THE SIGNIFICANCE OF DISEASES AND PARASITES OF THE MUSKRAT (ONDATRA ZIBETHICA) IN BRITISH COLUMBIA

by

Iola W. Musfeldt

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THE SIGNIFICANCE OF DISEASES AND PARASITES OF THE MUSKRAT (ONDATRA ZIBETHICA) IN BRITISH COLUMBIA.

INTRODUCTION

In the fall of 1944, as a preliminary to the present study, the investigator undertook a survey of the parasites of the muskrat at Burnaby Lake (Vancouver, B.C.). The results of this survey indicated that this problem was worthy of continuation throughout the province of British Columbia.

In order to complete such an investigation, a knowledge of the distribution of this prolific fur-bearer and a means to obtain many muskrat carcasses were necessary. As a result of returns from an 'outline questionnaire' sent to registered trappers, considerable information regarding the muskrat was obtained. From October 15, 1944 to May 15, 1947, 202 skinned carcasses were collected on which parasite and disease examinations were performed.

The purpose of this thesis is to present an analysis of the information on the problem of diseases and parasites of the muskrat in its existing state in this province. Previous studies in this field are also summarized.

HISTORICAL REVIEW

The muskrat, one of the staple fur-bearers of North America, has been studied extensively in the eastern and southern parts of this continent. However, there are few important inquiries regarding this prolific animal in its western ranges. Several investigations have taken place in Europe, since its introduction from America.

Since the early years of wildlife study, a great bulk of literature has accumulated on the life history, distribution, diseases and parasites of the muskrat. Among the earlier publications are those of R. MacFarlane (1905) and E.T. Seton (1909), in which several pages are devoted to the muskrat in the Mackenzie River district. There is also the revisionary work of Ned Hollister (1911) on the distribution of the muskrat in North America.

The few major studies on the muskrat west of the Rocky Mountains have been in California where T.I. Storer (1933), C.A. Sooter (1946) and A.L. Hensley and H. Twining (1946) have completed life history and distribution surveys. While bird and mammal surveys carried out in various localities in British Columbia by H.S. Swarth (1924), I. McT. Cowan (1939) and J.A. Munro (1947) include muskrat.

The diseases and especially the parasites of the muskrat have been studied quite extensively. However, it is apparent from the available literature that no

parasitological study has been undertaken in the western part of the species range.

According to the literature, publications on the diseases are limited to the papers of T. Warwick (1934) in England, F.R. Smith (1938) and H.L. Dozier (1943) in Maryland; an unpublished report from P.L. Errington (1946) in Iowa and a few scattered references in the papers of MacFarlane (1909), W.M. Rush (1927), R.L. Rausch (1946), J.E. Shillinger (1933), J.H. Brown (1944) and others. A.E. Woodhead (1930) reviews coccidiosis in the farmed muskrat.

Early literature on parasites includes a report by Linton in 1884, who noted that the muskrat was host to larval cestodes. In 1888, Leidy mentions finding two species of trematodes in the small intestine which he identified as Echinostomum echinatum Zedar and Amphistomum subtriquetrum Reed. The latter species was later renamed by F.D. Barker as Wardius zibethicus. Apparently undated, is the report of unidentified filaria from the muskrat by B.H. Ransom at the Bureau of Animal Industry, Washington, D.C. Another early report was Stiles and Hassel in 1894, who identified larval cestodes from the muskrat in Pennsylvania. Since these early beginnings until 1946, a great amount of data has been collected on the parasites of

the muskrat in many parts of North America and Europe.

Table 1 presents a summary of the reported parasites, their site of infection, location of report and the investigator. It is possible that this summary has a few omissions. It may be noted from this table that although the species of muskrat varies in range throughout North America, the different species of parasites have remained constant. This is also evident in England where the muskrat has been introduced. There, it has introduced its parasites and has as yet acquired no new normal ones.

It is noted too, that some of these parasites have an extensive distribution. These include Quinqueserialis quinqueserialis, Capillaria ransomia, Hymenolepis evaginata and Cysticercus fasciolaris which occur throughout North America as well as in Great Britain.

It is interesting to observe also the geographical distribution of the reported parasites in North America. The species of trematodes tend to be more numerous in the northern areas, while species of nematodes are more numerous in the southern ranges.

Besides its normal parasites, the muskrat has been found infected with certain accidental parasites both in England and North America. Of the former, Fasciola hepatica is the only accidental infection while in the latter, Schizotaenia sp., normally a porcupine parasite, has been reported.

	LOCATION IN HOST	CLASS	PARASITE	AREA RECORDED	CITATION
ECTOPARASITES	External Body	Mites Acarina	Tetragonyssus spiniger	Maryland Louisiana	F.R.Smith ('38) Geo.H.Penn Jr. ('42)
			Icharonyssus spiniger	Maryland	F.R.Smith ('38)
			Listrophorus sp.	Maryland	F.R.Smith ('38)
			Sarcophaga sp.	Louisiana	Geo.H.Penn Jr. ('42)
ENDOPARASITES	Small Intestine	Trematodes	Echinostomum revolutum	Pennsylvania Quebec, Canada Alberta, Canada Pennsylvania Illinois Colorado Ontario, Canada	Jos.Leidy (1888) P.C.Beaver ('37) P.C.Beaver ('37) P.C.Beaver ('37) P.C.Beaver ('37) P.C.Beaver ('37) R.Law & A.Kennedy ('32)
			Echinostomum coalitum	Nebraska Ohio Eastern Canada	F.D.Barker ('15) Rausch ('46) J.A.Allen ('34)
			Echinostomum callawayensis	Nebraska Eastern Canada Ontario, Canada	F.D.Barker ('15) J.A.Allen ('34) R.Law & A.Kennedy ('32)
			Echinostomum armigerum	Nebraska Eastern Canada Ontario, Canada Maryland	F.D.Barker ('15) J.A.Allen ('34) R.Law & A.Kennedy ('32) W.H.Krull ('35)
			Echinostomum sp.	Alberta, Canada	W.E.Swales ('33)
			Plagorchis proximus	Nebraska Eastern Canada Ohio Michigan Ontario, Canada	F.D.Barker ('15) J.A.Allen ('34) R.L.Rausch ('46) D.J.Ameel ('42) R.Law & A.Kennedy ('32)

	LOCATION IN HOST	CLASS	PARASITE	AREA RECORDED	CITATION
ENDOPARASITES	Small Intestine	Trematodes	Echinochasmus schwartzii	South.east Texas New Orleans Ontario, Canada	Asa C.Chandler ('41) Elm.E.Boyd & Robt.J. Reiber ('42) R.Law & A.Kennedy ('32)
			Phagicola nana	New Orleans	Elm.E.Boyd & Robt.J. Reiber ('42)
			Nudacotyle novicia	South.east Texas Louisiana Michigan Ontario, Canada	Asa C.Chandler ('41) Geo.H.Penn Jr.('42) D.J.Amell ('42) R.Law & A.Kennedy ('32)
			Echinoparyphium contiguum	Nebraska Ontario, Canada	F.D.Barker ('15) R.Law & A.Kennedy ('32)
			Phagicola langiniformis	South.east Texas	Asa C.Chandler ('41)
			Alaria mustelae	Eastern Canada Ontario	J.A.Allen ('34) R.Law & A.Kennedy ('32)
			Allassogonoporous marginalis	Michigan	Olivier ('38)
			Urotrema shillingeri	Maryland	Price ('31) L.R.Penner ('41)
			Pseudodiscus zibethicus	Michigan	D.J.Ameel ('42) (1)
	Small Intestine	Cestodes	Hymenolepis evaginata	Nebraska Louisiana East.Canada Gt.Britain Michigan Ontario Alberta Ohio	F.D.Barker ('15) Geo.H.Penn Jr.('42) J.A.Allen ('34) H.A.Bayliss ('35) D.J.Ameel ('42) R.Law & A.Kennedy ('32) W.E.Swales ('33) R.L.Rausch ('46)

	LOCATION IN HOST	CLASS	PARASITE	AREA RECORDED	CITATION
	Small Intestine	Cestodes	Anomotaenia telescopica	Nebraska	F.D.Barker ('15)
			Taenia crassicollis	Maryland	F.R.Smith ('38)
ENDOPARASITES	Small Intestine	Nematodes	Nematospinoides longispiculatus	Washington, D.C. New Jersey	Dr.G.E.Dikmons ('40)
			Trichuris opaca	Eastern Canada Michigan Ohio	J.A.Allen ('34) D.J.Ameel ('42) R.L.Rausch ('46)
			Capillaria ransomia	Nebraska Eastern Canada Michigan Ohio	F.D.Barker ('15) J.A.Allen ('34) D.J.Ameel ('42) R.L.Rausch ('46)
			Trichostrongylus fiberius	Eastern Canada	J.A.Allen ('15)
			Longistriata dalrymplii	South.east Texas	Asa C.Chandler ('41)
			Reticularia ondatrae	South.east Texas	Asa C.Chandler ('41)
			Longistriata adunca	Louisiana	Geo.H.Penn Jr.('42)
			Strongyloides ratti (var.ondatrae)	South.east Texas	Asa C.Chandler ('41)
ENDO-PARASITES	Small intestine and cecum	Protozoa	Giardia ondatrae	Louisiana	Bernard V.Travis ('39) Geo.H.Penn, Jr.('42)
			Eimeria steidae	Eastern Canada	J.A.Allen ('34)
			Trichomonas	Louisiana	Geo.H.Penn ('42)

	LOCATION IN HOST	CLASS	PARASITE	AREA RECORDED	CITATION
ENDOPARASITES	Stomach	Nematoda	Nematoda Physolaptera sp.	Louisiana Eastern United States	Geo.H.Penn Jr.('42) Geo.Shillinger ('33)
		Protozoa	Coccidia	Eastern United States	Geo.Shillinger ('33)
		Cestoda	Schizotaenia variabilis & S.Americana	Minnesota	Olsen ('39)
	Intestine and cacum	Trematodes	Quinqueserialis quinqueserialis (Notocotylus quinqueserialis) (2)	Nebraska Eastern Canada Gt.Britain Michigan Washington Ohio Ontario Michigan & Pennsylvania	F.D.Barker ('15) J.A.Allen ('34) H.A.Bayliss ('35) D.J.Ameel ('42) H.E.Metcalf ('15 coll.) R.L.Rausch ('46) R.Law & A.Kennedy ('32) E.C.Herber ('42)
			Catatropis filamentis (3)	Nebraska Eastern Canada Ontario Michigan	F.D.Barker ('15) J.A.Allen ('34) R.Law & A.Kennedy ('32) D.J.Ameel ('42)
			Hemistomum craterum	Nebraska? Eastern Canada Ontario	F.D.Barker ('15) J.A.Allen ('34) R.Law & A.Kennedy ('32)
			Wardius zibethicus (4)	Nebraska Eastern Canada Gt.Britain Ohio Ontario	F.D.Barker ('15) J.A.Allen ('34) Tom Warwick ('36) R.L.Rausch ('46) R.Law & A.Kennedy ('32)
			Notocotylus urbanensis	Maryland	Wm.Cort ('14) A.Hassall (1892)col.)
	Intestine & cecum	Nematode	Trichostrongylus fiberius	Nebraska	F.D.Barker ('15)
	Colon	Trematodes	Paramonostomum pseudo-(5) valeatum	Louisiana Southeast Texas	Geo.H.Penn Jr.'42) Asa C.Chandler ('41) E.W.Price ('31)
			Paramonostomum echinum	Colorado	Harrah ('22)(Gable '16 col.)

	LOCATION IN HOST	CLASS	PARASITE	AREA RECORDED	CITATION
ENDOPARASITES	Liver	Trematodes	Schistosomatium douthitti	Minnesota Michigan	D.J.Ameel ('42) L.R.Penner ('38)
			Opistorchis tonkae	Minnesota Michigan	L.R.Penner ('39) F.G.Wallace ('39)
			Psilostomum ondatrae	Eastern Canada Ontario	J.A.Allen ('34) R.Law & A.Kennedy ('32)
			Fasciola hepatica	Gt.Britain	Tom Warwick ('36)
	Liver	Nematodes	Capillaria hepatica	Gt.Britain Eastern Canada Michigan	H.A.Bayliss ('35) J.A.Allen ('34) D.J.Ameel ('42)
			Hepaticola hepatica	Gt.Britain Ontario	Tom Warwick ('34) R.Law & A.Kennedy (32)
	Liver	Cestodes	Cysticercus fasciolaris (larvae of Taenia taeniaformis (Batsch) 1786)	Gt.Britain Washington Penn. Maryland Eastern Canada Philadelphia Ontario Michigan Ohio	H.A.Bayliss ('35) Linton (1884) F.R.Smith ('38) J.A.Allen ('34) - ('84 & '05) R.Law & A.Kennedy ('32) R.E.Kuntz ('42) R.L.Rausch ('46)
			Taenia tenucollis larvae (Cysticercus innominabus hypudaei Leuk 1857) (6)	Gt.Britain Ontario, Canada	H.A.Baylis ('35) M.S.Skinner ('35)
			Urocystidium gemmiparum	Germany (?)	Biddard ('14)
			Cladotaenia sp.	Michigan	D.J.Ameel ('42) L.R.Penner ('38)
	Gall duct & bladder	Trematode	Monostomum affine	Pennsylvania	J.Leidy (1858)
	Omentum	Cestode	Cysticercus fasciolaris	Washington, Penn. Michigan	Linton (1884) D.J.Ameel ('42)

	LOCATION IN HOST	CLASS	PARASITE	AREA RECORDED	CITATION
ENDOPARASITES	Spleen	Trema-tode	Schistosomatium douthitti	Michigan Minnesota	D. J. Ameel ('42) L. R. Penner ('38)
	Blood	Trema-tode	Schistosomatium douthitti	Minnesota and Michigan	L.R.Penner ('38)
	Blood	Filaria	Dirofilaria sp.	Maryland	F.R.Smith ('38)
			Litomosoides carinii (microfilaria adults)	South.east Texas	Asa C.Chandler ('41)
		Arach-nida	Arachnida - Porocephalus crotali (nymphs)	Louisiana	Geo.H.Penn Jr.('42)
	Lung	Trema-tode	Paragonimus sp.(7)	Gt.Britain Minnesota	Tom Warwick ('36) D.J.Ammel ('32)

TABLE I - Parasite Records for the Muskrat (Ondatra sp.) as reported in the literature to 1946.

Footnotes:

(1) = U.lasiurensis Alicata ('32)
U.minuta Macy '33

(2) Notocotyle quinqueseriale Barker and Laughlin = Quinqueserialis Hindiu = Naviformia = Kossackia Barkeria = quinqueserialis

(3) C.filamentia, Price = C. filambriata, Barker

(4) Wardius zibethicus, Barker = Amphistomum subtriquetrum, Liedy ('84)= Cladorchis subtriquetrus Warwick (1936)

(5) = Neoparamonostomum

(6) Cysticercus innominabue hypudaei Leuk 1857 = Cysticercus talpae Rudolphi 1819

(7) - not typical rodent parasites

Not listed: W.Henry Leigh ('40) - reported protozoan and helminth parasites in Illinois.

METHODS of STUDY

It was impossible to investigate personally the many areas in the province of British Columbia that the muskrat inhabits. In order to overcome this situation, a pamphlet consisting of a questionnaire with a letter of introduction to this problem was sent to 750 registered trappers. The trappers contacted were chosen from the "List of Names and Addresses" of Holders of Special and Extra-special (trappers) Firearms licenses issued under the B.C. Game Act" which is compiled by the B.C. Provincial Game Commission. Similar pamphlets were sent also to the game-wardens throughout the province.

The returned questionnaires were segregated as "positive returns" if the list of fur-bearers trapped included muskrat, and as "negative returns" if no muskrat were taken. Each of these groups was divided into the area in which the trapline was located. (Plate I., Map of British Columbia).

From the returns of this questionaire considerable information was obtained regarding the distribution of the muskrat; areas in which it is trapped; other fur-bearers trapped in the same area; number of muskrat collected and diseases affecting it.

Also through this pamphlet, both trappers and game-wardens were requested to send to the University "express collect" fresh skinned muskrat carcasses during

trapping season for disease and parasite examination. In cases where the carcasses could not be received within a couple of days, there was sent to the trapper or game-warden a quart of 100% Formalin with directions for its use. These directions were to add the formal~~dehyde~~in to a pail of water and place the carcasses in this solution for 24 hours. Following this procedure they could be safely forwarded to the university.

When a carcass was received it was numbered according to trapline location and the following routine examination for diseases and parasites was performed. Several observations, incidental to the actual examination, were recorded. These included weight, sex, measurements, sexual activity and scars. Also recorded and preserved were diseased areas and in several instances, complete skulls and male genital organs (testes and seminal vesicles).

A complete examination of the internal organs included noting the condition of the respiratory, urinogenital, circulatory and digestive systems as well as the general condition of the body. The digestive tract was removed from the animal, tagged with the identification number and preserved in 5% formalin. This preserved the intestinal tract and removed decomposition odours. Just prior to parasitic examination it was soaked in water for a few hours to remove the formalin.

For the study of the internal parasites, the entire digestive tract was divided into the regions of stomach, upper small intestine, lower small intestine, cecum and colon. The small intestine was divided in half, that portion following the stomach was designated as "upper small intestine" while the "lower small intestine" was that attached to the cecum. The "cecum" included the cecum proper as well as that portion of the colon which is the same diameter as the cecum. The "colon" was the remainder of the colon and rectum.

Each segment was slit and the contents were washed into a millimeter-mesh sieve. The piece of intestinal tract was run over the left index finger and cleaned with water running through a glass tip on the water fawcett hose to remove adhering parasites. The sieve contents were washed with water to remove filterable debris. The remaining material was washed into a glass bowl. The parasites thus showed up whitish and opaque when examined against a black background.

In this manner, any parasites greater than one millimeter were counted and collected for identification. Protozoan parasites were not accounted because usually 24 hours had lapsed before receipt of the carcass. Hence, erroneous identification would result regarding specimens that might have been found.

For specific identification, in a high infection, a representative number of individuals of each species was collected, Otherwise, all the parasites were recovered and preserved in formol-alcohol. The trematodes were stained in a modified Mallory Triple Stain#; the cestodes, in Borax-Carmine or Acetic Alum Carmine, while the nematodes were mounted unstained in pure glycerol. The acanthocephalan parasite was mounted either unstained or stained in Acetic Alum Carmine.

