A BIOLOGICAL STUDY OF THE MUSKRAT, (*ONDATRA ZIBETHICA ALBA*, (SABINE) MILLER, 1912) IN MANITOBA

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by

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Figure I --- A litter of ten muskrats which were photographed on June 30th, at Pruden Bay Station, Netley Marsh. Their average total body length was approximately 135 mm. which placed them at six days of age. The animals have been tagged for experimental purposes.

FOREWORD

The early fur trade furnished the stimulus for exploration and the subsequent colonization of the North American continent.

> "Probably the oldest industry in the world was the taking of furs for clothing; aborigines the world over have been dependent upon fur animals for ages. The early invaders of North America pushed into the West for furs. If one reviews the history of North America, he soon learns that not gold, agricultural lands, or timber attracted the hardy adventurers, but rather the claims of the fur trade." (Hamilton, 1939)

The fur trade of Canada plays an important role in the economic status of this country. A large population of Northern Canada is primarily dependent upon the fur bearing animals. Approximately 60,000 Eskimos and 20,000 Indians are supported largely by the fur industry. These natives cannot subsist on agriculture due to the unsuitability of the soil and also because of their nomadic nature. Since there exists a sufficient native population in Canada to secure all the furs that can be marketed, certain restrictions have been placed on the number of white trappers.

With the increasing demand for furs, many of the fur - bearing species have been trapped very heavily resulting in a serious decrease in their numbers. If the conditions of the habitat became severe, the outcome would have been extermination if conservation measures were not brought into function. The purpose of management and regultion is to permanently maintain the fur supply on a sustained - yield basis.

INTRODUCTION

Total Canadian Fur Production

The twenty two fur-bearing animals of Canada are mostly carnivorous mammals but also included are two rodents of great importance. The latter are the beaver and the muskrat. The total Canadian fur production during the season 1947/48 ending June 30th, is shown in Table I. This crop was worth over 32 million dollars. Therefore the Canadian fur industry is of considerable value.

Muskrat Fur Production

The "banner of the fur trade" as formerly held by the beaver, has long since been replaced by the muskrat. Its broad distribution and enormous numbers as well as its great versatility which has enabled it to withstand prolonged heavy trapping and the severe fluctuations of its habitat have made this animal one of the most important species of the fur trade. It is trapped in Alaska, Canada, and in 47 states. Louisiana is by far the greatest producer and supplies approximately six million pelts yearly. The total North American production exceeds 10 million muskrat pelts annually.

Canadian production of these pelts amounted to over 3.5 million during the season 1947/48 ending June 30th. Table I states that their worth exceeded 9.5 million dollars. This same table also shows that the muskrat is the most abundant and the most valuable fur bearer in comparison to any of the other species which are obtained from the wild. It constitutes approximately 30% of the total value of all the Canadian fur revenue.

Table II, has all the territories of Canada arranged in their order of importance with respect to her muskrat fur production. Manitoba, in the season 1947/48 ending June 30th, surpassed all the other regions in her yield of muskrat furs.

The number of raw pelts taken in Manitoba from the season 1942/43 to the season 1948/49 ending March 31st is shown in table III. The total amount of pelts cropped in this province during the season 1948/49 was approximately 1.67 million. The muskrat furnished over 930,000 of these pelts or slightly less than 56% of the total catch. These furs produced a revenue exceeding 1.25 million dollars. The total value of the furs for the season 1948/49 ending March 31st, as shown by table IV, was over 2.5 million dollars. Therefore the muskrat constitutes almost 50% of the total Canadian fur catch revenue. The muskrat formed not only the majority of the pelts taken from the wild in Manitoba but also the greatest return for any one species.

The abundance and the pelt value of the muskrat do not remain stationary. Tables V and VI show these fluctuations. During the past season, the muskrat population has reached almost another all time high in Manitoba. The

TABLE I

TOTAL CANADIAN FUR PRODUCTION
Season 1947/48

Kind	No. of Pelts Wild Life	No. of Pelts Ranch raised	Total Value of Pelts	Average Value per Pelt
CANADA				
Badger	1,034	-	$ 1,380	$ 1.33
Bear, white	246	-	6,530	26.54
Bear, not specified	827	-	2,257	2.73
Beaver	135,629	-	4,382,241	32.31
Cat, domestic	-	31	16	0.52
Coyote or prairie wolf	21,728	-	64,787	2.98
Ermine (weasel)	528,029	-	1,201,271	2.27
Fisher	2,788	35	102,230	36.21
Fitch	-	231	739	3.20
Fox, blue	606	1,579	34,775	15.92
Fox, cross	5,771	785	36,716	5.60
Fox, platinum	-	30,433	660,147	21.69
Fox, red	46,124	370	120,854	2.60
Fox, silver	1,085	127,300	1,583,006	12.33
Fox, white-marked	-	19,789	254,119	12.84
Fox, white	55,354	69	616,210	11.12
Fox, not specified	109	20	438	3.40
Lynx	6,582	-	128,188	19.48
Marten	15,051	39	415,898	27.56
Mink, mutation	-	32,903	658,507	20.01
Mink, standard	92,191	529,412	10,426,077	16.77
Muskrat	3,569,157	-	9,518,064	2.67
Nutria	-	8	10	1.25
Otter	11,974	-	296,410	24.75
Rabbit	124,801	-	57,320	0.46
Raccoon	24,192	22	63,062	2.60
Skunk	19,096	-	12,770	0.67
Squirrel	2,543,798	-	1,577,887	0.62
Wild Cat	1,265	-	3,480	2.75
Wolf	1,231	-	3,539	2.87
Wolverine	452	-	4,064	8.99
TOTAL	7,209,120	743,026	32,232,992	-

(Figures obtained from the Dominion Bureau of Statistics)

TABLE II

CANADIAN MUSKRAT FUR PRODUCTION
Season 1947/48.

Territory	Number of Pelts (Wild)	Value Total	Value Average per Pelt
Manitoba ------------	1,004,762	$2,712,857	$2.70
Ontario -------------	862,490	2,587,470	3.00
Saskatchewan --------	510,730	1,368,756	2.68
Alberta -------------	463,193	1,097,767	2.37
North West Territories	395,992	864,782	2.30
Quebec --------------	161,101	434,973	2.70
British Columbia ----	67,191	161,258	2.40
Nova Scotia ---------	50,600	149,270	2.95
Yukon Territories ---	30,686	73,646	2.40
New Brunswick -------	21,299	63,897	3.00
Prince Edward Island	1,113	3,388	3.04

(Figures obtained from the Dominion
Bureau of Statistics)

TABLE III

RAW PELTS TAKEN FROM THE WILD IN MANITOBA, 1942/43 TO 1948/49

Species	1942/43	1943/44	1944/45	1945/46	1946/47	1947/48	1948/49
Weasel	113,080	155,567	124,815	109,613	103,656	91,600	99,705
Squirrel	326,203	228,803	445,214	300,847	399,658	224,677	580,707
Muskrat	280,838	581,862	855,724	958,099	808,692	822,998	930,330
Mink	18,356	21,067	15,338	12,801	15,850	18,778	22,932
Skunk	22,839	42,235	26,981	14,747	12,026	1,494	653
Badger	725	1,040	513	432	239	90	34
Wolf, Coyote	4,054	7,745	5,295	3,801	2,132	2,268	1,725
Wolf, Timber	-	-	565	511	403	247	255
Fox, Silver	955	859	523	433	258	201	165
Fox, Blue	14	9	4	6	23	2	8
Fox, Cross	6,072	5,027	3,042	2,107	1,430	826	828
Fox, White	470	363	311	297	1,449	89	47
Fox, Red	24,043	24,717	14,533	10,241	6,271	3,173	2,836
Wolverine	12	12	9	12	24	14	16
Beaver	Closed	13,248	5,399	9,057	7,878	12,443	14,099
Otter	1,772	1,816	2,277	1,804	1,850	2,093	2,103
Fisher	317	490	418	315	24	50	11
Marten	347	269	234	213	15	97	18
Bear	101	193	87	71	37	38	44
Lynx	596	525	311	149	27	20	74
Jack Rabbit	-	-	14,886	14,824	9,728	7,998	5,760
Raccoon	-	-	-	-	-	28	56

(Manitoba Government Annual Report 1948/49)

TABLE IV

ESTIMATED VALUATION OF FURS TAKEN FROM THE WILD, 1947/48 AND 1948/49

Species	Season 1947/48 Quantity	Estimated Valuation 1947/48	Season 1948/49 Quantity	Estimated Valuation 1948/49
Weasel	91,600	$ 215,260.00	99,705	$ 154,542.75
Squirrel	224,677	146,040.05	580,707	133,562.61
Muskrat	822,998	2,222,094.60	930,330	1,274,552.10
Mink	18,778	694,786.00	22,932	619,164.00
Skunk	1,494	1,120.50	653	326.50
Badger	90	135.00	34	44.20
Wolf, Coyote	2,268	6,804.00	1,725	4,312.50
Wolf, Timber	247	988.00	255	1,147.50
Fox, Silver	201	1,005.00	165	660.00
Fox, Blue	2	20.00	8	48.00
Fox, Cross	826	3,717.00	828	2,484.00
Fox, White	89	1,246.00	47	470.00
Fox, Red	3,173	9,519.00	2,836	5,672.00
Wolverine	14	140.00	16	128.00
Beaver	12,443	423,062.00	14,099	310,178.00
Otter	2,093	58,604.00	2,103	42,060.00
Fisher	50	1,500.00	11	275.00
Marten	97	2,910.00	18	360.00
Bear	38	76.00	44	88.00
Lynx	20	420.00	74	888.00
Jack Rabbit	7,998	5,198.70	5,760	1,728.00
Raccoon	28	56.00	56	112.00
		$3,794,701.85		$2,552,803.16

Decrease - 33%

TABLE V

FUR PRODUCTION FROM THE WILD, SHOWING HIGH, LOW AND AVERAGE PRODUCTION, 1924/25 TO 1948/49

Species	Highest Production Number	Highest Production Season	Lowest Production Number	Lowest Production Season	Average Production	Production Season 1948/49
Weasel	155,567	1943/44	56,187	1935/36	101,442	99,705
Squirrel (7 years)	580,707	1948/49	224,677	1947/48	358,015	580,707
Muskrat	958,099	1945/46	213,866	1927/28	468,702	930,330
Mink	28,888	1933/34	9,833	1927/28	16,900	22,932
Skunk	42,235	1943/44	653	1948/49	13,669	653
Badger	1,476	1927/28	Closed	Seasons	476	34
Wolf, Coyote	13,056	1927/28	1,725	1948/49	4,403	1,725
Wolf, Timber (5 years)	565	1944/45	247	1947/48	396	255
Fox, Silver	985	1933/34	86	1928/29	426	165
Fox, Blue	23	1946/47	-	1931/32	6	8
Fox, Cross	6,072	1942/43	795	1928/29	2,678	828
Fox, White	8,397	1924/25	47	1948/49	1,284	47
Fox, Red	24,717	1943/44	2,413	1928/29	9,940	2,836
Wolverine	88	1931/32	9	1944/45	27	16
Beaver	14,099	1948/49	Closed	Seasons	6,323	14,099
Otter	2,277	1944/45	714	1931/32	1,537	2,103
Fisher	953	1925/26	Closed	Seasons	362	11
Marten	2,191	1925/26	Closed	Seasons	542	18
Bear	598	1928/29	37	1946/47	194	44
Lynx	2,394	1925/26	Closed	Seasons	842	74
Jack Rabbit (5 years)	14,886	1944/45	5,760	1948/49	10,639	5,760
Raccoon (2 years)	56	1948/49	28	1947/48	42	56

TABLE VI

HIGHEST, LOWEST AND PRESENT AVERAGE VALUE OF PELTS TAKEN FROM THE WILD, 1928/29 TO 1948/49

Species	Highest	Season	Lowest	Season	1948/49
Weasel	3.05	1945/46	.46	1932/33	1.55
Squirrel (7 years)	.80	1945/46	.23	1948/49	.23
Muskrat	3.50	1945/46	.44	1931/32	1.37
Mink	40.00	1945/46	4.96	1931/32	27.00
Skunk	3.95	1943/44	.50	1948/49	.50
Badger	30.00	1928/29	1.30	1948/49	1.30
Wolf, Coyote	20.00	1928/29	2.50	1948/49	2.50
Wolf, Timber (5 years)	10.00	1944/45	4.00	1947/48	4.50
Fox, Silver	113.50	1928/29	4.00	1948/49	4.00
Fox, Blue	51.00	1928/29	6.00	1948/49	6.00
Fox, Cross	71.25	1928/29	3.00	1948/49	3.00
Fox, White	51.00	1928/29	10.00	1948/49	10.00
Fox, Red	31.25	1928/29	2.00	1948/49	2.00
Wolverine	17.00	1945/46	3.80	1932/33	8.00
Beaver	47.00	1945/46	7.50	1934/35	22.00
Otter	31.75	1928/29	9.60	1931/32	20.00
Fisher	68.00	1943/44	25.00	1948/49	25.00
Marten	55.00	1945/46	11.30	1931/32	20.00
Bear	6.25	1928/29	.85	1931/32	2.00
Lynx	46.00	1943/44	11.42	1931/32	12.00
Jack Rabbit (5 years)	.85	1945/46	.30	1948/49	.30
Raccoon (2 years)	-	-	-	-	2.00

TABLE VII

CANADIAN PRODUCTION OF MUSKRAT RAW FURS
Seasons 1928/29 to 1947/48

SEASON	NUMBER	TOTAL VALUE	AVERAGE VALUE
1928/29	2,785,994	3,924,949	1.41
1929/30	2,109,232	1,781,651	0.84
1930/31	2,639,086	2,143,148	0.81
1931/32	2,632,984	1,403,993	0.53
1932/33	2,731,490	1,581,606	0.58
1933/34	2,538,565	1,863,322	0.73
1934/35	1,983,747	1,784,252	0.90
1935/36	1,630,231	2,148,605	1.32
1936/37	1,607,897	2,250,971	1.40
1937/38	1,748,239	1,320,509	0.76
1938/39	2,295,550	2,011,469	0.88
1939/40	3,241,089	3,829,318	1.18
1940/41	2,795,218	4,990,762	1.79
1941/42	2,408,436	4,954,504	2.06
1942/43	2,068,468	5,671,910	2.74
1943/44	2,038,868	4,654,641	2.28
1944/45	2,377,629	6,299,411	2.65
1945/46	3,420,496	11,159,502	3.26
1946/47	2,795,687	5,431,833	1.94
1947/48	3,569,157	9,518,064	2.67

(Figures obtained from
Dominion Bureau of Statistics)

numerical increase is however offset by a drop in the pelt value. Table VII illustrates the fluctuations in abundance and value of the total Canadian Muskrat raw fur production. The last recorded season of 1947/48 ending June 30th, had the greatest muskrat catch for a period of 19 years. Over 3.5 million muskrat pelts have been marketed during that season yielding over 9.5 million dollars. This statistical survey shows the importance of muskrat fur production in Canada as well as in Manitoba alone.

Rehabilitation Projects

In order to maintain the Canadian fur industry at a high constant level, various government departments have proceeded with the development of marsh lands for the purpose of fur production and rehabilitation of the fur - bearing species. Various measures were put into practice as an attempt to counteract the tendency of these animals to decline. The first method which resulted in success for some of the fur - bearing species was a reconstructive one. Fur farms were brought into large scale productivity with respect to such animals as the fox and the mink. A more recent development resulted in fur rehabilitation programs, where especially the beaver and the muskrat are actively assisted to increase their numbers in their natural environment.

The first step in this direction was undertaken at The Pas, Manitoba, in connection with the rehabilitation of the muskrat.

> "In 1932 --- 54,000 acres of land were leased from the government of that province by private interests with the object of increasing the muskrat population by the control of water levels on the marshes they once inhabited."

In 1931 only 125 rats had been trapped from this area while in 1937 approximately 60,000 pelts were taken. This project proved that the muskrat population could be restored by water control measures.

In 1934 the Manitoba Government, assisted by the Dominion Government started a similar fur rehabilitation scheme on a area of 135,000 acres formerly known as the Summerberry Game Preserve. Since that time.....

> "Administration and maintenance costs have been fully met from production and the capital cost has been offset by the fact that 1,800 families previously on relief have been restored to a self - sustaining basis."

A few years later, two areas totalling 680,000 acres have been added to the original Summerberry project. Saskatchewan also has over 1,520,000 acres under similar control. Fur rehabilitation programs have met with some degree of success but various factors which cause severe declines in the animal populations during certain periods of time have not as yet been eradicated. These factors particularly affect the muskrat numbers.

Former Management Programs

In the past, management programs had concentrated on the following controls:

(a) Manipulation of water levels as a means of creating and maintaining a suitable habitat.

(b) Regulation of trapping in order to retain a suitable breeding stock each year.

These original programs were found to be inadequate in their attempt at maintaining muskrat production on the highest possible quantitative and qualitative sustained basis.

Biological Survey Project

In the spring of 1947, the provincial government of Manitoba broadened its management program by initiating a Biological Survey Party which was placed under the direction of Dr. J. A. McLEOD. This project has been in function every summer since its introduction.

The Problem

In order to acertain the problems of major importance which affect the muskrat population, a detailed biological study of this animal and its habitat was undertaken.

The observations have been integrated in two large sets of complex, dynamically opposed factors. These two groups of factors, depending on their relative magnitudes, are responsible for the density of the muskrat population.

Those factors which tend to increase the population form its biotic potential. Opposing the latter is a group of factors which tends to decrease this same population. These factors form the animal's environmental resistance. When both of the groups are equal, the population, remains stationary. If the biotic potential exceeds the environmental resistance, the population increases. But when the environmental resistance is greater than the biotic potential, the muskrat population will decrease until that resistance is reduced or otherwise the animals will be under a threat of complete extermination.

The work of the past few summers has enabled a detailed observation of certain trends which seriously influence the muskrat population. Methods of controlling unfavorable chains of events are discussed. These methods may be of immediate and future use for management techniques when the muskrat and its habitat are subjected to still more intense rehabilitation projects.

Derivation of Common Name

The muskrat has strongly developed perineal glands which discharge during the period of sexual excitement producing a strong musk odor. This characteristic has furnished the musk prefix of its name.

Originally this animal was called the Musquash by the Cree Indians. This name still persists in the London fur markets.

> "The first published description of the muskrat is to be found in "A map of Virginia, with a Description of the Country, the Commodities, People, Government and Religion Written by Captaine Smith, sometimes Governour of the Country." The author was none other than Captain John Smith whose name is so dramatically associated in early American history with that of the Indian maiden Pocohontas." (Arthur, 1928)

The captain wrote in 1612 and compared the animal to the water rat in its form and nature but with an exceedingly strong smell of musk.

The name "Musk Rat" has been traced back as far as 1635. Apparently this Christening was performed by a Jesuit father in Quebec. Father LeJeune's diary contained the French term Rat musque which in English free translation implies the name by which the animal is commonly called today. This same man wrote the following in 1656:

"There are found in these regions of America animals to which the French have given the name of Musk Rats, because in truth they resemble the rats of France -- except that they are much larger -- and smell of musk in the Spring. The French are very fond of this odor; the Savages dislike it as if it were a stench."

