrats in Maryland, and Penn(1942) found the mite on 13 of 53 muskrats in Louisiana. Radford (1943) reported *T. spiniger* from one muskrat in Maryland. Knight's (1915b) survey of the parasitic fauna of muskrats of British Columbia also included *Laelaps* multispinosus. Meyer and Reilly (1950) found this mite infesting 55 of 56 animals examined in Maine. Zapletal (1960) and Samsinak (1961) in Czechoslovakia reported L. multispinosus from muskrats. Recently Grundmann and Tsai (1967) found L. multispinosus infesting muskrats of the Great Salt Lake Valley of Utah.

Geographic Distribution: This organism is found in North America, Europe, and Eurasia.

Morphology: This dermanyssid mite is large and heavily spined. The distinctive character is that one of the spines on Femur I is almost half as long as the front legs. The anus has an even, but enormously thickened rim, and the anal setae are minute (Plates I and II).

Life Cycle: The actual life cycle of this blood feeding mite is unknown, but it is presumed to be a sequence of five stages: egg, hexapod larva, octopod protonymph, deutronymph, and adult (Asanuma, 1950).

Disease: This mite has not been found to be a vector of any disease. Knight (1951b) reported very heavy infestations which produced no visible sign of irritation or discomfort in muskrats.

PHYLUM PLATYHELMINTHES

CLASS TREMATODA

ORDER DIGENEA

FAMILY ECHINOSTOMATIDAE

Echinostoma revolutum (Froelich, 1802) Looss, 1899

Synonyms: As listed by Beaver (1937).

Synonym demonstrum

Distomum echinatum Zeder, 1803
Echinostoma miyagawi Ishii, 1932
Echinostoma cinetorchis Ando and Ozaki, 1923
Echinostoma armigerum Barker and Irvine, 1915
Echinostoma coalitum Barker and Beaver, 1915
Echinostoma mendax Dietz, 1909
Echinostoma paraulum Dietz, 1909
Echinostoma colubrae Zunker, 1925
Echinostoma limnicoli Johnson, 1920

Synonym inquirendum

Echinostoma sudanense Odhner, 1911
Echinostoma acuticauda Nicoll, 1914
Echinostoma callawayensis Barker and Noll, 1915
Echinostoma erraticum Lutz, 1924
Echinostoma nephrocystis Lutz, 1924
Echinostoma microrchis Lutz, 1924
Echinostoma echinocephalum (Rud., 1819) Cobb., 1860
Echinostoma dilatatum (Fischer, 1840) Cobb., 1860
Echinostoma armatum Molin, 1850

Site of Infection: Small Intestine

Incidence of Infection: 19 of 55 animals (34.54 per cent)

History: According to Beaver (1937), *Echinostoma coalitum* Barker and Beaver, 1915, and *E. armigerum* Barker and Irvine, 1915, along with seven other species are to be considered synonyms of *E. revolutum* (Froelich, 1802) Looss, 1899. He assumed that these species were physiological variants upon which the synonymous descriptions were based. Yamaguti (1958) felt that of the nine synonyms, E. cinetorchis must stand as a valid species. Beaver (1937) also listed ten other Echinostoma as possible synonyms, hence species inquirenda. For the sake of completeness, E. revolutum from muskrats is reviewed with its valid synonyms.

According to Beaver (1937), Leidy (1888) was the first worker to recover E. revolutum (= Echinostomum echinatum) from the small intestine of a muskrat in Pennsylvania. Barker (1915a; 1915b; 1916) reported E. coalitum and E. armigerum in the duodenum of muskrats in Nebraska. In their review of parasites of fur-bearing mammals of Ontario, Law and Kennedy (1932) reported the presence of E. armigerum, E. coalitum, and E. revolutum in the small intestine of muskrats. Swales' (1933) review of Canadian helminthology noted the presence of Echinostoma sp. and E. revolutum in Alberta and Ontario, respectively. Allen (1934) substantiated this work and listed E. armigerum in his review of economically important fur-bearers of Eastern Canada.

Krull (1935) reported the presence of E. coalitum in Maryland muskrats. Beaver (1937) reviewed the genus Echinostoma and also noted E. revolutum from muskrats in Alberta, Quebec, Colorado, Pennsylvania, and Illinois. Leigh (1940) and Gilford (1954) found E. revolutum in Illinois muskrats. Ameel (1942) working with muskrats of southern and central Michigan found 63 per cent of 252 animals infected with E. coalitum. Rankin (1946) found four of six muskrats in western Massachusetts harboring this parasite. Rausch (1947) reported 45 of 70 animals infected from seven localities in Ohio. Rider and Macy (1947) found 12 of 34 muskrats infected with E. revolutum in northwestern Oregon. Edwards (1949) found E. revolutum in 89 and 76 per cent of muskrats examined during the winters of 1945-1946 and 1946-1947. In Maine, Meyer and Reilly (1950) reported an incidence of 21 per cent of 104 animals checked for helminths.

Knight's (1951a) parasite study of muskrats of British Columbia reported E. coalitum. She reported that 58.75 per cent of the worms occurred in the small intestine, 18.75 per cent in the stomach, and 13.7 per cent in the caecum. This is the only report that mentions this parasite occurring in the stomach. She reported a maximum worm burden of 230 worms in the small intestine. This appears to be the heaviest reported infection for a single muskrat. In the same year, Goldsby and Johnston (1951) reported an infected muskrat from north central North Dakota which possessed 226 specimens of E. revolutum. Ball (1952) found Echinostoma sp. in one muskrat from western Colorado. Grabda (1954) was the first worker to report E. revolutum from Poland, and Bartik, et al., (1956) found eight of 32 animals examined in southern Moravia infected with E. coalitum. In 1955, Senger and Neiland found

12 of 34 muskrats infected in Oregon. In 1957, Senger and Bates (1957) reported 10 of 21 muskrats with E. revolutum in the Cache Valley of Utah. Each infected muskrat possessed approximately 35 worms. In relating parasitism to environment in Pennsylvania, Anderson and Beaudoin (1966) reported a 40 per cent incidence of infection in 45 muskrats from streams, seven per cent of 20 animals from rivers, and 78.5 per cent of 14 animals from marshes. Grundmann and Tsai (1967) found 34.4 per cent of 34 animals infected with this parasite from the Great Salt Lake Valley in Utah.

Geographic Distribution: Echinostoma revolutum is cosmopolitan, mainly through its wide and frequent occurrence in aquatic birds. In muskrats, the parasite occurs in North America and Europe.

Morphology: The collar of the animal has 37 spines with five spines occurring on each lappet and the remaining spines arranged in two alternate rows. The uterus is long and is coiled into 7 or more loops (Plate III).

Life History: Although Johnson (1920) has been given credit for solving the life cycle of Echinostoma revolutum, his description leaves much to be desired since he was working with dubious material. He gives the presence of 43 hooks on its oral collar as the definitive character of the cercarial stage, instead of the 37 hooks typical of this parasite. Until Beaver (1937) reviewed the species, the life cycle remained somewhat confusing. He found that the mature adult parasite sheds 2,000 to 3,000 eggs per day while located in the jejunum of the small intestine. Host specificity is almost non-existent; the worm parasitizes 23 species of birds and nine species of mammals, including man. The operculate eggs pass out with the feces and develop rapidly, although 18 days to one month are required for hatching. The free-swimming miracidium has a viability of about 18 hours. Its first intermediate host may be any one of a number of species of *Physa*, *Gyraulus*, *Lymnaea*, *Helisoma*, *Pseudosuccinea*, and *Segmentina*. The miracidia penetrate immediately, but the next stage of the life cycle is still obscure. Johnson (1920) and Beaver (1937) failed to find any evidence of a mother sporocyst stage, but Raisin (1933) working with the closely related genus of *Echinoparyphium recurvatum* was able to demonstrate a very transient mother sporocyst. The mother redia has no visible collar, but the daughter redia has a very prominent one. Daughter rediae produce cercaria after nine to ten weeks. The cercaria have 37 collar spines typical of this species. They emerge from the snail and swim actively waiting to encounter a suitable second intermediate host. Any of 43 species of snails, finger-nail clams, frogs (both larval and adult), and bullheads may serve as the second intermediate hosts. Encystment occurs in the soft parts of snails and clams, but in frogs and ictalurids, the cercaria enter the cloaca, migrate up the ureters, and encyst in the kidneys.

When the definitive hosts eat the second intermediate hosts, the metacercariae are released, migrate to the small intestine, attach by means of their collar spines, and begin to produce eggs after approximately 18 days.

Disease: Echinostomiasis. Extremely heavy infection may lead to severe enteritis (Goldsby and Johnston, 1951).

FAMILY NOTOCOTYLIDAE

Notocotylus urbanensis (Cort, 1914)
Harrah, 1922

Synonyms: *Monostoma* sp. Stiles and Hassall, 1894
Catatropis fimbriata Barker, 1915
Catatropis filamentis Barker, 1915
Notocotylus filamentis (Barker, 1915) Harwood, 1939

Site of Infection: Caecum and Large Intestine.

Incidence of Infection: 23 of 55 animals (41.81 per cent)

History: Cort (1914) described a monostome cercaria from *Physa gyrina* as *Cercaria urbanensis*. In Harrah's (1922) monograph on monostomes, he concluded that the *Monostoma* sp. collected from Maryland birds and muskrats by Hassall in 1892-93 were adults of *Cercaria urbanensis*; hence, they should be called *Notocotylus urbanensis*. Meanwhile, Barker (1915b) described *Catatropis filamentis* (= *C. fimbriata*) from Nebraska muskrats. There is strong evidence supporting the view that *Catatropis filamentis* and *Notocotylus urbanensis* are synonyms. This evidence is presented in the section on life history.

Law and Kennedy (1932), Swales (1933), and Allen (1934) reported *C. fimbriata* in muskrats from Eastern Canada. Leigh (1940) found this parasite in Illinois muskrats, and Ameel (1942) working with muskrats from central and southern Michigan, recorded five per cent of 252 muskrats infected with *C. filamentis*. Rider and Macy (1947) found 35 per cent of 34 muskrats infected with *N. urbanensis* in northwestern Oregon.

Edwards (1949) reported N. urbanensis occurring in three of 40 muskrats in central New York, and Meyer and Reilly (1950) found 36 of 104 Maine muskrats infected with N. filamentis. Knight (1951a) encountered this parasite in her muskrat parasite survey of British Columbia. Sweatman (1952) identified C. fimbriata in 32 of 108 muskrats in Ontario. Gilford (1954) found Notocotylus sp. in 4.5 per cent of 250 muskrats in Illinois. In Alaska, Dunagan (1957) reported N. filamentis from river and stream habitats. Grundmann and Tsai (1967) found 75 per cent of the muskrats sampled in the Great Salt Lake Valley possessed N. urbanensis.

Geog aphic Distribution: Alaska, Canada, and northern portion of the United States.

Morphology: This slender monostome has three longitudinal rows of papillae on its ventral surface, and possesses spines on the anterior half of it body (Plates IV and V).

Life History: There has been much controversy over this monostome since Harrah(1922) named the adult Notocotylus urbanensis. Luttermoser (1935) found that when encysted metacercariae from Stagnicola emarginata angulata, Physa parkeri, or P. magnalucustris were fed to muskrats, adult N. urbanensis could be recovered. Harwood (1939) concluded that the name N. urbanensis was open to question until an experimental connection could be demonstrated by careful feeding experiments showing that Cercaria urbanensis led to Notocotylus urbanensis.