The technique used in this work was devised by the author. It consisted of using 1:10 water dilutions of the regular Mallory Stains #1 and #2. If a specimen was overstained in Mallory #1, either acid or basic 75% alcohol was used to destain. Similarly, excess Mallory #2 stain was removed by basic 75% alcohol. Phenol-xylol was used for dehydration and balsam mounts. The paler stained specimens howed the best differentiation. It was found that this stain is most successful for the small trematodes only.

THE MUSKRAT IN BRITISH COLUMBIA

It will be noted from Plate I that in British Columbia there are two subspecies of muskrat, Ondatra zibethica osoyoosensis and O. z. spatulata. The former is of more southern distribution while the latter occupies the northern range. The coastal intergradation of the two subspecies apparently occurs in the Skeena district. The distribution shown in this map is only general, as subsequent discussion will reveal that much of the terrain of this province is unsuitable for muskrat inhabitation. For the purpose of this investigation subspecific references will be omitted.

This fur-bearer is indigenous to the mainland of the province. It has been successfully introduced onto several Islands in the Georgia Strait as well as onto Vancouver Island and onto Graham Island and Moresby Islands in the Queen Charlotte Islands.

The distribution of the muskrat is thus so extensive that there are probably few areas of suitable habitat which it has not at one time inhabited. However, maintenance and increase of population in these areas is largely limited by the adequacy of the habitat and its access to surrounding muskrat inhabited areas. Such adequacy

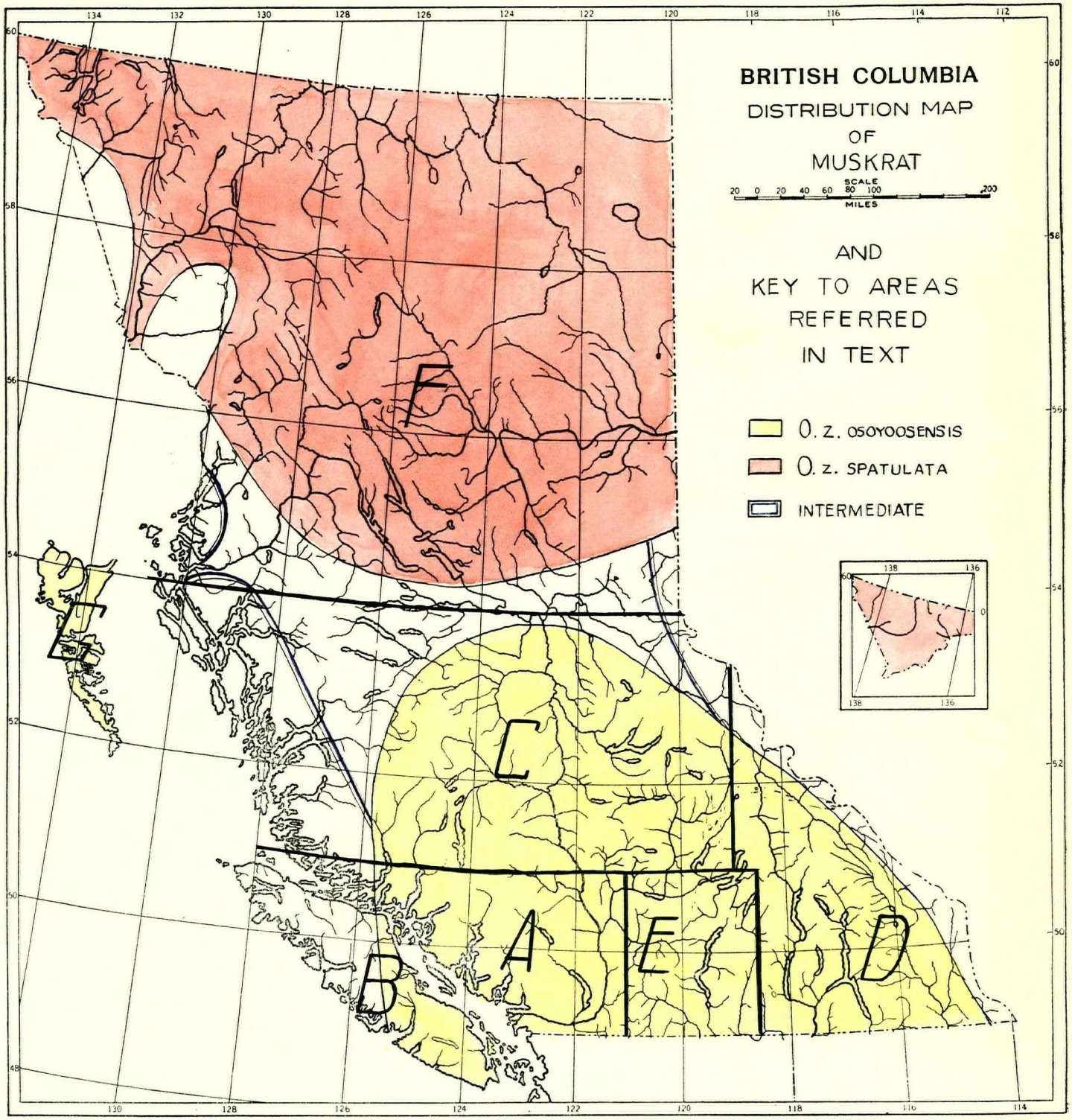

BRITISH COLUMBIA
DISTRIBUTION MAP
OF
MUSKRAT
SCALE
20 0 20 40 60 80 100 200
MILES
AND
KEY TO AREAS
REFERRED
IN TEXT
O. z. OSOYOOSENSIS
O. z. SPATULATA
INTERMEDIATE
F
C
B
A
E
D

PLATE I

depends on the food potential, both the type and the quantity.

GEOGRAPHICAL DIVISIONS FOR SURVEY

For the purpose of this investigation, the province has been divided into arbitrary areas using geographical boundaries. These areas, as shown in Plate I, are as follows:

A - area consists of that territory bounded by the coastline of the mainland in the west to 121° longitude in the east. The south to north limits are 49° to 51° N. latitude.

B - area includes Vancouver Island and all other islands lying west of the coast of A, with exception of the Fraser River delta islands and Nelson Island which are included in A area.

C - area is defined as that territory lying north from 51° to 54° N. latitude. It includes all coastal islands in the west, except the Queen Charlotte Islands and extends to 119° longitude in the east.

D - area lies in the south-eastern part of the province and is bounded by the Alberta-British Columbia border and the United States International Boundary. The western limit is 119°

BRITISH COLUMBIA

Scale, 50 miles to 1 inch

10 0 25 50 100 150 200

DISTRIBUTION OF THE MUSKRAT

Indicated by

in the northern part and 118° 30' in the south. These limits were set in order to include the Columbia River valley.

E - area is that territory situated between A and D. Its north-south limits are 51° and 49° N. latitude, while its east-west limits are 118° 30' and 121°.

F - area includes the vast region of northern British Columbia lying from 54° N. latitude to the Yukon border and from Alaska to Alberta boundaries.

G - area has been designated as the Queen Charlotte Islands.

DISTRIBUTION IN EACH AREA

A - area South-west British Columbia, Lower Mainland

The major populations of muskrat in this area are confined to the lower mainland, Lulu Island, Sea Island and Fraser River Valley. Other reported smaller populations occur in marshes around Pitt Lake, Seton Lake, Pemberton, Nelson Island, Sechelt Peninsula and Powell River.

The greater part of the lower mainland area is dyked land with tidal salt marshes. Most of the muskrats are bank-dwelling and are found along drainage ditches and sloughs at the mouths of small creeks. Lulu Island and Sea

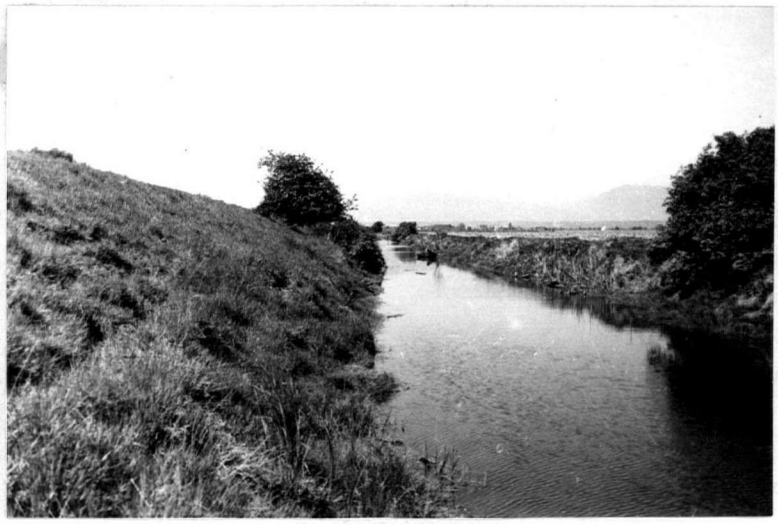


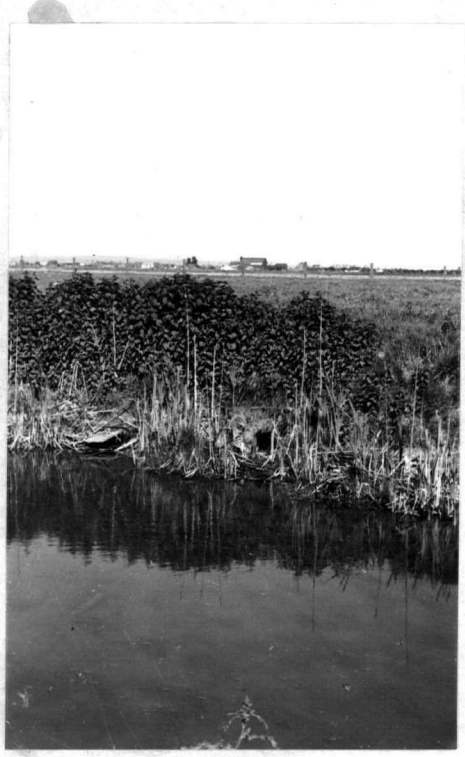
Fig. 1. Looking north from Blundell Road along dyke and ditch.

Fig. 2. Looking south from Blundell Road along dyke and ditch.

Lulu Island (A-area)

DRAINAGE DITCH HABITAT OF MUSKRAT.

PLATE IIa.



Close-up of a portion of the bank habitat shown in the above Fig. 1.

Lulu Island (A-area)

DRAINAGE DITCH HABITAT OF MUSKRAT.

PLATE IIb.

Fig. 1. Muskrat house composed of bulrushes.

Fig. 2. A floating piece of board forms this defecating post.

Burnaby Lake (A-area)

MARSH HABITAT OF MUSKRAT.

PLATE IIc.

Island are the principal muskrat trapping areas of this province.

Just east of the 122° meridian, the Fraser River valley becomes narrow and the terrain mountainous. The Skagit Range of the Cascade Mountains forms at this point a natural barrier to separate the interior and coastal muskrat populations.

The Fraser Valley population is the natural range while the scattered populations along the coast are transplantations. The Seton Lake and Pemberton Meadows probably represent migrations from the more interior ranges of the Cariboo (C-area).

The Nelson Island introduction was the only one for which records were available. In January 1926, three pair muskrats were liberated at Hidden Bay, Nelson Bay. A few years previous, an introduction was made at Green Lake, Nelson Island. By 1927, muskrats had spread over the entire island and one was trapped at Ruby Lake on the mainland. The following year, a fair stocking of muskrat was reported at the Pender Harbour lakes on Sechelt Penninsula. In 1929, another introduction which had been made at Gordon Pasha Lake (on the mainland, north of Nelson Island) was reported to be spreading.

B-area. Vancouver Island and Islands in the Georgia Strait

The muskrat is not indigenous to any parts of this area. Prior to its introduction onto Vancouver Island in

1924, the records show that no muskrat was found in the wild state.

At this time, under the direction of the B.C. Game Conservation Board, muskrats were trapped alive within the limits of the Burnaby Lake Game Reserve (Vancouver). (~~These were liberated at points that included Shaw Creek Game Reserve (Vancouver).~~) These were liberated at points that included Shaw Creek Game Reserve, Ucluelet, Jordan River, Port Alice, Hopkins Lake (Merville) and Comox.

At the time of these introductions there were many suitable places on this island for muskrat and the Game Conservation Board intended to carry on this work each year. This organisation, under the chairmanship of the late M.B. Jackson, K.C., existed from 1918 until 1926.

Storer (1938) had records of introduction of six muskrats each in 1923 and 1924 at Miller Creek, Forbes Landing, and Campbell River. In 1931 these localities were well populated and crop damage by muskrats was reported (R.M. Stewart, B.C. Police, Atlin, letter to Storer, December 4, 1931).

In 1927, reports from the Victoria district indicated that the muskrat was increasing and enlarging its range around Somenos Lake and Robertson River (Duncan). The next year, there was continued increase and spread throughout the lakes and flats at Duncan, Lake Cowichan and Saanich areas. Muskrats had also been seen at Port

Renfrew, thus migrating from the Jordan River area. In 1929, due to a rapid increase there were reports of agricultural damage by muskrats.

The following year 9,000 pelts were taken. Also, it is to be noted that seven years following its introduction, the muskrat is reported as a nuisance in southern Vancouver Island. In 1935, following an open season, the first record of a noticeable decrease took place. During the years that follow, there have been continued migrations into surrounding suitable areas.

Aside from these official transplantations, there have been introductions made by fur-farming interests for which there are no available records. If the interest failed, the animals were liberated to provide a new focus of introduction.

It was in this manner that the muskrat became established on certain islands in the Georgia Strait that include Salt Spring, Quadra, Thurlow, and Denman Islands. The transplantation onto the last named island took place in 1933 (T. Pearce, Courtenay, June 1933 to Storer). It is possible that the Salt Spring Island population represents a migration from that at Duncan.

C - area, Central British Columbia.

The muskrat is widely distributed throughout this area. ~~From~~ ~~Fig.~~ 3, It is noted that the greatest number occur on suitable creeks and marshes on the Chilcotin River

and south of Quesnel, west of the Fraser River. East of this river, they are most abundant in the "lakes region", south-east of Williams Lake. Muskrat are also present, but scarce west of the Cascade Mountains. They are rare in the high altitude-deep snow country in the eastern part of this area. A certain amount of muskrat are trapped along the northern limits in the Prince George and Vanderhoof districts.

J.A. Munro (1947) reported that there were no places in this northern area as favorable for muskrat as some localities in southern British Columbia (E-area). According to Munro, "the waters vary in elements making up the food potential and some could be classified as sub-marginal."

PLACE	AREA	HOUSES
Tilly Lake (Tatla Lake region)	2 x 1.5 mi.	8
Small marsh (Big Creek region)	1 x 0.25 mi.	0
Exeter Lake (100-Mile House)	1 x 0.5 mi.	7
Edmonds Lake (do.)	1 x 0.5 mi.	12
4 small lakes, each (Bella Coola)	½ x ¼ mi.	4
3 lakes & marsh (Chilako River)	2 sq. mi.	25
Puntchesakut Lake (Quesnel)	2 x ½ mi.	1
Dragon Lake (Quesnel)	3¼ x 1 mi.	3

TABLE 2 HOUSES ON INDIVIDUAL AREAS.

The above table indicates a few small areas with

the number of occupied houses on each for 1945. This number is said to vary, often greatly, from one year to another. There is apparently adequate reason to believe that the beaver-muskrat association furnishes a source of population maintenance of the latter. Several trappers have found that as the beaver declines so does the muskrat.

D - area. Kootenay and Columbia Rivers Valleys.

In this area, the majority of muskrat are trapped from Golden south, along the marshes of the Columbia River to its source at Columbia Lake, an area of about 110 sq. mi. Except for a small population along St. Mary's River, near Kimberley, muskrat are scarce in the Fernie District.

Reports indicate that there very few in the Arrow Lake district while they seem fairly abundant in the Slocan district. In the Kootenay Lake district, muskrat are trapped along the Duncan River in the north while a few are found at the south end near Creston.

In the Kootenay National Park, muskrats have been seen in Sinclair Creek and identified by tracks along the shores of Dog Lake and Dolly Varden Creek Valley (Munro & Cowan).

This part of British Columbia is of an extremely rugged terrain. Most of the lakes and streams are rocky and glacier-fed with shores unsuitable for a marsh habitat.

E - area. South Central British Columbia.

In the Okanagan district of this area are found

some exceedingly suitable muskrat marshes. In fact, the bulk of muskrat pelts from this area are collected from the Okanagan Lake south to the Osoyoos Lake along the Okanagan River. Other localities where small muskrat catches are taken include the southern regions of the Similkameen River, Lac le Jeune (20 mi. south of Kamloops), and Pennask Lake and Nicola Lake districts, both near Merritt. The Princeton-Hedley District is not a muskrat-producing area.

The following table illustrates a few reported populations that occur outside of the Okanagan District.

PLACE	AREA	HOUSES
Garcia Lake (10 mi. N.E. Merritt)	30 A.	1 House & 6 bank dens
Campbell Lake (20 mi. S.E. Kamloops)	100 A.	6
White Lake (20 mi. S.E. Kamloops)	40 A.	6
Lac le Jeune, west end	25 A.	8

Table 3 - Small populations that typify E - area.

F - area. Northern British Columbia.

In this expanse of territory north of the 54° Latitude, fair returns were received from the 'outline questionaire' considering the isolation of many places. From 10 positive and 18 negative returns, the distribution map of the muskrat in this area was compiled. ~~(Fig. 6)~~ Muskrat colonies are generally small. Some trappers reported a few muskrats in beaver ponds in the fall, but the following spring they had disappeared.

Apparently the most favourable muskrat areas are those just north of Prince George and the Fort Fraser Districts. The latter is a continuation of the muskrat area around Vanderhoof in C - area. Frederick Velten, trapping along the Dease River, reported considerable muskrat on his 22 mile trapline. 118 pelts were collected in 1946.

A few are present along the Stikine River, but the silted condition of this river is unfavourable to the species. Swarth, in 1922, reported that muskrats were scarce along its entire length. They are also scarce in the coastal district from Alice Arm to Prince Rupert. They are absent in marshes along the Copper River but present in the marshy south end of Lakelse Lake. In this area they are mainly bank-dwelling muskrats.

I. McT. Cowan, in a bird and mammal survey of the Peace River District, reported muskrats in three small lakes in the vicinity of Fort St. John.

In north-west British Columbia, in the Atlin District, a few are reported on small marshy areas of Tagish and Teslin Lakes. They are not trapped as apparently unfavourable conditions prevents any population increase.