(Jesuit Relations, 1897 - 1901)

Taxonomy of the Muskrat

The muskrat is a mammal belonging to the rodent family. Its scientific name has undergone many changes since its first introduction by Linnaeus.

Castor zibethicus Linnaeus, 1766.

Ondatra zibethicus Link, 1795.

Fiber zibethicus True, 1885.

Ondatra zibethica Miller, 1912.

There are fifteen subspecies. Seven occur in Canada and the remaining eight are only found in the United States.

Distribution

No animal can survive all the different environmental conditions which exist in the world. Some animals are more versatile than others and consequently they occupy greater areas which usually are geographically far apart. The muskrat is one of these animals. However, the muskrat is specialized for a semi-aquatic habitat. It depends on certain semi-aquatic plants and their root systems for food and housing. In order to secure these lower plant systems efficiently the substratum must be soft and wet allowing easy burrowing. Therefore the muskrat is limited in its distribution to marshy areas bearing the needed plants in a soft, wet substratum.

The muskrat has a very wide distribution in North America, occuring all the way from the northern tree limit in the Arctic regions south to the Mexican border. It is absent from the dry areas occurring in the western plains and the alpine tundras of high mountain ranges. Manitoba has three subspecies of muskrats but only Ondatra zibethica alba, (Sabine) Miller, 1912 is of great importance because of its abundance and wide distribution. The subspecies is commonly referred to as the Hudson Bay Muskrat. It occurs in the Hudson Bay drainage system of Manitoba and extends as far north as the initial boundary of the Barren Grounds.

THE HABITAT

General

The muskrat is primarily dependent upon certain plants for its subsistence. The type of soil and the climatic conditions determine the amount and the variety of vegetation produced. In order to arrive at a thorough understanding of the habitat which is so fundamental from the standpoint of muskrat production, something must be known about the soils and their developmental history. The soils are the result of the actions of climate and organic organisms upon geological deposits.

The Geological Histories Of The Major Areas Studied

1. Saskatchewan River Delta

Silurian limestone (Ellis, 1938) comprises the parental geological base of this area. This formation is in the shape of a "spear-head". The point originates in the region between the southern shores of Lakes Winnipeg and Manitoba. The main body extends in a northwesterly direction in the Inter-lake area. At the northern extremeties of Lakes Winnipegosis and Winnipeg, the rock formation broadens very sharply towards the east and west.

Due to the ice movements of the glacial and post-glacial periods, this fairly flat Silurian base was covered with a thin, flat layer of boulder till. The deposit was composed chiefly of limestone. Following the recession of the glaciers and the formation of Lake Agassiz, clay and coarse gravel was added over the boulder till.

The Saskatchewan River, draining a large portion of the territory east of the Rocky Mountain watershed, emptied into Lake Agassiz. The sediments, accumulated by this river from the southern portions of Alberta and Saskatchewan, were deposited at its mouth. This resulted in a large, flat flood-plain which subsequently formed a delta. This delta is inter-laced with numerous channels which are continuously being silted in and new ones are formed again.

Due to the fairly flat nature of the delta and be-cause of the absence of a valley in the immediate neighbor-hood, the river periodically overflows its banks. This results in a further deposition of silt and the filling of the exist-ing depressions with water (Fig. 2). Since the silt deposits consist of much impervious clay and because of the close prox-imity of the limestone base, this water and also the water of precipitation are retained.

The water-filled depressions are generally fairly broad, shallow areas in which the water depth does not usually exceed ten feet (McLeod, 1948). These areas together with the unflooded portions of the territory, have various plants of the different stages of hydrosere succession. These have produced layers of organic matter which are periodically cov-ered over by silt deposits following the heavy floods.

Figure 2.--- Aerial view of portion of flood plain showing channels and sloughs.

(After McLeod, 1947)

This process has been repeated many times as can be seen in a cross section of the substratum (Fig. 3).

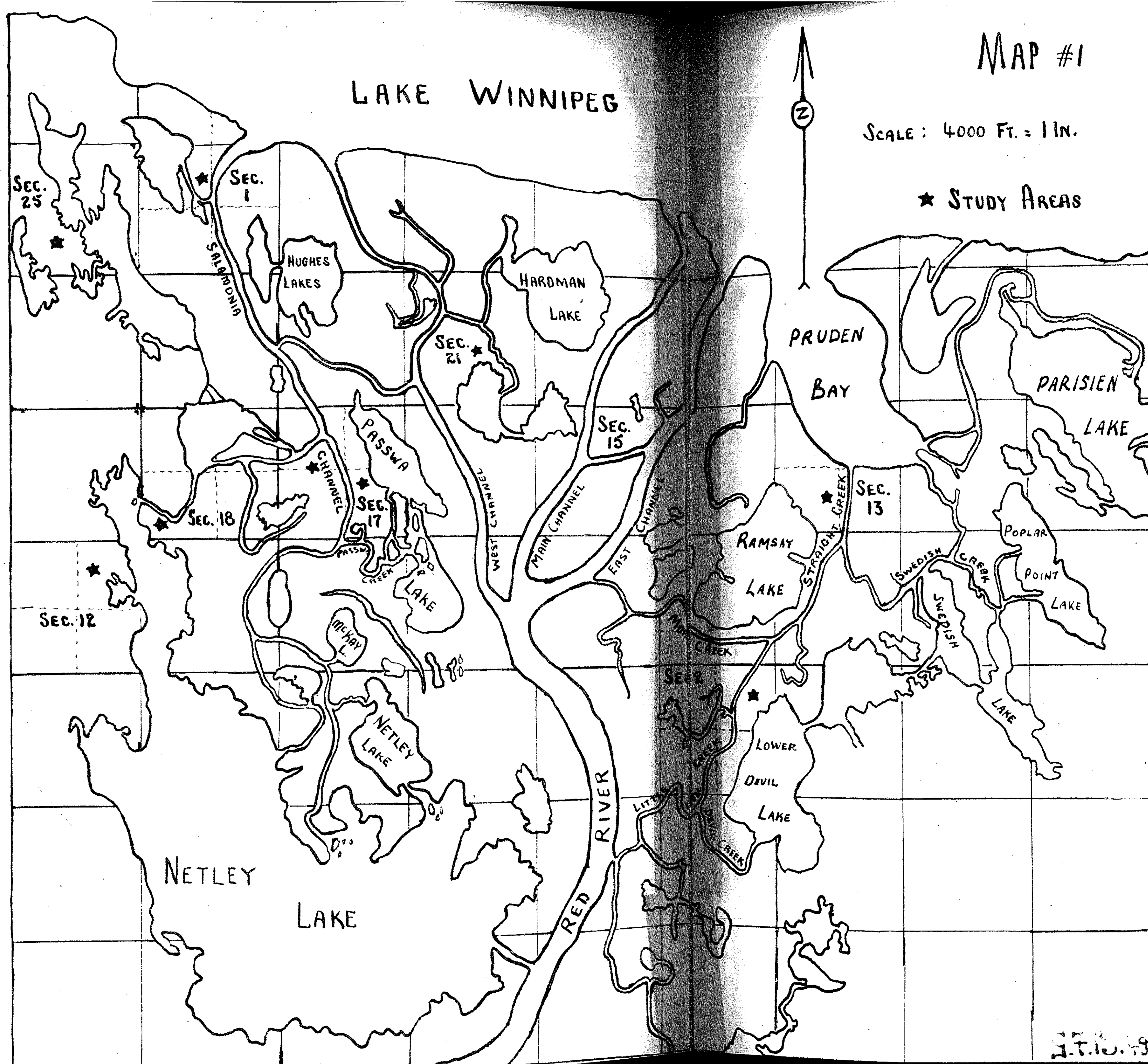
2. Netley Marsh

This area is situated at the southern end of Lake Winnipeg. This whole region was once the bottom of the great Lake Agassiz. The parental geological base is composed of Ordovician limestone. The great former ice movements have covered this stone formation with a deposit of boulder till and gravel. Following the break-through of drainage rivers into the Hudson Bay, the lake gradually receeded. In so doing, it threw up a series of temporary shorelines by means of joint action of ice and water.

Such temporary shores effectively separated a number of regions which once were parts of the bottom of the glacial lake. The higher elevations remained as dry land while the depressions retained some of the water and became small lakes or marshes. Netley Marsh was the result of such similar action.

Lake Winnipeg has been a fairly stable body of water for quite a long number of years. Water action has produced a sandy ridge at its southern end. This has separated a large portion of former lake bottom from the open lake. The area has remained as a series of small lakes and marsh sloughs which are suitable for muskrat production (Map I).

Figure 3.--- Side of pit dug near river channel showing stratification of silt and clay. (After McLeod, 1947)


MAP #1
LAKE WINNIPEG
N
SCALE: 4000 FT. = 1 IN.
★ STUDY AREAS
SEC. 25
SEC. 1
SALAMONIA
HUGHES LAKES
HARDMAN LAKE
SEC. 21
PRUDEN BAY
PARISIEN LAKE
SEC. 15
PASSWA
CHANNEL
SEC. 17
SEC. 18
SEC. 12
WEST CHANNEL
MAIN CHANNEL
EAST CHANNEL
SEC. 13
STRAIGHT CREEK
RAMSAY LAKE
POPLAR POINT LAKE
SWEDISH CREEK
SWEDISH LAKE
PASSWA CREEK
LAKE
McKAY L.
MOSS CREEK
SEC. 8
NETLEY LAKE
LOWER DEVIL LAKE
DEVIL CREEK
RED RIVER
NETLEY LAKE

The territory has undergone heavy sedimentation because of the reduction in the water movements and because of the abundant sediment brought in by the Red River. Netley Marsh communicates with Lake Winnipeg through a series of deep channels (Map I).

Any serious water depth fluctuation at the southern end of the lake causes a readjustment of the marsh waters so as to create an equilibrium between the two levels. Strong north winds often produce a change of 24 inches in the water level of the marsh in a period of 24 hours. Because of these fluctuations in the marsh water level, the habitat which is suitable for the muskrat is relatively unstable as compared to some of the other muskrat producing territories. These fluctuations seriously affect the plant growth on which the muskrat is dependent.

3. Delta Marsh

Delta Marsh is situated at the southern end of Lake Manitoba. Its formation history is quite similar to that of Netley Marsh. However there is one striking difference. There are no large channels connecting the marsh with the lake. Two small communications have been effectively dammed off by artificial means. Also no large rivers carry in sediments as is the case in Netley Marsh. As a result, the muskrat suitable habitat is quite stable because there are no serious fluctuations in the marsh water levels.

4. Oak Lake

Oak Lake with a maximum area of approximately 10 square miles (McLeod, 1948) is situated in the south-western corner of Manitoba. The parental geological deposit consists of Cretaceous shales. This lake occupies a shallow basin which formerly was part of the bottom of Lake Souris. In the past, prolonged water action produced a light sandy substratum of alluvial and lacustrine origin. The maximum water depth varies between 12 to 15 feet (McLeod, 1948).

Two streams, Bell and Pipestone Creeks, serve as a source of inflow of spring waters from the higher regions to the west during periods of heavy run-off. During the rest of the year, precipitation furnishes the only water-replenishing source. Following such heavy spring floods, the excess waters are removed from the lake southward by means of Plum Lake, Plum Creek and by this route reach the Souris River.

The contours of this lake do not have a suitable gradation from the shore towards the deeper waters. Therefore a satisfactory flooded substratum for growth of such plants as Typha does not exist under average conditions. The only valuable vegetation for muskrats consists of Scirpus validus. During periods of lowered water depths, this plant furnishes satisfactory food and shelter for the animal throughout the year. During high water levels, the only possible lodge location areas consist of narrow shorelines on which sedge plants predominate. Such areas are unsatisfactory from the view point of overwintering the muskrat population.

5. Whitewater Lake

Whitewater Lake occupies an area of approximately seven square miles (McLeod, 1948). Its geological history and location are quite similar to that of Oak Lake. This body of water has no permanent inflowing or outflowing streams. It is really a large catch basin which collects spring flood waters from the higher neighboring lands. Also water seeps up through the substratum bringing with it many soluble compounds which are toxic to most plants. This seepage is made possible because of the very high water table of this region during the average years.

The contours of this lake are ideal from the standpoint of muskrat suitable habitat. The substratum has a very gentle slope and consequently supports a luxurient growth of Typha vegetation. The average water depth varies from 6 to 18 inches (McLeod, 1948). Therefore cover, food, and water levels are ideal during all seasons of the year for the support of muskrats.

The Stages of Hydrosere Succession

During the survey of muskrat producing areas, the following hydrosere stages were encountered:

1. Submerged Stage (water depth 8 to 20 feet)
2. Floating Stage (water depth 6 to 8 feet)
3. Reed-swamp Stage (water depth 1 to 6 feet)
4. Sedge-meadow Stage (water less than 1 foot)
5. Woodland Stage

The Reed-swamp Stage was found to be the only sere which is suitable for sustained muskrat production.

The Reed-swamp Stage

Since this sere was determined to be necessary for muskrat production, a detailed study of its character, occurrence and maintenance was undertaken. Where the water levels have remained quite stationary over a period of several years, this successional stage is present wherever a suitable flooded bottom occurs. Generally soil with a water depth from 1 to 4 feet supports the plants of this sere. The depth may be increased to as much as 6 feet depending upon the nature of the substratum and the strength of the water currents.

Their is a definite zonation of marsh plants from the deep to the shallow waters as follows:

1. Scirpus validus zone.

2. _Scirpus fluviatilis_ zone
3. _Typha_ zone
4. _Phragmites_ zone.

The above mentioned plants are the dominants of the reed-swamp stage of the hydrosere. They possess a well developed rhizome system which provides a firm anchorage to the flooded substratum as well as a means of vegetative reproduction. This type of asexual reproduction is usually the only means of migration and plant regeneration in flooded areas because seedling reproduction is impossible due to the abundance of surface water.

All of these plants are not only satisfactory but also essential for optimum food and shelter materials. Throughout the summer months, all portions of the vegetation are utilized. The rhizome systems provide the main means of subsistence during the critical winter months.

The Influence of Water Levels on the Reed-Swamp Stage

Unusually high or low water levels generally produce a deleterious effect on the vegetation of the reed-swamp stage. Floods of sufficient duration or of great magnitude destroy the emergent vegetation. _Scirpus validus_ vegetation was removed without leaving a trace in many of the severely flooded Summerberry regions. Remnants of luxurient growths of _Phragmites_ and _Typha_ were seen in the form of dead stalks and floating divots. (Figs. 4, 5, 8, and 9.)

Figure 4. --- Regression of succession produced by prolonged raising of the water level. The reed-swamp sere has undergone almost complete destruction and is being replaced by the floating stage (Summerberry Marsh, 1949).

Figure 5. --- The drowned remains of *Phragmites* and *Typha* vegetation following recent flooding. The muskrat suitable habitat has been destroyed. No muskrat lodges could be found in the immediate vicinity (Summerberry Marsh, 1949).

Figure 6. --- Absence of emergent vegetation in lake due to the excessively high water levels. Muskrats were absent in such areas (Summerberry Marsh, 1949).

Because of high banks and the absence of drainage outlets, many of the Summerberry lakes retained a considerable amount of the recent flood waters. In many cases this resulted in open lakes with no emergent or floating vegetation except the willows on the unflooded banks (Fig. 6). In other areas which retained less water, the reed-swamp sere was replaced by water lilies which represent the floating stage (Fig. 4). Such retrogressive succession was common in many of the Summerberry lakes.

Following the destruction of the reed-swamp sere, the existing muskrat populations sought temporary shelter on the banks in the willows which are the components of the woodland sere. The population of the heavily flooded lakes dropped to almost zero. The decrease was due to migration in some cases but mainly to mortality following the severities of winter because of the lack of an adequate supply of nourishing, palatable food and suitable shelter.

In some of the Summerberry lakes and especially in Netley Marsh, the high water receeded partially or completely. Partial water lowering enabled the re-establishment of the still living _Phragmites_ vegetation and the introduction of _Equisetum limosum_ (Figs. 6 and 7). _Typha_ and _Scirpus validus_ which were the most seriously affected by high water levels and in the majority of cases totally destroyed, could not reestablish themselves in many of the still partially flooded areas.

Figure 7. --- Establishment of a marginal fringe of Equisetum vegetation following the recession of flood waters. In the background, uprooted willows offer proof as to the severity of the recent flood (Summerberry Marsh, 1949).

Figure 8. --- The results of a recent flood and its partial recession. A zone of Phragmites stands in the foreground. Drowned out Typha stalks can be seen in the middle. In the left background, the dark zone illustrates the recent growth of Equisetum (Summerberry, 1949).

Figure 9. --- Photograph of the same area as in Fig. 8 showing the former broad zone of Typha vegetation. Only a few muskrat lodges could be located.

Regeneration of the Reed-Swamp Sere

Some of the marsh areas, however, drained to such an extent that many of the flooded portions were exposed as water-soaked soils bearing the remains of drowned basal stocks and roots of former vegetation (Fig. 14). Such moisture saturated soils, now devoid of surface water, furnished an excellent medium for the germination of various reed-swamp seedlings. Young *Typha* plants were the first to make their appearance (Figs. 10 and 11). Following the further recession of water, more seedlings became established (Figs. 12 to 17). *Scirpus validus* seedlings were next in making their appearance in dominant proportions (Fig. 15). Various secondary species of the reed-swamp sere such as Acorus, Sagittaria, and Sparganium also made their introduction (Fig. 13).

By October 8th, 1949 the *Scirpus validus* and *Typha* seedlings had reached an average height of approximately 4 feet (Fig. 17). The rhizome systems of both types of vegetation had undergone extensive growth and vegetative reproduction was being carried out. Generally, *Typha* seedlings occupied a broad zone which was situated on the drier soil bordered by old *Carex* and *Phragmites* vegetation. A zone of *Scirpus validus* and *Typha* dominants followed (Fig. 16). The most recently exposed soil contained a broad band of vegetation with *Scirpus validus* as the dominant plant (Figs. 15 and 17).

Figure 10. ---- Recession of water from an area in Netley Marsh. A new zone of soil was drained free of surface waters between the *Phragmites* - *Carex* vegetation and the soil which still was covered with water.
(Transect, July 22/49).

Figure 11. ---- Establishment of *Typha* seedlings on the drained soil zone of the preceeding figure.

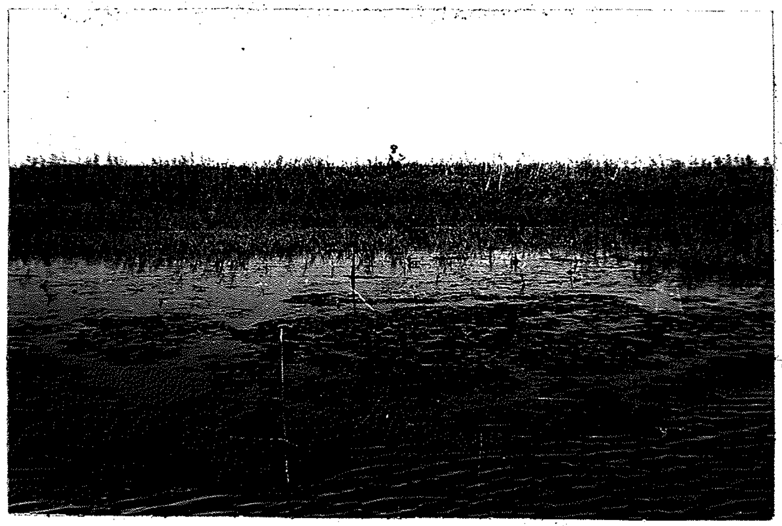


Figure 12. --- The same area as in Figs. 10 and 11 but photographed on August 5/49. The *Typha* seedlings have grown rapidly and have extended the width of the zone.