A major ciricism of Luttermoser's (1935) work is that he must have been working with dubious material, i.e., cercariae of Notocotylus urbanensis and N. stagnicolae.

Experimental evidence linking Cercaria urbanensis and N. urbanensis was provided by Herber (1942; 1955; 1964). He found that eggs shed in the feces are ingested by Physa gyrina. Miracidia hatch and immediately penetrate the digestive tract and move to the digestive gland, the mesentary, or the mantle. Herber (1940) reported the appearance of the first mother sporocyst 11 days after exposure. Each mother sporocyst contains 4-8 mother redia, which appear in approximately 30 days. The daughter rediae appear six weeks post exposure. The released cercariae immediately encyst on any solid object. The process of encystment takes approximately 30 minutes. Cysts are infective within a short time to the definitive hosts; i.e., Ondatra, Microtus, and Rattus. The adult matures in the large intestine in about 24 days.

Based on feeding experiments and comparative morphologies, Herber (1955) considered Notocotylus urbanensis, Catatropis fimbriata (= C. filamentis), and Paramonostomum echinum to represent the same species, namely N. urbanensis.

Disease: No name has been given to infections with this parasite, and no pathology has been described, although Edwards (1949) noted blood in the fluke's ceca.

Quinqueserialis quinqueserialis (Barker and Laughlin, 1911) Harwood, 1939

Synonyms: *Notocotylus quinqueserialis* (Harrah, 1922) nec. Barker and Laughlin, 1911

Quinqueserialis hassalli McIntosh and McIntosh, 1934

Site of Infection: Caecum and Large Intestine.

Incidence of Infection: 26 of 55 animals (47.27 per cent).

History: *Quinqueserialis quinqueserialis* is generally the most common trematode encountered in muskrats. In 1911, Barker and Lauglin described this species from the caecum of 27 muskrats taken in the vicinity of Callaway, Nebraska. Subsequently, Barker (1915a, 1915b, 1916) reported several instances of infection in Nebraska. Law and Kennedy (1932), Swales (1933), and Allen (1934) reported this parasite in muskrats of eastern Canada. Baylis (1935) and Warwick (1936) reported this parasite in muskrats of Great Britain. In 1942, Ameel found 80 per cent of 252 muskrats infected in Michigan, and Herber (1942) reported the occurrence of *Q. quinqueserialis* in the caecum of muskrats, meadow voles (*Microtus pennsylvanicus*), and meadow jumping mice (*Zapus hudsonius*) in the vicinity of Burt Lake, Michigan, and Carlisle, Pennsylvania. Rausch (1946) studied Ohio muskrats in seven adjacent marshes and found 34 of 70 muskrats parasitized with *Q. quinqueserialis*.

Edwards (1949) reported this parasite from 47 of 53 muskrats (89 per cent) in central New York. Meyer and Reilly (1950) found this parasite in 78 per cent of 104 animals. Knight

(1951a) found that the incidence of _Q_. _quinqueserialis_ ranged from 40.5 to 93 per cent in five areas sampled. Infections of 200 to 350 parasites per animal were not uncommon, and one muskrat harbored 850 trematodes of this species. Ball (1952) found 26 of 31 muskrats infected in western Colorado. Rausch (1952) reported that _Q_. _quinqueserialis_ was common in muskrats in Alaska. Gilford (1954) found 6.3 per cent of 250 muskrats harboring this parasite in Illinois. Dunagan(1957) reported incidences of this helminth ranging from 86 to 93.6 per cent in Alaska muskrats. In the same year, Senger and Bates (1957) reported the occurrence of _Q_. _quinqueserialis_ in seven of 21 muskrats from the Cache Valley of western Utah. Schell (1960) reported this parasite from muskrats in Idaho. Anderson and Beaudoin (1966) compared the infection rates in stream, river, and marsh muskrats in Pennsylvania. It was found that the infection rates were 40 per cent, 10 per cent, and 8 per cent, respectively. Infections were common in adult animals, but were absent from juvenile marsh and river animals. In Utah, Grundmann and Tsai (1967) found the incidence of infection was 96.6 per cent in muskrats from the Great Salt Lake Valley.

Geographic Distribution: Alaska, Canada, the northern portion of the United States, and England.

Morphology: A robust monostome fluke with five rows of papillae on its ventral surface (Plates VI and VII).

Life History: Herber (1940, 1942) investigated the life cycle of *Quinqueserialis quinqueserialis* and found natural infections occurring in the caecum of muskrats in Douglas, Walloon, and Burt Lakes in Michigan. He found that adult worms in the caecum of muskrats shed embryonated, filamentous, and operculated eggs. The eggs do not hatch until consumed by the first intermediate host, *Gyraulus parvus*. There is also a single report that *Physa gyrina* can serve as a host (Schell, 1960).

The eggs hatch in the snail's intestine releasing ciliated miracidia which migrate into the underlying tissue. The miracidia lose their cilia and transform into mother sporocysts in approximately nine days. Four mother rediae are produced in each mother sporocyst. These burst through the body wall of the mother sporocyst and migrate to the hepato-pancreas. This process takes place approximately 19 days post infection. Daughter rediae develop rapidly and are found free in the liver 20 days post infection. Immature cercariae leave the daughter rediae in three days, and then spend another three days reaching maturity in the snail's liver. Thus the larval stage requires 26 days from egg to mature cercaria. Cercariae encyst when they encounter a solid object, the entire process taking five or six minutes. When muskrats and voles feed upon emergent vegetation, they swallow the metacercariae which are released in the small intestine. From here they migrate to the caecum where they attach and mature in approximately 16 days.

Disease: No name has been attributed to infections of *Q. quinqueserialis* and no pathology has been reported. Host blood in the intestinal ceca of the fluke was reported by Edwards (1949).

FAMILY PLAGIORCHIIDAE

Plagiorchis proximus Barker, 1915

Synonyms: No recorded synonyms.

Site of Infection: Small Intestine.

Incidence of Infection: 8 of 55 animals (14.54 per cent).

History: This parasite was described by Barker (1915b) from the small intestine of muskrats in Nebraska. Law and Kennedy (1932), Swales (1933), and Allen (1934) reported *P. proximus* in muskrats from Eastern Canada. McMullen (1937) found light infections of this helminth in muskrats from the Douglas Lake area of Michigan. Ameel (1942) later found *P. proximus* in 23 per cent of 252 muskrats from central and southern Michigan. Rausch (1946) reported infections in three of 70 animals from several locations in Ohio, while Rankin (1946) reported this parasite in muskrats from Massachusetts. In central New York, Edwards (1949) found infections in 14 of 53 muskrats (26 per cent). In 1950, Meyer and Reilly found six of 104 muskrats infected in Maine. In British Columbia, Knight (1951a) found the incidence of *P. proximus* varied from zero to 68.2 per cent in the five areas sampled. Rausch (1952) and Dunagan (1957) reported *P. proximus* as common in muskrats of Alaska. Ball (1952) in western Colorado found *P. proximus* occurring in the small intestine of 26 of 34 muskrats. Grabda (1954) recorded this parasite from muskrats in Poland. *P. proximus* is apparently one of three (also

Quinqueserialis quinqueserialis and Hymenolepis evaginata) North American helminths carried to the Old World by muskrats. Anderson and Beaudoin (1966) found that P. proximus only occurred in streams, but not in river or marsh muskrats in Pennsylvania. Grundmann and Tsai (1967) found 43.5 per cent of the muskrats in the Great Salt Lake Valley in Utah infected with this parasite.

Geographic Distribution: Alaska, Canada, and the northern portion of the United States. Also reported from Europe (Poland).

Morphology: A small trematode with lobed testes, and with the descending limb of the uterus passing between the oblique testes and filling the posterior part of the body (Plate VIII).

Life History: The general features of the life cycle of Plagiorchis proximus were solved by McMullen (1937). He found that sporocysts develop in Stagnicola emarginata angulata and produce a stylet cercaria which is identical with Cercaria polyadena Cort, 1914. The xiphidocercariae can become metacercariae while still in the sporocyst of the snail, or they can be shed and infect second intermediate hosts, such as chironomid, dragonfly, mayfly, and mosquito larvae. Tadpoles, snails, and small fish may be penetrated, but the metacercariae die soon after encystment. In the larval insect host, the metacercariae must mature for several days before becoming infective. In feeding experiments, "mice" were the only animals which became infected, and even these proved somewhat refractive.

<u>Disease</u>: No name has been applied to infections with *Plagiorchis proximus*, and no pathology has been reported.

EATON'S CORRASABLE BOND U S A BERKSHIRE COTTON FIBER CONTENT

CLASS CESTOIDEA

ORDER CYCLOPHYLLIDEA

FAMILY HYMENOLEPIDIDAE

Hymenolepis evaginata Barker and Andrews, 1915

Synonyms: No recorded synonyms.

Site of Infection: Small Intestine.

Incidence of Infection: 2 of 55 animals (3.62 per cent).

History: In Barker's (1915b) paper on muskrat parasites from Nebraska, one finds the first published description of *H. evaginata*. Since F. D. Barker and Mitchell Andrews jointly described the cestode in an earlier unpublished report, the scientific name bears dual authorship even though Barker (1915b) authored the paper alone.

Law and Kennedy (1932), Swales (1933), and Allen (1934) noted the presence of this parasite in muskrats from Ontario and Alberta. Baylis (1935) and Warwick (1936) found two areas in Great Britain where this parasite occurred. Ameel (1942) reported this parasite in 26 per cent of 252 muskrats in southern and central Michigan, and Penn (1942b) reported two muskrats infected in Louisiana. Rankin (1946) reported finding this parasite in muskrats in his parasite survey of the small mammals of Massachusetts. Edwards (1949) found six of 53 muskrats infected in central New York. Meyer and Reilly (1950) found 43 of 104 muskrats in Maine infected with this parasite. Knight (1951a) reported scattered infections of *Hymenolepis evaginata* in British Columbia. Ball (1952), working with muskrats in western Colorado, found *H. evaginata* in four of 34 animals, while Sweatman (1952) found 26 of 108 muskrats infected in Ontario. Gilford (1954) found 0.4 per cent of 250 muskrats infected in Ontario. Senger and Bates (1957) found six muskrats of 21 infected with this parasite in the Cache Valley of Utah, while Dunagan (1957) reported this parasite in Alaska.

Morphology: This tapeworm possesses an armed rostellum with two rows of hooks. The mature proglottids have the three testes typical of the genus *Hymenolepis*. Due to the great number of species in this genus, the reader should consult Hughes (1941b) for the distinctive characters of this cestode.

Geographic Distribution: Alaska, Canada, the United States and Great Britain.

Life History: An exhaustive review of the literature has failed to reveal any description of the life cycle of *H. evaginata*.

Disease: No name has been formulated for this infection and no description of pathology has been found in the literature.

FAMILY TAENIIDAE

Hydatigera taeniaeformis Batsch, 1786

Synonyms:[1] *Taenia taeniaeformis* (Batsch, 1786) Wolfhugel, 1911
Taenia crassicollis Rudolphi, 1810
Cysticercus fasciolaris Batsch, 1786

Site of Infection: Liver.

Incidence of Infection: 9 of 55 animals (16.36 per cent).