There are possibly many similar small muskrat populations throughout F-area, but their scant numbers makes trapping impractical.

PLACE	AREA	HOUSES
Lake on Morice River (Topley)	1 x 1 mi.	5
Mosquito Lake (Dease River)	1 x ½ mi.	30 push-ups
Smith Lake (Dease River)	1 x ½ mi.	22 "
Goose Lake (Dease River)	1 x ½ mi.	6 "
Marsh #1 (Fort Fraser)	40 A.	20
Marsh #2 (Fort Fraser)	160 A.	25

Table 4. Examples of Small Populations in F - Area.

The above table illustrates the distribution in some reported areas. In many places, the muskrats are bank-dwelling, hence accurate figures were not obtained.

G - area. Queen Charlotte Islands.

The muskrat on these islands is limited to Graham Island and Moresby Island, on the former, according to Hallett (Pritchard, 1934), 15 muskrats were liberated between 1924-1925. In April 1933, they had spread 30 miles over rough country and were reported causing damage to dykes and ditches.

FUR-BEARER	A		B		C		D		E		F		G	
	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.
MUSKRAT	10	-	5	-	22	-	12#	-	7	-	8#	-	3	-
BEAVER	2	1	0	1	14	1	10	0	7	1	7	9	0	-
COYOTE	2	1	0	0	11	6	4	5	6	4	6	7	0	-
FISHER	0	0	0	0	6	1	0	0	0	0	7	4	0	-
FOX	2	2	0	0	11	1	1	1	0	1	7	10	0	-
LYNX	3	0	0	0	7	3	6	6	6	2	4	6	0	-
MARTEN	2	5	2	4	7	3	8	8	4	1	7	11	2	-
MINK	7	6	4	7	17	1	12	8	8	8	8	2	0	-
OTTER	2	1	0	4	4	0	1	0	5	0	4	3	1	-
RACOON	4	4	5	8	0	0	0	0	0	0	0	0	0	-
SKUNK	1	2	1	0	1	0	2	2	1	0	0	0	0	-
SQUIRREL	2	2	1	1	14	5	6	5	5	3	6	7	0	-
WEASEL	3	3	2	2	16	5	9	7	6	3	7	12	1	-
WOLF	1	0	0	0	2	0	0	0	0	0	6	4	0	-
WOLVERINE	1	0	0	0	0	0	0	0	0	0	3	3	0	-
TOTAL	10	7	5	11	22	8	13#	11	7	4	10#	18	3	0
SUM FOR AREA	17		16		30		24		11		28		3	

TABLE 5. DISTRIBUTION OF THE FUR-BEARERS ON 127 REGISTERED TRAPLINES THROUGHOUT BRITISH COLUMBIA.

WHERE MUSKRAT WAS INDICATED AS 'FEW' OR 'SCARCE', THE POSITIVE RETURN RECEIVED HALF VALUE.

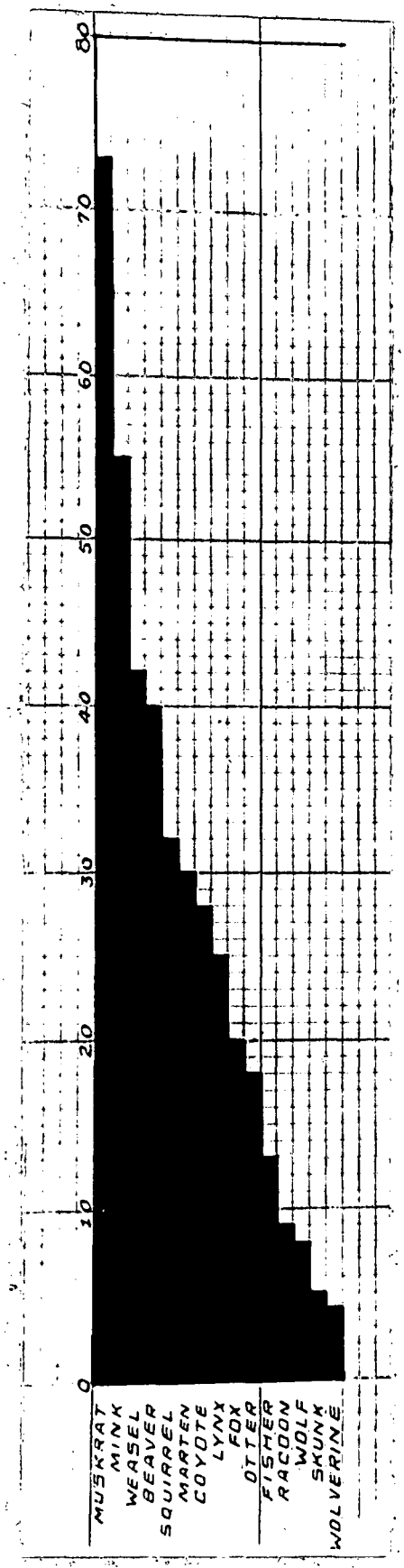


PLATE III

OTHER FUR-BEARING ANIMALS ON THE SAME REGISTERED TRAPLINE AS RECORDED FROM 73 POSITIVE RETURNS OF THE 'OUTLINE QUESTIONNAIRE'.

In this connection, A.L. Pritchard (1934) suggests, "Was the introduction of the muskrat in the Queen Charlotte Islands unwise?". At this time, they were reported as depleting the pink salmon fry at the experimental counting screens.

In recent years, there has been little mention of the population on Graham Island. However, it is presumed that the population has spread around Massett Inlet and the Rivers entering it.

Records of other official muskrat transplantations are not available. However, private introductions have been completed. George W. Leary, Port Clements, introduced the muskrat in 1929, onto about 100 acres of meadowland. This area is divided into four sloughs, about 25 acres each, with the Tl-ell River running through the center.

In 1934, his first trapping season netted over 200 pelts. Since 1936, the muskrats have been less numerous and the 1946 trapping season netted only 116 pelts. Mr. Leary believes that the food potential is sufficient to maintain only the existing population. He has also found that they breed later in the spring and produce smaller litters than they do in the southern parts of the range.

POSITION OF THE MUSKRAT AS A FUR-BEARER

Plate 3, based on the 73 positive returns of the 'outline questionnaire' shows that mink, weasel and beaver respectively are the fur-bearers appearing most frequently

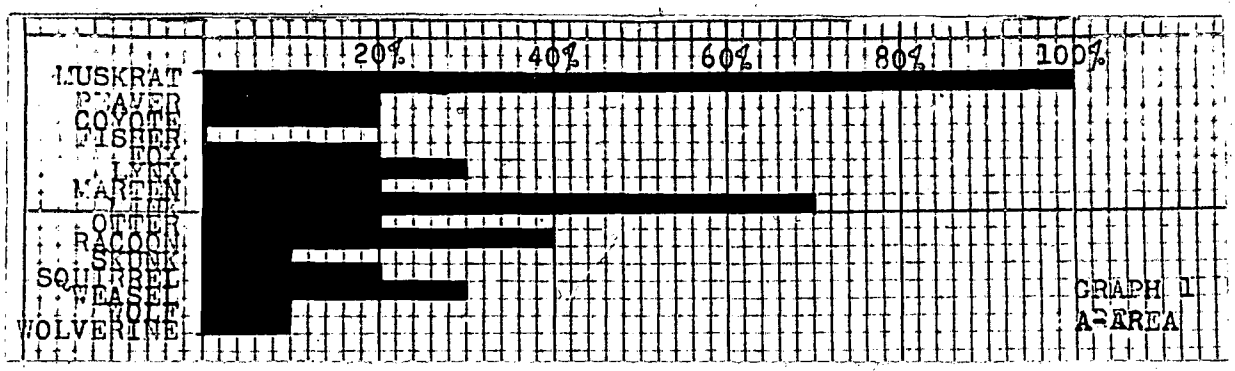
on the same registered trapline. When this Graph is compared with the table on the royalty collected from pelts of fur-bearing animals in the Report of the Provincial Game Commission, 1945, it is found that with the exception of squirrel which is first, the order of the five most important fur-bearers is identical.

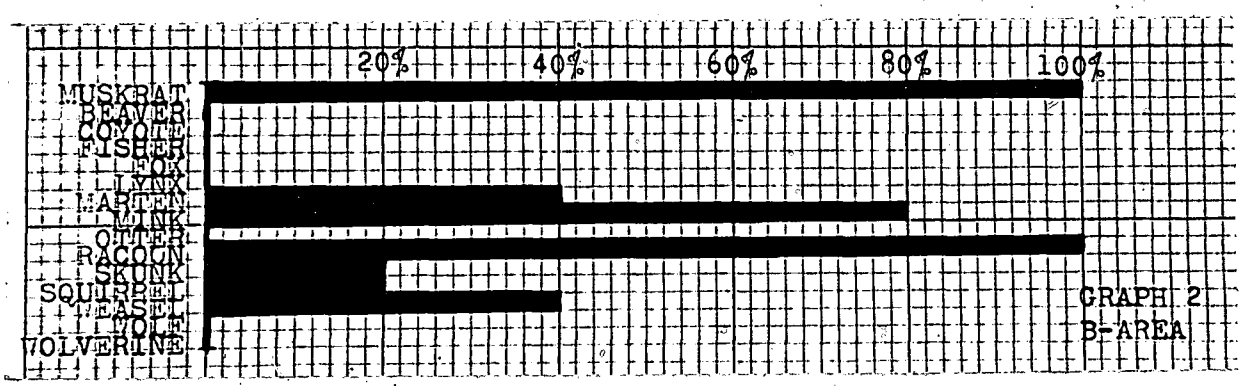
Graphs 1 to 7 inclusive illustrate the relation of muskrat to other fur-bearers in each area throughout British Columbia. These Graphs were derived from the list of animals trapped on the 73 registered traplines which contained muskrat. From this list, for each area, the percentage of each fur-bearer was calculated using the muskrat as 100%. These figures were then graphically represented. This formed a convenient means for a qualitative comparison of the fur-bearing animals in the different areas of this province.

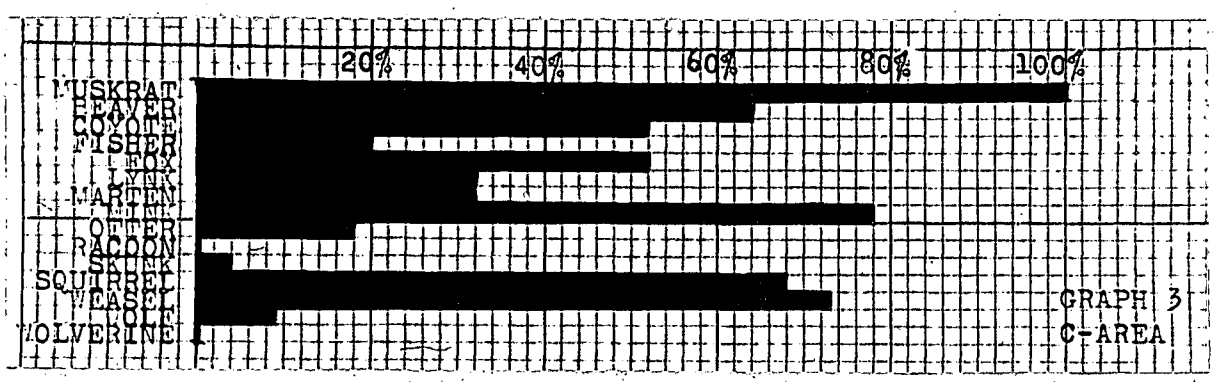
For A - area, Graph 1 shows that mink and racoon are the next most important mammals collected. The negative returns, Table 5, show that mink and racoon form the main collection.

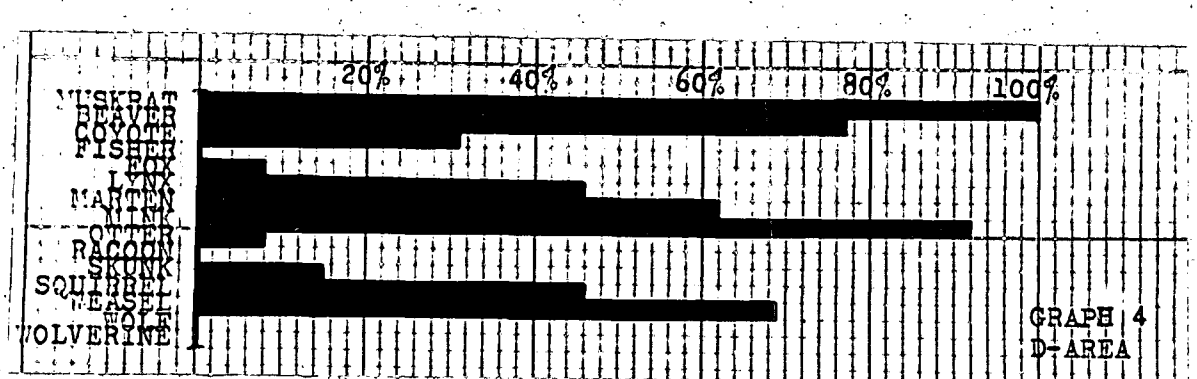
In B - area, Graph 2, racoon is collected to a similar degree as muskrat while mink, marten and weasel are next in importance. Non-muskrat areas produce mainly mink and racoon.

From Graph 3, in C - area, the mink, weasel and beaver are found on muskrat traplines. The coyote, weasel and squirrel are produced more in non-muskrat areas.



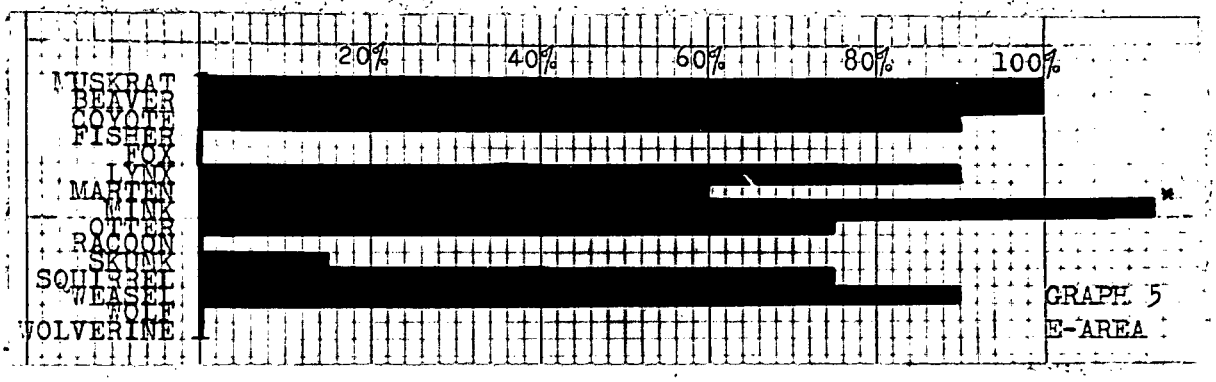


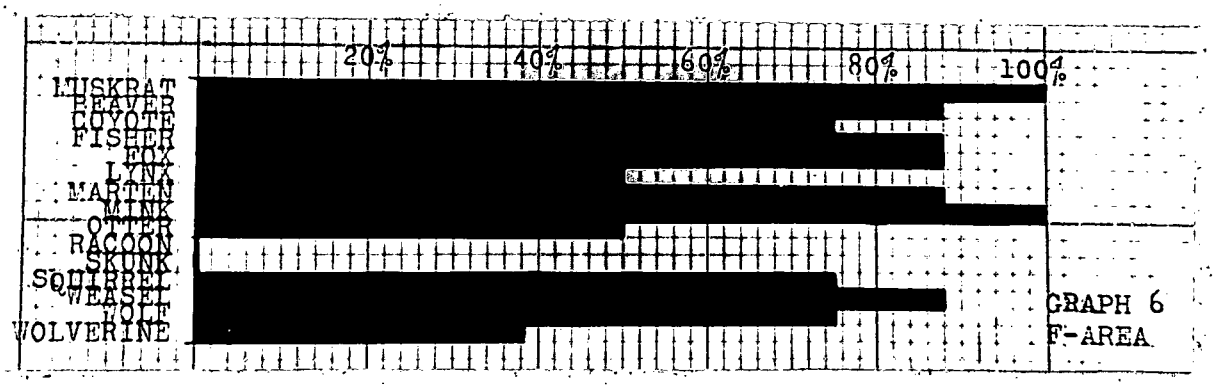


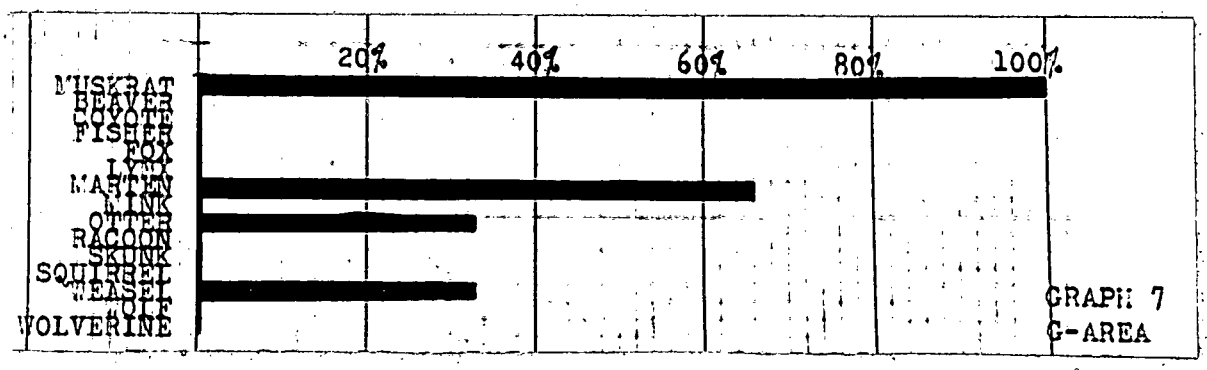


GRAPHS 1, 2, 3 and 4

THE RELATION OF MUSKRAT TO OTHER FUR-BEARERS IN AREA.







GRAPHS 5,6 and 7

THE RELATION OF MUSKRAT TO OTHER FUR-BEARERS IN AREA.

In D and E - areas, as noted in Graphs 4 and 5, the mink and beaver are placed with the muskrat. In non-muskrat areas of D -area, marten, mink and weasel are most evident while in E - area, the coyote, weasel and squirrel are the principal fur-bearers.