Figure 13. --- Composition of Transect Area:

(Left to Right):

1. *Typha* seedling
2. *Sagittaria*
3. *Acorus*
4. *Carex*
5. *Scirpus validus*

(Netley Marsh, August 5/49)

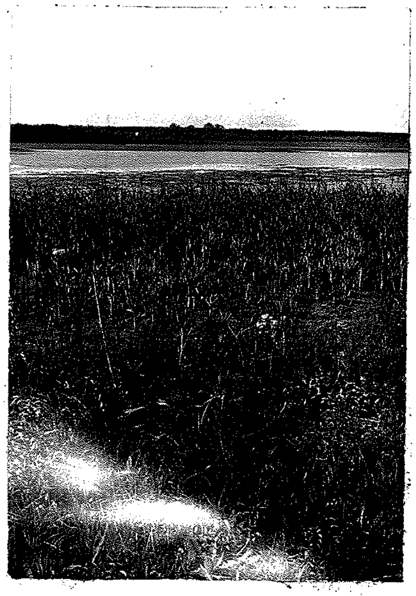


Figure 14. --- Transect Area at August 27, 1949. Note the further recession of water leaving more exposed mud bottom which formerly possessed *Scirpus fluviatilis* vegetation.

Figure 15. --- Transect Area at August 27, 1949. *Scirpus validus* vegetation occupies that portion of the drained zone which borders the free water.

Figure 16. --- Transect Area at August 27, 1949. Mixed vegetation of *Scirpus fluviatilis* and *Typha*. Both of these plants are dominants of the reed-swamp sere.

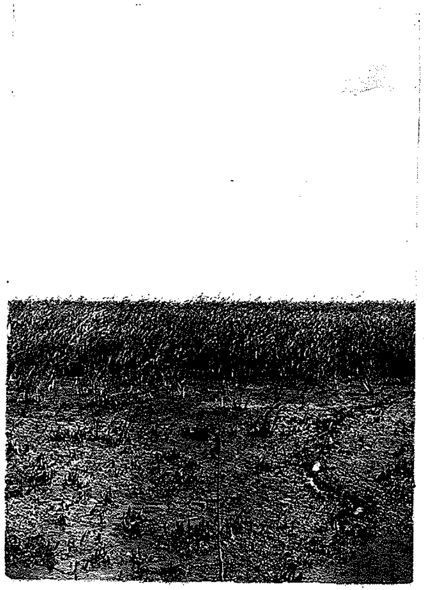
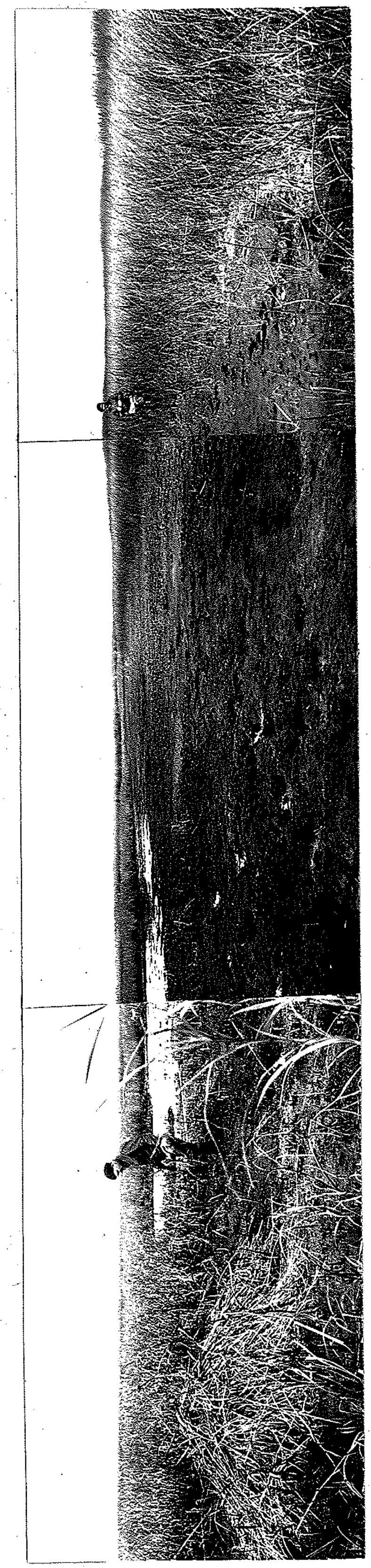


Figure 17 --- Panoramic view of Transect Area on September 8, 1949. On the right can be seen the marginal strip of _Phragmites_ which is growing on the bank. Next comes the zone of sexual reproduction bearing _Scirpus validus_ and _Typha_ seedlings. In the middle is the exposed soil. On the left stands a muskrat lodge in _Scirpus fluviatilis_ vegetation which borders soil which is covered with water. This area should be ideal as a muskrat habitat if the water level is raised before the end of the fall in 1950.



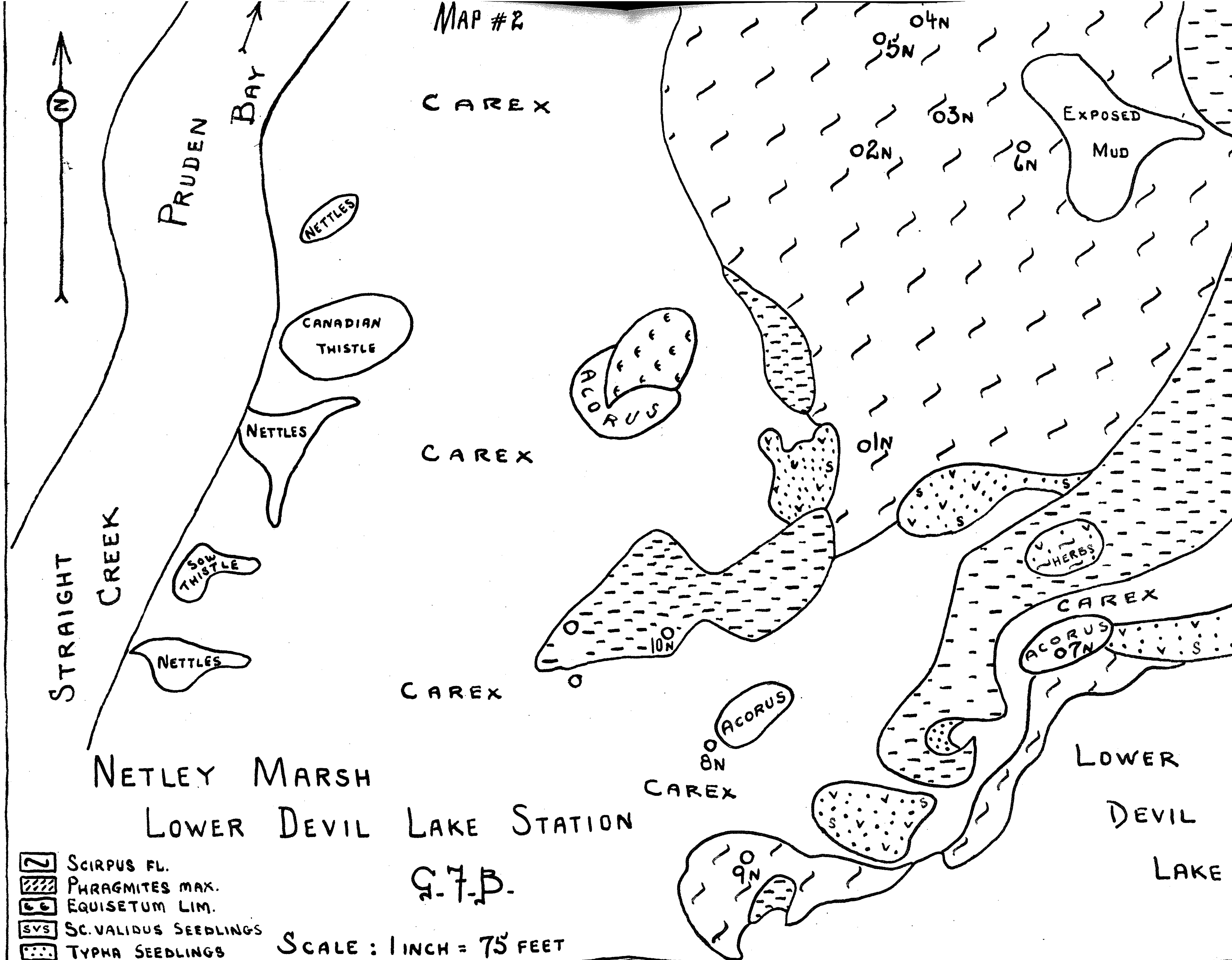
A considerable portion of the marsh areas showed such favorable habitat regeneration by means of sexual reproduction. In Netley Marsh, the following observational areas had seedlings introduced in abundant quantities:

1. Lower Devil Lake Station (Map II, Figs. 18 and 19).
2. Passwa Lake Station (Map III).
3. Pruden Bay Station (Map IV).

Many portions of this reed-swamp seedling vegetation were originated after the drawing of the maps and consequently are not recorded. Only a few areas in the Summerberry Marsh showed suitable, sexual reed-swamp regeneration (Fig. 20).

Mud Flat Succession

Sedimentation is important in bringing about new areas which are suitable for the growth of reed-swamp plants. This process is quite common, especially in Netley Marsh, due to the gradual deposition of sediments which are being brought in by the constant movement of water. When such sedimentation flats lose their surface water, seed germination is initiated (Figs. 21 to 25). If this process begins in the spring, a dense stand of mixed vegetation will result in the fall (Fig. 26). Reed-swamp vegetation predominates in such areas. In time, provided the water level is slightly raised, such plants as *Scirpus* and *Typha* will assume full dominance of the mud flat. In such a manner, new areas which are very suitable as a muskrat habitat, are being constantly formed.



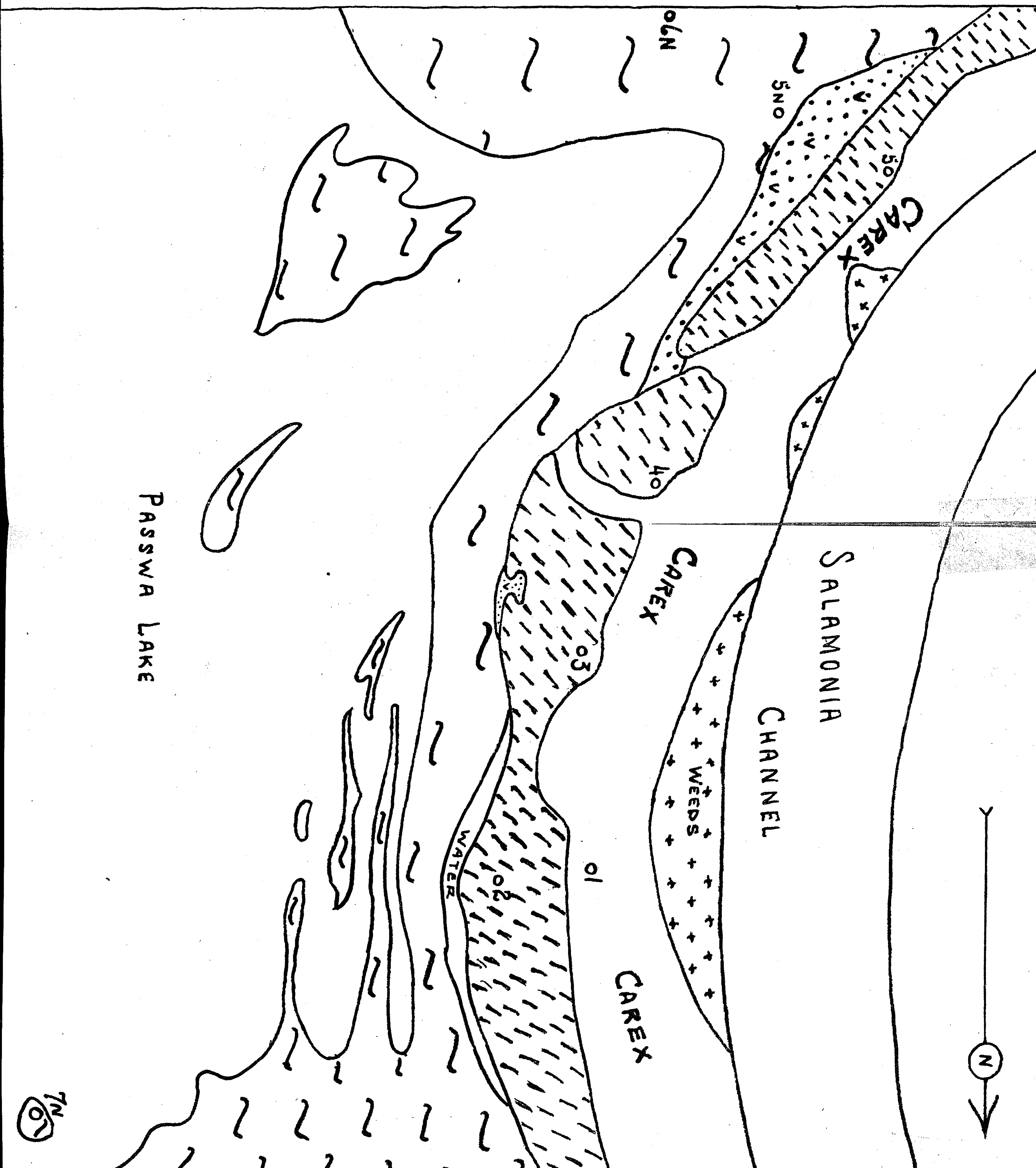
MAP #2
N
PRUDEN BAY
STRAIGHT CREEK
CAREX
CAREX
CAREX
CAREX
CAREX
NETTLES
CANADIAN THISTLE
NETTLES
SOW THISTLE
NETTLES
ACORUS
ACORUS
ACORUS
HERBS
EXPOSED MUD
O4N
O5N
O3N
O2N
O6N
O1N
10N
O7N
8N
9N
LOWER DEVIL LAKE
NETLEY MARSH
LOWER DEVIL LAKE STATION
G.7.B.
SCIRPUS FL.
PHRAGMITES MAX.
EQUISETUM LIM.
SC. VALIDUS SEEDLINGS
TYPHA SEEDLINGS
SCALE : 1 INCH = 75 FEET

NETLEY MARSH

PASSWA LAKE STATION

MAP #3.

JULY-27-1949 G.7.B.



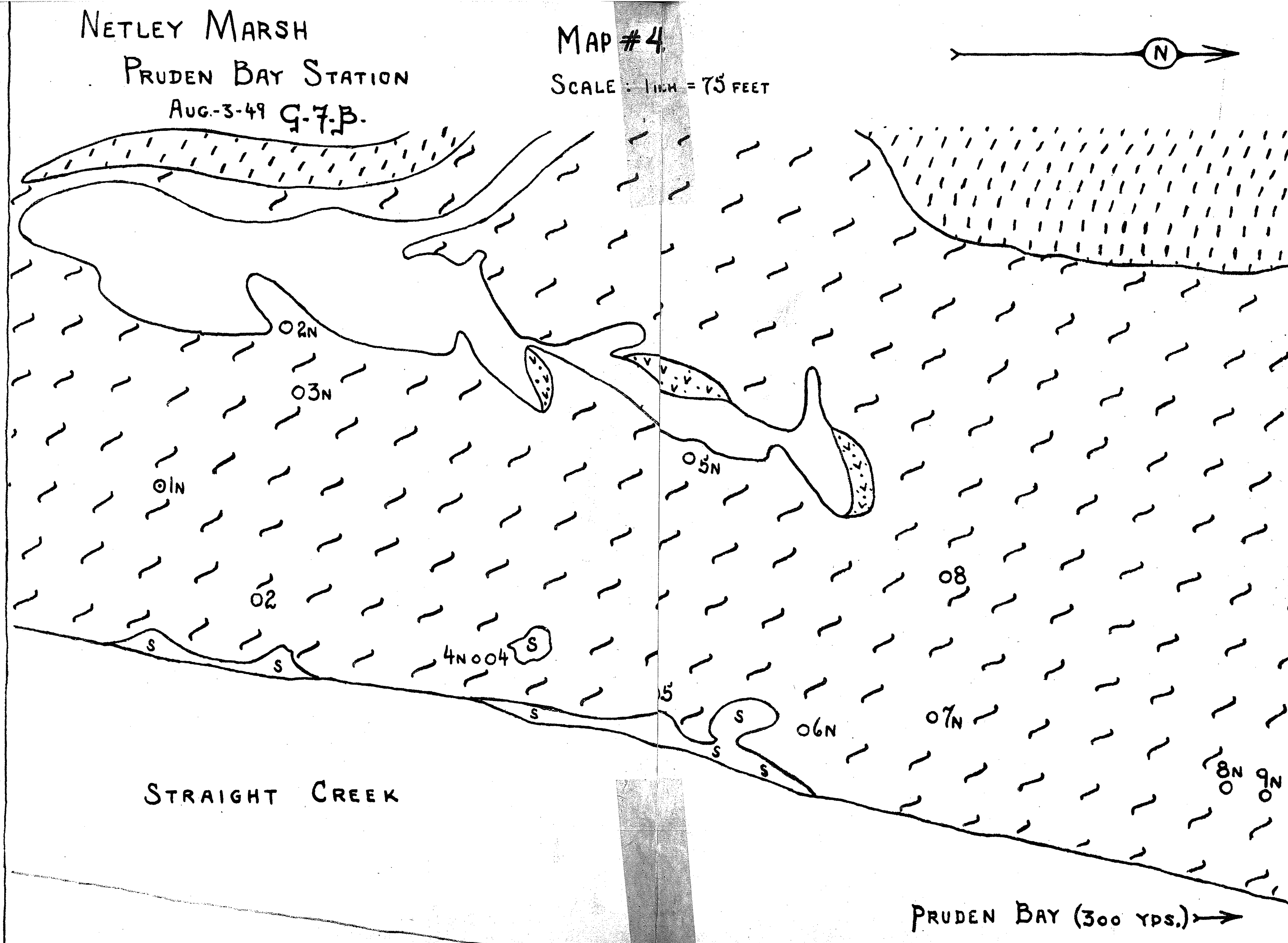

NETLEY MARSH
PRUDEN BAY STATION
AUG.-3-49 G-7-B.
MAP #4
SCALE: 1 INCH = 75 FEET
N
2N
3N
1N
5N
2
8
4N
4
S
5
6N
7N
8N
9N
STRAIGHT CREEK
PRUDEN BAY (300 YDS.)

Figure 18. --- *Typha* seedlings developed on recently drained soil at Lower Devil Lake Station (Netley - August, 1949).

Figure 19. --- A recently constructed lodge in *Acorus calamus* seedling vegetation at Lower Devil Lake Station (Netley - August, 1949).