History: The first report of this parasite from North American muskrats was by Linton (1915), who collected the larval form (*Cysticercus fasciolaris*) from the liver of a muskrat in 1884. Barker (1916) found *C. fasciolaris* in muskrats in muskrats in Nebraska. Law and Kennedy (1932), Swales (1933), and Allen (1934) reported the presence of this parasite from Ontario and Alberta. Baylis (1935) and Warwick (1936) reported the parasite from muskrats in Great Britain while Cameron and Parnell (1933), surveying parasites of small mammals in Scotland, found one infection. Smith (1938) reported infections in Maryland muskrats. Ameel (1942), working with muskrats in southern and central Michigan, found 3 per cent of 252 muskrats bearing this parasite, while Kuntz (1943) reported it from the same area. Rausch (1946) found 6 per cent of the livers of muskrats infected with the larval stage of *T. taeniaeformis*

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[1]Only the three common synonyms are listed. The reader should consult Hughes (1941a) for old and obscure synonyms, and Esch and Self (1965) for recent views on the subject.

in Ohio. Rider and Macy (1947) found this parasite in northwestern Oregon. Tiner and Chin (1948) found four muskrats of 21 in Illinois infected with T. taeniaeformis. Edwards (1949) in New York found 6 per cent of 53 muskrats infected. Knight (1951a) found only 14 animals of 252 trapped bearing this parasite in British Columbia. Sweatman (1952) reported one out of 108 muskrats infected in Ontario. Grabda (1954) found this parasite in muskrats in Poland. Gilford (1954) found 2.2 per cent of 250 muskrats infected in Illinois. Senger and Neiland (1955) reported nine of 34 muskrats infected with T. taeniaeformis in Oregon. Anderson and Beaudoin (1966), in Pennsylvania, found infected muskrats in streams and rivers, but not in marshy environments.

Geographic Distribution: Canada, the United States, and also reported from muskrats in England and Poland.

Morphology: The larva of this species is surrounded by a capsule of connective tissue embedded in the liver. The cysts range from 3-4 to a maximum of 12 mm in diameter. Cysticercus fasciolaris is much tangled within the cyst, and its precocious segmentation is the basis for the term "strobilocercus." The scolex is armed with two rows of hooks, and the first row of hooks is approximately twice as long as the second (Plate X).

Life History: The definitive hosts of Hydatigera taeniaeformis include about two dozen species of Felidae and Mustelidae. The domestic dog, Canis familiaris, has also been reported as a host for this cestode. Ripe proglottids maturing in the intestine burst, and pass out with the feces. Rodents (*Ondatra*, *Microtus*, *Rattus*, and *Arvicola*) feeding on feces or contaminated food, ingest the eggs which hatch in the small intestine liberating the oncosphere. The oncosphere penetrates the small intestine and migrates to the liver where it grows into an encysted strobilocercus larva. With time such cysts may become calcified, or they may be ingested by a definitive host. In the latter case, the strobilated cysticercus is liberated in the small intestine by the action of proteolytic enzymes according to physiological experiments by Rothman (1959), attaches to the small intestine, and matures within a few weeks.

Disease: Infection with cysticercus larvae is properly termed "cysticercosis." Apparently the larvae do not directly harm the host, even though massive infections of over 100 cysts per liver have been reported (Warwick, 1936). However, Gallati (1956) and several other investigators have reported an association between the cysts of *H. taeniaeformis* and liver cancer in rodents.

PHYLUM ASCHELMINTHES

CLASS NEMATODA

ORDER ENOPLIDA

SUPERFAMILY TRICHUROIDEA

FAMILY TRICHURIDAE

Trichuris opaca Barker and Noyes, 1915

Synonyms: No synonyms recorded.

Site of Infection: Proximal portion of small intestine.

Incidence of Infection: 1 of 55 animals (1.81 per cent).

History: *Trichuris opaca* was described from Nebraska muskrats by Barker (1915b). Allen (1934) found this parasite in the small intestine of muskrats in eastern Canada. Ameel (1942) reported *T. opaca* as occurring in 14 per cent of 252 muskrats of central and southern Michigan. Rausch (1946) found *T. opaca* in one specimen (2 worms) from 70 muskrats in Ohio. Edwards (1949) found one worm in the caecum of a New York muskrat. Tiner (1950) collected specimens from muskrats in Wisconsin. Knight (1951a) reported one of 205 muskrats infected with a few of these worms in British Columbia. Ball (1952) found one of 34 muskrats examined in western Colorado infected with this worm. Senger and Bates (1952) reported sparse infections of *T. opaca* in muskrats taken from the Cache Valley in Utah. Sweatman (1952) found only one specimen of *T. opaca* in the caecum of 108 muskrats in Ontario. Gilford (1954) found 1.3

per cent of 250 muskrats infected in Illinois. Senger and Neiland (1955), working in Oregon, found two of 34 muskrats infected with this parasite. Dunagan reported from 0 to 11.9 per cent incidence with this nematode in four areas of Alaska. Anderson and Beaudoin (1966) in Pennsylvania found T. opaca occurring infrequently in muskrats in streams and marshes, but never in river muskrats. Grundmann and Tsai found T. opaca in 6.2 per cent of the muskrats examined in the Great Salt Lake Valley in Utah.

Geographic Distribution: Alaska, Canada, and the United States.

Morphology: A typical whip-worm with an esophageal region extending about two-thirds the length of the body. Males lack a bursa, but the posterior portion of the body is coiled into a spiral and possesses a single spicule (Plate XI).

Life History: An exhaustive review of the literature has failed to reveal any description of the life cycle of T.opaca. However, from such closely related species as T. trichiura, it may be assumed that the life cycle is direct; i.e., no intermediate host is required.

Disease: No name has been given to infections with this parasite, and no pathology has been described.

DISCUSSION

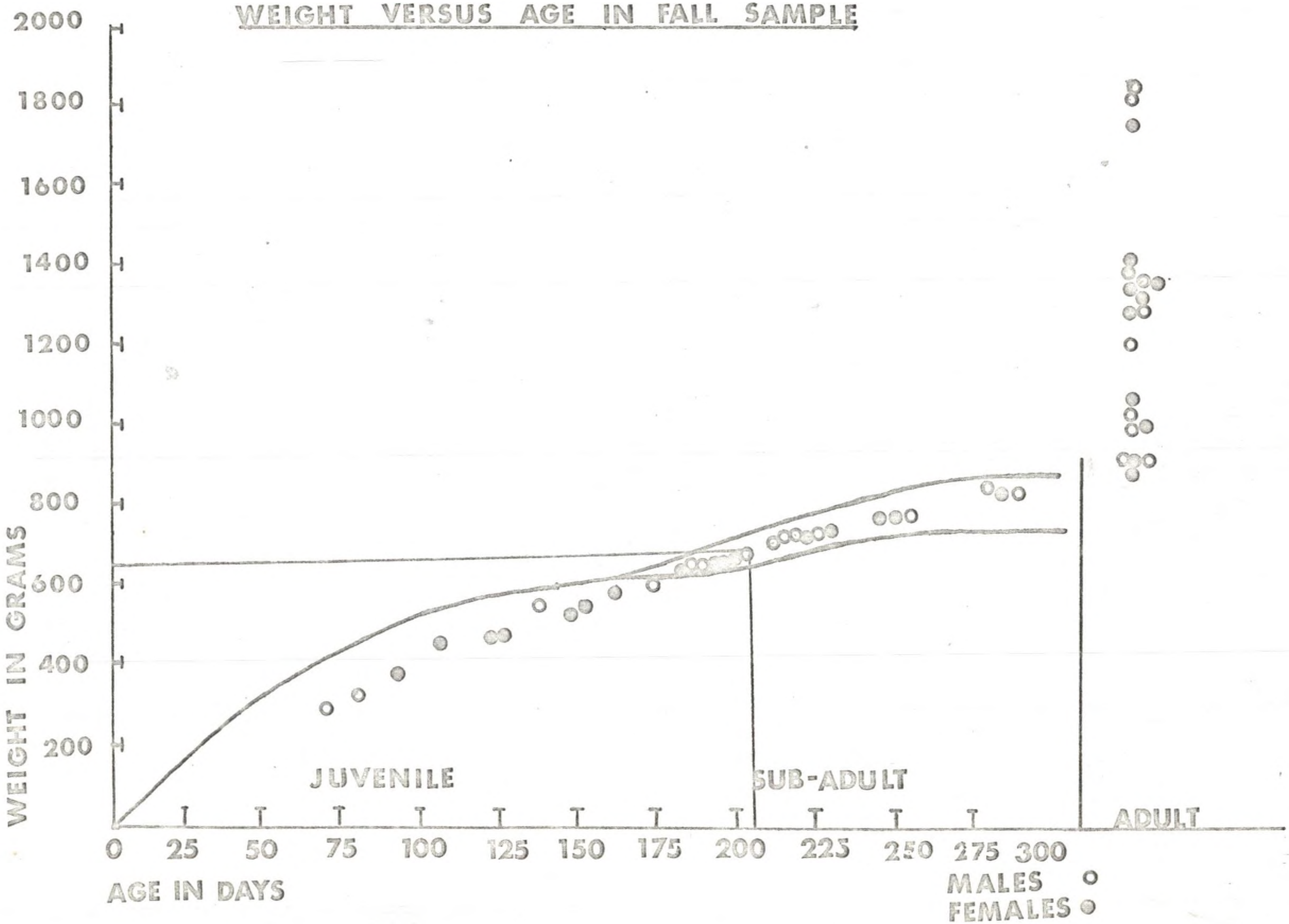
Only 14 of 55 muskrats were recovered alive in the traps. In most of the cases, the animals were dead in the water due to drowning. In 37 cases, the animals gnawed off their feet in order to escape the trap, and although the Coulee was trapped along much of its length, no animals with missing feet were recovered. According to Errington (1963) such animals presumably die of shock, and their carcasses are eaten by predators or scavengers. All of English Coulee musk-rats were identified as <u>Ondatra zibethica cinnamominus</u>. This opinion is supported by actual comparisons with other specimens from the museum vertebrate collection at the University.

In only one instance was a predator caught, a mink. According to Seabloom (personal communication), tracks have been reported along the English Coulee during the winter, but no specimens have been trapped. Dogs and cats (known predators of muskrats) abound along the English Coulee, and several have been observed chasing muskrats, and in one case, swimming after one.

The estimated age structure of the muskrat population was based on body weight. Animals over 625 grams were assumed to have reached adulthood. According to Seabloom (1958), such animals should be approximately 205 days old. Text figure 3 shows the age distribution of the fall sample as correlated

FIGURE 3

WEIGHT VERSUS AGE IN FALL SAMPLE



with weight. The curve in this graph represents the expected weights at various ages, with the upper bifurcation signifying males and the lower, females. Distinct weight differences between the sexes, as reported by Seabloom (1958), were not apparent in this study.

As seen in Table 4, the helminth burden was quite uniformly distributed so far as multiple infections were concerned. This would indicate that the helminths are acquired mainly by chance and that once acquired there is no predilection for acquiring other species. A comparison between juvenile and adult animals shows that the percentage of uninfected juveniles was appreciably greater than that for adult animals. This corresponds with Anderson and Beaudoin's (1966) study of Pennsylvania muskrats in which they found no hypersusceptibility to parasitism among juvenile muskrats.

Table 5 gives total occurrence of multiple infections, including ectoparasites. In this comparison, there is no real difference between the percentage of uninfected juveniles and adults. It is probable that high populations of mites occur within the bank lodges, and that the majority of the young cannot help but acquire this infestation.