In F - area, according to Graph 6, mink are trapped to the same degree as muskrat. From the negative returns, it was found that weasel, mink marten and fox form the greatest pelt returns; beaver is also collected to a lesser extent.

Among other fur-bearers trapped on Graham Island of G - area are marten, otter and weasel.

DISEASES AND PARASITES OF THE MUSKRAT

From October 15, 1944 to May 15, 1947, 202 muskrats were examined for the presence of diseases and parasites. Carcasses received during the legal trapping season were skinned, hence external parasites could not be enumerated. The following specimens were collected outside the legal trapping season: A1 to A14, October 1944; A34 to A41, summer of 1945; B7 to B9, November 1946 and E33, May 1947.

The legal trapping season for muskrat varies throughout British Columbia. In the lower mainland of A-area and B-area, it is a winter season from December 1 to February 28. Throughout the remainder of the province, muskrats are trapped in the spring from March 15 to May 15. In the more northern localities, trapping sometimes does not begin until the end of May, as it is often difficult prior to the cessation of freeze-ups. Thus the seasonal nature of this investigation offered slight opportunity for a comparison study of interseasonal incidence.

As stated previously, protozoan parasites were not studied due to the usually advanced state of decomposition of the carcass. However, in the light of the absence of typical protozoan lesions, it may be assumed that pathogenic protozoa were absent in the carcass examined.

It is noted from Table 1 that there is an absence of previous study on protozoan parasites of the muskrat.

This may be attributed to the fact that most parasitological studies on the muskrat have been performed on caracsses sent for examination.

The present survey revealed that the muskrat is infected by two different pulmonary infections as well as being prone to a tumorous condition, infection of wounds and internal abscesses. It is host to eleven species of helminth parasites. ~~Ten~~ Nine of these have been previously recorded as infecting the muskrat, while a species of Acanthocephala appears to be a new record for this host. A second species of castode is a new record for the muskrat.

DISEASES AND PATHOLOGIES

Pulmonary Infection

Four muskrats from two widely separated localities were found to be affected by a pulmonary infection. Two of these specimens, A42 and A61 were from Lulu Island while E13 and E26 came from Rutland Flats and Mill Creek in the Okanagan.

Description of the Lesions.

In all cases, similar lesions were observed. The infection is apparently one of the blood since all lobes of the lung were equally affected. The degree of infection is indicated by the density of the lesions. The following description was taken from specimens that had undergone at least 24 hours decomposition. This change was more advanced in specimens E13 and E26, because they were not received

until at least 48 hours after death.

The lesions appeared as petechial greyish-white circular areas on the surface of the lung. Where several areas had coalesced, the area appeared whitish and root-like surrounded by a paler grey area. Each circular area contained one spherical white capsule, which could be easily dissected from the surrounding tissue. A coalesced area would contain several capsules. These capsules were a fairly uniform size, varying from 0.24 to 0.27 mm. in diameter. If a capsule was placed between a microscopic slide and cover-slip, considerable pressure was required to break the wall; whereupon it liberated thousands of coccus-like organisms. When stained with methylene blue, each organism was composed of a homogenous finely granular substance. The general condition of the animal was good, the flesh was in good colour, the other organs were normal and parasitism was usually normal.

Histopathology of the Lesions.

A section of the lung from A42 was fixed in Formol-alcohol and stained with Harris-haemotoxylin and counter-stained with alcoholic eosin.

The lesions were distributed throughout the lung tissue in a density similar to that observed on the surface. Each lesion involved little tissue, being compact within its capsule wall inside an alveolus. The lung tissue was not stimulated to produce any further walling off. The tough

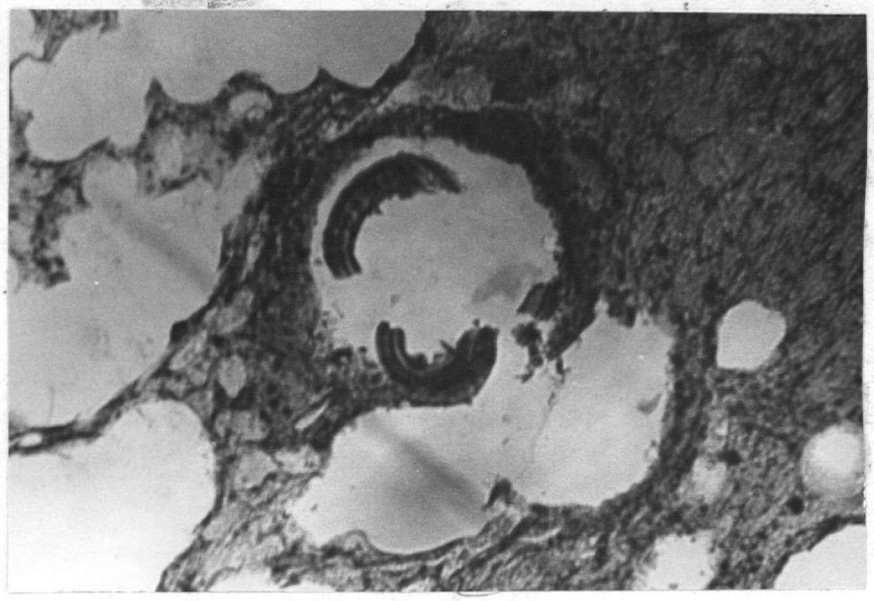


Fig. 1. Photomicrograph showing the position and wall of a pulmonary lesion from the unidentified pulmonary infection.

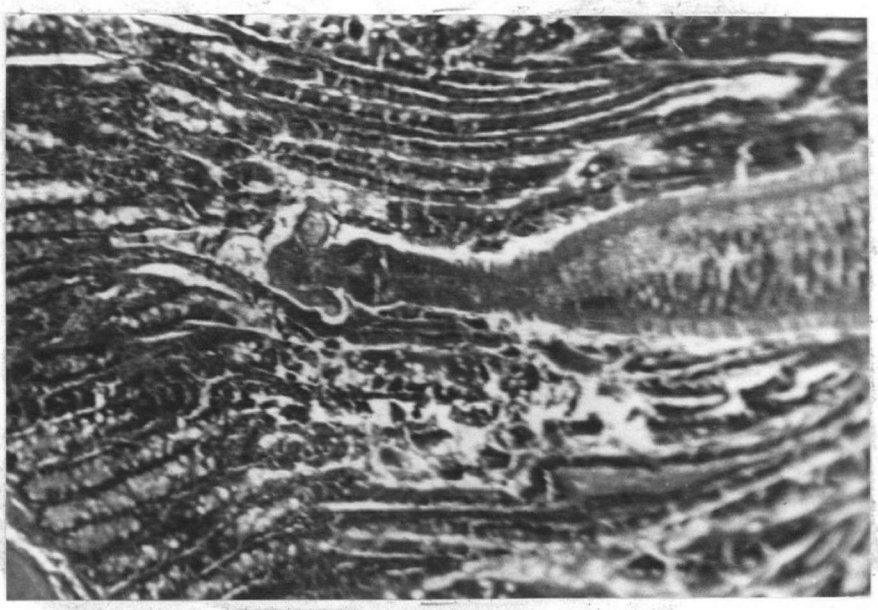


Fig. 2. Photomicrograph showing H. octocoronata embedded between the villi in the small intestine.

PLATE XI

capsular wall was composed of a compact homogenous anuclear substance laid down in a double layer. It sectioned poorly and appeared to be a product of the causative organism. The internal layer absorbed the haemotoxylin stain while the external layer absorbed the eosin stain. The contents of the capsule stained haemotoxylin, Plate XI, Figure 1.

Experimental studies to identify the causative organism.

The lungs of the diseased muskrats, E13 and E26, were kept fresh by freezing in physiological saline.

On March 21, 1947, 65-70 capsules were dissected from the lungs of E13. These capsules were washed and centrifuged several times in sterile physiological saline, then crushed in a mortar. This unfiltered material was injected into six rabbits as follows:

RABBIT NO.	AMOUNT OF INJECTION	METHOD
16	1.5 cc.	intravenous
21	0.7 cc.	intravenous
10	0.4 cc.	intrathoracic
25	0.4 cc.	intrathoracic
5	0.5 cc. (app.)	intranasal
6	1.0 cc. (app.)	intranasal

On May 2, 1947, rabbits #16, #21, #25 and #6 were killed and examined. None of these rabbits showed typical pulmonary lesions like those found in the muskrats.

Rabbit #21, however, showed six pinhead sized whitish lesions on the surface of the liver. These lesions

could be removed from the surrounding tissue in a manner, similar to the original pulmonary lesions. The presence of oocysts in a microscopic smear of these lesions proved them to be coccidia.

Should these liver lesions have been a result of the original pulmonary organism from the muskrat, and since rabbit #21 received the smaller does, it would have been expected that rabbit #16, which received twice the dose, be similarly infected. This was not the case. Therefore, it was concluded that the coccidial infection of rabbit #21 was independent of the attempted experimental infection.

When it was found that the rabbits examined did not contract the infection, post-mortem of the other rabbits seemed unnecessary.

Further experimental work was conducted on the albino rat. On May 21, 1947, two male rats, one less than six months old and the other about a year were injected intrathoracically with a strong 1 cc. sterile physiological saline suspension of crushed capsules. It was brought to the attention of the investigator that the older rat was infected with tuberculosis.

On June 4, 1947, these rats were killed and examined. The typical tubercular lesions were present in the older animal. The pulmonary systems of both animals were placed in physiological saline and allowed to macerate. After four hours, scattered foci of infection were found to be present in both systems. These lesions were similar to those present

in the muskrat and dissimilar to the tubercular lesions. The younger rat appeared more heavily infected than the older one. These lesions were smaller than those present in the muskrat. Immediately following death, they are masked by the white air-filled alveolae and hence become prominent only upon collapse of the alveolae.

At the time of writing, further experimental work is in progress to identify the causative organism.

Death due to tumorous condition.

May 10, 1945, Dr. I. McT. Cowan found a muskrat at Burnaby Lake Game Reserve that had been dead for 3 - 4 days. Examination revealed the presence of three large tumors: one on the side of the neck and two in the axillary region. The lungs had 5 scattered foci of infection, which ranged from 2 - 5 mm. diameter. It was apparent that death was caused primarily by the tumorous condition; the pulmonary condition probably was secondary.

Histopathology of the tumors was difficult to interpret due to extensive post-mortem decomposition. There appeared to be however, a prurulent center with a fibrous connective tissue capsule. Connective tissue had also penetrated into the center of the lesion.

The gross appearance of the fixed pulmonary lesions leads the investigator to believe that they are probably tuberculous in nature. They resemble closely the typical tubercular lesions of the albino rat that result from

infection by Corynebacterium rodentium. The histopathology was difficult to follow due to the advanced decomposition that preceded fixation.

Other minor pathologies.

These lesions were small and appeared, in general, not to interfer with the health of the infected animal.

MUSKRAT NO.	REGION	DESCRIPTION
C27	transverse colon	several distinctly separate ectymotic hemorrhagic areas. Intestinal wall scrapings revealed no protozoan infection.
D4	mid-lumbar region	oval, walled-off, cyst-like lesion, 25 mm. x 13 mm. containing yellow pus. A Giemsa stained smear revealed only lymphocytes and polymorphonuclear leukocytes. The lumbar lymph nodes were slightly enlarged.
D6	ventral lumbar region	small elongated cyst-like node, 10 mm. x 5 mm. similar in appearance and consistency as the lesion of D4. No enlargement of lymph nodes.

TABLE 6. Minor Pathologies.

The above table illustrates the lesions that occurred, that were apparently not a result of wounds.

Pathologies due to wounds.

From time to time, muskrats were found with abscesses that had developed following a wound. These abscesses apparently did not impair the animal's survival. Often these wounds left no external evidence. The wound

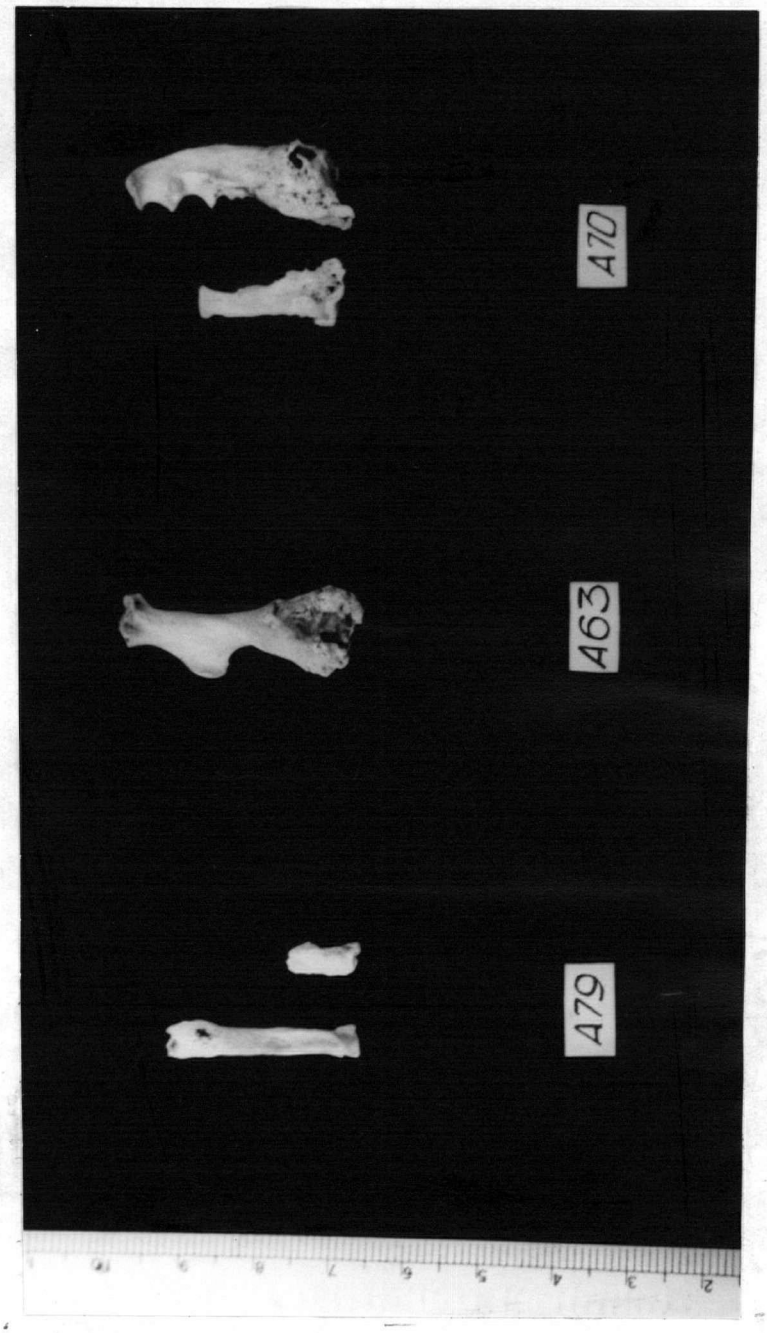


PLATE IV

Osteitis of Forelimb Bones following Loss of Anterior Foot.

healed externally while an abscess developed internally. This followed various types of wounds; that left when a foot was lost following an excape from a trap, Plate IV, and wounds as a result of intraspecific strife.

MUSKRAT NO.	REGION	DESCRIPTION OF LESION
A55 A63 A70 A79	left fore limb	The bones had become infected due to the loss of the foot. The axillary lymph gland is usually enlarged.
C18	left posterior lobe of lung	Following a lung puncture, a permanent adhesion to the costal wall resulted. All external evidence had healed and there was no evidence of fractured ribs. Histopathology revealed that the abscess had one primary focus and two secondary foci. It was completely walled off by fibrous connective tissue.
E33	left abdominal wall near diaphragm	An abscess had developed at a point where the diaphragmatic muscle meets the lateral abdominal wall. It was 15 mm. long and oval-shape and contained greenish-yellow pus. Also, at this point the stomach was permanently adhered to the abdominal wall. The abscess developed following a stomach puncture. External evidence had healed.

TABLE 7. Description of Lesions as a result of mechanical injury.

REPORTED DISEASES OF THE MUSKRAT IN BRITISH COLUMBIA

Analysis of the reports from game-wardens and trappers throughout this province regarding diseases of muskrat are limited mainly to infections resulting from intraspecific fighting and trapping wounds. These wounds become infected and as a result abscesses develop. In a few instances, a specific outbreak of disease has been reported.

In A - area, at Port Coquitlam approximately 3 in 100 muskrats trapped have infected wounds following the loss of a foot in a previous trapping. At Lulu Island, in the same area, two animals with externally infected wounds were trapped in December, 1946. Both of these muskrats were young, probably from 1946 litters.

In B - area, at Duncan, about 10% of the muskrats are affected by external abscesses, according to two independent reports.

In C - area, at Williams Lake and Kleena Kleene, trappers indicate that most infected wounds may be attributed to intraspecific strife. Such wounds are in evidence during the spring sexual fighting. Hence, pelts taken at this time are often valueless. Internal abscesses similar to those found in this survey were reported from Tatla Lake District.

In D and E - areas, there were reports of widespread occurrence of abscesses among the muskrats. In the spring of 1946 about 65% of those trapped around the Nicola River, in late spring, showed infected fighting wounds. In 1937, in the vicinity of Brisco, in D - area, the muskrat catch was scant. Those collected were heavily infected with boils. This condition disappeared in the following years. H. Tyler reported that muskrats at the southern end of Windermere Lake were also similarly afflicted. It was noted that this condition was more prevalent in those that build among the bulrushes.

In F - area, the only wounds that affect the muskrat populations are those received during intraspecific fighting. In the Stikine River District however, trappers have caught muskrats, and also found them dead infected with abscesses at the sides of the lower jaw.

In 1938, at the Queen Charlotte Islands, Mr. G.W. Leary picked up some muskrats dead. Examination of the carcasses revealed no apparent cause of death. This was the only report of disease among the muskrat populations in G - area.

Analysis of Wounds.

It is apparent from the reports and the carcasses examined that there is a high tolerance for wounds due to intraspecific strife. Such wounds do occasionally become infected. However, they heal

externally and the organisms become concentrated inside a connective tissue capsule. The general health of the animal is not affected.

This was illustrated in muskrats C18 and E33 where punctures of internal organs had taken place. Although an adhesion and an abscess had formed, the wound had healed externally. Also, the animals appeared in good health.

Frequently, a trapped muskrat will escape with the resulting loss of a foot. This wound will often heal completely with no infection. There are instances however, when such a wound will become infected. This infection invades the bone and produces an osteitis. Such inflammation usually centers around the injured joints, which become dislocated in the animal's fight for freedom. The lymph glands of the region also become infected.