Figure 20. --- A broad zone of recently drained soil, situated between the willows and open water, bearing the following seedlings:

Acorus,
Scirpus validus,
Sparganium,
Typha,
and various annuals.

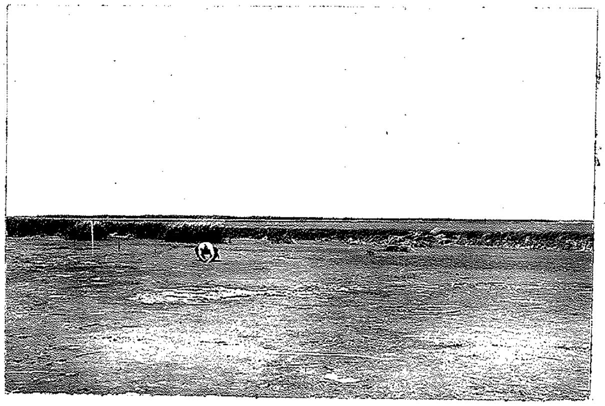
This area was devoid of any emergent vegetation in the early part of the summer (Summerberry - August, 1949).

Colonization of a mud flat which was produced by the deposition of sediments and exposed by the recession of high water levels (Netley Marsh, 1949).

Figure 21. --- Nude appearance (May 24th).

Figure 22. --- Beginning of seed germination (June 30th).

Figure 23. --- Miscellaneous assortment of seedlings (June 30th). Seed germination progressing.



Progressing Colonization of the Same Mud Flat (Netley Marsh, 1949).

Figure 24. --- Seedlings increasing in density and size (July 11th).

Figure 25. --- Scirpus validus and Typha seedlings making their first appearance (July 22nd).

Figure 26. --- Complete colonization of the mud flat (August 26th). The predominating plants are of the following families:

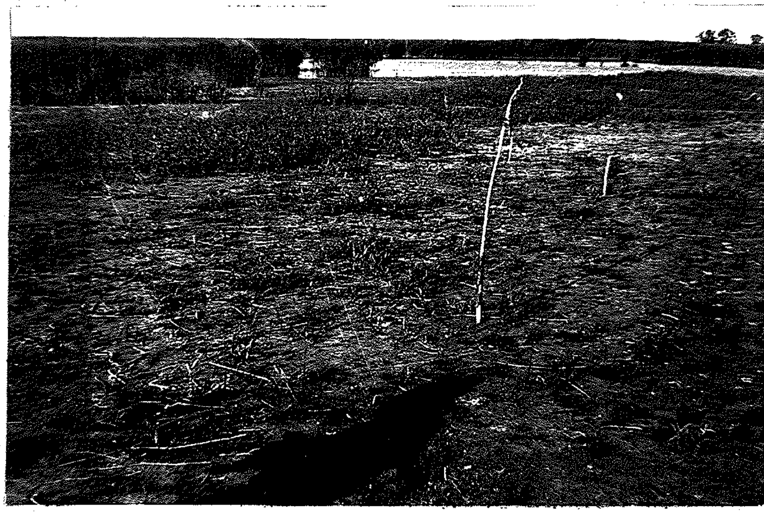
Cyperaceae,

Graminaceae,

Leguminoseae,

Typhaceae.

The vegetation is over 4 feet in height.



THE MUSKRAT

Morphology and Physiology

The muskrat is a small, sturdily constructed animal with a distinctly constricted neck (Fig. 27). The average adult has a head and body length of approximately 12 inches and a tail length of 10 inches. Such an animal weighs about two pounds. The body form has certain peculiarities which are also characteristic of other rodents possessing the burrowing habit. The head is quite large and rounded. The eyes are relatively small but the sense of hearing, smell and touch (vibrissae) are well developed. Such a relative development of sense organs is indicative of animals which possess a nocturnal habit. The incisors are quite large and strong which makes it possible for the animal to utilize plants of large size and firm texture.

The limbs are quite short and exhibit a marked difference in size between the fore and hind members. The fore legs are relatively small bearing four clawed digits. They are very prehensile enabling dexterous manipulation of short stalks when feeding. Being buttressed against, a rugged pectoral girdle by a well developed musculature, the fore limbs are very efficient for burrowing in a soft, wet substratum. The hind legs are larger and possess five, clawed digits. The presence of stiff hairs and partial webbing on these appendages make them a valuable aid in swimming.

Figure 27.--- A muskrat kit of approximately six months growth.

The tail is characteristically flattened laterally, scaled, and almost devoid of hairs. It is used as an organ of support when the animal feeds in an erect position. The tail also acts as a rudder when the animal is swimming.

The fur of the muskrat, besides its great commercial value, offers the necessary protection from the severities of the environment. It is very warm because of its density, softness, and water resistance (wax). The pelage is composed of two types of hairs:

(1) dense, soft under fur of uniform distribution

(2) less dense, unevenly distributed, firm, glossy, long guard hairs.

The guard hairs bear most of the darker pigment and consequently produce the darker coloration on the dorsal and lateral surfaces of the pelt.

The animal can dive with great dexterity and remain submerged for a long period which may extend for 15 minutes. Because of its small lungs and rapid respiration rate, the animal undergoes an anaerobic existence while under water. The oxygen required for metabolism is probably derived from the degradation of carbohydrates. The cessation of breathing while under water is referred to as submergence apnea (Koppanyi and Dooley, 1929) (Irving, 1939).

Consequently the muskrat is a highly speciallized animal which is well adapted for a semi-aquatic form of life. However,these speciallizations limit the animal in its versatility to efficiently cope with any other type of habitat. In order to realize its maximum potentialities, the habitat must be of the type previously described.

Biotic Potential

The sum total of the factors tending to increase muskrat abundance constitute what is referred to ecologically as the animal's biotic potential. These factors are more or less dependent on the inherent qualities of the animal itself. The biotic potential is discussed under the following four headings:

I Reproductive Potential
II Nutritive Potential
III Protective Potential
IV Survival Potential

I Reproductive Potential

Reproduction In General

Reproduction in animals accomplishes two important functions:

(a) "to increase the number of individuals and
(b) to produce individuals that have combinations of characteristics that differ from those of their parents and that may enable them better to survive in the particular

environment in which they are produced".

(Pearse, 1926).

Reproduction stimuli are produced by the increased intensity of light together with rising temperatures especially in the Temperate Zone. In Manitoba the sexual activities of the muskrat commence in the early spring and continue during the summer until their cessation in the late fall. This period of time determines the maximum number of litters that this animal can produce annually.

The Manner of Mating.

The muskrat is a polygamous animal. While the monogamous type of mating is efficient for all types of population conditions, the polygamous animals are inefficient when the breeding stock is sparse. The possibility of fertilization being affected in all the females of a thin population is extremely small due to the short oestrus period at which time the male may be absent.

Oestrus Period

The oestrus period in small mammals of the rodent family is very short. This phenomenon occurs in the female when the ova are mature and ready to accept the male sperms. At this time, the female is in a great state of excitement. The temperature and metabolic activities are greatly accelerated by the stimulation produced through a complex interaction of hormones secreted by the animal's endocrine glands. The oestrus period of the muskrat lasts only a few hours and recurs for a few days (McLeod, 1948). If the female is not fertilized during the oestrus period, the ova will perish and consequently no litter will be produced during that month. This is due to the fact that the succeeding ova will reach maturity in approximately one month following the last oestrus period.

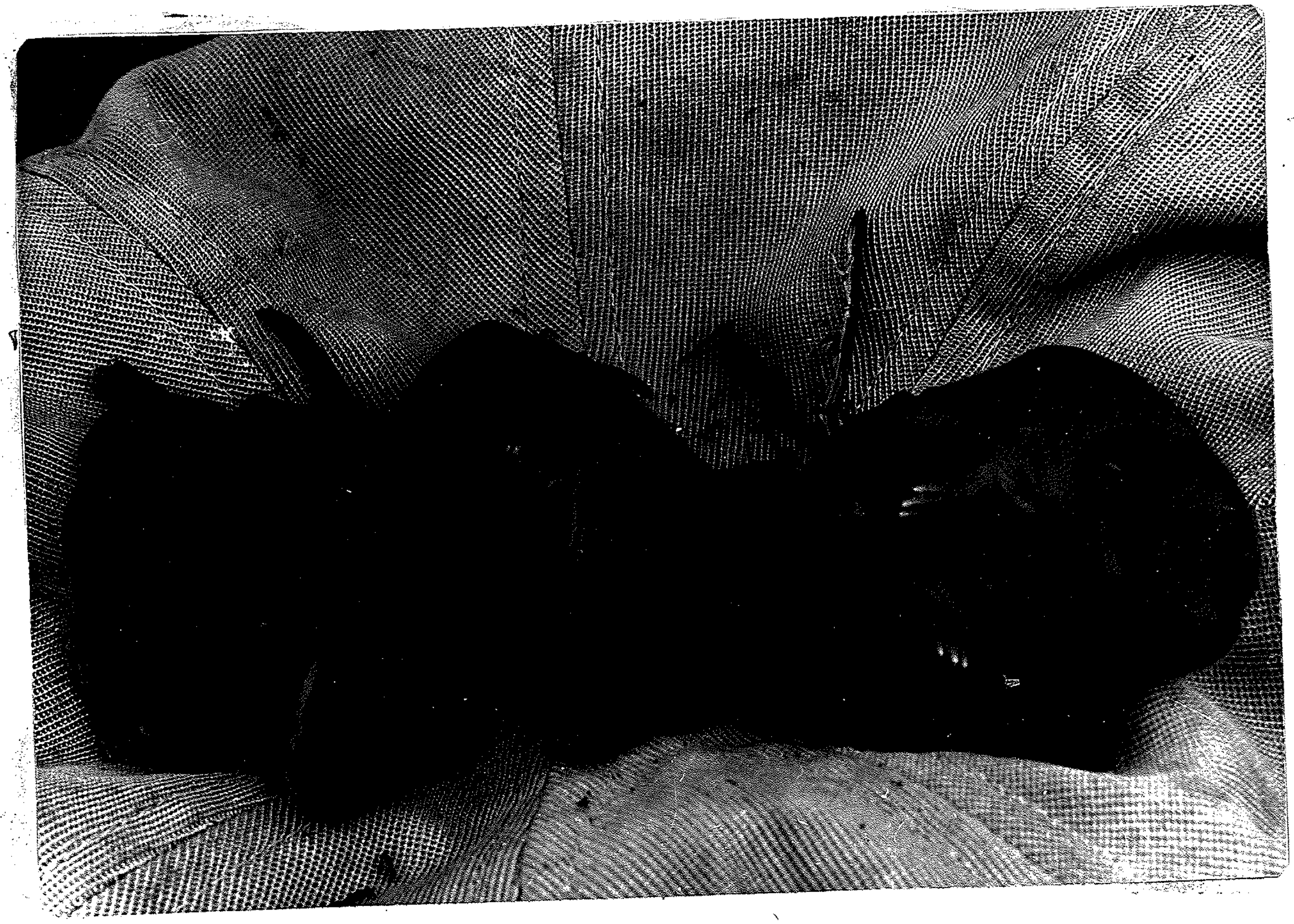
Gestation Period

There has been no definite experimental evidence for the exact period of time of gestation. However most workers agree from close observations of the muskrat's breeding habits that the interval extends from 23 to 30 days. Here in Manitoba, field data support the 25 day period of gestation.

Condition of the Young at Birth

Muskrats when born are helpless and require an average period of about three weeks of parental care before they are able to look after themselves. This attention assures a greater survival rate. At birth the young are blind and naked (Fig. 28). They require nutrition and shelter. Their locomotion is almost completely limited to the search for a teat on which to feed. The young are nourished from milk glands on the ventral surface of the parental female by means of mammae. The maximum number of mammae in a fully matured female are six pectoral and four inguinal pairs. The young develop a coat of hair shortly after a week's growth.

Figure 28.--- A litter of seven young muskrats which are two days of age (Netley Marsh, 4/8/49).



Their eyes are completely opened by the fifteenth day under average conditions. They become quite active after the opening of their eyes. Their powers of endurance are greatly increased. Now they are able to leave the nest and dive down the plunge hole and swim for quite a long distance. The young at twenty days are able to stay submerged for nearly two minutes at their first dive. They are able to stay under water for a few more periods after this but the time of submergence decreases rapidly. At thirty days they are well able to look after themselves except in the matter of housing.

Number of Litters Per Breeding Season

The average time required for the production of a subsequent litter is approximately 30 days. This interval is derived as follows:

2 days lapse following parturition
3 days of recurrent oestrus periods
25 day period of gestation

TOTAL: 30 days for the delivery of the litter.

These conclusions are supported by the field data on the following pages as represented in Graph I. Taking the peaks of the corrected curves into consideration, it is evident that the maximum number of first litters was produced in the interval of May 20th -- 24th. The next crest occurs in the period of June 23rd -- 27th and represents the largest number of second litters. Evidence for the assumption that the same female produced a second litter after 30 days was derived as follows:

(a) The last litter was produced in the same house as the first young. This deduction was made possible by selecting permanent areas for study. The houses were all located, mapped, and numbered by means of marked stakes (Maps 2 to 4).

(b) Members of the first litter were captured in the near vicinity and plunge holes of the same house.

By similar reasoning, the third litter was produced in the interval of July 23rd -- 27th. Thus it is practically possible to assume that the time between subsequent litters is a period of approximately 30 days. Such conclusions cannot be derived from the peak which occurs from August 22nd -- 26th because of the smallness of last year's sample and the absence of data for it this summer.

1949 MUSKRAT LITTER DATA

(?) - incomplete litter

ø - eyes closed

O - eyes opened

Date	Location	Date of birth	No. in litter	No. of litter	Total length (cms.)	Weight (ozs.)	Age in days	Sex Ratio M. to F.	Condition of eyes	Where collected	Remarks as to Nest and Young Muskrats
May 13	Whitewater Lake	May 11 or 12	5	1	9.6	.8	1-2	2:3	Ø	In nest	Nest closed, dry lined, condition good, no mites.
May 13	Whitewater Lake	May 11 or 12	5	1	9.7	.8	1-2	4:1	Ø	Open Nest	Nest exposed to weather, condition good, no mites.
May 24	N.E. Lower Devil Lake	May 21	5	1	11.1	1.0	3	2:3	Ø	In Nest	Condition good, no mites.
May 24	N.E. Lower Devil Lake	May 19	6	1	12.7	1.3	5	5:1	Ø	Near Nest	Condition very good, quite active no mites.
May 24	N.E. Lower Devil Lake	May 18	5	1	13.4	1.6	6	2:3	Ø	Near Nest	Condition excellent quite active, no mites.
May 25	S.W.¼ Sec. 18 Netley	May 23	8	1	11.0	.9	2	7:1	Ø	In Nest	Condition good, no mites.
May 25	S.W.¼ Sec. 18	May 23	5	1	10.9	.9	2	2:3	Ø	In Nest	Litter cold and wet, no mites.
May 25	S.W.¼ Sec. 18	May 21	3 (?)	1	12.1	1.2	4	1:2	Ø	Near Nest	Animals active, no mites.
May 25	S. W. ¼ Sec. 18	May 22	8	1	11.3	1.0	3	5:3	Ø	In Nest	Quite active, no mites.
May 25	S. W. ¼ Sec. 18	May 25	6	1	9.2	.7	0	4:2	Ø	In Nest	Condition dry and warm, no mites.
May 25	S.W. ¼ Sec. 18	May 22	3 (?)	1	11.4	1.1	3	1:2	Ø	Plunge hole	Very active, wet no mites.
May 25	S. W. ¼ Sec. 18	May 24	7	1	9.6	.7	1	4:3	Ø	In Nest	Condition very good, few mites.
May 27	Pruden Bay	May 18	6	1	15.8	2.4	9	3:3	Ø	In Nest	Condition excellent, no mites, good fur
May 27	Pruden Bay	May 20	1 (?)	1	14.0	1.6	7	1:0	Ø	Plunge hole	Very active, wet, no mites.

Date	Location	Date of birth	No. in litter	No. of litter	Total length (cms.)	Weight (ozs.)	Age in days	Sex Ratio M. to F.	Condition of eyes	Where collected	Remarks as to Nest and Young Muskrats
May 27	Pruden Bay	May 21	3 (?)	1	13.8	1.7	6	3:0	Ø	Plunge hole	Quite active, some escaped, no mites.
May 27	Pruden Bay	May 23	9	1	12.1	1.1	4	5:4	Ø	In Nest	Condition very good, no mites.
May 27	Pruden Bay	May 23	8	1	12.4	1.2	4	6:2	Ø	In Nest	Condition excellent, no mites.
May 27	E. Pruden Bay	May 20	6	1	14.2	1.5	7	2:4	Ø	In Nest	Condition good dry and warm, no mites.
May 31	Lake Francis	May 19	7	1	11.0	1.0	2	4:3	Ø	In Nest	condition good few mites.
May 31	Lake Francis	May 28	10	1	11.6	1.0	3	5:5	Ø	In Nest	Condition very good, no mites.
June 2	Cadham Bay	May 25	3 (?)	1	15.1	1.7	8	3:0	Ø	Plunge hole	Very active, no mites.
June 2	Cadham Bay	May 20	9	1	18.2	3.0	13	7:2	0	In Nest	Very active, no mites.
June 2	Cadham Bay	May 19	4 (?)	1	19.7	3.5	14	4:0	0	Plunge hole	Very active, wet, no mites.
June 2	Cadham Bay	May 20	8	1	18.9	3.2	13	2:6	Ø	In Nest	Condition good, no mites.
June 2	Cadham Bay	May 25	8	1	15.0	2.0	8	3:5	Ø	In Nest	Quite active, few mites.
June 2	Cadham Bay	June 1	2 (?)	1	9.7	.8	1	0:2	Ø	Plunge hole	Condition fair.
June 2	Cadham Bay	May 18	7	1	20.3	3.2	15	5:2	0	Near Nest	Condition good no mites.
June 3	N.E. Simpson Bay	May 27	7	1	14.1	1.7	7	4:3	Ø	In Nest	Warm and dry, no mites.
June 3	Simpson (Delta)	June 1	2 (?)	1	10.7	1.0	2	1:1	Ø	Near Nest	Very active, no mites.