Of the eight species of parasites recovered in the course of this study, the mite, Laelaps multispinosus, was found most frequently. While a quantitative sample was not taken, since the toothbrush technique would yield only qualitative sampling, it was felt that the infestation was never great. Sometimes five minutes of rather vigorous brushing would elapse before one ectoparasite was recovered. No difference was observed in the number of ectoparasites found, whether the animal was found on land or in water. The most frequent site of residence was under the axillae and behind the ears. No example of what Knight (1951b) reported as infestation around the eyes was seen. Since the majority of animals were recovered dead, the small number of ectoparasites per host can be accounted for.

Echinostoma revolutum, a large blood-red trematode residing in the small intestine, was found in 34.54 per cent of the animals sampled. Numbers of parasites per infected animal parallel those reported by Knight (1951a). It was the only parasite found that is of interest in a public health context, in that it can infect man. No differences in the numbers encountered were apparent in the fall and spring samples.

Quinqueserialis quinqueserialis was one of two species of monostome flukes recovered. It is a robust trematode with five rows of papillae on its dorsal surface, and was the trematode most commonly found (47.27 per cent of the animals sampled). These parasites occurred in the caecum, but never in overwhelming numbers. These parasites were present in equal numbers during the spring and fall samples.

Notocotylus urbanensis, which is distinguished from Q. quinqueserialis by the presence of three rows of papillae on the dorsal surface, was also found in the caecum and large intestine. There was a decrease in the number found as the fall proceded, and no animals trapped in the spring possessed these worms. This result may reflect seasonal differences in numbers. Due to the small spring sample size, however, such a conclusion is reduced to the realm of speculation. In a majority of cases, N. urbanensis and Q. quinqueserialis resided together in the caecum, and although fewer in number they were not morphologically different from those found in animals harboring single infections. These worms were found in 41.81 per cent of the sample.

Plagiorchis proximus, a rather small trematode inhabiting the small intestine, was difficult to observe because its size and color resembled that of cut villi. It was not found until the last part of the fall, but from the spring collection, one muskrat harbored 94 worms in the intestine. Three of the eight animals possessing P. proximus were collected in the spring, suggesting some seasonal effect on the incidence of the parasite.

The only species of adult tapeworm encountered was Hymenolepis evaginata. This cestode inhabited the small intestine of two animals. The only other tapeworms of the genus Hymenolepis that infect the muskrat are H. oregonensis and H. ondatrae. According to Macy and Biggs (1953), the latter parasite, when present in large numbers can cause epizootics among muskrat populations.

The larval stage of Hydatigera taeniaeformis was found in the livers of nine muskrats. In all but one case, a single worm was found per cyst. The cysticercus was very much entangled within the cyst. In the lone exception, three very small cysticerci were found. There was no evidence of cancerous growths arising from these cysts as reported by Gallati (1956) and other workers.

The only nematode found in this study was Trichuris opaca. Although severly damaged, it possessed the typical morphology of a whipworm, and when cleared in lactophenol was found to be a male. It was keyed to T. opaca by using the original description of Barker (1915b) and the amended one of Tiner (1950). If specimens of this worm are found in future surveys, the worker is advised to abandon the tooth paste technique of gut content extrusion since the worm's forebody is embedded in the wall of the intestine and damage will often result to the parasite. Such destructive procedures may be why this worm has been reported in low numbers in most other surveys.

No animals examined showed any signs of ill-health. The quality of pelts, general muscle tone, and in cases where live muskrats were caught, fighting ability, revealed no signs of weakness or disease. No differences in the condition of fall and spring samples could be discerned. The populations seemed healthy, well-fed, and their pelts possessed the characteristic sheen of healthy animals.

The only evidence of abnormal conditions seen in this survey were a calcified liver and shrivelled gall bladder in a male muskrat. The great weight (1937 gm) and whitened muzzle of this animal indicated that it was quite old, so these abnormalities were probably related to age alone. No examples of wounding were found that would indicate intra- or inter-specific strife, except for one muskrat that had multiple lacerations, presumably from fighting the trap.

In considering the helminths found in this survey, the question arises concerning the adequacy of the English Coulee gastropod fauna in serving as intermediate hosts. Trichuris opaca, Hydatigera taeniaeformis, and Hymenolepis evaginata may be neglected since their life cycles do not involve molluscs. Echinostoma revolutum is known to infect Lymnaea, Physa, and Helisoma. Notocotylus urbanensis utilizes Physa, and Quinqueserialis infects Gyraulus (and possibly Physa). All of the above snails occur in the English Coulee. The only questionable case is that of Plagiorchis proximus which, according to McMullen (1937) uses Stagnicola. This snail had not been collected from the English Coulee, but it may exist there in small numbers. Two other possible explanations for the occurrence of P. proximus in the Coulee include possible utilization of some other species of snail, or the influx of the fluke from another locality. The relatively greater incidence of _P. proximus_ in the spring collection tends to support the last explanation. However, the small spring sample reduces this conclusion to the realm of speculation.

The sampling of muskrats from a single habitat is a major deficiency of this study. Anderson and Beaudoin (1966) examined stream, river, and marsh habitats and noted significant differences in the percentages of parasite infections. Their figures for stream habitats compare favorably with those of this study, and it is conceivable that river and marsh habitats in North Dakota would show the same trend.

The fact that only seven species of helminths were found needs comment. In comparison with most other surveys this number seems very small (Table 6). The restriction of sampling to a single habitat is probably the major reason for the limited numbers, but a second cause might be the existence of some stress factor, as yet undefined, present on the ecotone. A third factor, that of the saline conditions, may play an important role if the gastropod fauna is limited by water chemistry. There is evidence for and against this hypothesis from two areas which are generally considered more saline than the English Coulee. Muskrats from the Lower Souris Wildlife Refuge in North Dakota had a low incidence of infection and possessed only two species of helminths (Goldsby and Johnston, 1951), while hosts from the Great Salt Lake

TABLE 6

Helminths of English Coulee Muskrats
Compared with some Other Surveys

Geographic Area	Worker	Number examined for helminths	Per cent infected	Species of helminths identified
North Dakota	Boyd, this thesis	55	74.5%	7
Michigan	Ameel, 1942	252	*80%	13
Colorado	Ball, 1952	34	*76.5%	5
Nebraska	Barker, 1915a	42	90.5%	14
Alaska	Dunagan, 1957	326	*93.6%	9
Illinois	Gilford, 1954	250	55.4%	14
Utah	Grundmann and Tsai, 1967	34	*96.6%	12
Br. Columbia	Knight, 1951a	205	74 %	13
Maine	Meyer and Reilly, 1950	104	97.1%	10
Oregon	Senger and Neiland, 1955	34	*58.8%	8
Ontario	Sweatman, 1952	108	*81.5%	11

*Total percentage figures not given by authors, hence frequency of most common parasite is listed.

Valley had a high incidence of infection by 12 species of helminths (Grundmann and Tsai, 1967). Based on the snail fauna of the study area, it seems unlikely that salinity is to blame for the limited variety of helminth species from English Coulee muskrats.

Except for the reduced number of species, there does not appear to be anything unique about the parasites or their ecology from the ecotone. According to Grundmann and Tsai (1967), the trematodes *Plagiorchis proximus*, *Notocotylus urbanensis*, *Quinqueserialis quinqueserialis*, and *Echinostoma revolutum*, the cestode *Hymenolepis evaginata*, and the nematode *Trichuris opaca* have such a wide distribution that failure to find them is due to inadequate sampling or to a local condition.

SUMMARY

During the fall of 1966 and the spring of 1967, 55 muskrats were trapped along the reaches of the English Coulee, Grand Forks County, North Dakota. These muskrats were necropsied and all ecto- and endoparasites collected. The parasites were stained and identified and the number of worms counted to discern the parasite burden.

Eight species of parasites were found. The only ecto-parasite encountered was Laelaps multispinosus (89.09 per cent). Four species of trematodes were found. These included Echinostoma revolutum (34.54 per cent), Notocotylus urbanensis (41.81 per cent), Quinqueserialis quinqueserialis (47.27 per cent), and Plagiorchis proximus (14.54 per cent). Two cestodes were found. These included Hymenolepis evaginata (3.62 per cent) and the larval stage of Hydatigera taeniaeformis (16.36 per cent). The only nematode found was Trichuris opaca (1.81 per cent).

It was concluded that the parasite burden was not sufficient to cause disease, and no obvious pathologies were found in any of the muskrats examined.

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Appendix I

Plates I-XI

Explanation of symbols used in plates

b. bladder

c. caeca

cp. cirrus pouch

e. esophagus

m. metraterm

o. ovary

os. oral sucker

p. pharynx

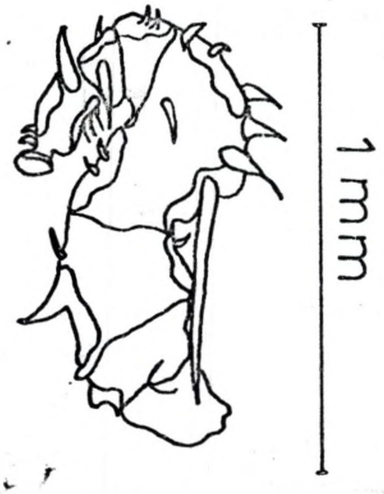
t. testes

u. uterus

vs. ventral sucker

vt. vitellaria


1 mm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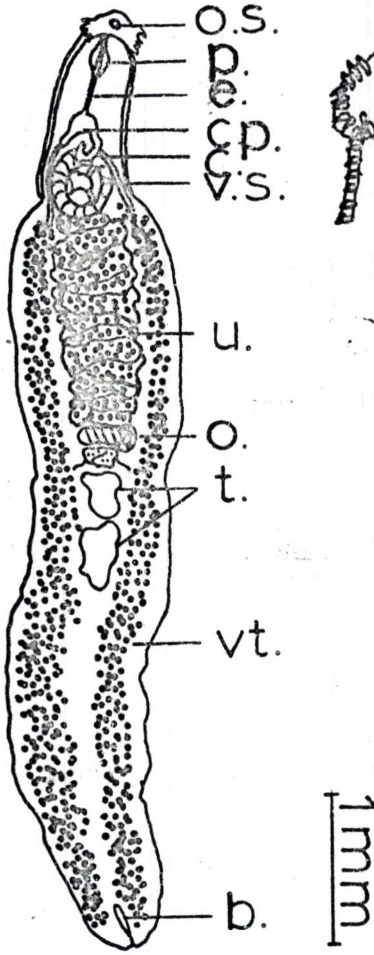

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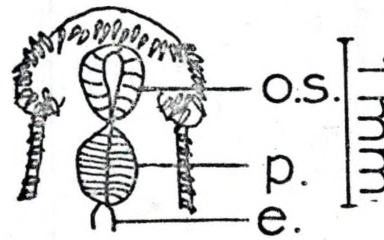