In this survey, four muskrats from A - area were thus injured. A63, a male adult of an 1946 litter, was trapped on January 12, 1947. As shown in Plate IV, ~~Fig.~~ 8 the entire lower humerus was involved in the osteitis. This infection had apparently developed since December 1, 1946, the beginning of the trapping season.

Analysis of specific diseases and their effects.

Actual mortality from disease is difficult to ascertain in the muskrat. This situation is especially

difficult to analyse when the investigator is dependent on reports of its occurrence and not on personal observations. It is evident however, from the carcasses examined that this fur-bearer is affected by at least two specific diseases. Reports from the trappers indicate a possible third specific disease. The tumorous condition of the dead muskrat at Burnaby Lake is probably more of a developed condition than a disease that could be disseminated through a population.

The two respiratory infections however, appear to be likely diseases that might decimate a population. The pulmonary condition present in both A and E - areas is a condition that may be spread by direct contact between diseased and healthy animals.

This disease appears to be similar to that described by T. Warwick in 1934, which was prevalent among muskrats in Shropshire. His description of the lesions resembles that found in this survey. Also, in both cases, the animals appeared healthy.

It is in the experimental studies that these two infections seem to differ. Warwick found that the rat did not contract the disease. However, he omits stating the period that lapsed between injection and autopsy of the experimental animals. In this experimental work, it was found that the rat was infected following two weeks incubation period. The lesions were small and did not become evident until after maceration of the tissue.

TABLE 8. FREQUENCY DISTRIBUTION OF THE ADULT HELMINTH PARASITES OF THE MUSKRAT IN BRITISH COLUMBIA

ADULT CLASS	PARASITE SPECIES	REGION	A 80 — INFECTION AV.	A 80 — INFECTION EXT.	A 80 — SPEC. AV.	A 80 — SPEC. %	B 9 — INFECTION AV.	B 9 — INFECTION EXT.	B 9 — SPEC. NO.	B 9 — SPEC. %	C 64 — INFECTION AV.	C 64 — INFECTION EXT.	C 64 — SPEC. NO.	C 64 — SPEC. %	D 16 — INFECTION AV.	D 16 — INFECTION EXT.	D 16 — SPEC. NO.	D 16 — SPEC. %	E33 — INFECTION AV.	E33 — INFECTION EXT.	E33 — SPEC. NO.	E33 — SPEC. %
TREMATODA	ECHINOSTOMUM COALITUM	STOM.	3.2	1-13	15	18.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		INT.	20.7	1-130	47	58.75	-	230	1	11.1	9.8	2-23	7	10.5	7.3	2-13	3	18.6	3.5	1-6	2	6-1
		CEC.	5.4	1-27	11	13.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		COL.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ECHINOPARYPHIUM CONTIGUUM	STOM.	-	-	-	-	-	-	-	-	24.4	1-61	5	7.5	-	-	-	-	-	-	-	-
		INT.	-	-	-	-	-	-	-	-	107.1	6-240	13	19.5	-	-	-	-	-	-	-	-
		CEC.	-	-	-	-	-	-	-	-	16.3	2-51	7	10.5	-	-	-	-	-	-	-	-
		COL.	-	-	-	-	-	-	-	-	12.0	2-43	5	7.5	-	-	-	-	-	-	-	-
	QUINQUESERIALIS QUINQUESERIALIS	STOM.	1.5	1-2	2	2-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		INT.	3.3	1-7	3	3.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		CEC.	69.8	2-298	34	42.5	76.8	2-201	8	88.8	121.3	7-376	27	40.5	85.3	4-304	15	93.0	89.0	1-850	15	45.5
		COL.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	NOTYCOTYLUS URBANENSIS	STOM.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		INT.	-	-	-	-	-	-	-	-	-	-	-	-	-	15	1	6.2	-	-	-	-
		CEC.	-	-	-	-	-	-	-	-	-	10	1	1.5	-	-	-	-	-	-	-	-
		COL.	13.7	3-38	13	16.25	2.5	2-3	2	22.2	13.3	2-128	23	34.5	13.5	1-69	12	74.4	1-0	1	2	6-1
	PLAGIORCHIS PROXIMUS	STOM.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		INT.	-	1-165	2	2.5	-	-	-	-	30.8	1-109	20	30-0	54-0	4-233	11	68.2	17.6	1-74	13	39.4
		CEC.	-	-	-	-	-	-	-	-	-	-	-	-	4.5	2-7	2	12.4	-	-	-	-
		COL.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CESTODA	HYMENOLEPIS SP.	STOM.	3.7	1-7	3	3.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		INT.	59.5	1-250	40	50.0	2	1-3	5	55.5	6.0	1-18	7	10.5	6.0	1-16	3	18.6	7.6	1-15	5	15.2
		CEC.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		COL.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEMATODA	CAPILLARIA RANSOMIA	STOM.	5.0	5	1	1.25	-	-	--	-	-	-	-	-	-	-	-	-	-	-	-	-
		INT.	5.4	1-27	9	11.25	-	-	-	-	1	1	5	7.5	6.3	2-10	4	24.8	10.3	1-55	14	42.4
		CEC.	2	2	1	1.25	-	6	1	11.1	-	-	-	-	-	-	-	-	-	-	-	-
		COL.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--
ACANTHO-CEPHALA	POLYMORPHUS SP.	STOM.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		INT.	-	-	-	-	-	-	-	-	1.8	1-3	4	6.4	-	-	-	-	-	-	-	-
		CEC.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		COL.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Warwick identified the causative organism as a haemolytic streptococcus that is related to other streptococci of animal origin. This organism was highly pathogenic to mice. The causative organism that is producing the infection in the British Columbia muskrats has not yet been identified. Experimental studies are still in progress.

In the discussion on the mortality produced by this infection, Warwick states that the animals were found when population densities were rather low, hence it is unlikely that carcasses of dying animals would be frequently found." He believed that mortality must have been fairly widespread.

PARASITES

Table 8, illustrates the distribution of the adult helminth parasites of the muskrat in British Columbia. Besides these parasites which were found in more than one carcass, there were found a few specimens of male Trichuris opaca in the intestine of a muskrat from Lulu Island. Two species of larval cestodes, Taenia taeniaformis and Cladotaenia sp., were found in the liver as cysts. The latter also occurred in a cyst at the base of the mesentry.

Discussion of the Parasites.

Trematoda

Echinostomum coalitum Barker 1915

Family Echinostomidae Looss 1902

Subfamily Echinostominae Looss 1899

Genus Echinostomum Rudolphi 1809

Status

This species was first described as a parasite of the muskrat by Barker in 1915. Accordingly, it may be distinguished by a "well defined reniform collar" consisting of 37 spines. These are arranged in an alternate row of 27 large spines on the rim and 5 spines on each lappet.

P.C. Beaver (1937) while completing a study of Echinostomum revolutum (Froelich) reduced 16 other named species including E. coalitum to synonymy with E. revolutum. He inferred that physiological differences in different species of hosts would often lead one to believe that a new species had been found.

Since the investigator has not had the opportunity of examining many specimens of E. revolutum which typically infects aquatic birds, the original specification 'E. coalitum from the muskrat' has been used in this study. The specimens collected were typical for the species, hence redescription is unnecessary.

Infection

There was a wide range of infection by E. coalitum. It rated the highest incidence in A - area, where infection averaged 58.75% in the small intestine with 18.75% and 13.7% in the stomach and cecum respectively.

It is interesting to note the variation in infection in the different localities within a given area. From the following table, it may be observed that although Burnaby

Lake muskrats presented a 58.3% infection, it registered an average incidence of 35.1 worms. This is compared with a 79.1% infection by an average of 10.3 worms at Lulu Island. These two localities are approximately 20 miles apart. Had more examinations been completed from the Sea Island muskrats, it is possible that the infection would compare closely to that of Lulu Island.

PLACE	INFECTION TOTAL	% INFECTION	TOTAL INFECTION	AVERAGE INFECTION
Burnaby Lake	24/41	58.3%	843	35.1
Lulu Island	19/24	79.1%	196	10.3
Sea Island	1/7	14.3%	3	-
Pitt Meadows	2/4	50.0%	50	25.0
Clayburn	1/4	25.0%	4	-

Table 9. Comparison of infection in localities in A - area by E. coalitum.

Although only one muskrat from B - area was infected, it contained 230 individuals. As may be noted in Table 8, only small percentage infections were recorded in C, D and E areas. In C - area, only muskrats from Williams Lake were infected. In D -area, only carcasses from Radium were parasitised.

Discussion

According to Table 1, E. coalitum has been recorded three times since Barker's original record. Swales (1933) reported in a review of Canadian helminthology, Echinostomum sp.

from the muskrat in Alberta. P.C. Beaver (1937) includes several records from eastern North America of the species E. revolutum.

Echinoparyphium contiguum Barker and Bastron

Family Echinostomidae Looss 1902

Subfamily Echinostominae Looss 1899

Genus Echinoparyphium Dietz 1909

Status

This is another species of trematode reported in F.D. Barker's publication of 1915. It was originally described as a"small trematode, 3.3 to 4.3 mm. The collar has 37 spines arranged in alternate rows of 14 oral and 15 aboral spines on the rim and one set of 4 on each lappet."

P.C. Beaver (1937) disputes the validity of the above description and states that the specimens identified as Echinoparyphium contiguum in the B.A.I. of the U.S.D.A. "have more than 37 spines, having 45 in some and 47 in others." On the other hand, Barker and Noll describe some specimens as belonging to the species Echinostomum callawayensis which have "a collar armed with a double row of alternately arranged spines varying in number from 37 to 41, 31 to 33 on the rim and 2 to 5 on each flap."

There has been only one report of Echinoparyphium sp. from the muskrat since 1915, that by Law and Kennedy in 1932. Of this record Beaver states that "unfortunately the cephalic spines are not included in the description, and no specimens could be procured."

As a result of the apparently conflicting description by Barker and the absence of more recent study on this species, it is pertinent that a detailed description be presented at this time from the specimens at hand.

Description

This composite description is based on a series of specimens collected from muskrats in the Williams Lake District of C - area. These specimens were prepared for study according to the technique outlined on page 14.

In an infection, the size of the worms does not vary greatly. The length averages about 2.8mm. while the width at the level of the acetabulum is 0.4 mm. The width at the level of the posterior testes is 0.3 mm.

The acetabulum is situated about one-third of the total length posterior to the oral sucker. The former is about 0.34 mm. while the latter is 0.12 mm. diameter.

The complete cephalic spination consists of 41 spines. These are arranged as a double alternating row of 33 spines on the rim and 4 on each lappet. The rim spines average 0.067 mm. being slightly longer than the lappet spines which are 0.059 mm. The body cuticle is smooth, with slight striations but no scales like Echinostomum sp.

The narrow muscular pharynx is not very prominent. It is connected to the oral sucker by a short esophagus. The pharynx bifurcates just anterior to the acetabulum to form the two branches of the digestive tract. The posterior limits of the branches were not apparent in the specimens

examined.

The paired elliptical testes which lie tandem in posterior half of the body, are approximately 0.31 x 0.17 mm. The club-shaped cirrus pouch is situated just anterior to the acetabulum and to the right of the median line. In some specimens, a long smooth muscular cirrus was observed projecting from it. The seminal vesicle is not evident.

The small globular ovary lies anterior to the left of the anterior testis. The smaller oval Mehlis's gland lies median to it. A seminal receptacle is not apparent. The vitellaria duct passes across the ventral side of the body between the ovary and the anterior testis. The vitellaria glands are represented by prominent dark irregularly globular masses lying parallel to the lateral borders of the body from the acetabulum to the posterior tip. Near to the posterior, they merge across the dorsal part of the body. The extremely short loosely-coiled uterus lies between the ovary and acetabulum. It passes to the left of the acetabulum to open by the indistinct genital pore at the left of the midline. The non-operculate oval eggs are few, numbering from 9 to 22 in the specimens examined. They are approximately 0.117 mm. long.

The excretory ducts were not apparent in these specimens. However, the slender, elongated median excretory reservoir extends from the posterior of the second testis and opens at the posterior tip of the worm.

Infection

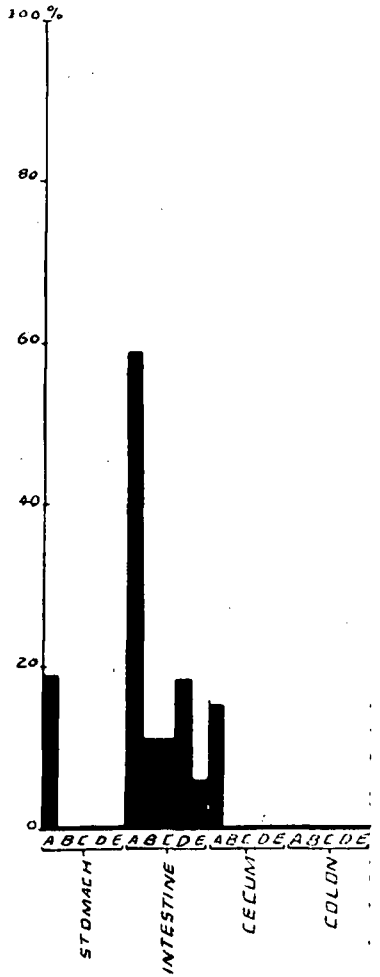
In this investigation it was found that the distribution of this species was limited to C - area. A total of 1393 worms were recovered from 13 infected muskrats. As may be observed from Table 8, they were distributed throughout the entire digestive tract. The greatest infection occurred in the small intestine where an average of 107.1 worms was collected.

Discussion

This description attempts to remove the conflicting distinguishing characteristics outlined by Barker. In this connection, it is believed that he described the species, Echinostomum callawayensis and Echinoparyphium contiguum from a mixed series of specimens. This discrepancy was noted when characteristics in these trematodes fitted both descriptions while others were not clarified by either description.

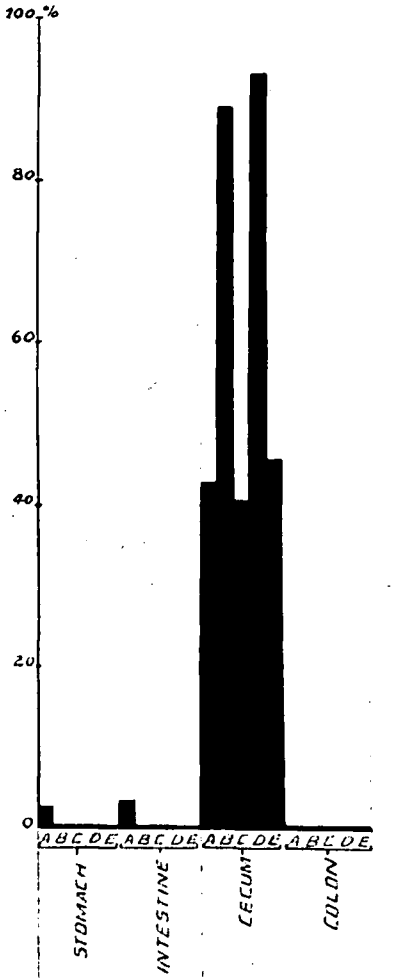
Neveu-Lemaire indicates that this genus can be separated from other genera in the subfamily Echinostominae by the position of the ventral sucker. In this genus, Echinoparyphium, it is situated in the anterior quarter of the body while in the other genera, Echinostomum, Euparyphium and Hypoderaeum, it is situated close to the oral sucker.

Beaver separates Echinoparyphium from Echinostomum on the basis of the cephalic spination and the length of the



ECHINOSTOMUM COALITUM.
GRAPH 1

PLAGIORCHIS PROXIMUS
GRAPH 2



N. Q. QUINQUESERIALIS
GRAPH 3

TABLE 10. COMPARISON OF SITE OF INFECTION IN EACH AREA OF OCCURRENCE.

uterus. On the basis of my study, it is recommended that these genera be separated upon the following characteristics:

Echinoparyphium - 41 cephalic spines
extremely short, loosely coiled uterus

Echinostomum - 37 cephalic spines
long compactly coiled uterus

Plagiorchis proximus Barker

Family Plagiorchidae Luhe 1901

Genus Plagiorchis Luhe 1899

Status

This distome was also described orginally by Barker in 1915, as a parasite of the muskrat. Since this date, this host has been reported infected by this trematode in Ontario, Ohio, Michigan and Eastern Canada.

The specimens from the muskrat in British Columbia were identified by the description of Barker.

Infection

Mature specimens of this trematode occurred in the small intestine of B.C. muskrats in two readily distinguished varieties, which will be referred to as the 'typical' and the 'atypical'. The former is the described 'elongated oval-shaped' trematode. The latter is a small oval trematode in which the posterior half of the body is almost cylindrical while the anterior half is flattened. Plate VI, Fig. 1 and 2. It was at first thought that these

were separate species. However, detailed examination revealed no essential distinguishing characteristics between the two varieties, other than shape and size. It was also noted that the atypical variety always occurred in the presence of the typical variety.

The atypical variety occurred only in muskrats from C - and D - areas. The greater number were collected in D - area, where a range of 10.6% to 13.2% atypical specimens were collected. This variety was recorded only from Springhouse in C - area.

AREA	PLACE & DATE	INF./TOTAL	INFECTION		
			TOTAL	ATYPICAL SPECIMENS NO.	%
C	Springhouse, 1947	2/12	238	11	4.9%
D	Radium, 1946	2/6	27	2	11.1%
	Brisco, 1946	5/5	151	20	13.2%
	Windermere, 1947	4/5	421	55	10.6%

Table 11. Infection by atypical variety of P. proximus.

Discussion

Additional evidence for wide local variation in infection by a species of parasite is noted in the infection by this species in C - area. This variation is illustrated in the following tabulation. The distance from Springhouse to Williams Lake is about 12 miles, while that from Ochiltree to Williams Lake is north-east about 17 miles.

PLACE & DATE	INF./TOTAL CARCASSES	INFECTION TOTAL	INFECTION AVERAGE	% INFECTED
Williams Lake				
March, 1946	5/24	260	52	20.6%
March, 1947	2/12	48	24	16.6%
Ochiltree, 1946	3/14	32	10.6	21.4%
Springhouse, 1947	9/12	238	26.4	75.0%
Mapes, 1947	1/2	38	-	-

Table 12. Comparison of infection in localities throughout C - area.