Date	Location	Date of birth	No. in litter	No. of litter	Total length (cms.)	Weight (ozs.)	Age in days	Sex Ratio M. to F.	Condition of eyes	Where collected	Remarks as to Nest and Young Muskrats
June 3	Simpson	May 23	6	1	17.2	2.6	11	5:1	Ø	Near nest	Condition good, no mites.
June 3	Division Bay	May 24	6	1	16.5	2.3	10	4:2	Ø	In nest	Warm and dry, no mites.
June 3	Belle Point	May 23	3 (?)	1	17.3	2.5	11	1:2	Ø	Near nest	Condition good, no mites.
June 3	Blackfox Lake	May 15	10	1	23.0	3.7	19	10:0	0	In next	Warm and dry, no mites.
June 3	Blackfox Lake	May 23	4 (?)	1	17.5	2.6	11	2:2	Ø	Plunge hole	Quite active, no mites.
June 3	Wilson Lake	-	1 (?)	1	-	-	-	0:1	Ø	Plunge hole	Able to swim well.
June 3	Wilson Lake	June 2	5	1	9.5	.7	1	2:3	Ø	In nest	Good condition, no mites.
June 3	Clair Lake	May 23	9	1	17.1	2.3	11	6:3	Ø	In nest	Warm and dry, no mites.
June 9	Pruden Bay	May 15	4 (?)	1	26.4	5.6	25	3:1	0	Plunge hole	Quite active crawlers and swimmers.
June 9	Pruden Bay	May 21	9	1	23.6	4.2	19	6:3	0	Near nest	Condition excellent.
June 9	Pruden Bay	May 24	7	1	20.5	3.1	16	7:0	0	Near nest	Condition excellent.
June 9	Pruden Bay	May 24	5	1	20.7	3.6	16	1:4	0	Near nest	Condition excellent.
June 9	Pruden Bay	June 6	6	2	11.8	1.0	3	2:4	Ø	In nest	Condition good, umbilicus healed, no mites.
June 9	N.E. Lower Devil Lake	June 2	7	1-2	14.6	1.7	7	5:2	Ø	Near nest	Condition fair, no mites.
June 9	N.E. Lower Devil Lake	May 23	6	1	21.2	1.3	17	6:0	0	Near nest	Condition sluggish, mites.

Date	Location	Date of birth	No. in litter	No. of litter	Total length (cms.)	Weight (ozs.)	Age in days	Sex Ratio M. to F.	Condition of eyes	Where collected	Remarks as to Nest and Young Muskrats
June 9	N.E. Lower Devil Lake	May 21	6	1	23.0	4.2	19	5:1	0	Near nest	Condition sluggish, mites.
June 10	S.W.$\frac{1}{4}$ Sec. 18 Netley	June 8	5	1-2	10.7	.9	2	0:5	Ø	In nest	Condition fair.
June 10	S. W. $\frac{1}{4}$ Sec. 18	June 1	10	1-2	15.9	1.9	9	1:9	Ø	In nest	Condition good, very few mites.
June 10	S. W. $\frac{1}{4}$ Sec. 18	May 26	5	1	19.0	3.2	14	5:0	0	Near nest	Condition good, fewmites.
June 10	N. W. $\frac{1}{4}$ Sec. 30	May 30	5	1	17.2	2.3	11	4:1	Ø	Near nest	Condition good, few mites.
June 16	N. W. $\frac{1}{4}$ Sec. 30	May 29	6	1	23.4	3.6	19	5:1	0	Plunge hole	Very active, condition good.
June 22	Pakow Lake 9	June 21	6	2	10.5	.8	1	2:4	Ø	In nest	Condition fair, some mites.
June 22	Pakow Lake 8	June 19	5	2	11.7	1.1	3	4:1	Ø	In nest	Condition poor, white with mites.
June 22	Pakow Lake 8	May 31	4 (?)	1	25.0	4.3	22	3:1	0	Plunge hole	Able to swim well.
June 23	Baptizing Lake 8	June 17	4 (?)	2	13.4	1.5	6	1:3	Ø	Plunge hole	Condition fair, few mites.
June 24	Richard Zone Lake 34	June 21	3	2	11.3	1.1	3	2:1	Ø	Near nest	Condition fair, few mites.
June 24	Richard Lake 34	June 22	7	2	11.0	.9	2	4:3	Ø	In nest	Condition good, few mites.
June 24	Richard Lake 34	June 6	3 (?)	1-2	22.5	3.9	18	3:0	0	Plunge hole	Very active.
June 24	Richard Lake 36	June 6	4 (?)	1-2	22.6	3.8	18	3:1	0	Plunge hole	Very active.
June 24	Richard Lake 36	June 19	9	2	12.8	1.2	5	3:6	Ø	in nest	Condition fair, many mites.

Date	Location	Date of birth	No. in litter	No. of litter	Total length (cms.)	Weight (ozs.)	Age in days	Sex Ratio M. to F.	Condition of eyes	Where collected	Remarks as to Nest and Young Muskrats
June 29	N.W.¼ Sec. 30 Netley	June 28	8	2	9.8	.7	1	4:4	Ø	In nest	All were wet, caught with adult female
June 29	N. W. ¼ Sec. 30	May 29	5 (?)	1	30.5	-	30	5:0	0	Plunge hole	Condition good, few mites.
June 30	Pruden Bay	June 21	7	2	15.7	2.2	9	5:2	Ø	In nest	Condition excellent, no mites.
June 30	Pruden Bay	June 24	10	2	13.8	1.4	6	6:4	Ø	In nest	Condition excellent, no mites.
June 30	Pruden Bay	June 23	11	2	14.2	1.7	7	4:7	Ø	In nest	Condition excellent, no mites.
June 30	Pruden Bay	June 24	3 (?)	2	13.4	1.6	6	1:2	Ø	Plunge bole	Some were wet, quite active.
June 30	N.E.¼ Sec. 30 Netley	May 31	2 (?)	1	-	-	30	1:1	0	In water	Condition good, vicious.
July 1	S. W. ¼ Sec. 18	June 29	4	2	10.7	.8	2	0:4	Ø	Near nest	Condition fair.
July 1	N. E. ¼ Sec. 18	June 21	1 (?)	2	16.7	3.1	10	1:0	Ø	In water	Condition good.
July 1	N.E. ¼ Sec. 18	June 24	6	2	14.0	1.6	7	2:4	Ø	Near nest	Condition fair, few mites.
July 4	Passwa Lake	July 3	6	2	10.1	.8	1	1:5	Ø	In nest	Condition fair, few mites.
July 4	Passwa Lake	June 3	1 (?)	1	29.5	7.1	30	1:0	0	In water	Very active swimmer, vicious
July 5	N. W. ¼ Sec. 21	June 20	5 (?)	2	19.9	3.0	15	5:0	0	Plunge hole	Some mites, old female seen swimming with young attached.
July 5	N. W. ¼ Sec. 21	June 15	1 (?)	2	23.7	4.1	20	0:1	0	In water	Excellent swimmer.
July 5	N. W. ¼ Sec. 21	July 2	8	2	11.7	1.0	3	4:4	Ø	In nest	Condition good, no mites.

Date	Location	Date of birth	No. in litter	No. of litter	Total length (cms.)	Weight (ozs.)	Age in days	Sex Ratio M. to F.	Condition of eyes	Where collected	Remarks as to Nest and Young Muskrats
July 5	N. W. ¼ Sec. 21	June 22	8	2	18.5	2.8	13	4:4	Ø	Near nest	Condition very good, few mites.
July 5	N. W. ¼ Sec. 21	June 29	8	2	13.2	1.3	6	6:2	Ø	In nest	Condition excellent, no mites.
July 5	S. W. ¼ Sec. 21	June 24	3 (?)	2	17.0	2.7	11	2:1	Ø	Plunge hole	Condition very active.
July 8	N.W. ¼ Sec. 25	June 3	1 (?)	2	35.0	11.7	30	1:0	0	In water	Condition active, and very vicious.
July 8	N. W. ¼ Sec. 25	June 25	5	2	18.1	2.1	13	4:1	0	Near nest	Condition good.
July 8	N. W. ¼ Sec. 25	June 3-8	5 (?)	2	33.9	11.3	30	3:2	0	Plunge hole	Condition very active.
July 12	Pruden Bay	June 29	8	2	18.7	2.6	13	5:3	Ø	Near nest	Condition excellent, no mites.
July 12	Pruden Bay	June 24	3 (?)	2	22.6	3.6	18	3:0	0	Plunge hole	Condition excellent, no mites.
July 12	Pruden Bay	June 29	2 (?)	2	18.9	2.4	13	2:0	0	Plunge hole	Condition excellent, no mites.
July 12	Pruden Bay	July 9	6	2-3	11.5	.9	3	1:5	Ø	In nest	Condition excellent, no mites.
July 13	S. W. ¼ Sec. 18	June 23	5	2	24.1	4.5	20	5:0	0	Near nest	Condition good.
July 13	S. W. ¼ Sec. 18	June 10-15	6	1	38.4	14.7	30	4:2	0	Plunge hole	Condition very active, some mites.
July 13	N. E. ¼ Sec. 18	June 30	4	2	18.8	3.0	13	4:0	Ø	Near nest	Condition fair.
July 20	Passwa Lake	June 23	1 (?)	2	27.6	6.5	27	1:0	0	In water	Condition very active.
July 15	Delta	June 25	2 (?)	2	23.7	4.1	20	2:0	0	In water	Condition very active.

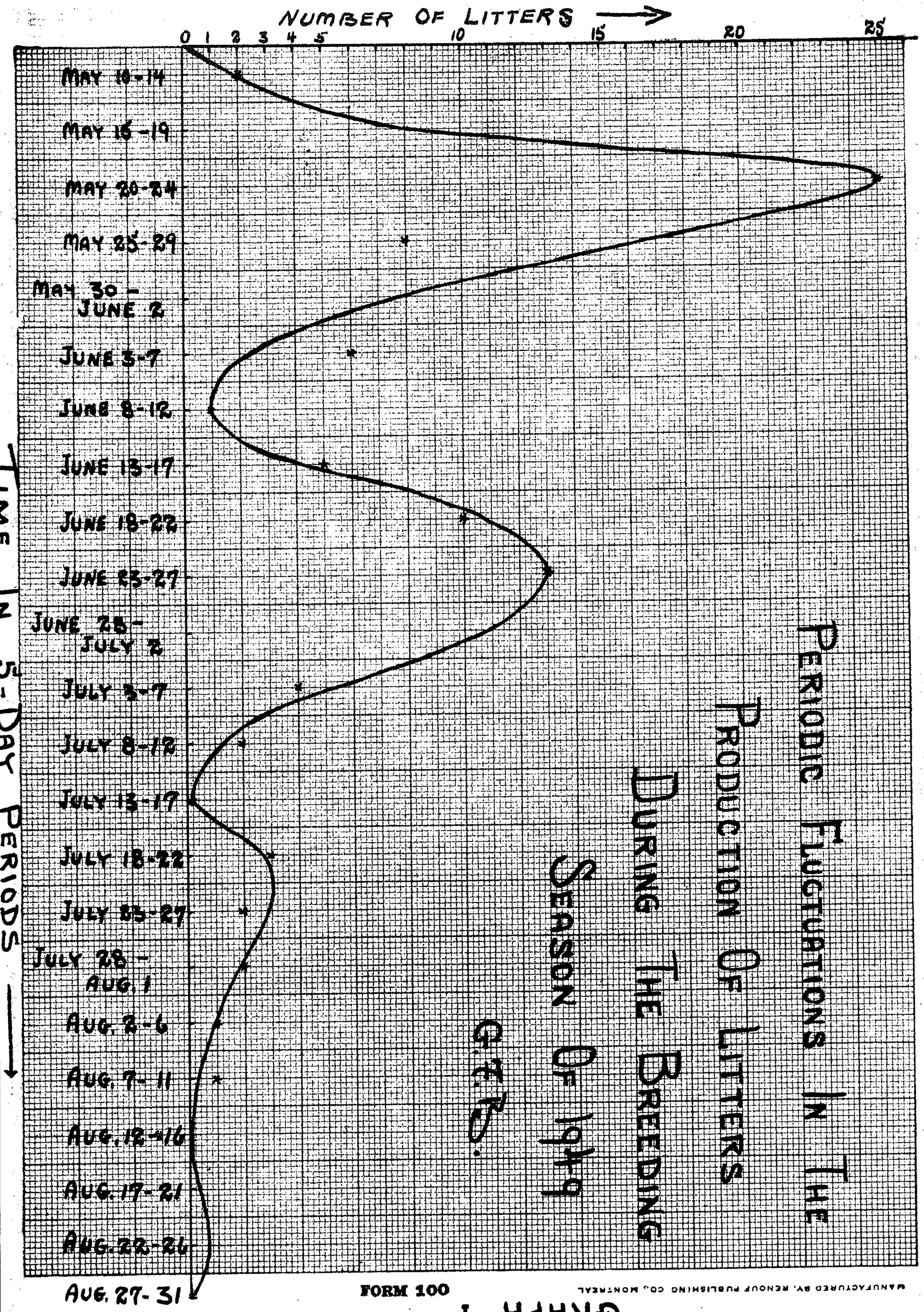
Date	Location	Date of birth	No. in litter	No. of litter	Total length (cms.)	Weight (ozs.)	Age in days	Sex Ratio M. to F.	Condition of eyes	Where collected	Remarks as to Nest and Young Muskrats
July 15	Delta	July 3	10	2	17.7	2.9	12	5:5	Ø	In nest	No mites, fair condition.
July 15	Delta	June 27	6	2	22.0	3.2	18	6:0	0	Near nest	Condition fair, few mites.
July 15	Delta	June 26	8	2	23.2	4.1	19	8:0	0	Near nest	Condition good, no mites.
July 15	Delta	June 17	3 (?)	2	27.8	5.7	28	3:0	0	Plunge Hole	Condition very active.
July 15	Delta	June 19	2 (?)	2	26.9	6.2	26	2:0	0	In water	Condition fair
July 15	Delta	June 29	3 (?)	2	20.4	3.3	16	2:1	Ø	Plunge hole	Condition poor, many mites, one dead rat also - 5 days old.
July 16	Cook's Ck. Delta	June 29	5	2	21.9	3.2	17	4:1	Ø	Near nest	Condition good, few mites.
July 16	Cook's Creek	June 25	3 (?)	2	24.5	4.0	21	3:0	0	Plunge hole	Condition good, few mites.
July 16	Cook's Creek	June 10-15	5	1	35.9	11.2	30	3:2	0	Plunge hole	Condition very active.
July 16	Cook's Creek	June 30	5	2	20.9	2.9	16	1:4	0	Near nest	Condition very active, Doz. mites each.
July 16	Cook's Creek	July 1	4 (?)	2	20.0	3.0	15	1:3	Ø	Plunge hole	Condition very active, Doz. mites each.
July 19	N.E.$\frac{1}{4}$ Sec. 18 Netley	July 5	4 (?)	2	18.9	2.8	14	4:0	Ø	Open nest	Condition poor, all young bruised & cut as if transported.
July 22	Pruden Bay	July 20	7	3	10.9	.9	2	1:6	Ø	New nest	Young scratched & bruised - transferred?

Date	Location	Date of birth	No. in litter	No. of litter	Total length (cms.)	Weight (ozs.)	Age in days	Sex Ratio M. to F.	Condition of eyes	Where collected	Remarks as to Nest and Young Muskrats
July 22	Pruden Bay	July 5	3 (?)	2-3	21.3	1.3	17	2:1	0	In water	Condition good, in new house, few mites.
July 28	S. W. ¼ Sec. 18	July 28	7	3	9.8		0	3:4	Ø	Open nest	Condition poor, some very cold, rest dead.
July 28	S. W. ¼ Sec. 18	July 18	8	3	16.4		10	6:2	Ø	Dry nest	Condition very good, dry & warm, no mites.
July 29	S. W. ¼ Sec. 18	July 12	2 (?)	3	21.3		17	2:0	0	Near nest	Condition very active good divers.
July 29	N. W. ¼ Sec. 30	July 23	2 (?)	3	13.7		6	1:1	Ø	Plunge hole	Condition good, very active, few mites.
Aug. 3	Lower Devil Lake	July 22	6	3	17.7		12	5:1	Ø	Plunge hole	Condition good, few mites.
Aug. 4	Lower Devil Lake	Aug. 2	7	3	10.5		2	3:4	Ø	Dry nest	Condition warm and dry, no mites.
Aug. 4	Lower Devil Lake	July 25	5-1 dead	3	16.6		10	3:3	Ø	Near nest	Condition good, few mites, recent dead of same litter.
Aug. 11	Whitewater Lake	Aug. 8	2 (?)	3	11.8		3	0:2	Ø	Dry nest	Condition fair, no mites, litter bruised & cut badly from translocation.
Aug. 18	Richard Zone, The Pas	July 30	1 (?)	3	23.5	4.5	19	1:0	0	In water	Condition very active, good diver & swimmer, no mites.

TABLE VIII

Summary of Results Pertaining to Litter Data

Total number of young examined	590
Total number of litters examined	112
Total number of complete litters present	71
From complete litter data, the following are obtained:	
Total number of males	279 or 58.4%
Total number of females	199 or 41.6%
Average size of complete litters	6.7
Total number of incomplete litters examined	41



NUMBER OF LITTERS →
0 1 2 3 4 5 10 15 20 25
MAY 10-14
MAY 15-19
MAY 20-24
MAY 25-29
MAY 30 - JUNE 2
JUNE 3-7
JUNE 8-12
JUNE 13-17
JUNE 18-22
JUNE 23-27
JUNE 28 - JULY 2
JULY 3-7
JULY 8-12
JULY 13-17
JULY 18-22
JULY 23-27
JULY 28 - AUG. 1
AUG. 2-6
AUG. 7-11
AUG. 12-16
AUG. 17-21
AUG. 22-26
AUG. 27-31
TIME IN 5-DAY PERIODS →
PERIODIC FLUCTUATIONS IN THE PRODUCTION OF LITTERS DURING THE BREEDING SEASON OF 1949
G.T.B.

GRAPH I

Reproductive Trends

Graph I can be simplified in order to show only general trends in the reproductive activities. This for is ? illustrated by Graph II. Theoretically, during a long favorable breeding season, one female muskrat can only produce four litters under optimum conditions. This possibility is rarely fulfilled in nature due to the following factors:

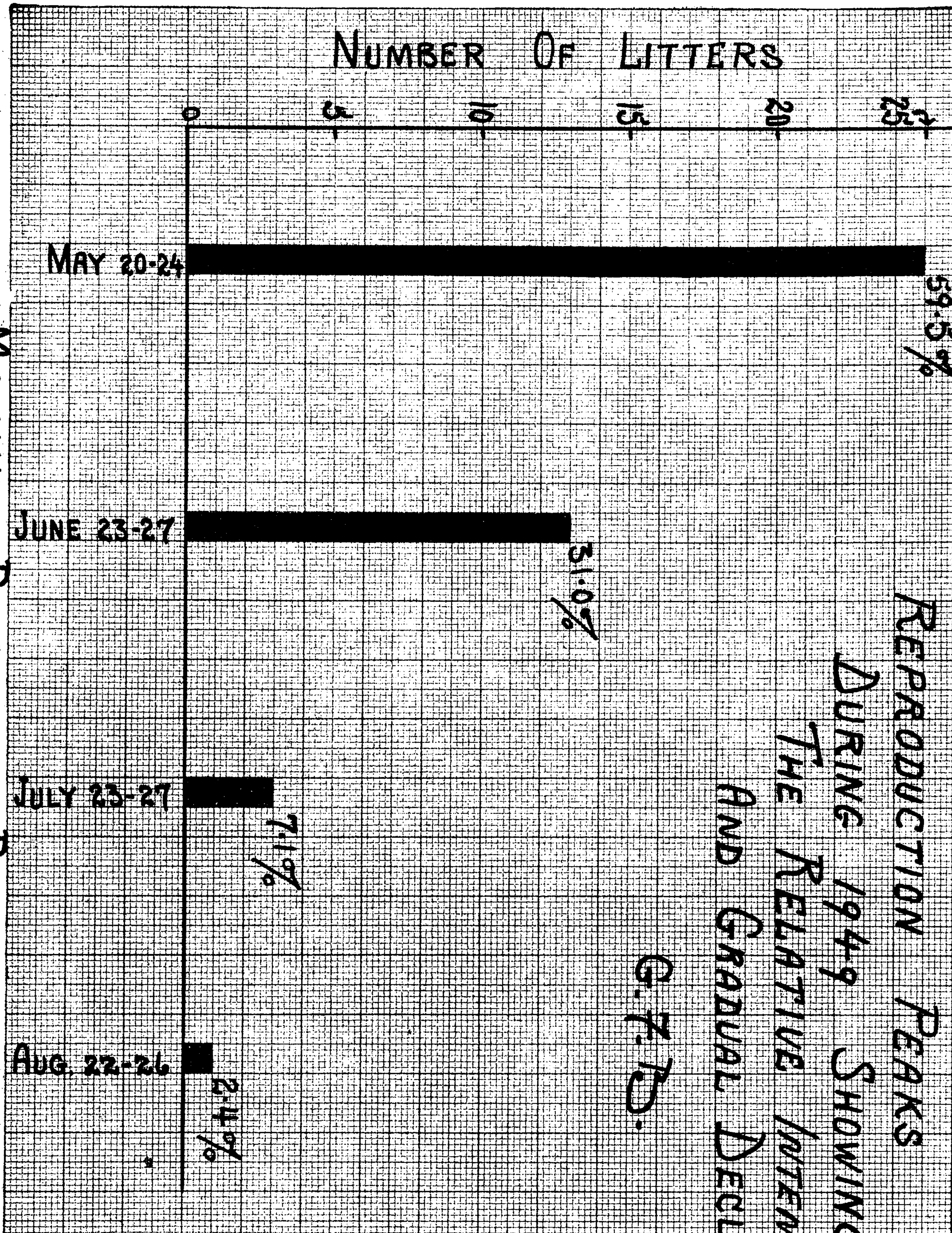
(a) A sparse breeding population would cause inefficient breeding due to the failure in accomplishing fertilization during the short oestrus period.