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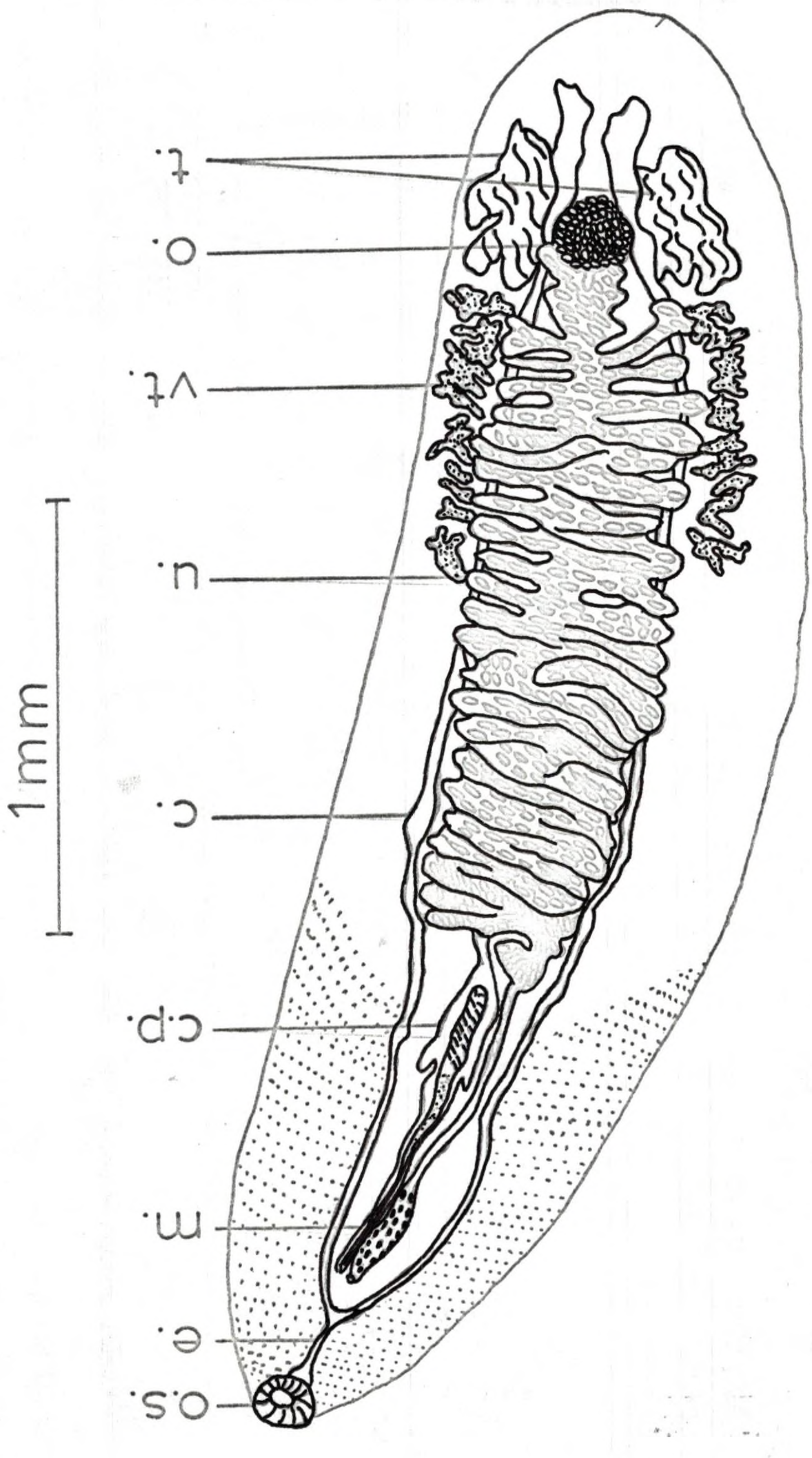

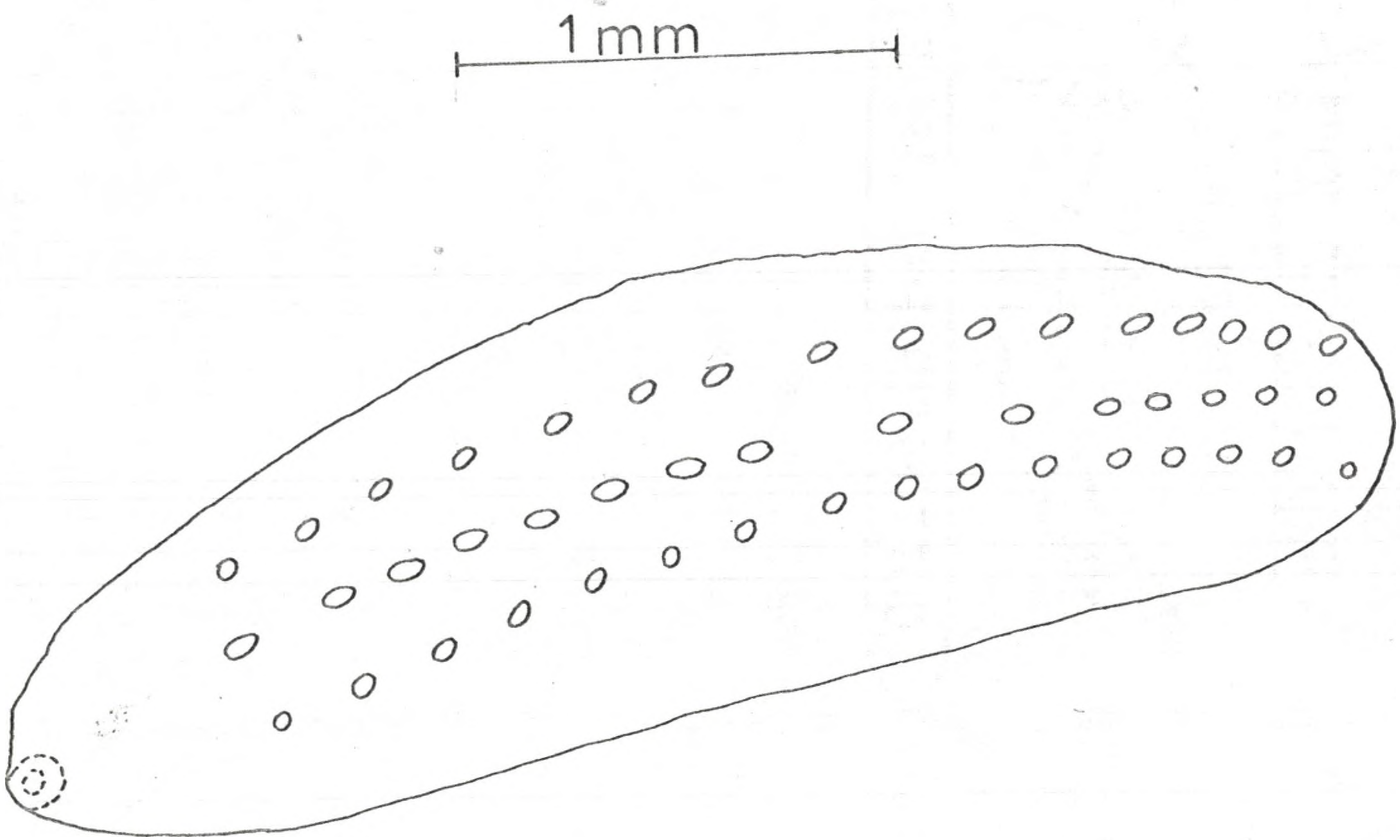

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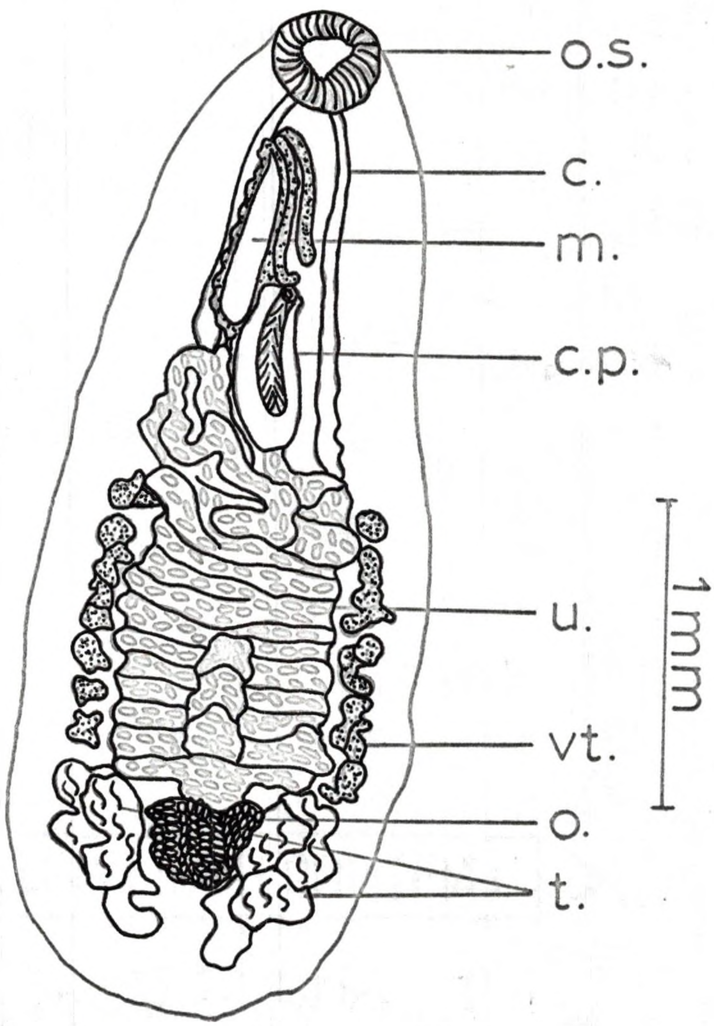

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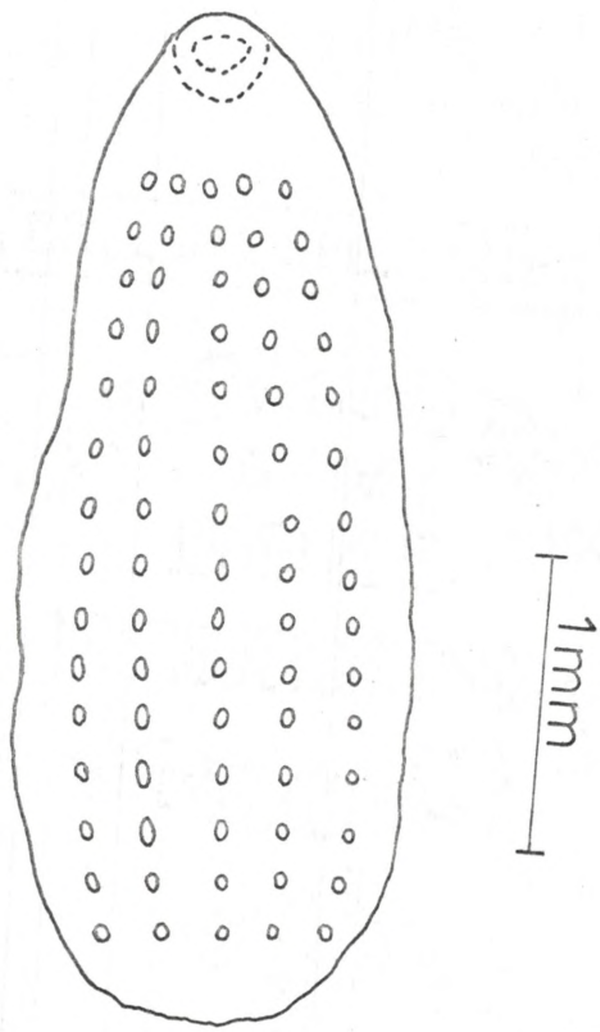