It is noted that for 1947, the intensity of the infection does not vary greatly between Williams Lake and Springhouse. The percent of muskrats infected however, is 75% at Springhouse and 16.6% at Williams Lake. An opposite condition was in effect in 1946 for two adjoining localities. The percent infected variation between Williams Lake and Ochiltree was only 20,8% to 21.4%. The average density of infection at Williams Lake was 52 which outnumbered that of 10.6 worms recovered from muskrats at Ochiltree.

The above table also illustrates the range of infection in muskrats collected in successive years from the same locality. This range shown for Williams Lake was 20.8% for 1946 with a decrease of 4.2% to 16.6% for 1947. Although the percentage of infection did not vary greatly for the same period, the intensity of infection varied widely. In 1946, the average infection was 52 while for 1947, it was 24. It is thus noted that an over-all decrease had taken place.

Quinqueserialis quinqueserialis (Barker and Laughlin 1911)

Family Notocotylidae Luhe 1909

Subfamily Notocotylinae Kossack 1911

Genus Quinqueserialis Herber 1942

Status

The two species of Notocotylinae that infect the muskrat in British Columbia are readily distinguished macroscopically from one another by the number of rows of protusible glands on the ventral surface. Q. quinqueserialis has five rows while Notocotylus urbanensis has three rows.

Q. quinqueserialis was first described by Barker and Laughlin in 1911 as Notocotylus quinqueserialis from specimens found in the cecum of the muskrat. In 1942, in a description of the host-cycle, E.C. Herber listed it as in the genus Quinqueserialis. He separated this genus from that of Notocotylus on the basis that the former has five rows of ventral glands while the latter has only three rows.

Like those genera of the subfamily Echinostominae, these are also frequent parasites of aquatic birds and small rodents. It is thus illustrated further that the parasitology of one vertabrate is closely related to that of another within the same habitat.

Other records of Q. quinqueserialis as a parasite of the muskrat are outlined in Table 1.

Infection

From Table 10, it is noted that this species is almost exclusively a parasite of the cecum. Even in a high

infection, it was confined to this region of the digestive tract. In A- area, a negligible number of specimens were collected from other segments of the intestine.

In A-, C- and E- areas, the percentage of infection ranged from 40.5% to 45.5%, while in B- and D- areas, it was 88.8% and 93.0% respectively. The intensity of infection was extremely variable.

AREA	PLACE	INF./TOTAL CARCASSES	TOTAL	INFECTION AVERAGE	% INF.
	Burnaby Lake	15/41	508	33.8	36.8
	Lulu Island	11/24	490	44.5	45.8
A	Sea Island	1/7	12	-	14.2
	Pitt Meadows	4/4	567	141.7	100.0
	Clayburn	4/4	700	175.0	100.0
B	Duncan	8/9	615	76.8	86.6
	Williams Lake	12/24('46) 12/12('47)	922 1900	76.8 158.3	50.0 100.0
C	Ochiltree	1/14	164	-	7.1
	Springhouse	0/12	-	-	-
	Mapes	2/2	300	150.0	100.0
	Brisco	5/5	173	34.6	100.0
D	Radium	5/6	420	84.0	83.3
	Windermere	5/5	740	148.0	100.0
	Oliver	2/2	132	66.0	100.0
E	Mill Creek & Rutland	9/24	381	42.3	37.5
	Kelowna	2/3	82	41.0	66.6
	Princeton	1/1	850	-	-

Table 13. Distribution of Q. quinqueserialis in each district.

Table 13 illustrates a considerable variation within A - area. The Fraser River Valley (Pitt Meadows and Clayburn) were 100% parasitised compared with a range of 14.2% to 45.8% among lower mainland muskrats. Also, the former animals showed a higher intensity of infection, 141.7 to 175. while the latter ranged from 33.8 to 44.5.

Discussion

The infection on Sea Island was slightly irregular to this average. This may be explained by the fact that muskrats from Lulu Island examined at the same time were also not infected. It is thus possible that if carcasses from Sea Island had been examined during January, they would have been infected to a similar degree as those from Lulu Island.

In C- area, Williams Lake was the only locality with any measurable infection. There was a great difference in the infection at a similar period between 1946 and 1947. In 1946, the average intensity was 76.8 in a 50% infection, while for 1947, it was 158.3 in 100% infection. Although only two carcasses from the Vanderhoof District were examined, a high infection was present.

D - area is interesting in that the percentage infection did not vary greatly. There was extensive variation in the intensity of infection however, from the centrally located Radium. North to Brisco, a distance of 20 miles, it was only 34.6 while south to Windermere, also 20 miles, it was 148.

E- area presented irregularities that are due to insufficient examinations from localities other than Mill Creek and Rutland Flats. There was found however, a close relation between the average incidence in muskrats from Kelowna and those from the Mill Creek locality.

Notocotylus urbanensis (Cort 1914)

Family Notocotylidae Luhe 1909

Subfamily Notocotylinae Kossack 1911

Genus Notocotylus Diesing 1839

Status

As mentioned previously, this trematode is readily distinguished from Q. quinqueserialis. The description of E.C. Harrah (1922) was used to identify specimens found in the digestive tract of several muskrats in this province. Of specimens described by Harrah, it is said, "Medium sized worms 2.5 mm. to 3.5 mm. long by 0.5 to 1.0 mm. wide, having three rows of ventral glands each row containing 13 to 14 glands".

W.W. Cort (1914) described Cecaria urbanensis. However, it was Harrah who studied the mature adult worms and recently excysted immature specimens; compared the latter to Cort's description of the cecaria and concluded that one foreruns the other. Luttermoser (1935) confirmed the conclusion of Harrah, by experimental infection with Cecaria urbanensis into domestic ducklings and a muskrat and recovered adult specimens of N. urbanensis from the intestine.

Available literature shows that this trematode has been reported from the Maryland muskrats. Other hosts include Aix sponsa (wood duck) and Dafila acuta (pintail duck) from which A. Hassall collected specimens in the intestine in 1893.

Infection

N. urbanensis was the least abundant trematode collected from the British Columbia muskrats. Previous reports indicate that it is primarily a parasite of the intestine and cecum. It was found however, that in this region the more common site of infection is the colon.

From the following tabulation, it will be noted that the average colonic infection in A-, C-, and D- areas varied from 13.5 to 13.7 worms. The percent infection however, was 16.25% in A- area, 34.5% in C- area and 74.4% in D- area. A smaller infection occurred in B- and E- areas. Negligible infections occurred in other segments of the digestive tract.

AREA	PLACE	NO. INF./TOTAL	INFECTION		
			TOTAL	AVERAGE	% INF.
A	Burnaby Lake	3/41	41	13.1	7.3
	Lulu Island	6/24	74	12.3	25.0
	Sea Island	1/7	4	-	14.2
	Pitt Meadows	1/4	21	-	25.0
	Clayburn	1/4	3	-	25.0
B	Duncan	2/9	5	2.5	22.2
C	Williams Lake '46	10/24	206	20.6	41.6
	'47	9/12	92	10.2	75.0
	Springhouse	1/12	2	-	9.3
	Ochiltree	1/14	13	-	7.1
	Mapes	2/2	10	5.0	100.0
D	Radium	4/6	126	31.5	66.6
	Brisco	3/5	12	4.0	60.0
	Windermere	5/5	28	5.6	100.0
E	Mill Creek & Rutland	0/24	-	-	-
	Kelowna	1/3	1	-	-
	Oliver	0/2	-	-	-
	Princeton	1/1	1	-	-

Table 14. Infection by N. urbanensis in B.C. muskrats, 1944 - 1947.

Discussion

The above tabulation shows that the local variation in percent infection within an area is not great. For instance, in A-area, three fairly separated localities registered 25% infection. Similarly in C-area, Springhouse and Ochiltree presented parallel infections.

NEMATODA

Capillaria ransomia Barker and Noyes 1915

Family Trichuridae Railliet 1915

Subfamily Capillariinae Railliet 1915

Genus Capillaria Zeder 1800

Status

This is the only nematode which was found infecting the muskrat to any extent. Three specimens of Trichuris opaca were collected from one muskrat from Lulu Island. Capillaria sp. are readily distinguished from Trichuris sp; the former have a long slender whip-like body while the latter has the stouter posterior half distinctly separated from the slender anterior half of the body.

Capillaria ransomia was another internal parasite of the muskrate in Nebraska that was described by F.D. Barker in 1915. The reported literature reveals that it has been collected from this host in several areas, including eastern Canada, Michigan and Ohio.

Infection

Table 8 indicates a small incidence of infection

from all areas of this province.

The main site of infection is the small intestine. In A-area however, specimens were collected from the stomach and cecum of two carcasses. In B-area, the nematodes were recovered from the cecum of the one muskrat so infected.

Discussion

E-area reported the highest average intensity of infection as well as the highest percentage of infection. The tabulation following illustrates the distribution of Capillaria ransomia in this area. It is noted also that the highest single infection was collected from a muskrat in this area.

PLACE	INF./TOTAL CARCASSES.	INFECTION		
		TOTAL	AVERAGE	RANGE
Kelowna	1/3	28	-	-
Oliver	2/2	69	34.5	14-55
Princeton	0/1	-	-	-
Mill Creek & Rutland	11/24	47	4.2	1-11

Table 15. Distribution of C. ransomia in E-area.

CESTODA

Hymenolepis sp.

Family Hymenolepididae Railliet and Hanry 1909

Sunfamily Hymenolepidinae Ransom 1909

Genus Hymenolepis Weinland 1858

Status

Only cestodes belonging to this genus were collected from the intestine of the muskrat in this province. Hymenolepis evaginata, the typical muskrat species was originally described by Barker and Andrews in 1915 from the Nebraska muskrat. This parasite has been reported since as infecting this host in many widely scattered areas including Louisiana, Michigan, Ohio, eastern Canada and Great Britain, where it was apparently introduced with its adult host.

In British Columbia two species were evident; the typical muskrat species, H. evaginata and H. octocoronata, which normally infects Myocaster coypus (coypu or nutria), a south american rodent. These species were identified easily, from R.C. Hughes, "Key to species of Hymenolepis".

Infection

Except for 3.75% muskrats in A-area infected by an average number of 3.7 worms in the stomach, this is exclusively a parasite of the small intestine. Infection was only slight, ranging from 10.5% in C-area to 18.6% in D-area. Similarly, the intensity of infection was also slight, being an average range of 6 to 7.6 worms. In B-area, 55.5% muskrats were infected by an average of 2 cestodes.

These enumerations are based on the number of scolices recovered. The method of slitting the intestine for examination often divided a long cestode into several pieces.

TABLE 16. INTESTINAL INFECTION BY H. OCTOCORONATA

LOCALITY in A-AREA	INF./TOTAL CARCASSES	INFECTION EXT.	AVERAGE	TOTAL
Infection by "large" variety				
Burnaby Lake	11/41	1-24	8.3	92
Lulu Island	11/24	1-26	7.7	85
Sea Island	1/7	12	-	12
Pitt Meadows	3/4	1-3	2	6
Clayburn	3/4	1-3	2	6
Infection by "small" variety				
Burnaby Lake	3/41	60-many innum.	-	-
Lulu Island	5/24	60-250±	-	1000
Sea Island	6/7	40-250±	-	700
Pitt Meadows	3/4	125-250±	-	500
Clayburn	3/4	12-200±	-	270
Muskrats infected by both varieties				
Burnaby Lake	2/41			
Lulu Island	5/24			
Sea Island	2/7			
Pitt Meadows	2/4			
Clayburn	3/4			

TABLE 17. INFECTION by H. EVAGINATA in C, D and E. AREAS

AREA	LOCALITY	NO. INF./TOTAL CARCASSES	INFECTION EXTREMES	TOTAL
C	Williams Lake			
	1946	NO CESTODES		
	1947	3/12	1-7	11
	Ochiltree	NO CESTODES		
	Springhouse	NO CESTODES		
	Mapes	2/2	1	2
D	Radium	2/6	1-16	17
	Brisco	NO CESTODES		
	Windermere	1/5	-	1
E	Mill Creek & Rutland	3/24	1-15	29
	Kelowna	NO CESTODES		
	Oliver	NO CESTODES		
	Princeton	NO CESTODES		

Also, due to the delicate nature of the anterior segments of these species, intact scolices were sometimes difficult to collect.

Microscopic examination of intact scolices of representative specimens revealed considerable variation within the two species prevalent in B.C. muskrats.

In A-area, H. octocoronata occurred in three distinct varieties. Of these varieties, two possessed identical rostellar armature, but were distinguished by size. In the "small" variety, the intensity of infection ranged from 60 to 250+. In the "large" variety, it ranged from 1 to 26 individuals. These varieties both possessed a rostellum armed with elongated hooks in a circlet of 8, which is typical for the species H. octocoronata. The third variety, occurring within the "small" variety, was disclosed by microscopic examination of intact scolices. This aberrant type possessed a rostellum armed by 9 dissimilarly shaped hooks, compared to those of the above varieties. Plate VIII, fig. 1 and 2. However, the arrangement of the internal organs of the proglottid is identical to typical H. octocoronata specimens. According to R.C. Hughes (1941) there is apparently no described species bearing nine rostellar hooks. Literature since this date also reveals no nine-hooked species. With the rostellar armature as the only distinctive character, these specimens are classified as an aberrant type of the species H. octocoronata.

Throughout C-, D- and E-areas, the typical muskrat species, H. evaginata, occurred. Infection was slight and scattered. In C-area negligible incidence occurred at Williams Lake and Mapes during March, 1947. In D-area, Radium reported the higher infection, where two muskrats contained 17 cestodes. Incidence was also scattered and negligible in E-area. Table 17 lists the degree of infection in the various localities surveyed.

Description

H. octocoronata (von Linstow 1879) Fuhrmann 1924 also Meggitt 1924.

As mentioned previously, this species occurred in two varieties that are distinguished by the size of the strobila. In the "small" variety they measured 30-50 u. x 315-330 u., while in the "large" variety they were 120-160 u. x 680-720 u.

The rostellar armature of the pestle-shaped scolex consists of eight long, slightly curved hooks. The average length of which is 68u. The nine hooks of the "small" aberrant type are 45-47u. The four deep circular suckers are 0.1mm. diameter.

The three disc-like testes, 0.058 mm. diameter, lie in a triangular position, one on the poral side and two on the aporal side. The slender club-shaped unilateral cirrus pouch extends about two-thirds across the width of the proglottid. The spinous cirrus is approximately 0.027mm. long.

The median bilobed ovary lies near the posterior border of the proglottid, the eggs are 0.027 mm.

Since this is the first record of this species of Hymenolepis from the muskrat, this brief description seems pertinent. H. evaginata Barker and Andrews in Barker 1915.

Redescription of this species is unnecessary since all specimens collected from the muskrat in this province are typical for the species.

However, a regional difference occurred in the size of the rostellar armature. Hughes (1941) indicated that the length of the hooks are 7 u. All British Columbia specimens, the length averaged 13 u. Their shape and proportions are the same.

Discussion

As Henry in a review of the parasites and parasitic diseases of the nutria indicates that H. octocoronata may be considered a normal parasite of this fur-bearing mammal. It is indeed, interesting that the muskrat on the lower mainland of A-area have acquired an introduced parasite. The adaptation is logical, since both the described host and the acquired host are aquatic rodents of similar ecology. It is known that the nutria were introduced into the Fraser River valley and Lower Mainland not more than 10 years ago by fur-farming interests. The extent of their natural distribution is not known, however.

The presence of this species also in Vancouver

Island muskrats and the fact that there is evidence forthe presence of nutria in this region indicates that the acquisition of H. octocoronata by the muskrat in this area is separate from that on the mainland. Also no muskrat have been transplanted to Vancouver Island since the introduction of nutria ~~to~~ from the Lower Mainland.

The existence of atypical varieties of cestodes has been reported in several instances. It is apparent that individual physiology of the host is not responsible since 12 muskrats examined contained both the "large" and "small" varieties of H. octocoronata.

The distribution of the small 9-hooked variety of this species is however, less constant than the normal 8-hooked varieties. Only two muskrats, from Lulu Island and Sea Island, were infected. The existence of this type was concluded after all intact scolices from carcasses A48 and A62 were examined.

The distribution of these two species of cestodes seems logically explained by the presence of the natural barrier (Skagit Range of the Cascade Mountains) that separates the interior and coastal populations of muskrat and confines the nutira to the Fraser River valley.

According to Henry, Sprehn observed an inflammation of the intestinal mucosa in instances of high infection by H. octocoronata. In the muskrat no abnormal condition was evident, despite the fact that the incidence sometimes

attained 200+ cestodes in a concentration of a 6 inch segment of the small intestine.

Larval Cestodes

The liver of the muskrat in this province is infected by two species of larval cestodes: the strobilocercus of Taenia taeniaformis and the proliferating cysticercus of Cladotaenia sp. The latter species also occurred in encapsulated cysts at the base of the mesentry.

Since the first record by Linton in 1884, Taenia taeniaformis has been reported several times as a larval parasite of the muskrat (Table 1). It infects the liver of other rodents namely, Mus sp. and Microtus sp. The adult cestode typically infects Felis sp.

Natural infections of Cladotaenia cooperi larva have been reported by L.R. Penner (1938) from Microtus pinetorum scalopsoides and Peromyscus leucopus noveborascensis. The adult was recovered from Accipiter cooperi (Cooper's hawk).

Experimental infection of several small rodents including two young muskrats by eggs of Cladotaenia sp. from the goshawk produced typical cysticerci in the liver, pancreas, kidneys and mesentries (Penner, unpublished reserach in Ameel, 1942). Following the description of two larval cestodes from the muskrat, D.J. Ameel (1942) states that consideration should be given to raptorial birds as possible hosts for small hooked proliferating cysticerci.

Infection

Taenia taeniaformis was present only in muskrats from Rutland in E-area. In this infection, 14 carcasses contained from 1 to 3 larvae, a total of 21 encysted singly on the periphrary of the liver lobes. Compared to previous descriptions, these specimens were typical for the species.

Cladotaenia sp., identified by A. McIntosh in 1944, occurred in muskrats at Burnaby Lake and Lulu Island in A-area. In A4, A6 and A75, this larva was present in cysts at the base of the mesentry. These cysts varied in size from 10 to 30 mm. Several individual scolices were collected from the duodenum of A2. It is possible that these scolices were related to the two cysts in the liver. The detail of the scolex was similar to the liver scolices.

PLACE	SPEC. No.	No. of CYSTS
Burnaby Lake	A2	2
	A8	9
	A12	1
	A23	2
Lulu Island	A46	10
	A54	3
	A75	12

Table 18. Distribution of CTadotaenia sp. in A-area.