(b) The length of the breeding season may be greatly shortened because of temperature due to such frequent occurrences as a late spring break-up or an early severe winter.

(c) Food and water conditions may be unfavorable or below their optimum value.

(d) Certain essential amino acids, trace elements, or vitamins.(Tocopherol) may be deficient or entirely absent producing a suboptimum condition of the animal.

(e) Resorption of embryos occurs if severe environmental conditions are encountered for any length of time.


NUMBER OF LITTERS
0
5
10
15
20
25
MAY 20-24
59.5%
JUNE 23-27
31.0%
JULY 23-27
7.1%
AUG. 22-26
2.4%
MAXIMUM PRODUCTION PERIODS
REPRODUCTION PEAKS DURING 1949 SHOWING THE RELATIVE INTENSITIES AND GRADUAL DECLINE
G.T.D.

GRAPH II

(f) Late sexual maturity may follow if the young of last year have undergone a severe winter. Also a young female may be unable to withstand continual production of large litters because of the drainage of nutrients for further body growth.

(g) The production of large litters will produce great reproductive fatigue in a breeding female and further litter production may be cancelled or only a few young may be delivered.

(h) The population density increases as the breeding season proceeds. This may produce acute food shortages or great intraspecific strife. It is a well known fact that over-crowding tends to reduce the number of young which survive because of the increased mortality rate.

(i) Plagues and other diseases decrease reproductive vigor because of the extra taxation imposed on the animal's metabolic activities. Even after the defeat of the pathological agent, much energy is required to repair the damages which were inflicted. This again produces a serious drain on the nutrition required for the birth of healthy young.

(j) Ectoparasites and endoparasites in sufficient concentrations or of sufficient pathogenicity may produce harmful effects on the animal.

<u>Number of Young Per Litter</u>

In finding the size of the litters, much difficulty was encountered. This was due to the action of the maternal female. If a house was entered when the young were being suckled, the adult female would escape, taking with her some of the young which had not disengaged their hold of the mammae. The mammae are constricted at their base and enlarged distally from the body. This enables the young to be dragged out of the nest while still grasping the mamma. Therefore the litter data represents a minimum number of young. In order to make the litter size data valuable, the incomplete litter observations were not used in the calculations. The average number of young per litter during 1949 was found to be 6.7 individuals (Table VIII). The frequency of the litter sizes is shown in Graph III. The largest litter found in 1949 contained 12 young (Fig. 30).

<u>Age of Sexual Maturity</u>

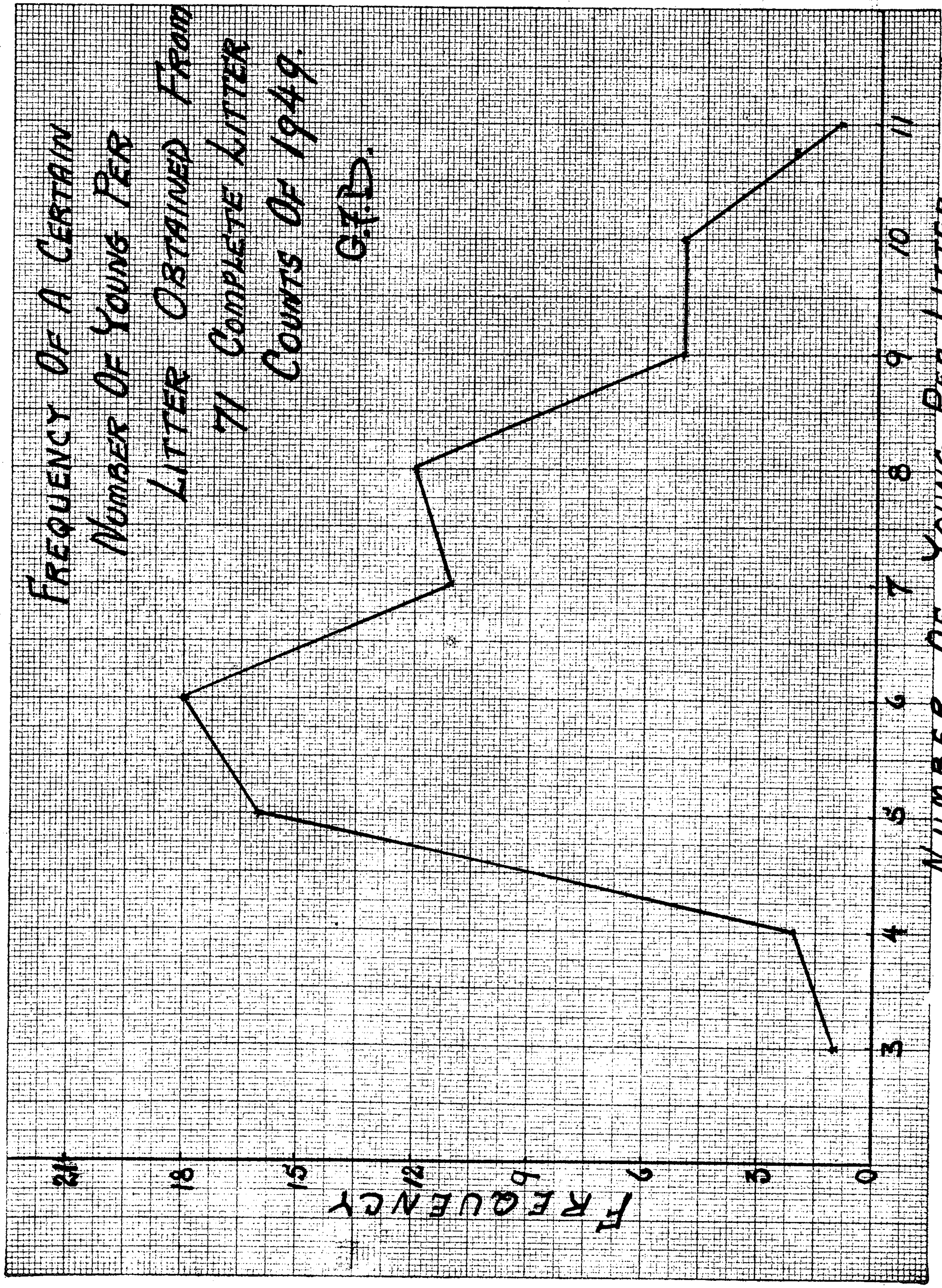
Dissections of a large number of muskrat carcasses from the spring of 1949, revealed a large percentage of young, sexually immature individuals. These observations indicate that the young of the previous year do not reproduce during

Figure 29.--- The second muskrat litter located in 1949. It was composed of four, recently born young in an open nest (Whitewater Lake, 14/5/49).

Figure 30.--- The largest litter found in 1949. It was composed of 12 young (Netley Marsh, 30/6/49).

Figure 31.--- The second largest litter encountered in 1949. It contained 11 young. These animals were tagged before photographing (Netley Marsh, 30/6/49).

GRAPH III


FREQUENCY OF A CERTAIN NUMBER OF YOUNG PER LITTER OBTAINED FROM 71 COMPLETE LITTER COUNTS OF 1949.
G.F.D.
FREQUENCY
0
3
6
9
12
15
18
21
NUMBER OF YOUNG PER LITTER
3
4
5
6
7
8
9
10
11

that season. It is quite possible that they do produce litters in the following spring. Intensive studies of the ovaries and testes should be carried out in order to definitely settle this point.

Growth

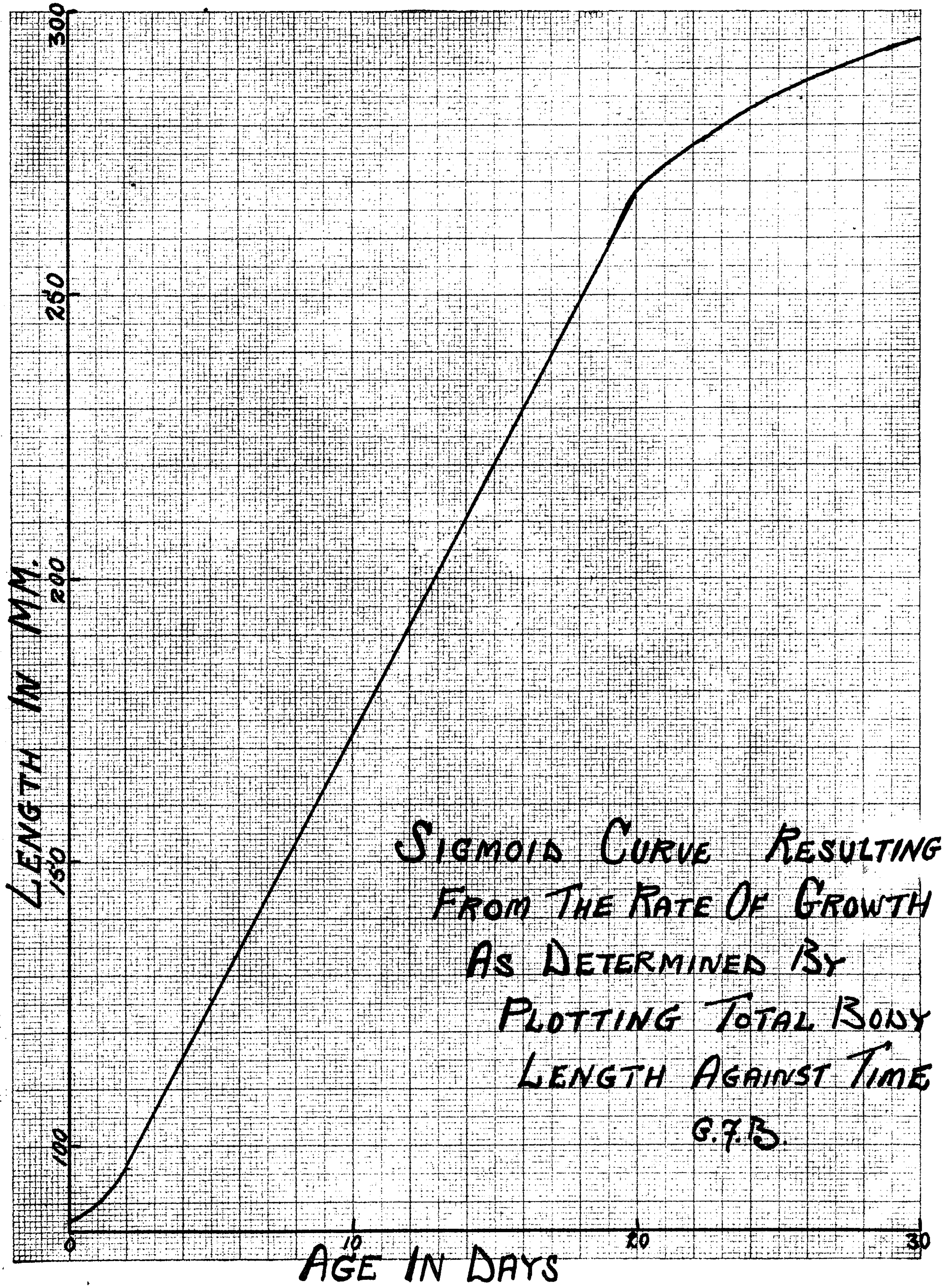
Growth rates of muskrats were obtained by plotting 34 different measurements of 22 separate individuals (Table IX). All of the latter individuals were tagged in the field and then recaptured from their native habitat. This means that the only cause for a serious decline in the growth rate was due to heavy tagging damages. The growth rate of a muskrat was found to follow the general pattern of a sigmoid surve (Graphs 4 and 5). After 20 days of age, the muskrat's growth rate declined gradually in comparison to its former rapidity. It was found that individuals which are tagged between 10 to 15 days of age had no appreciable decrease in the growth rate (Graph VI). However when younger animals are tagged or if the tagging damages are too great, the growth rate is appreciably retarded (Graph VII).

TABLE IX

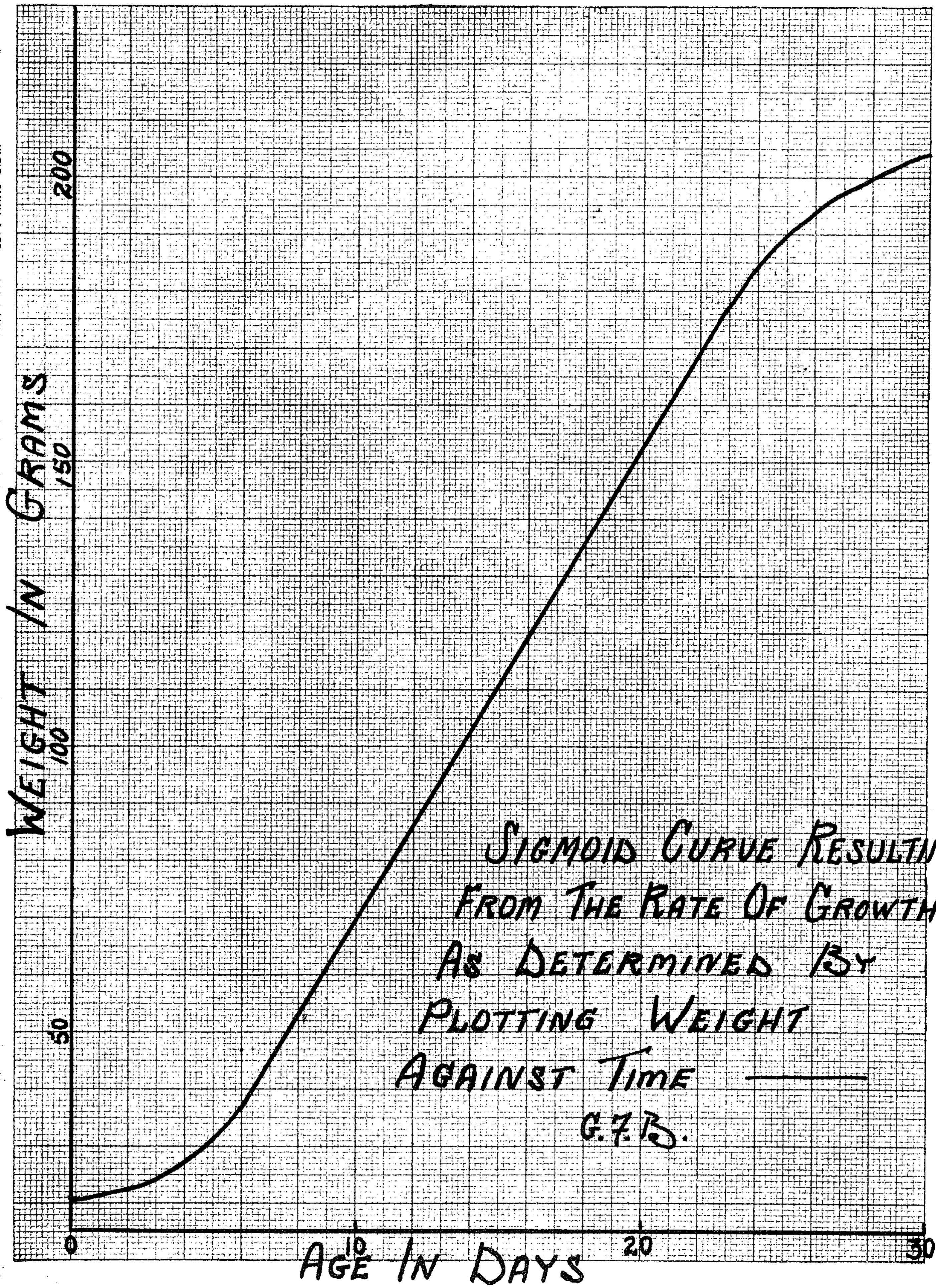
AGE, LENGTH, AND WEIGHT DATA OF 22 SEPARATE INDIVIDUALS

July 28, Netley Marsh.......	4 muskrats, 0-days of age total length 87 mm. each average weight 20.6 g. each
May 13, Whitewater Lake.....	5 muskrats, 2-days of age total length 96 mm. each average weight 22.6 g. each
May 24, Netley Marsh........	6 muskrats, 5-days of age total length 126.1 mm. each average weight 36.5 g. each
June 9, Netley Marsh........	same litter as above, now 16-days total length 230.6 mm. each average weight 119.5 g. each
May 27, Netley Marsh.......	4 muskrats, 9-days of age total length 157.0 mm. each average weight 63.1 g. each (tagged)
June 9, Netley Marsh.......	same as above, now 22-days total length 264.0 mm. each average weight 160.1 g. each
July 4, Netley Marsh.......	1 muskrat, 30-days of age total length 295.0 mm. average weight 204.0 g.
June 30, Netley Marsh......	2 muskrats, 6-days of age total length 138.0 mm. each average weight 39.0 g. each (tagged)
July 12, Netley Marsh......	same litter as above, now 19-days total length 288.0 mm. each average weight 69.2 g. each