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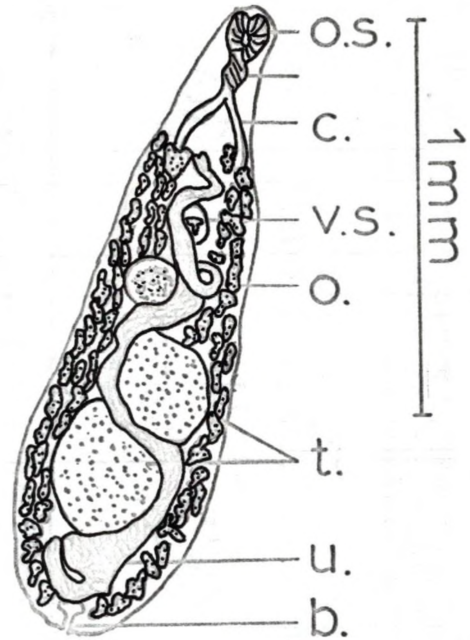

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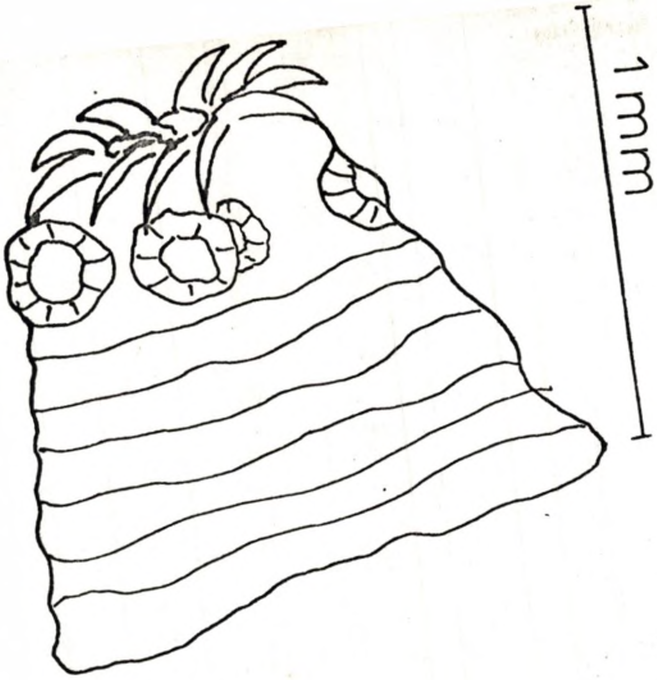

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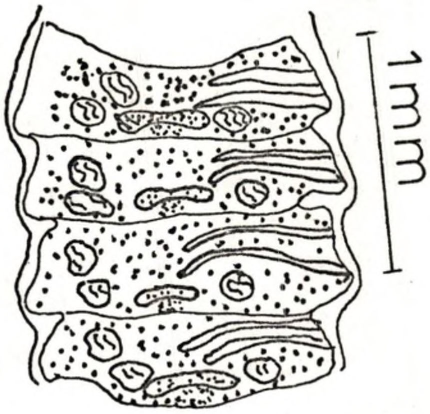

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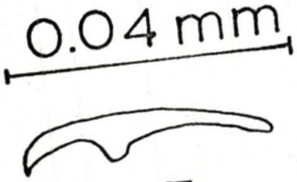

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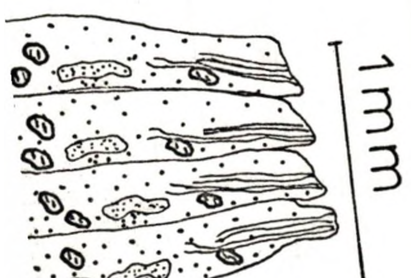

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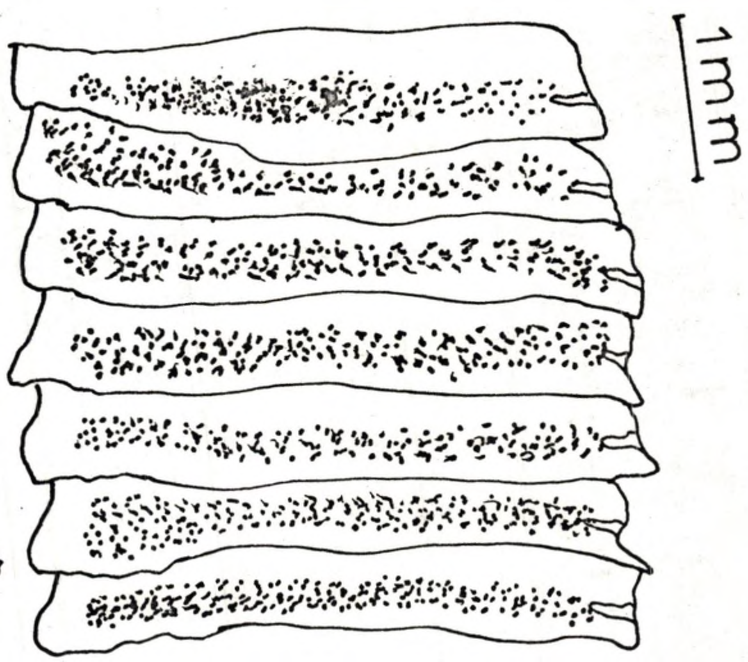

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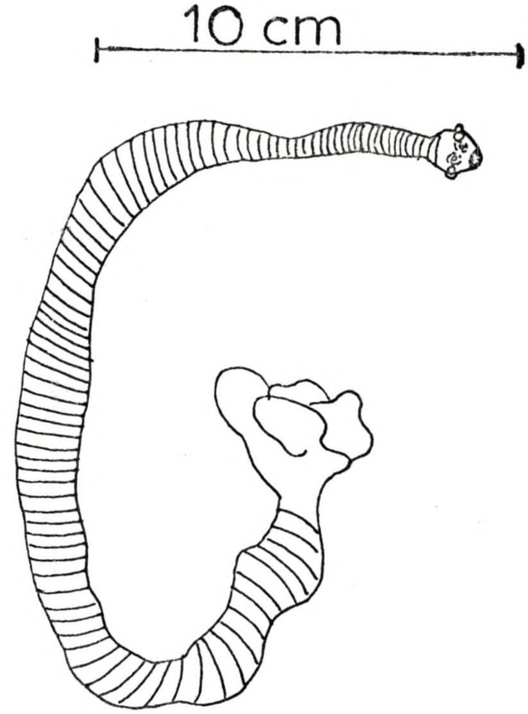

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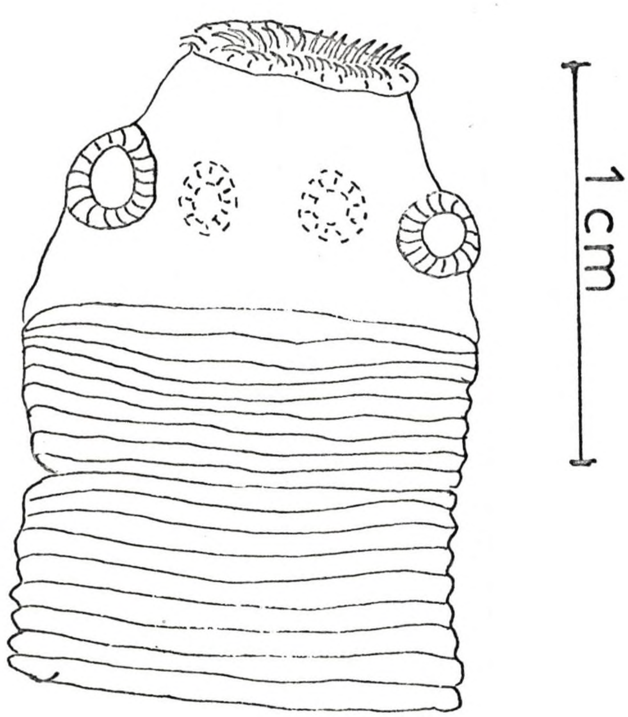

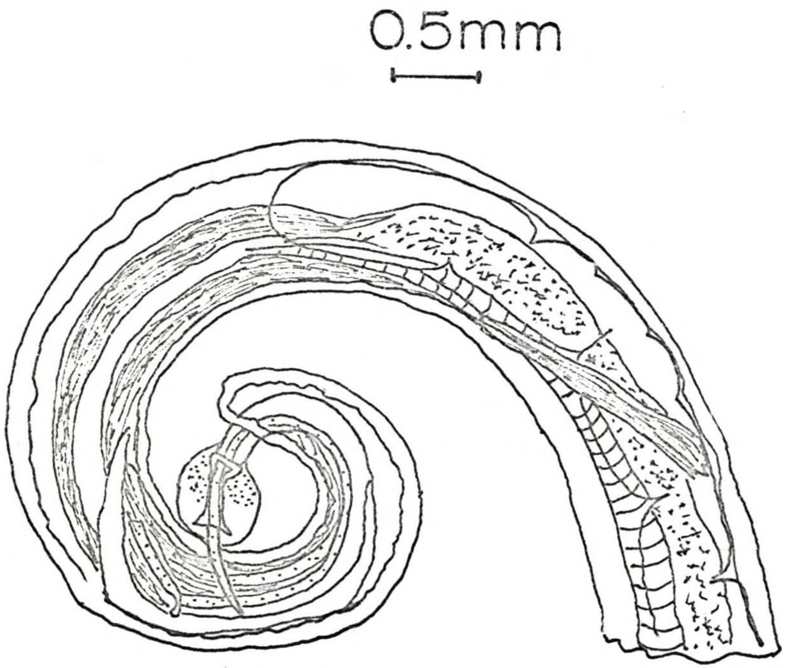

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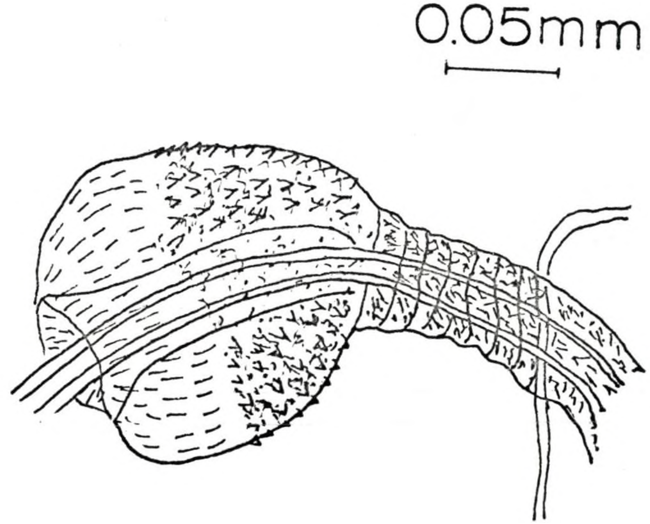

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APPENDIX II

Literature Review

LITERATURE REVIEW

Parasite Records for the Muskrat (*Ondatra* sp.)