Description

Each liver cyst of Cladotaenia sp. usually contained one bladder with several scolices on it, the general number being 8 to 12. A mesenteric cyst would contain numerous bladders with one to many scolices on each.

For examination of the rostellar armature, a scolex was crushed between a microscopic slide and cover-slip in a glycerol mount. In those specimens examined, there were from 42 to 48 small hooks arranged in a double row (Plate VI, fig. 2). The rostellar hooks from cysticerci in the mesenteric cyst of A75 were poorly defined, but it is assumed from their number that they are the same species as the other cysts.

Discussion

The infection by larval cestodes of the muskrat in British Columbia is slight. This incidence is apparently not detrimental to the health of the host, as all carcasses so infected were in a normal condition.

As previously discussed it is noted that both species are typically larval parasites of small rodents while the adult occurs in typical predators of these mammals. Thus further evidence is given to the hypothesis that parasitism is related to the ecological associations of animals.

The Cladotaenia sp. present in the carcasses examined somewhat resembles the first species of larval cestode described by D.J. Ameel. However, since he does not

identify it, this resemblance is based on his description and illustration of cysts. The shape of the hooks is quite different. With this in mind, the British Columbia species may be a closely related species.

ACANTHOCEPHALA

Except for an acanthocephalan, all genera of internal parasites of the muskrat found in this survey have been previously recorded from this host. Seven specimens of a species belonging to this group of parasites were recovered from four muskrats in C-area. Six of these came from three carcasses at Ochiltree in 1946, while one was collected from a muskrat at Springhouse in 1947.

Using the key of H.J. Van Cleave (1923), distinguishing characters indicate that these specimens belong to the family Corynosomidae and related to the genus Polymorphus Lühe 1911. Species in this genus are parasitic in aquatic birds. A recent publication of Helen L. Ward which redescribes the species Polymorphus obtusus Van Cleave, 1918 indicates that the species from the muskrat is related to it.

Description

The specimens examined measured 2 to 2.4 mm. long and 1.0 mm. wide.

The cylinderical club-shaped protusible proboscis is covered with 9 or 10 parallel alternating rows of uniformly sized spines, 45 u. long. It fits into an elongated proboscis receptacle that extends to the body constriction. The two

elongated sac-like lemnisci lie posteriorly from this receptacle.

The anterior third of the body is wider than the posterior. From the constriction it extends cloak-like around the base of the proboscis. The external surface of this region is covered by innumerable rows of minute spines that decrease in size toward the constriction. The posterior two-thirds of the body is non-echinate.

The posterior tip of the body also extends from a constriction and is of considerably smaller diameter. In the male, it is slightly flared to form a bursa-like tip. In the female, it is rounded toward the genital aperture.

In the male, the two elongated testes lie together at about the middle of the body. They measure 1.36 mm. long and 0.088 mm. wide. Posterior to them is a voluminous enlargement that represents the cement receptacle. This is connected to the genital opening by ducts. The cement glands are between the receptacle and the testes.

In the female, the body cavity is filled with numerous ovarian masses. The short funnel-shaped uterine duct extends from the posterior constriction to the tip of the body. The females examined contained no mature ova on which dimensions could be taken.

Discussion

When these specimens are compared with H.L. Ward's description notable differences are evident. But the

following similarities indicate that the species are related; the spinous anterior region of the body; the presence of anterior and posterior constrictions of the body; the shape of the cement receptacle is similar and the copulatory bursa are similarly shaped. The differences lie in the shape of the testes, which are oval in her description and the proboscis. These differences are definitely significant and further research is necessary before concluding the exact relation of this species to other species of Polymorphus.

Present knowledge indicates that acanthocephalan parasites are relatively unimportant. The infection from the muskrat is apparently insignificant. It is possible that this is an accidental host, since Van Cleave indicates that this genus is parasitic in birds.

RESULTS of THIS INVESTIGATION

This survey revealed that 74.0% of the muskrats examined contained more than 5 specimens of internal parasites. Since all the carcasses were apparently in good condition at death, this percentage may be accounted as normal parasitism.

AREA	LOCALITY	TOTAL EXAMINATIONS	TOTAL INFECTED	% INFECTED
A	Burnaby Lake	41	31	75.6
	Lulu Island	24	20	80.0
	Sea Island	7	5	55.5
	Pitt Meadows	4	4	100.
	Clayburn	4	4	100.
B	Duncan	9	7	77.7
C	Williams Lake,			
	1946	24	17	70.8
	1947	12	12	100.
	Ochiltree	14	2	11.1
	Springhouse	12	8	66.6
	Mapes	2	2	100.
D	Radium	6	5	83.3
	Brisco	5	5	100.
	Windermere	5	5	100.
E	Mill Creek & Rutland	24	15	62.5
	Kelowna	6 - 2#	2	50.0
	Oliver	2	2	100.
	Princeton	1	1	-
TOTAL		202	148	74.0

Table 19. Degree of Normal Parasitism in the Muskrat in British Columbia.

#2 carcasses discarded as too decomposed for examination.

It is suggested that for further study in this field, a basic number of 12 specimens be utilized, if comparison studies are to be completed.

Reports from A-area indicate that the 1946 catch was the smallest since 1945 when a peak was reached. One trapper attributed the 1945 peak to overtrapping due to high prices at that time. Examination of a graph of the royalty paid on muskrat pelts will reveal that this peak was one of normal occurrence.

If the actual returns for the 1946 season are a minimum for this cycle, it may be interesting to note the relation of the pulmonary infection to low population densities. At present insufficient evidence prevents further discussion of this relation in British Columbia. However, as indicated previously, Warwick noted a relation but hesitated to define it.

It is concluded that mortality as a result of excess parasitism is probably negligible in the muskrat in this province. The mortality as a result of disease cannot be determined at this time due to insufficient evidence.

SIGNIFICANCE of DISEASE and PARASITISM in BRITISH COLUMBIA MUSKRATS.

As indicated above, only normal parasitism was encountered in this survey. It is apparent that other predisposing factors must be present before any abnormal condition associated with the parasitism will manifest itself. In such instances, the parasitism would be the secondary cause of the diseased condition.

It has been shown in Table 8 that a definite distribution exists for the different parasites of the muskrat. From this table, it is noted that Echinostomum coalitum and Hymenolepis coccoronata are dominant in A-area, whereas Echinoparyphium contiguum infects this host only in C-area. The greatest infection by Plagiorchis proximus occurred in D-area while Capillaria ransomia infected more muskrat in E-area. There is thus a constant incidence variation of parasites throughout B.C. It has also been observed that definite local variations in incidence and percentage of infection occur.

It is difficult to attribute such variations to climate due to the relatively short distance in which they occur. Other factors that may contribute to this variation are water, potential and type of food and population densities.

The condition of the water has been shown to be an important factor in the dissemination of parasites and especially disease. The stagnant nature of water in

drainage ditches would facilitate higher infection than the usually faster-moving waters of creeks and ponds.

Abundant evidence shows that certain diseases are disseminated through water. For instance, the prevalence of tularemia among muskrat in Alberta. The organism, once introduced on to an area prevails until the entire population is killed (Parker to Brown, 1944). Apparently the causative organism in the pulmonary infection studied by Warwick was spread through water. He found the diseased animals 16 miles apart.

As for parasites, many cestodes and nematodes and all trematodes require water in order to propagate.

The type of food present is the second factor that contributes to the different degrees of infection by diseases and parasites between two local populations. Food potential is a limiting factor for the survival and increase of a population. Abundant desirable vegetation prevents overcrowding on the feeding areas, thus decreasing the chance of contact between healthy and diseased animals.

In connection with diet and parasites, a predominance of coarse fibrous grass-like vegetation in the digestive tract of muskrats from the Mill Creek and Rutland locality was noted. This was in contrast to the usual stomach and cecal content of finely divided yellow or green vegetation. Slight parasitism was associated with this fibrous diet.

Regarding the basis for a comparison between the age of a muskrat and the intensity of a parasitic infection, it was noted that in those carcasses on which age determination was possible, no relation exists. A juvenile animal was apparently parasitised to a degree similar to that of an adult trapped at the same time. Parasitism in those kits examined was nil. This complete absence of parasites should not be accepted as a normality, since only six carcasses were examined throughout a period of 10 days from one locality (Burnaby Lake, A-area). It may be also noted that an adult examined during the same period was free of parasites.

CONCLUSIONS

This investigation revealed that the muskrat trapped in British Columbia is not greatly affected by disease and parasites. Analysis of reports from game-wardens and trappers indicate that this important fur-bearer is apparently more affected by wounds due to intra-specific strife than by actual diseases. These wounds which are most dominant during the spring sexual fighting reduce the value of pelts collected at this time. In some localities, particularly the Lower Mainland, where trapping is carried out within municipal boundaries, and several trappers collect on the same territory, considerable maiming of muskrats results when an animal escapes from a trap. This is more evident where traps are not "drown set". Pathological conditions include two pulmonary conditions and a tumorous condition.

With regard to parasitism, although 74.0% of the carcasses were infected, the infection in each carcass was not sufficient to produce any pathological condition. With the exception of one, all species of parasites recovered from the muskrat in this province have been previously recorded. This list includes: trematodes, Echinostomum coalitum, Echinoparyphium contiguum, Quinqueserialis quinqueserialis, Notocotylus urbanensis and Plagiorchis proximus; adult cestodes, Hymenolepis evaginata and Hymenolepis octocoronata; larval cestodes, Taenia

taeniaformis and Cladotaenia sp.; nematodes, Capillaria ransomia and a few Trichuris opaca. The new record is an Acanthocephala, related to Polymorphus (Family Corynosomidae)

From analysis of the information collected in this study, the following conclusions are derived:

1) It is apparent that the parasites which infect the muskrat in British Columbia are or have become normal to this host.

2) There is a definite regional prevalence for two species of these parasites. Hymenolepis octocoronata is found only in A-area (Lower Mainland and Fraser River valley), and B-area (Vancouver Island) while Echinoparyphium contiguum is limited to C-area (central B.C.).

3) There are certain local differences in the intensity and incidence of infection by the different species of parasites. These differences are not attributed to climate but to different water and food conditions.

4) There is no apparent difference, due to age, in the degree of parasitism between adult and juvenile muskrats.

5) Mortality, as a result of excess parasitism, is probably negligible in the muskrat in British Columbia.

ILLUSTRATIONS

Plate V

Echinostomum callawayensis. Ventral view. Drawn, at X150, with camera lucida. Note: shell gland = Mehlis' gland.

Plate VI

Fig. 1 Oral sucker and cephalic spination of E. callawayensis. Drawn, at X250, with camera lucida.

Fig. 2 Rostellar hook of the cestode, Cladotaenia sp. Drawn, at X300, with camera lucida.

Plate VII

Plagiorchis proximus.

Fig. 1 A typical specimen, as determined from the description of F.D. Barker

Fig. 2 A specimen of the 'aberrant type' that is present in the muskrat in British Columbia.

Both figures are drawn, at X150, with camera lucida.

Plate VIII

Fig. 1 Rostellar hook of the 'large' and 'small' varieties of Hymenolepis octocoronata. Scale, 10 mm. = 25.1 u.

Fig. 2 Rostellar hook of the 'small aberrant' variety of H. octocoronata. Scale, 10 mm. = 25.1 u.

Fig. 3 Rostellar hook of Hymenolepis evaginata. Scale, 10 mm. = 3.7 u.

Above figures drawn with camera lucida. Fig. 1 & 2 at X 300. Fig. 3 at X900.

Fig. 4 Immature proglottids of H. octocoronata. A composite drawing, the outline of which was completed with

camera lucida, at X150.

Plate IX

A possible new species of Acanthocephala.

Fig. 1 Composite drawing showing internal organs of male. Outline drawn by camera lucida at X150.

Fig. 2 Detail of the hooked proboscis. Drawn, at X200, with camera lucida.

Fig. 3 Detail of the individual hooks of proboscis. Drawn with camera lucida, at X300. Scale, 10 mm. = .13 u..

Plate X

A possible new species of Acanthocephala. Composite drawing of the internal organs of a female. Outline drawn with camera lucida, at X150.

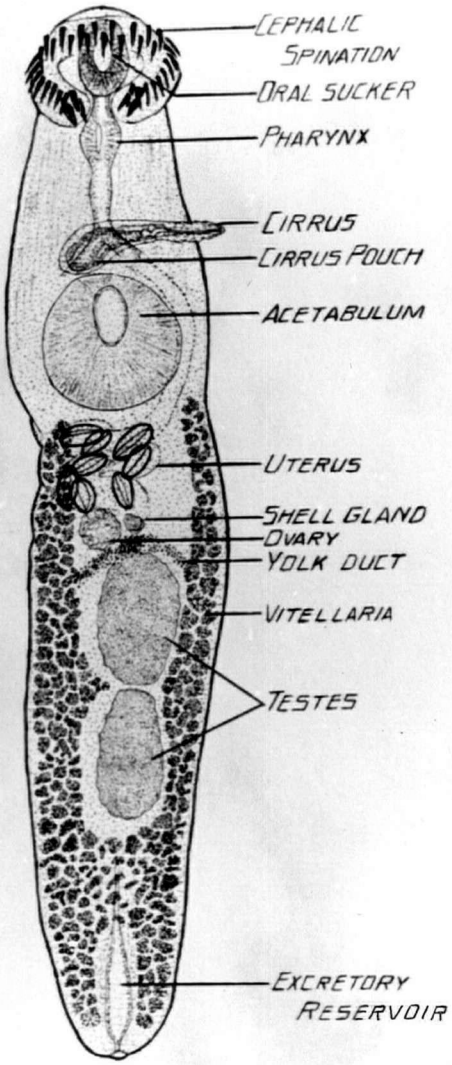

CEPHALIC SPINATION
ORAL SUCKER
PHARYNX
CIRRUS
CIRRUS POUCH
ACETABULUM
UTERUS
SHELL GLAND
OVARY
YOLK DUCT
VITELLARIA
TESTES
EXCRETORY RESERVOIR

PLATE V

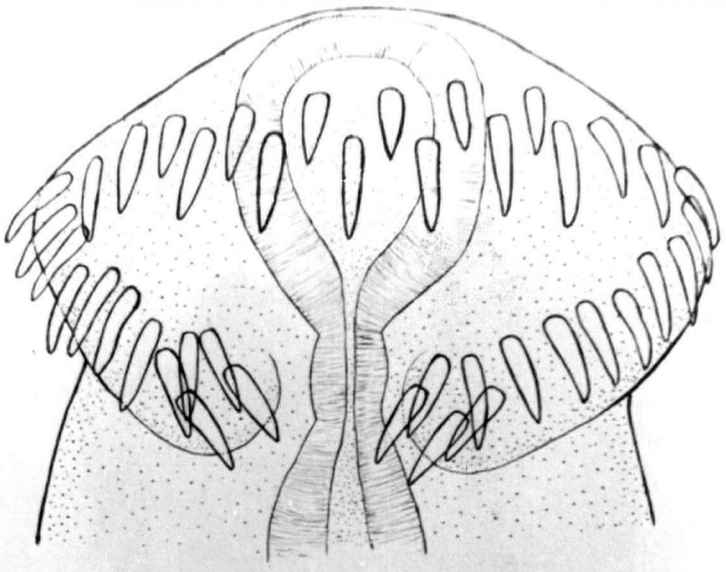


Fig. 1

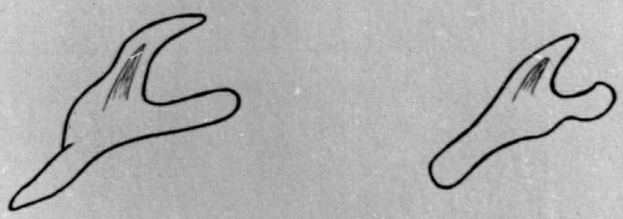
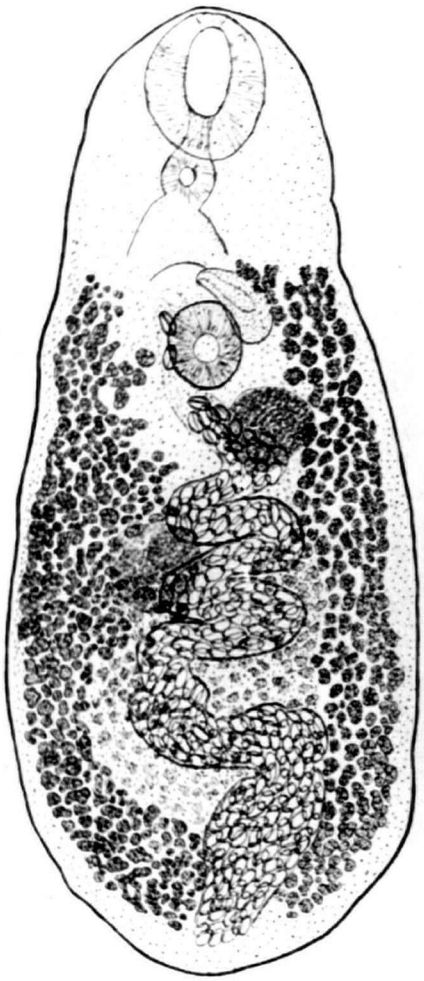