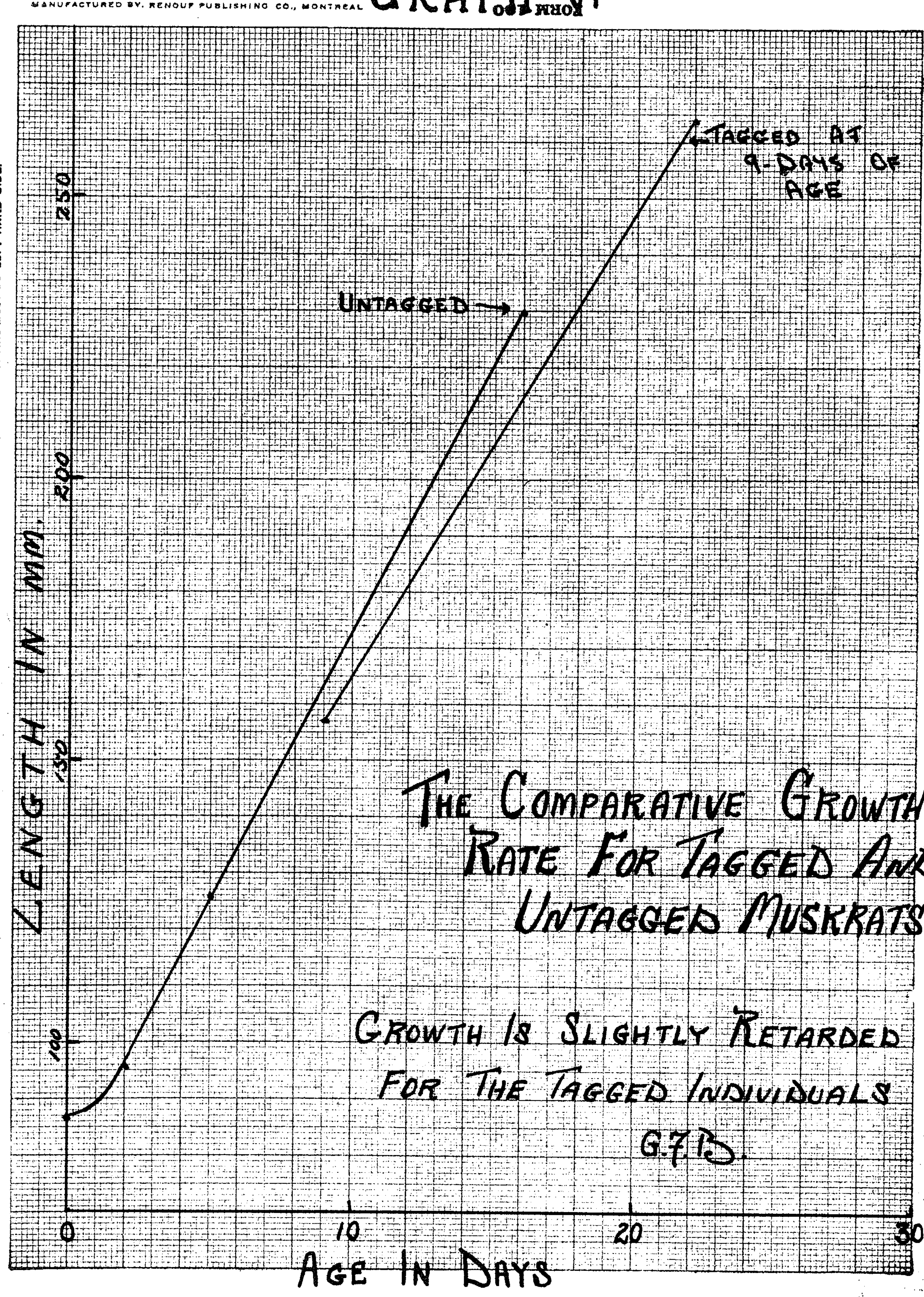
GRAPH IV


LENGTH IN MM.
300
250
200
150
100
0
10
20
30
AGE IN DAYS
SIGMOID CURVE RESULTING FROM THE RATE OF GROWTH AS DETERMINED BY PLOTTING TOTAL BODY LENGTH AGAINST TIME
G.F.B.

GRAPH V

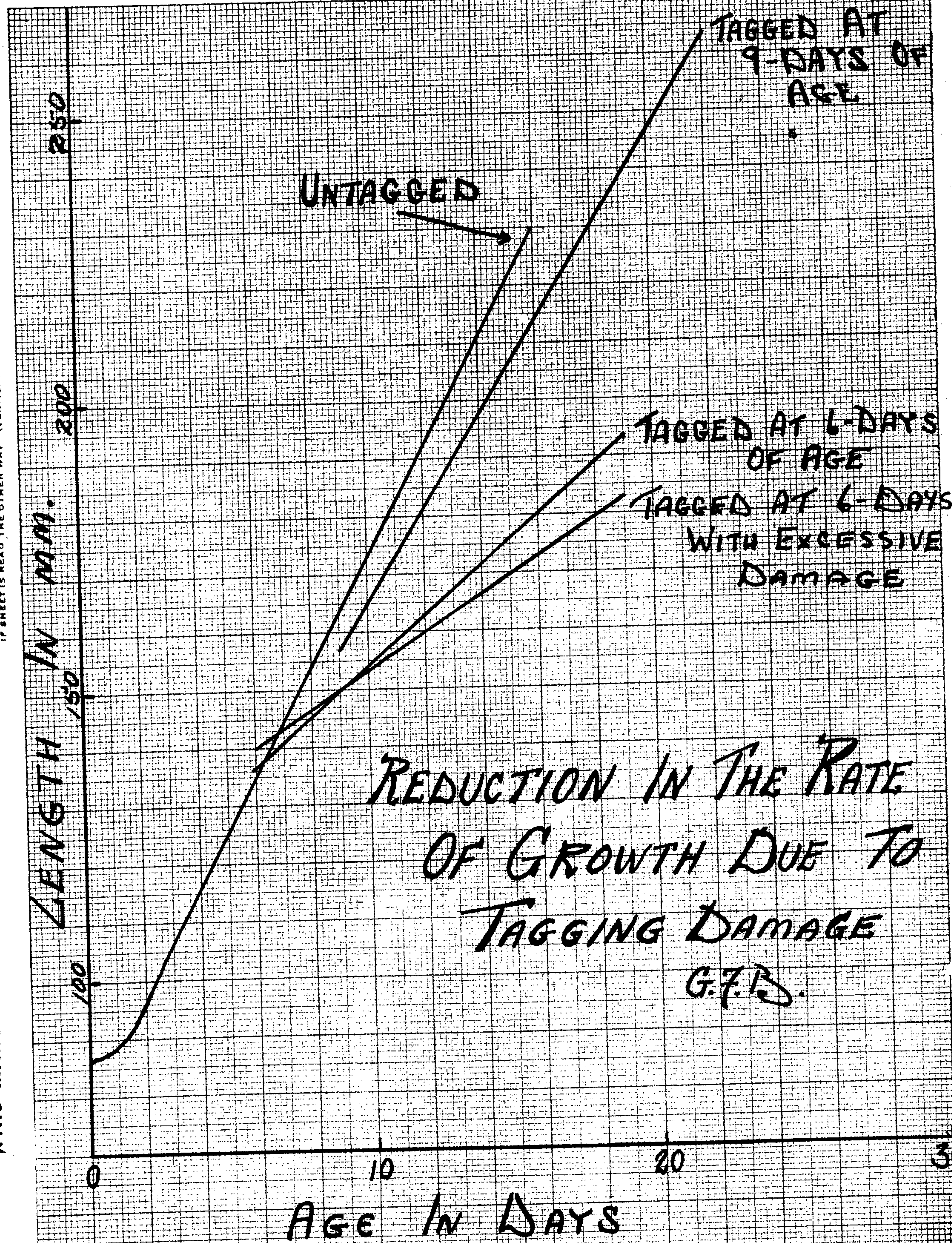

WEIGHT IN GRAMS
50
100
150
200
0
10
20
30
AGE IN DAYS
SIGMOID CURVE RESULTING FROM THE RATE OF GROWTH AS DETERMINED BY PLOTTING WEIGHT AGAINST TIME
G.7.B.

GRAPH VI



MANUFACTURED BY. RENOUF PUBLISHING CO., MONTREAL
FORM 100
IF SHEET IS READ THE OTHER WAY (VERTICALLY), THIS MUST BE LEFT-HAND SIDE.
LENGTH IN MM.
100
150
200
250
0
10
20
30
AGE IN DAYS
UNTAGGED
TAGGED AT 9-DAYS OF AGE
THE COMPARATIVE GROWTH RATE FOR TAGGED AND UNTAGGED MUSKRATS
GROWTH IS SLIGHTLY RETARDED FOR THE TAGGED INDIVIDUALS
G.F.B.

GRAPH VII


TAGGED AT 9-DAYS OF AGE
UNTAGGED
TAGGED AT 6-DAYS OF AGE
TAGGED AT 6-DAYS WITH EXCESSIVE DAMAGE
LENGTH IN MM.
250
200
150
100
0
10
20
30
AGE IN DAYS
REDUCTION IN THE RATE OF GROWTH DUE TO TAGGING DAMAGE
G.F.B.

II Feeding Potential

Food Habits

The muskrat is omnivorous in its feeding habits. Figures 32 and 33 illustrate some of the animal constituents in their diet. Such animal products are scarce in many parts of the general muskrat habitats. They are abundant in Netley Marsh along the various creeks, channels, and river branches. In general, the greatest density of muskrats occurs in the back pot-holes which are lacking in the bivalve molluskans and small fishes except for some large snails which have been stated to be used as food. Therefore, the principal diet of the muskrat consists of plant material.

Many authors state that the muskrats are nocturnal in their feeding habits. This summer, the greatest feeding activities were observed in the late evening, night, and early morning. This is only a generality because quite a few animals have been found securing food throughout the entire day.

Structural Adaptations

The muskrat possesses two pairs of vertically opposed, specialized incisor teeth. These teeth are elongated and protrude anteriorly. They are chisel-like in their structure. This makes them adapted for a vegetable diet which is fairly woody in texture. The rest of the teeth are specialized for further pulverization of the material. The modifications

Figure 32.--- A living shiner with the posterior portion of its body eaten off as found at Netley Marsh. (Photo taken by J. B. Nash)

Figure 33.--- A group of bivalve molluscan shells of the genera <u>Anodonta</u> and <u>Lampsilis</u> near a muskrat burrow. They were brought out of the water and eaten on the shore (Netley Marsh).

and specializations of the limbs for manipulation and procuration of food have already been described.

The length of the alimentary canal is intermediate between that of a carnivore and a herbivore. Therefore, physiologically a muskrat is adapted for an omnivorous diet. If the animal is deprived of all the animal material from its diet, it must consume plant foods quite frequently because it has no structural adaptation for storing large amounts of this type of food. Strict herbivores generally possess check pouches, crops, or specialized stomachs for storage purposes. Because the muskrat is unable to do this, it must eat frequently in order to obtain enough nutrients for its metabolic processes.

Plants Utilized As Food

The following list provides the most important families of plants which are utilized by muskrats as food.

1. Typhaceae - Cattail Family

   Typha latifolia, common cattail
   Typha angustifolia, narrow-leaf cattail

2. Cyperaceae - Sedge Family

   Scirpus fluviatilis, river bulrush
   Scirpus validus, soft-stem bulrush
   Carex spp. sedges

3. Graminaceae - Grass Family

   Phragmites maximus, reed
   Calamagrostis, bluejoint
   Echinochloa, wild millet

4. Equisetaceae - Horsetail Family

   Equisetum, horsetail

5. Sparganiaceae - Burreed Family

   Sparganium, burreed

6. Araceae - Arum Family

   Acorus calamus, sweet flag

7. Najadaceae - Pond-weed Family

   Potamogeton spp. pond-weeds

8. Alismaceae - Water Plantain Family

   Alisma spp. water plantain
   Sagittaria, arrowhead

9. Nymphaeaceae - Water Lily Family

   Nuphar spp. water lilies

10. Ranunculaceae - Buttercup Family

11. Compositae - Aster Family

    Aster spp. wild asters

12. Scrophulariaceae - Figwort Family

    Spp. not identified

Sow thistle is also eaten readily when available.

There also occur a few other families which are highly suspected of being useful as food because of their frequent occurrence in large aggregates in most of the muskrat marshes. They are as follows-

1. Haloragidaceae - Water Milfoil Family

   Myriophyllum spp. milfoils

2. Lemnaceae - Duckweed Family

   Lemna spp. duckweeds

3. Lentibulariaceae - Bladderwort Family

   Utricularia spp. bladderworts

The only way in which a satisfactory conclusion can be reached for the relative proportions of submerged plants consumed by a muskrat is through a large series of stomach analyses. Until this research has been carried out, the value of these plants may be underestimated.

Food Preference

Typha latifolia, the cattail, (photo #18), is one of the most desirable muskrat foods. Due to very high water levels during the past years, its growth was destroyed to a few isolated patches. Therefore its importance as an available food was seriously reduced to a minimum because of its scarcity during this summer. Nevertheless, Typha seedlings, ~~photo #14~~ became firmly established this summer on exposed areas where the water had receded after it had destroyed the former vegetation. This new seedling growth was being moderately utilized for food by muskrats. The cattail furnishes one of the most nutritive and most easily accessible foods which can be utilized throughout the entire year. The large rhizomes and new shoots are taken in the Spring. During the summer and early Fall, the basal portions of the stems furnish succulent and highly palatable food material. During the late Fall and

Winter months, the fleshy rhizomes are easily obtained from the soil by burrowing. Whitewater Lake is dominated by this type of vegetation. This area produced muskrat pelts of the highest quality during the 1948 trapping season. This fact indicates the value of Typha as an ideal food. All the remaining areas which were visited this year showed signs of Typha recovery but this was still small comparative growths and therefore unavailable in any large quantities for muskrat consumption.

Scirpus fluviatilis, the river bulrush, appeared to be one of the most important chosen foods in the Netley Marshes during the summer. The Pruden Bay Station was dominated almost entirely by this plant. The vegetation of this area was mapped in the Summer as shown on Map #4. The Passwa Station, Map #3, and the Lower Devil Lake Station, Map #2, were also composed of great portions of this same type of vegetation. These latter stations also had Phragmites maximus, the flagreed and Carex spp., the sedges in fairly large aggregates. However, the muskrats did not utilize these plants to any great extent as food in comparison to the river bulrush vegetation. Generally by far the greatest density of muskrat populations in the Netley Marshes was located in such areas which possessed a considerable quantity of the river bulrush. In the early Spring the large cormbs were dug up and eaten. Later during this same season, the young shoots were consumed. Throughout the rest of the Summer and Fall seasons the maturing stems are utilized continuously. In the Winter and Early Spring seasons the submerged roots are very accessible to the muskrats. In the Netley Marshes very few lodges were located in this type of vegetation due to the excessive depth of the water. Generally, this bulrush offers a highly desirable food because the animals would swim quite a few yards distance in order to reach it. This year quite a good growth of Scirpus validus seedlings was present on exposed mud flats which were flooded out during the past year. At Oak Lake quite a few muskrats have taken up their permanent abodes in this type of vegetation. There condition was reported to be excellent by Mr. A. Henderson who trapped quite a large area possessing this type of predominating vegetation in the early Spring of 1949. Therefore, the softstem bulrush forms a very excellent diet for muskrats throughout the entire year. This plant was also found to be abundant at Whitewater Lake and The Pas. In general, Scirpus validus vegetation is of great importance as a muskrat food because of the animal's preference and its high nutritive value.

Acorus calamus, the sweet-flag occurred in many places of the Summerberry and Netley marshes following the recession of the water levels. This plant was found to be heavily utilized throughout the year, following its occurrence in the early summer. The basal portions of the leaves and all of the underground root system, were being utilized as food. This type of vegetation seems to be desirable because of its palatability, preference, large edible portions, and accessibility.

Sparganium, the bur-reed, arose to large concentrations on areas which were exposed following the decrease in the water levels in the Spring. This growth was being heavily utilized by muskrats in the Summerberry regions in the late Summer. This plant seemed to be of importance when present, because of its palatability not only in the stem and basal portions of the leaves but also in the succulent, easily accessible underground root systems.

Potamogeton spp. the pond-weeds, and many similar types of plants occur in great concentrations in the waters of lakes, pools, and streams. These types of plants seem to be very palatable and easily obtained by the muskrat population in all of the areas. The use and importance of such vegetation cannot be stated with the past methods of investigation. Only stomach analyses will determine its true value. These foods are present throughout the entire year and can be obtained most easily by the muskrat population.

Phragmites maximus, the flag-reed, was generally present in the Delta, Netley, Oak Lake, and The Pas marshes. This vegetation occurred frequently as only a narrow fringe either on fairly dry ground or in water not exceeding a foot. Deeper waters soon led to its extinction due to the bouyancy of the plant's root system. Nevertheless, this vegetation was moderately utilized by the muskrat population residing in its vicinity. The basal parts of the shoots were the portions that were frequently consumed during the summer and fall seasons. The remainder of the plant seemed to be unsuitable as food. The underground root system was not considered to be valuable food because of its complex network which formed a solid mass of rootlets and soil particles. This portion was almost impossible to procure especially after winter had set in and the soil had frozen due to the lack of sufficient ice and water. Generally, the flag-reed was found to be unsatisfactory as a muskrat food for the whole year when compared to such plants as the cattail or bulrush.

Equisetum, the horsetail, is a very common plant in the Summerberry Marshes. It was heavily utilized by the muskrats in the summer and early fall seasons. Usually only the bottom portions of the stems were eaten. The muskrats preferred this food in the summer as shown by the numerous cuttings. However, as summer progressed this vegetation was made less palatable due to aging. Therefore progressively smaller amounts were utilized as food. This same plant growth was found in a few of the Netley Marsh areas. This food is of great importance because of its palatability and easy procuration during the season of greatest litter rearing.

Sagittaria, the arrowhead was found in the marsh and lake margins of the Summerberry and Netley marshes in a number of heavy concentrations. It was utilized as food by the muskrat population when it was available. Its importance as food was not easily determinable due to the possibility that ducks also cropped this vegetation heavily. Nevertheless, cuttings were found in a number of lodges near such growths.

Carex spp., the sedges, were present in all the areas under consideration this year. Generally, this type of vegetation occurred only on dry land or land that was occasionally flooded with a few inches of temporary water. In the spring, summer, and fall seasons the small basal portions of the stems were utilized as food. In order to get sufficient food, the muskrat was forced to cut down a great area of this vegetation. Usually, after a month, only a few remaining old stalks were present as the new shoots take some time in growing. It was observed that only those muskrats utilized the sedges which were forced unto such vegetation due to rapidly rising water levels which drove them back to higher grounds where they were able to build their lodges. Such populations suffered during the winter as indicated by the lack of accessible root systems of a favorable type. The sedges possess fine root systems with many rootlets which hold the soil tenaciously. On freezing, the scanty rootlets are almost unavailable as food except at a maximum expenditure of energy. Therefore, Carex vegetation is not an ideal food for the muskrats even during the summer. The population generally left such areas as soon as the water levels dropped and other food became accessible.

From the foregoing discussion, the following segregations seem feasible--

Class I - Excellent food vegetation

Typha

Class II - Very good

Scirpus fluviatilis
Scirpus validus

Class III - Good

Acorus
Sparganium
Potamogeton? (only hypothetical at present)

Class IV - Fair

Phragmites
Equisitum
Sagittaria

Class V - Poor

Carex

Since the preferred food types are fairly well established, the work of marsh management should be directed towards the production and upkeep of the desirable food vegetation in its optimum concentration.