As Reported in the Literature to May, 1967

Location in host	Class	Parasite	Area Recorded	Author
Ectoparasites				
Pelt	Diptera	*Sarcophaga* sp.	Louisiana	Penn, 1942b
	Arachnida	*Ixodes banksi*	Maryland Michigan Michigan*	Bishopp, 1911 Hays and Lawrence, 1957 Lawrence and Graham, 1955
	Anoplura	*Polyplax* sp.	Britain	Warwick, 1936
		Polyplax spiniger	Germany	Freund, 1930
		Polyplax spinulosus	Germany	Freund, 1930
	Acarina	*Acarus siro* var. *canis*	Germany	Freund, 1930
		Dermacarus sp.	Britain	Warwick, 1936

*Taken from *Castor canadensis*, but essential for keying

Location in host	Class	Parasite	Area Recorded	Author
	Acarina	Dermacarus validus	Brit. Col.	Knight, 1951b
		Eutrombicula harperi	Brit. Col.	Knight, 1951b
		Ichoronyssus spiniger	New York	Ewing and Stover, 1915
			Maryland	Smith, 1938
		Hirstionyssus isabellinus	Czech.	Zapletal, 1960
		Labidophorus hypudai**	Utah	Grundmann and Tsai, 1967
		Listrophorus americanus	Maryland	Grundmann and Tsai, 1967
			Brit. Col.	Knight, 1951b
			Maryland	Radford, 1944
			Maryland	Smith, 1938
			Czech.	Zapletal, 1960
		Listrophorus dozieri	Utah	Grundmann and Tsai, 1967
			Maryland	Radford, 1944
		Listrophorus validus	Ontario	Banks, 1909
			Maryland	Dozier, 1947
			Brit. Col.	Knight, 1951b
			Maryland	Radford, 1951
			Britain	Warwick, 1936

**Non-parasitic, but may be considered consort species.

Location in host	Class	Parasite	Area Recorded	Author
	Acarina	*Laelaps multispinosus* (= *Tetragonyssus spiniger*)	Ontario Maryland Montana Mass. New York Brit. Col. Maryland Maryland Czech. Louisiana Britain Czech.	Banks, 1909 Dozier, 1947 Ewing, 1923 Ewing, 1923 Ewing and Stover, 1915 Knight, 1951b Radford, 1943 Smith, 1938 Samsinak, 1961 Svihla and Svihla, 1931 Warwick, 1936 Zapletal, 1960
		Myobia sp.	Britain	Warwick, 1936
		Myobia ichoronyssus	Maryland	Radford, 1943
		Ornithonyssus ondatrae	Czech.	Samsinak, 1961
		Ornithonyssus sylviarum	Czech.	Samsinak, 1961
		Radfordia sp. resembling *leminia*	Brit. Col.	Knight, 1951b
		Trombicula (*Neotrombicula*) *richmondi*	Penn.	Brennan and Wharton, 1950

Location in host	Class	Parasite	Area Recorded	Author
	Acarina	*Trombicula (Neotrombicula) bisignata*	Penn.	Brennan and Wharton, 1950
In Nests				
		Aceosejidae Acaridae Cheyletidae Dermanyssidae Diplogynidae Eremaeidae Erythraeidae Ereynetidae Hydrachnellae Laelaptidae Macrochelidae Mesostigmatidae Obatidae Parasitidae Stigmaeidae Trombidiidae	Iowa	Buckley and Hicks, 1962
		Ornithonyssus sylviarum++	Iowa	Buckley and Hicks, 1962
		Pellonyssus passeri++	Iowa	Buckley and Hicks, 1962

++Listed as contaminant from bird.

Location in host	Class	Parasite	Area Recorded	Author
Small Intestine	Trematoda	(Para) alaria mustelae	Eastern Canada	Allen, 1934
			Alaska	Dunagan, 1961
			Ontario	Law and Kennedy, 1932
			Ontario	Swales, 1933
			Ontario	Sweatman, 1952
		Allassogonoporus marginalis	Michigan	Olivier, 1938
		Echinochasmus schwartzi	Ontario	Allen, 1934
			Louisiana	Byrd and Reiber, 1942
			Texas	Chandler, 1941
			Ontario	Law and Kennedy, 1932
			Louisiana	Penn, 1942b
			Maryland	Price, 1931a
			Ontario	Swales, 1933
		Echinoparyphium contiguum	Ontario	Allen, 1934
			Michigan	Ameel, 1942
			Nebraska	Barker, 1915b, 1916a
			Brit. Col.	Knight, 1951a
			Ontario	Law and Kennedy, 1932
			Ontario	Swales, 1933

Location in host	Class	Parasite	Area Recorded	Author
	Trematoda	Echinoparyphium recurvatum	Maine	Meyer and Reilly, 1950
			Minnesota	Penner, 1949
		Echinoparyphium sp.	Poland	Grabda, 1954
		Echinostoma armigerum syn. to E. revolutum (Beaver, 1937)	Eastern Canada	Allen, 1934
			Nebraska	Barker, 1915b 1916
			Ontario	Law and Kennedy, 1932
		Echinostoma callawayense	Eastern Canada	Allen, 1934
			Nebraska	Barker, 1915b, 1916
			Alaska	Dunagan, 1957
			Ontario	Law and Kennedy, 1932
			Minnesota	Macy, 1942
			Ohio	Rausch, 1946
			Ontario	Sweatman, 1952
			Ontario	Swales, 1933
		Echinostoma coalitum syn. to E. revolutum (Beaver, 1937)	Michigan	Ameel, 1942
			Nebraska	Barker, 1915b
			Czech.	Bartik et al., 1956
			Ontario	Law and Kennedy, 1932
			Canada	Knight, 1951a
			Maryland	Krull, 1935
			Ohio	Rausch, 1947
			Ontario	Sweatman, 1952

Location in host	Class	Parasite	Area Recorded	Author
	Trematoda	<u>Echinostoma revolutum</u>	Ontario	Allen, 1934
			Penn.	Anderson and Beaudoin, 1966
			Alberta	Beaver, 1937
			Quebec	Beaver, 1937
			Colorado	Beaver, 1937
			Penn.	Beaver, 1937
			Illinois	Beaver, 1937
			New York	Edwards, 1949
			Illinois	Gilford, 1954
			N. Dakota	Goldsby and Johnston, 1951
			Poland	Grabda, 1954
			Utah	Grundmann and Tsai, 1967
			Maryland	Krull, 1935
			Ontario	Law and Kennedy, 1932
			Penn.	Leidy, 1888
			Illinois	Leigh, 1940
			Maine	Meyer and Reilly, 1950
			Mass.	Rankin, 1946
			Ohio	Rausch, 1946
			Oregon	Rider and Macy, 1947
			Utah	Senger and Bates, 1957
			Oregon	Senger and Neiland, 1955
			Ontario	Swales, 1933

Location in host	Class	Parasite	Area Recorded	Author
	Trematoda	_Echinostoma_ sp.	Colorado	Ball, 1952
			Nebraska	Barker, 1915a
			Alberta	Swales, 1933
		Euryhelmis pacificus	Oregon	Senger and Macy, 1952
			Oregon	Senger and Neiland, 1955
		Levinseniella brachysoma	Minnesota	Penner, 1949
		Mediogonimus ovilacus		Penner, 1949
		Metorchis conjunctus	Penn.	Anderson and Beaudoin, 1966
			Ontario	Sweatman, 1952
		Nudacotyle novicia	Michigan	Ameel, 1932b
			Michigan	Ameel, 1942
			Nebraska	Barker, 1916a
			Texas	Chandler, 1941
			Illinois	Gilford, 1954
			N. Carolina	Harkema and Miller, 1962
			Maine	Meyer and Reilly, 1950
			Louisiana	Penn, 1942b
			Ontario	Swales, 1933

Location in host	Class	Parasite	Area Recorded	Author
	Trematoda	*Opisthorchis tonkae*	New York	Edwards, 1949
		Phagicola lageniformis	Texas	Chandler, 1941
		Phagicola nana	Louisiana	Byrd and Reiber, 1942
		Plagiorchis maculosus		Penner, 1949
		Plagiorchis micracanthos		Penner, 1949
		Plagiorchis muris		Penner, 1949
		Plagiorchis proximus	Penn.	Anderson and Beaudoin, 1966
			Eastern Canada	Allen, 1934
			Michigan	Ameel, 1942
			Colorado	Ball, 1952
			Nebraska	Barker, 1915b, 1916a
			New York	Edwards, 1949
			Illinois	Gilford, 1954
			Poland	Grabda, 1954
			Utah	Grundmann and Tsai, 1967
			Brit. Col.	Knight, 1951a
			Ontario	Law and Kennedy, 1932

Location in host	Class	Parasite	Area Recorded	Author
	Trematoda	*Plagiorchis proximus*	Maine	Meyer and Reilly, 1950
			Mass.	Rankin, 1946
			Ohio	Rausch, 1946
			Alaska	Rausch, 1952
			Ontario	Swales, 1933
			Ontario	Sweatman, 1952
		Plagiorchis sp.	Nebraska	Barker, 1915a
		Pseudodiscus zibethicus	Michigan	Ameel, 1942
			New York	Edwards, 1949
			Illinois	Gilford, 1954
			Maine	Meyer and Reilly, 1950
		Psilotrema marki	Poland	Grabda, 1954
		Psilotrema pharyngeatum	Poland	Grabda, 1954
		Psilotrema sp.	Utah	Grundmann and Tsai, 1967
		Stichorchis subtriquetrus	Penn.	Leidy, 1888
			England	Warwick, 1936
		Stephanoproraoides markewitschi	Russia	Sharpylo and Sharpylo, 1959

Location in host	Class	Parasite	Area Recorded	Author
	Trematoda	Urotrema scabridum (= U. shillingeri)	Mexico Maryland Maryland	Caballero, 1942 Penner, 1941 Price, 1931
Small Intestine	Cestoda	Andrya macrocephala	Penn.	Anderson and Beaudoin, 1966
		Andrya ondatrae	Ohio	Rausch, 1948
		Andrya sp.	Ohio Utah	Rausch, 1947 Grundmann and Tsai, 1967
		Anomotaenia sp.	Nebraska	Barker, 1915a
		Anomotaenia telescopica	Nebraska	Barker, 1915b
		Hymenolepis sp.	Nebraska Ohio Oregon Alberta	Barker, 1915a Rausch, 1946 Senger and Neiland, 1955 Swales, 1933

Location in host	Class	Parasite	Area Recorded	Author
	Cestoda	Hymenolepis evaginata	Eastern Canada	Allen, 1934
			Michigan	Ameel, 1942
			Nebraska	Barker, 1915b
			Colorado	Ball, 1952
			Great Britain	Baylis, 1935
			Alaska	Dunagan, 1957
			New York	Edwards, 1949
			Illinois	Gilford, 1954
			Brit. Col.	Knight, 1951a
			Ontario	Law and Kennedy, 1932
			Maine	Meyer and Reilly, 1950
			Maryland	Olsen, 1939
			Louisiana	Penn, 1942b
			Mass.	Rankin, 1946
			Utah	Senger and Bates, 1957
			Alberta	Swales, 1933
			Ontario	Swales, 1933
			Ontario	Sweatman, 1952
			Great Britain	Warwick, 1936
		Hymenolepis octocoronata	Brit. Col.	Knight, 1951a
		Hymenosphenacanthoides ondatrae (= Hymenolepis ondatrae)	Utah	Grundmann and Tsai, 1967
			Oregon	Rider and Macy, 1947

Location in host	Class	Parasite	Area Recorded	Author
	Cestoda	*Rodentolepis oregonensis* (= *Hymenolepis oregonensis*)	Oregon Oregon	Neiland, 1952 Senger and Neiland, 1955
	Nematoda	*Capillaria* sp.	Ohio	Rausch, 1946
		Capillaria marii	Russia	Karpovich, 1957
		Capillaria ransomia	Eastern Canada Michigan Nebraska Wash., D. C. Brit. Col.	Allen, 1934 Ameel, 1942 Barker, 1915b, 1916 Hall, 1916 Knight, 1951a
		Longistriata adunca	Louisiana	Penn, 1942b
		Longistriata dalrymplei	Texas	Chandler, 1941
		Nematospiroides longispiculatus	New Jersey Illinois	Dikmans, 1940 Gilford, 1954
		Rictularia sp.	Wash., D. C. Louisiana	Dikmans, 1940 Penn, 1942b
		Rictularia ondatrae	Texas	Chandler, 1941