Fig. 2

PLATE VI



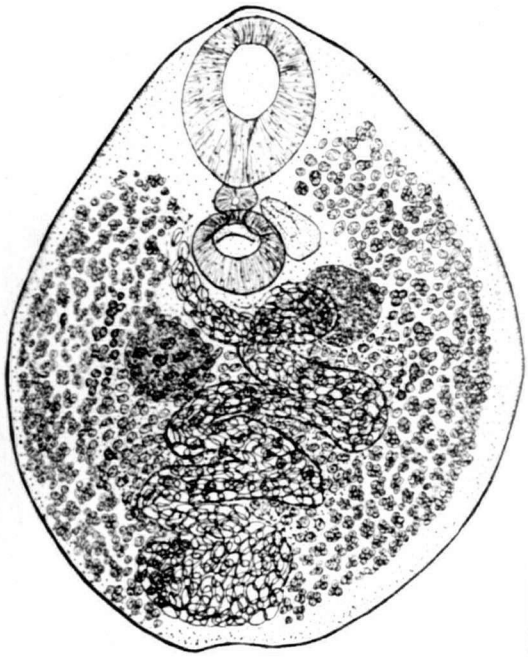


Fig. 1

Fig. 2

PLATE VII

Fig. 1

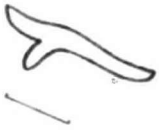


Fig. 2

Fig. 3

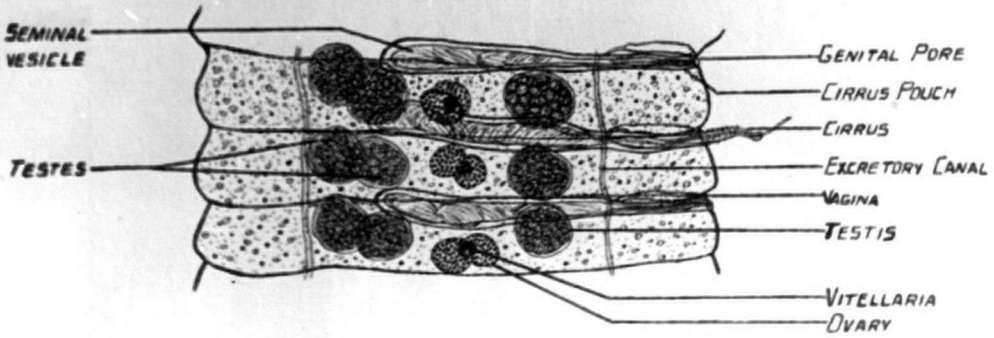


Fig. 4

PLATE VIII

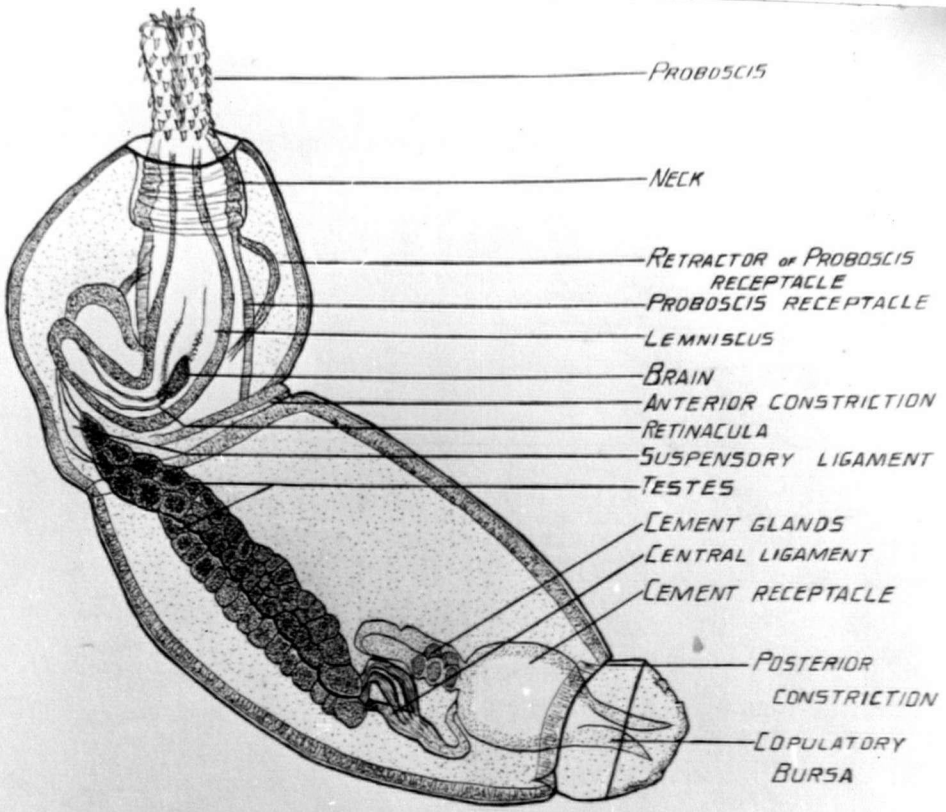


Fig. 1

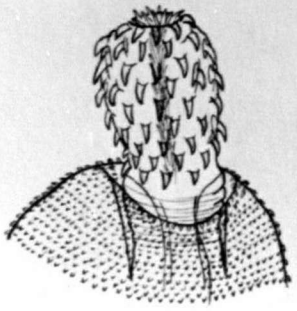


Fig. 2

Fig. 3

PLATE IX

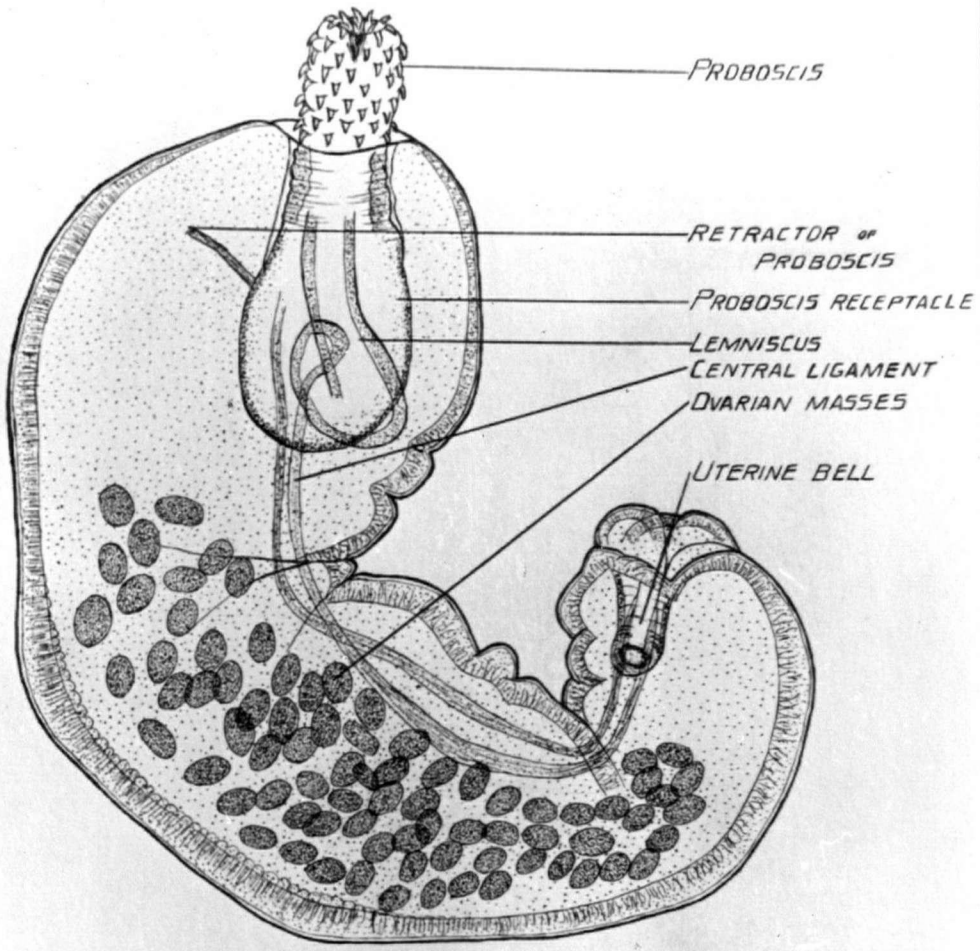

PROBOSCIS
RETRACTOR OF PROBOSCIS
PROBOSCIS RECEPTACLE
LEMNISCUS
CENTRAL LIGAMENT
OVARIAN MASSES
UTERINE BELL

PLATE X

REFERENCES

ALLEN, J.A.

1934 Parasites of Fur-bearing Animals. 5th Pacific Sci. Congr. Can. Proc. 1933 5: 2981-9.

AMEEL, D.J.

1932 The Muskrat, a New Host for Paragonimus. Sci. N.S. 75 (1945): 382.

1942 Two Larval Cestodes from the Muskrat. Trans. Amer. Micr. Soc. 61 (3): 267-271. 1 Pl.

BARKER, F.D.

1915 Parasites of the American Muskrat. (Fiber zibethicus). J. Parasitol. 1 (4): 184-197.

1916 A New Monostome Trematode Parasite in the Muskrat, with a Key to the Parasites of the American Muskrat. Trans. Amer. Micr. Soc. 35 (3): 175-184.

BAYLISS, H.A.

1935 Some Parasitic Worms from the Muskrats in Great Britain. Ann. Mag. Nat. Hist. London 15 (10): 543-549.

BEAVER, P.C.

1937 Experimental Studies on Echinostoma revolutum (Fröelich), a Fluke from Birds and Mammals. Ill. Biol. Mongr. 15 (1): 1-96.

BROWN, J.H.

1944 The Susceptibility of Fur-bearing Animals and Game Birds to Tularemia. Can. Field Naturalist 58 (2): 55-60.

BRYD, E.E. and REIBER, R.J.

1942 Three Flukes from Small Mammals. J. Tenn. Acad. Sci. 17 (1): 143-156.

CHANDLER, Asa C.

1941 Helminths of Muskrats in South-east Texas. J. Parasitol. 27 (2): 175-181.

CORT, W.W.

1914 Larval Trematodes from North American Fresh-water Snails. J. Parasitol. 1 (2): 65-84.

COWAN, I. McT.

1939 Vertebrate Fauna of the Peace River District of British Columbia. Occasional Papers of B.C. Prov. Mus. No. 1: 1-102.

DOZIER, H.L.

1943 Occurrence of Ringworm Disease and Lumpy Jaw in the Muskrat in Maryland. J. Amer. Vet. Med. Assoc. 102 (795): 451-453.

ERRINGTON, P.L.

1946 Special Report on Muskrat Disease. Excerpted from the Quarterly Report, July to September, 1946. Iowa Cooperative Wildlife Research Unit.

HARRAH, E.C.

1922 North American Monostomes Primarily from Freshwater Hosts. Ill. Biol. Mongr., Urbana. 7: 1-106.

HENRY, A.

1931 Les Parasites et les Maladies Parasitaire due Ragondin. Bull. Soc. Nat. Acclimat. France. 78 (12): 421-447.

HENSLEY, A.L. and TWINING, H.

1946 Some Early Summer Observations on Muskrats in North-eastern California Marshes. Calif. Fish & Game 32 (4): 171-181.

HERBER, E.C.

1942 Life History Studies of Two Trematodes of the Subfamily Notocotylinae. J. Parasitol. 28 (3): 179-184.

HOLLISTER, N.

1911 A Systemic Synopsis of the Muskrats. North American Fauna, No. 32.

HUGHES, R.C.

1940 The Genus Hymenolepis Weinland 1858. Tech. Bull. Okla. Agric. Exp. Sta. 8: 1-42.

1941 A Key to the Species of Tapeworms in Hymenolepis. Trans. Amer. Micr. Soc. 60 (3): 378-414.

KUNTZ, R.E.

1943 Cysticercus of Taenia taeniaformis with Two Strobilae. J. Parasitol. 29 (6): 424-25.

LAW, R.G. and KENNEDY, A.H.

1932 "Parasites of Fur-bearing Animals". Dept. of Game & Fisheries, Ont. Bull. No. 4: 1-30.

LEIGH, W.H.

1940 "Preliminary Studies on Parasites of Upland Game Birds and Fur-bearing Mammals in Illinois." Bull. Ill. Nat. Hist. Surv. 21 (5): 185-194.

LLOYD, H.

1925 Introduction of the Muskrat and Rocky Mountain Goat on Vancouver Island. Can. Field Naturalist. 39: 151-52.

LUTTERMOSER, G.W.

1935 A Note on the Life History of the Monostome, Notocotylus urbanensis. J. Parasitol. 21 (6): 456.

MacFARLANE, R.

MacFARLANE, R.

1905 Notes on the Mammals Collected and Observed in the Northern MacKenzie River District, with Remarks on Explorers and Explorations of the Far North.
Proc. U.S. Nat. Mus. 28: 737.

McINTOSH, A.

1940 Cladotaenia foxi n.sp. in falcon, Falci peregrinus. North America.
Proc. Helminthol. Soc., Washington, 7: 71-73.

MEGGITT, F.J.

1924 Cestodes of Mammals.
iv+282 pp. London.

MUNRO, J.A. and COWAN, I. McT.

1944 Preliminary Reports on the Birds and Mammals of Kootenay National Park, British Columbia.
Can. Field Naturalist 58 (2): 34-51.

MUNRO, J.A.

1947 Observations of Birds and Mammals in Central British Columbia.
Occas. Papers, B.C. Prov. Mus. No. 6, 1-165.

NEVEU-LEMAIRE, M.

1936 Traite d'Helminthologie Medicale et Vetinaire.
xxi+1-1514 pp. avec 787 fig. Vigot Frères, éditeurs.

OLIVIER, L.

1938 A New Trematode (Allassogonoporus marginalis from the Muskrat.
J. Parasitol. 24 (2): 155-160.

OLSEN, O.W.

1939 Schizotaeniasis in Muskrats.
J. Parasitol. 25 (3): 279.

PENN, G.H., Jr.,

1942 Parasitological Survey of Louisiana Muskrats.
J. Parasitol. 28 (4): 348-349.

PENN, G.H., Jr., and MARTIN, E.C.

1941 The Occurrence of Porocephaliasis in Louisiana Muskrats.
J. Wildlife Management 5 (1): 13-14.

PENNER, L.R.

1938[a] A Hawk Tapeworm which produces Proliferating Cysticercus in Mice.
Abst. suppl. J. Parasitol. 24: 25

1938[b] Schistosomatium from the Muskrat, O.zibethica in Minnesota and Michigan.
J. Parasitol. 24 (6): suppl. 42 pp.

1941 The Status of Urotrema shillingeri Price 1931 (Trematoda: Urotrematidae).
Trans. Amer. Micr. Soc. 60 (3): 359-364.

PRICE, E.W.

1931 Four New Species of Trematode Worms from the Muskrat (O. zibethica) with a Key to Trematode Parasites of the Muskrat.
Proc. U.S. Nat. Mus. 79 (4): 1-131.

PRITCHARD, A.L.

1934 Was the Introduction of the Muskrat in the Queen Charlotte Islands Unwise?
Can. Field Naturalist, 48: 103.

RAUSCH, Robert, L.

1946 Parasites of the Ohio Muskrats.
J. Wildlife Management 10 (1): 70

RUSH, W.M.

1927 Notes on the Diseases of Wild Game Mammals.
J. Mammalogy 8 (2): 163-65.

SETON, E.T.

1909 Life Histories of Northern Animals. Vol. 1.
C. Scribner's Sons, New York, 1220 pp.

SHILLINGER, J.E.

1933 The Significance of Wildlife Disease.
Proc. 5th Pac. Sci. Congr. 4: 2977-81.

SMITH, F.R.

1938 Muskrat Investigations in Dorchester County, Maryland, 1930-34.
Circ. U.S. Dept., Agr. No. 474, 1-24 pp.

STORER, Tracy I.

1938 The Muskrat, as Native and Alien; a Chapter in the History of Animal Acclimatization.
Calif. Fish and Game 24 (2): 159-175.

SVIHLA, A. and SVIHLA, R.D.

1931 The Louisiana Muskrat.
J. Mammalogy 12 (1): 12-28.

SWALES, W.E.

1933 A Review of Canadian Helminthology. I. The present status of knowledge of the helminth parasites of domesticated and semi-domesticated mammals and economically important birds in Canada, as determined from work published prior to 1933.
Can. J. Res. 8: 468-477.
II. Additions to Part I, as determined from a study of parasitic helminths collected in Canada.
Can. J. Res. 8: 478-481.

SWARTH, H.S.

1922 Birds and Mammals of the Stikine River Region of Northern British Columbia and Southeastern Alaska.
Univ. Calif. Publ. Zool. 24 (2): 125-314, plate 8, 34 fig. in text.

1924 Birds and Mammals of the Skeena River Region of Northern British Columbia.
Univ. Calif. Publ. Zool. 24 (3): 315-344. plate 9-11, 1 fig. in text.

TRAVIS, B.V.

1939 Descriptions of Five New Species of Flagellate Protozoa of the Genus Giardia.
J. Parasitol. 25 (1): 11-17.

VAN CLEAVE, H.J.

1923 A Key to the Genera of Acanthocephala. Trans. Amer. Micr. Soc. 42 (4): 184-191.

WALLACE, F.G. and PENNER, L.R.

1939 A New Liver Fluke of the Genus Opistorchis. J. Parasitol. 25 (5): 437-440.

WARD, Helen, L.

1943 A Redescription of Polymorphus obtusus Van Cleave, 1918. (Acanthocephala). J. Parasitol. 29 (4): 289-291.

WARWICK, T.

1937 The Occurrence of Disease among Muskrats (O. zibethica). in Great Britain during 1934. J. Animal Ecol. 6 (1): 112-114.

WEBSTER, J.D.

1947 Studies on the Genus Hymenolepis with description of Three New Species. J. Parasitol. 33 (2): 99-106.

WOODHEAD, A.E.

1930 The Diseases of the Muskrat. Amer. Fur Breeder 3 (1): 30.

A B S T R A C T

From 750 "outline questionaire" pamphlets mailed to registered trappers in British Columbia, 133 or 17.7% were returned. Of these, 9.7% trapped muskrat on their territory and 8.0% reported no muskrats. Through the cooperation of game-wardens and trappers 202 muskrat carcasses were sent during trapping season from 17 different localities to the University of British Columbia for examination for diseases and parasites from October 1944 to May 1947.

This survey revealed that 74.0% of the carcasses were parasitised by 12 species of internal parasites. These included: trematodes, Echinostomum coalitum, Echinoparyphium contiguum, Quinqueserialis quinqueserialis, Notocotylus urbanensis and Plagiorchis proximus; adult cestodes, Hymenolepis octocoronata and Hymenolepis evaginata; nematodes, Capillaria ransomia and a few Trichuris opaca and a new record of infection for this host, an Acanthocephala, related to the genus Polymorphus (Corynosomidae). Two larval cestodes were found infecting the liver; the strobilocercus, Taenia taeniaformis and a proliferating cysticercus, Cladotaenia sp.

Pathological conditions affecting the muskrat include two different pulmonary conditions and a tumorous condition. There was also frequent infection of wounds.

It was concluded that:

1) The parasitism in British Columbia muskrats is normal.

2) There is considerable regional difference in the prevalence and abundance of these normal parasites.

3) There is no apparent difference, due to age, in the parasitism of adult and juvenile muskrats.

4) The mortality, as a result of excess parasitism, is probably negligible.

Also included in this investigation ~~is~~ are a complete historical review of the parasites of the muskrat and a distributional survey of this fur-bearer.