Location in host	Class	Parasite	Area Recorded	Author
	Nematoda	*Skrjabinomerus desmanae*	Russia	Karpovich, 1957
		Strongyloides ratti var. *ondatrae*	Texas	Chandler, 1941
		Trichostrongylus sp.	Oregon	Rider and Macy, 1947
			Nebraska	Barker, 1915a
		Trichostrongylus calcaratus	Texas	Chandler, 1941
			Texas	Chandler, and Melvin, 1951
		Trichostrongylus fiberius	Eastern Canada	Allen, 1934
			Nebraska	Barker, 1915b
		Trichuris sp.	Ontario	Allen, 1934
			Nebraska	Barker, 1915a
			Texas	Chandler, 1950
		Trichuris opaca	Eastern Canada	Allen, 1934
			Michigan	Ameel, 1942
			Penn.	Anderson and Beaudoin, 1966
			Colorado	Ball, 1952
			Nebraska	Barker, 1915b
			Alaska	Dunagan, 1957
			New York	Edwards, 1949
			Illinois	Gilford, 1954

Location in host	Class	Parasite	Area Recorded	Author
	Nematoda	<u>Trichuris opaca</u>	Utah	Grundmann and Tsai, 1967
			Oregon	Senger and Neiland, 1955
			Ohio	Rausch, 1946
			Ontario	Sweatman, 1952
			Illinois	Tiner, 1950
	Acanthocephala	<u>Polymorphus</u> sp.	Alaska	Dunagan, 1957
			Brit. Col.	Knight, 1951a
			Alaska	Van Cleave, 1953
Small Intestine and Caecum	Protozoa	<u>Chilomastix</u> sp.	Britain	Bishop, 1934
		<u>Coccidia</u>		Woodhead, 1930
		<u>Eimeria steidae</u>	Eastern Canada	Allen, 1934
		<u>Eimeria ondatra-zibethica</u>		Martin, 1930
			Russia	Svanbec, 1962
		<u>Giardia ondatrae</u>	Colorado	Ball, 1952
			Utah	Grundmann and Tsai, 1967
			Louisiana	Penn, 1942a, b
			Iowa	Travis, 1939

Location in host	Class	Parasite	Area Recorded	Author
	Protozoa	Giardia sp.	Britain	Bishopp, 1934
			Britain	Warwick, 1936
		Retortamonas sp.	Britain	Bishop, 1934
			Britain	Warwick, 1936
		Trichomonas sp.	Britain	Bishop, 1934
			Utah	Grundmann and Tsai, 1967
			Louisiana	Penn, 1942b
			Britain	Warwick, 1936
	Trematoda	Catatropis fimbriata (Syn. of Notocotylus filamentis)	Eastern Canada	Allen, 1934
			Michigan	Ameel, 1942
			Nebraska	Barker, 1915b
			Alaska	Dunagan, 1957
			Illinois	Harrah, 1922
			Ontario	Law and Kennedy, 1932
			Illinois	Leigh, 1940
			Maine	Meyer and Reilly, 1950
			Ontario	Swales, 1933
			Ontario	Sweatman, 1952

Location in host	Class	Parasite	Area Recorded	Author
	Trematoda	_Fibricola cratera_	Eastern Canada	Allen, 1934
			Nebraska	Barker, 1915b
			Iowa	Becker (Errington, 1963)
			Illinois	Gilford, 1954
			Utah	Grundmann and Tsai, 1967
			Ontario	Law and Kennedy, 1932
			Ontario	Swales, 1933
		Notocotylus sp.	Illinois	Gilford, 1954
			Oregon	Senger and Neiland, 1955
		Notocotylus urbanensis	New York	Edwards, 1949
			Utah	Grundmann and Tsai, 1967
			Brit. Col.	Knight, 1951a
			Oregon	Rider and Macy, 1947
			Ontario	Sweatman, 1952
		Quinqueserialis quinqueserialis	Eastern Canada	Allen, 1934
			Michigan	Ameel, 1942
			Pennsylvania	Anderson and Beaudoin, 1966
			Colorado	Ball, 1952
			Nebraska	Barker, 1915a,b

Location in host	Class	Parasite	Area Recorded	Author
	Trematoda	<u>Quinqueserialis quinqueserialis</u>	Nebraska	Barker and Laughlin, 1911
			Britain	Baylis, 1935
			Alaska	Dunagan, 1957
			New York	Edwards, 1949
			Illinois	Gilford, 1954
			Utah,	Grundmann and Tsai, 1967
			Michigan	Herber, 1942
			Pennsylvania	Herber, 1942
			Brit. Col.	Knight, 1951a
			Ontario	Law and Kennedy, 1932
			Washington	Metcalf, 1915
			Maine	Meyer and Reilly, 1950
			Ohio	Rausch, 1946
			Alaska	Rausch, 1952
			Idaho	Schell, 1960
			Utah	Senger and Bates, 1957
			Oregon	Senger and Neiland, 1955
			Britain	Warwick, 1936
		<u>Wardius zibethicus</u>	Eastern Canada	Allen, 1934
			Pennsylvania	Anderson and Beaudoin, 1966
			Nebraska	Barker, 1915b
			Ontario	Law and Kennedy, 1932
			Ohio	Rausch, 1946
			Michigan	Smith, 1958
			Britain	Warwick, 1936

Location in host	Class	Parasite	Area Recorded	Author
	Nematoda	*Trichostrongylus fiberius*	Nebraska	Barker, 1915b
			Oregon	Rider and Macy, 1947
		Ascaris lumbricoides	Pennsylvania	Anderson and Beaudoin, 1966
			Nebraska	Barker, 1916a
			Illinois	Gilford, 1954
			Illinois	Tiner and Chin Hsuing Ta, 1948
			Illinois	Tiner, 1951
		Ascaris sp.	Utah	Grundmann and Tsai, 1967
Colon	Trematoda	*Paramonostomum echinum* (Syn. of *Notocotylus urbanensis*)	Colorado	Harrah, 1922
		Paramonostomum pseudalveatum	Texas	Chandler, 1941
			Utah	Grundmann and Tsai, 1967
			Louisiana	Penn, 1942b
			Louisiana	Price, 1931a
			Maryland	Price, 1931a
	Nematoda	*Syphacia obvelata*	Poland	Grabda, 1954

Location in host	Class	Parasite	Area Recorded	Author
Stomach	Protozoa	Coccidia	Eastern U.S.A.	Shillinger, 1934
	Nematoda	*Physaloptera* sp.	Louisiana	Penn, 1942b
	Cestoda	*Cladotaenia circi*	Minnesota	Penner, 1949
		Monoecocestus variabilis	Minnesota	Olsen, 1939
		Monoecocestus americanus	Minnesota	Olsen, 1939
Liver	Trematoda	*Fasciola hepatica*	Europe	Warwick, 1936
		Opisthorchis tonkae	Minnesota	Wallace and Penner, 1939
		Pseudosilostoma ondatrae (= *Psilostomum ondatrae*)	Eastern Canada Ontario Ontario Oregon Ontario	Allen, 1934 Law and Kennedy, 1932 Price, 1931a Price, 1931a Swales, 1933
		Schistosomatium douthitti	Michigan Minnesota Michigan Michigan	Ameel, 1942 Penner, 1938b Penner, 1938b Penner, 1942

Location in host	Class	Parasite	Area Recorded	Author
	Cestoda	*Cladotaenia* sp. (larva)	Michigan	Ameel, 1942
			N. Dakota	Goldsby and Johnson, 1951
			Canada	Knight, 1951a
		Hydatigera taeniaeformis	Pennsylvania	Anderson and Beaudoin, 1966
			Michigan	Ameel, 1942
			Nebraska	Barker, 1916a
			Britain	Baylis, 1935
			Scotland	Cameron and Parnell, 1933
			New York	Edwards, 1949
			Ohio	Gallati, 1956
			Illinois	Gilford, 1954
			Poland	Grabda, 1954
			Brit. Col.	Knight, 1951a
			Michigan	Kuntz, 1943
			Ontario	Law and Kennedy, 1932
			Pennsylvania	Linton, 1888 (Barker, 1915b)
			Pennsylvania	Linton, 1915
			Massachusetts	Rankin, 1946
			Ohio	Rausch, 1946
			Oregon	Rider and Macy, 1947
			Oregon	Senger and Neiland, 1955
			Maryland	Smith, 1938
			Ontario	Swales, 1933
			Britain	Warwick, 1936

Location in host	Class	Parasite	Area Recorded	Author
	Cestoda	Taenia tenuicollis (larva)	Ontario	Skinker, 1935
			Alaska	Locker, 1955
			Montana	Locker, 1955
			Britain	Baylis, 1935
			Britain	Warwick, 1936
		Taenia crassiceps (larva)	Ontario	Skinker, 1935
		Taenia sp. (larva)	Maine	Meyer and Reilly, 1950
	Nematoda	Capillaria hepatica	Eastern Canada	Allen, 1934
			Michigan	Ameel, 1942
			Britain	Baylis, 1935
			Ontario	Law and Kennedy, 1932
			Maine	Meyer and Reilly, 1950
			Louisiana	Penn, 1942b
			Ontario	Price, 1931
			Britain	Warwick, 1936
		Capillaria michiganensis	Michigan	Read, 1949
			Utah	Grundmann and Tsai, 1967
		Capillaria sp.	Ohio	Rausch, 1946

Location in host	Class	Parasite	Area Recorded	Author
	Pentastomida	*Porocephalus crotali*	Louisiana	Penn, 1942a,b
Gall bladder	Trematoda	*Amphimerus pseudofelineus*	Nebraska	Barker and Laughlin, 1911
			Illinois	Gilford, 1954
		Opisthorchis tonkae	Minnesota	Wallace and Penner, 1939
	Cestoda	*Hydatigera taeniaeformis*	England	Beddard, 1912
Omentum	Cestoda	*Hydatigera taeniaeformis*	Ontario	Law and Kennedy, 1932
Peritoneum	Cestoda	*Cladotaenia* sp.	N. Dakota	Goldsby and Johnston, 1951
		Hydatigera taeniaeformis	Pennsylvania	Linton, 1915
Spleen	Trematoda	*Schistosomatium douthitti*	Michigan	Ameel, 1942
			Minnesota	Penner, 1938b
			Michigan	Penner, 1938b
Blood	Trematoda	*Schistosomatium douthitti*	Minnesota	Penner, 1938b
			Michigan	Penner, 1938b
			Illinois	Gilford, 1954

Location in host	Class	Parasite	Area Recorded	Author
	Nematoda	<u>Dirofilaria immitis</u>	New York Maryland	Goble, 1942 Smith, 1938
		<u>Litomosoides carinii</u>	Texas	Chandler, 1941
Lungs	Trematoda	<u>Paragonimus kellicotti</u>	Michigan Minnesota	Ameel, 1932b Ameel, 1942
	Cestoda	<u>Cladotaenia</u> sp.	N. Dakota	Goldsby and Johnston, 1951
	Pentastomida	<u>Porocephalus crotali</u>	Louisiana Louisiana	Penn, 1942a, b Penn and Martin, 1941
		<u>Porocephalus</u> sp.	Louisiana	Svihla and Svihla, 1938
	Nematoda	<u>Rodentocaulus ondatrae</u>	Russia	Schulz, <u>et al</u>., 1933
Salivary glands	Trematoda	<u>Ptyalincola ondatrae</u>	Michigan	Wootton, 1966