Amount of Food Required -

The amount of food material which a muskrat will require for its optimum conditions will vary according to the following -

(a) condition of the vegetation as determined by its -

(i) quality
(ii) accessibility
(iii) utilizable nutritive portion

(b) condition of the animal as determined by its -

(i) age
(ii) reproduction activities
(iii) state of health

Quantitative and qualitative feeding experiments were not carried out throughout the summer due to the lack of sufficient time for the limited number of individuals who participated in this summer's biological survey. However, work in this line was carried out last year under the direction of Dr. J. A. McLeod. The quantitative results were as follows -

> "An adult muskrat normally consumes from 10 to 20 oz. of food per day, or from 30 to 50% of its own body weight."

Qualitative experiments have not as yet been attempted. They appear to be of great importance and may show yearly fluctuations in some of the essential components of plant materials. These fluctuations, if they are present, may have some relation to cyclic rise and decline of the muskrat population.

Starvation -

Many muskrats are known to perish during severe winters in certain types of habitats. These habitats are generally poor in coverage and in the existing supply of available food materials. Many people claim that the animals freeze to death due to the low temperatures. The animals undoubtedly do freeze but not because of the severe temperature alone. These animals are probably in a stage of severe starvation. As starvation becomes acute, the animal's ability to procure food drops progressively until they die from acute starvation. This was the case in some of the Carex areas during the winter of 1948 to 1949.

Carrying Capacity

Each area possesses a definite quantity of food which can be utilized by any one type of animal. This quantity determines the maximum population that can be supported without the destruction of the habitat. If the population exceeds the food carrying capacity of an area, the habitat will be destroyed by the severe coaction which results. The animal numbers reach high magnitudes when the biotic potential is very high while the environmental resistance is low. The excess numbers increase their own environmental resistance as coaction on the vegetation progresses. When the habitat is nearing its destruction, the animals must migrate to new areas or else their numbers will rapidly decrease due to the greatly increased mortality rate which is brought about by the following factors -

(a) intraspecific predation
(b) interspecific predation
(c) starvation
(d) development of epizootic diseases

The food carrying capacity of the Pruden Bay Station, Netley Marsh was calculated as follows -

Map Reference #4

Total area of the habitat	16.8 acres or 734,062.5 sq. ft.
Total area occupied by water	171,562.5 sq. ft.
Total emergent vegetational area	562,500.0 sq. ft.

This total emergent vegetation area was subdivided into -

(a) _Scirpus_ _fluviatilis_	596,250.0 sq. ft.
(b) _Phragmites_ _maximus_	45,000.0 sq. ft.
(c) _Sagittaria_	7,032.0 sq. ft.
(d) Seedlings of _Typha_ and _Scirpus_ _validus_	4,218.0 sq. ft.

During the summer the following data, relating to the river bulrush vegetation, was obtained for each square foot of area

Average edible portion of stems	1 1/2 lbs.
Average edible portion of corms	2 lbs.
Total edible portion	3 1/2 lbs.

Therefore, the area occupied by the bulrush vegetation produced 1,771,875 lbs. of food. Assuming that the remaining vegetation produced at least one pound of edible food per square foot, 56,250 lbs. of food resulted.

Therefore, the total edible food, not including _Potamogeton_ and other submergent species, at this station amounted to 1,828,125 lbs. 10% of this food may be wasted by the animals during transportation or the process of eating.

This left 1,645,312.5 lbs. of food to be potentially taken in by the muskrats. Each muskrat during 24 hours should consume approximately 2 lbs. of this food.

Therefore, this total area has the theoretical possibility of being able to support 2,254 muskrats per year. In other words, one acre of this habitat could support 134 muskrats per annum.

However the muskrat cannot efficiently utilize all of the edible materials which are present in a marsh after a certain limiting concentration. When this concentration is reached more energy is wasted in seeking the food than can be replenished upon obtaining it. Also in order to keep the area in its maximum production status for a long period of time, a portion of the vegetation must be preserved in order to insure sexual as well as asexual reproduction of the plant growth. Even if 25%of the muskrat population is removed in order to overcome the limiting efficient concentration of food vegetation and to allow sufficient plant reproduction, the area at the Pruden Bay Station can support 1,680 animals or 100 muskrats per acre. These calculations are based on the food and building material capacity of the area and no definite conclusions can be stated regarding the detrimental effects which might be set up due to population pressures. If population pressures come into force before the above stated carrying capacity is realized, then the animal numbers must be kept at a certain status below that possiible number as calculated from carrying capacity alone.

The game manager must have this information as soon as possible in order to be able to allow the optimum breeding population to remain on an area by setting the correct trapping quotas. The size of the breeding stock will depend on the carrying capacity of the individual vegetational habitats unless this capacity is so high as to enable the production of such a large number of muskrats which will produce population pressures with their ensuing detrimental effects.

III Protective potential

Most animals possess certain inherent characteristics which enable them to survive the severe fluctuations in their environment and certain types of predations. The muskrat possess a warm, water-resistant fur which offers the body great protection from exposure. Their ability of diving and swimming is highly developed. This enables them to escape many of their predators. Because of the highly developed limbs and claws the animal can burrow quite efficiently (Figs. 34 and 35). The animals can escape many of their avian predators by entering their burrows. The muskrat's ability to construct houses (Figs. 36 to 41) is of great importance in their protective potential. By this means the animals are able to survive the great fluctuations which are encountered in the Manitoban Marshes. Another great factor in the protective potential of muskrats is their parental care of the newly-born offspring. The young are protected from the fluctuating temperatures and the direct exposure

Figure 34.--- A muskrat runway leading to a burrow in the seedling vegetation of _Scirpus validus_.

Figure 35.--- A runway from the edge of a channel leading up to a burrow on the bank where _Phragmites_ predominates (Netley Marsh, 1949).

Figure 36.--- Note in the background a winter lodge which is precariously situated due to the lack of cover and exposure to wave action. The narrow strip of vegetation is composed of Carex spp. (Oak Lake, 19/5/49).

Figure 37.--- A newly constructed house in a cover of Phragmites and Scirpus validus. The measurements are;

water depth.......... 7 inches,
height above water... 19 inbhes,
average diameter..... 66 inbhes.

The lodge was situatbed in an area where cover, food, and water conditions were near an optimum (Oak Lake, 12/8/49).

Figure 38.--- A recently constructed muskrat lodge in Scirpus fluviatilis vegetation. The measurements are:

water depth.......... 6 inches,
height above water.... 26 inches,
average diameter...... 108 inches.

Seven young muskrats were found in a large maternity nest (Netley Marsh, 4/8/49).

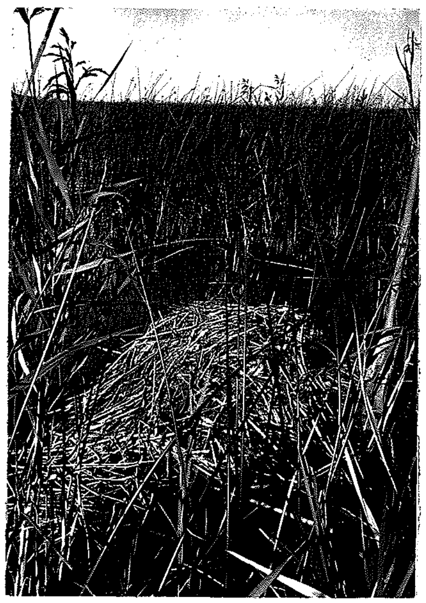


Figure 39.--- Value of cover vegetation during winter. Regions which were deviod of emergent vegetation had ice formation over two inches in thickness (at the right). Areas which possessed such emergent vegetation as Scirpus fluviatilis had only a very thin sheet of ice (at the left).

(Netley Marsh, 19/11/49).

Figure 40.--- A winter lodge in the midst of Scirpus fluviatilis vegetation. Note the circular zone immediately surrounding the house. This is the result of previous coaction. Measurements: water depth........... 10 inches,

Height above water.... 20 inches,

average diameter...... 80 inches.

(Netley Marsh, 19/11/49)

Figure 41.--- Collection of snow in areas where there is a sufficient growth of reed-swamp plants such as Phragmites maximus. The snow prevents deep freezing of water and enables the muskrat to obtain corms and rhizomes from the unfrozen submerged substratum (Netley Marsh, December, 1949).

to sunlight by being sheltered in a warm, dry nest inside the lodge.

Since house construction is one of the most valuable factors comprising the muskrat's protective potential, detailed observations were carried out during the summer of 1949 (Data on pages 58 to 74). Table X summarizes the results. From the table it is evident that all of the preferred cover and construction plants belong to the reed-swamp vegetation.

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
May 13	Whitewater Lake	Trash	Scirpus fluviatilis	27	20	48	1	Occupied
May 13	"	"	"	30	18	48	2	"
May 13	"	"	"	29	22	48	1	"
May 13	"	"	(Typha, (Scirpus fl. & (Algae balls	26	19	48	1	Young present
May 13	"	"	(Typha & (Scirpus fl.	25	14	42	1	Occupied
May 13	"	"	Typha	27	22	48	1	"
May 13	"	"	(Typha & (Scirpus fl.	26	16	48	1	"
May 13	"	"	"	29	16	48	1	"
May 13	"	"	"	29	16	42	1	"
May 13	"	"	"	30	20	48	1	"
May 13	"	"	"	23	22	54	0	Under construction
May 13	"	"	"	24	10	48	2	Young present
May 13	"	"	"	8	15	46	1	Occupied
May 13	"	"	"	10	20	45	1	"
May 13	"	Carex	(Typha, Carex, (Phragmites & (Scirpus fl.					
May 13	"	"	"	24	14	38	1	"
May 13	"	"	(Typha & (Scirpus fl.	24	20	48	1	"
May 13	"	Typha	"	23	14	32	1	"
May 13	"	"	"	18	14	38	1	"
May 13	"	"	"	12	14	36	1	"
May 14	Oak Lake	Carex	Carex Grasses	13	20	54	1-3	Unoccupied 13 similar houses were located.
May 14	"	"	" "	12	21	50	1	Occupied

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
May 14	Oak Lake	Carex	Carex, Grasses	12	36	96	2	Unoccupied
May 14	"	"	Carex, Mud	10	25	78	1-3	97 similar houses were located - unoccupied.
May 15	"	"	Carex, Mud	10	24	54	1	Occupied
May 15	"	"	" "	12	26	70	3	"
May 15	"	"	Carex, Grasses	6	16	50	2	"
May 15	"	"	" "	10	28	60	2	Unoccupied, remains of a mink nest.
May 15	"	"	" "	.5	20	60	1	Unoccupied
May 15	"	"	(Carex, Grasses (& mud	9	12	38	1	Occupied, wet plug of mud present.
May 15	"	"	" "	10	15	40	1	Unoccupied
May 15	"	"	(Carex, (Scirpus fl.	21	35	56	1	"
May 15	"	"	"	12	12	36	1	"
May 15	"	"	"	8	18	48	1	"
May 15	"	"	"	8	18	54	1	"
May 15	"	"	"	12	36	72	3	Occupation doubtful.
May 15	"	"	(Carex, (Scirpus fl. & (mud	0	18	72	1	Unoccupied except for mice 5 similar houses located
May 24	N.E. Devil Lake	Phragmites	Phragmites				1	Young present
May 24	"	"	"	.5	18	40	1	" "
May 25	Netley Marsh	"	(Phragmites (& Scirpus	14	22	66	2	Occupied
May 25	" "	"	"	20	18	84	1	"
May 25	" "	Scirpus fl.	Scirpus fl.	6	18	72	1	"

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
May 25	Netley Marsh	Scirpus fl.	(Scirpus fl.	3	30	74	0	Occupation doubtful.
May 25	" "	Phragmites	Phragmites	6	22	70	3	Occupied
May 25	" "	"	"	7	26	74	1	Young present
May 25	" "	"	"	7	25	76	1	" "
May 25	" "	Carex	(Phragmites (& Carex	0	35	74	1	Occupied
May 25	" "	"	Carex	0	17	72	1	"
May 25	" "	"	"	0	33	84	1	"
May 25	" "	"	"	0	26	78	1	"
May 25	" "	"	"	0	24	70	1	Occupation doubtful.
May 25	" "	"	"	.5	36	72	1	Occupied
May 25	" "	Phragmites	Phragmites	.0	24	74	0	Under construction
May 25	" "	"	"	2	26	90	1	Young present
May 25	" "	Carex	(Carex & (Phragmites	1	25	80	1	Occupied - 2 similar houses were found.
May 25	" "	"	Carex	.5	24	78	1	Unoccupied - 11 similar houses were found.
May 25	" "	Scirpus fl.	Scirpus fl.	11	22	80	2	Occupied
May 25	" "	" "	" "	7	23	68	1	Young present
May 25	" "	" "	" "	0	27	92	1	Occupation doubtful
May 25	" "	" "	" "	1	22	99	1	Occupied
May 25	" "	" "	" "	0	20	58	2	Unoccupied
May 25	" "	" "	" "	0	19	72	1	"
May 25	" "	" "	" "	0	20	76	1	"
May 25	" "	" "	" "	1	24	84	1	Occupied
May 25	" "	" "	" "	1	22	66	1	"
May 25	" "	" "	" "	7	16	70	1	Maternity nest

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
May 25	Netley Marsh	Phragmites	(Scirpus fl. & (Phragmites	2	22	72	1	Occupied
May 25	" "	"	" "	0	18	102	1	Unoccupied
May 25	" "	"	" "	0	24	68	2	Occupied
May 25	" "	"	" "	0	27	98	0	Occupation doubtful
May 25	" "	"	" "	6	16	72	0	Unoccupied
May 25	" "	Scirpus fl.	Scirpus fl.	2	22	74	1	Young present
May 25	" "	"	" "	3	24	70	0	Unoccupied - 1 other house of same type present
May 25	" "	"	(Scirpus fl. (& Phragmites	1	26	69	1	Occupied
May 25	" "	"	" "	0	22	60	0	Unoccupied
May 25	" "	"	" "	.5	40	80	1	Maternity nest
May 25	" "	"	" "	1	25	68	0	Unoccupied - 3 other houses of same type present.
May 25	" "	"	" "	0	18	67	0	Unoccupied - 1 other house also located.
May 25	" "	"	" "	2	24	90	1	Occupied
May 25	" "	"	" "	0	26	62	1	"
May 25	" "	"	" "	0	20	60	0	Unoccupied - 6 similar houses located.
May 25	" "	Carex	(Carex & (Scirpus fl.	0	14	62	0	Unoccupied
May 25	" "	(Phragmites, (Scirpus fl.	(Phragmites & (Scirpus fl.	3	24	73	2	Young present
May 25	" "	" "	" "	4	36	78	1	Maternity nest.

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
May 25	Netley Marsh	(Phragmites, (Scirpus fl.	(Phragmites & (Scirpus fl.	6	30	80	1	Maternity nest.
May 25	" "	" "	" "	1	28	82	1	Occupied
May 25	" "	Phragmites	Phragmites	0	16	114	2	"
May 25	" "	(Phragmites & (Scirpus fl.	(Phragmites & (Scirpus fl.	2	18	82	0	Unoccupied
May 25	" "	" "	" "	0	22	78	1	"
May 25	" "	" "	" "	0	27	84	1	Occupied
May 25	" "	" "	" "	0	24	120	0	Unoccupied
May 25	" "	" "	" "	0	54	70	0	"
May 25	" "	Scirpus fl.	(Scirpus fl. & (mud	0	24	88	0	"
May 25	" "	(Phragmites, (Scirpus fl. (typha	Phragmites	2	23	60	1	Occupied
May 25	" "	Carex	Carex	0	18	60	0	Unoccupied
May 25	" "	Phragmites	(Phragmites & (Scirpus fl.	0	25	66	1	Occupied
May 25	" "	Carex	Carex	0	16	58	0	"
May 25	" "	Scirpus fl.	Scirpus fl.	0	24	70	1	"
May 25	" "	"	"	8	18	70	0	"
May 25	" "	"	"	4	18	60	0	"
May 25	" "	Phragmites	Phragmites	0	36	94	1	Unoccupied
May 25	" "	"	"	0	14	58	0	"
May 25	" "	"	"	0	30	92	0	"
May 25	" "	Carex	Carex	0	26	64	1	"
May 25	" "	"	"	0	20	70	1	"
May 25	" "	"	"	0	23	68	0	"
May 25	" "	"	"	0	14	50	0	Occupied
May 25	" "	"	"	0	26	70	0	"
May 26	" "	Phragmites	Phragmites	0	36	73	1	"
May 26	" "	Carex	Carex	0	29	90	1	"
May 26	" "	Phragmites	Phragmites	0	34	84	1	"

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
May 26	Netley Marsh	Carex	Carex	0	19	64	0	Unoccupied
May 26	" "	"	(Carex & (Phragmites	0	14	40	0	"
May 26	" "	" "	Carex	0	24	80	1	Occupied
May 26	" "	"	"	1	26	76	0	Unoccupied
May 26	" "	Phragmites	Phragmites	0	36	73	1	Occupied
May 26	" "	Carex	Carex	0	29	90	1	"
May 26	" "	Phragmites	Phragmites	0	34	84	1	"
May 26	" "	Carex	Carex	0	19	64	0	Unoccupied
May 26	" "	"	(Carex & (Phragmites	0	14	40	0	"
May 26	" "	"	Carex	0	24	80	1	Occupied
May 26	" "	"	"	1	26	76	0	Unoccupied
May 26	" "	"	"	0	22	78	0	Occupation ?
May 26	" "	"	"	0	27	84	1	Occupied
May 26	" "	"	"	0	26	92	1	"
May 26	" "	"	"	0	30	114	1	"
May 26	" "	"	"	0	21	76	1	Unoccupied
May 26	" "	Scirpus fl.	Scirpus fl.	6	30	118	1	Occupied
May 27	Pruden Bay	"	"	0	26	96	0	Unoccupied
May 27	" "	"	"	0	23	82	0	"
May 27	" "	"	"	0	26	96	1	Young present
May 27	" "	"	"	0	27	110	1	Occupied
May 27	" "	"	"	6	26	92	1	Young present
May 27	" "	"	"	3	30	90	1	" "
May 27	" "	"	"	2	14	106	1	" "
May 27	" "	"	"	6	20	90	1	" "
May 27	" "	"	"	6	24	96	1	Occupied
May 27	" "	"	"	6	18	90	1	Young present
May 27	" "	"	"	5	23	92	1	" "
May 27	Netley Marsh, Section 12	"	"	0	17	78	0	Unoccupied

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
May 27	Netley Marsh, Section 12	Scirpus fl.	Scirpus fl.	0	15	80	0	Unoccupied
May 27	" "	"	"	0	18	110	2	Occupied
May 27	" "	Carex	Carex	0	21	95	0	Unoccupied
May 27	" "	"	"	0	11	89	0	"
May 27	" "	"	"	0	25	72	1	Occupied
May 27	" "	(Carex & (Typha	(Carex & (Typha	0	22	86	0	Unoccupied
May 27	" "	Carex	Carex	.5	16	82	1	Occupied
May 27	" "	(Carex & (Typha	(Carex & (Typha	.5	19	70	1	"
May 27	" "	Carex	Carex	0	22	82	2	"
May 27	" "	"	"	0	23	86	1	Occupation ?
May 27	" "	"	"	0	20	80	1	Unoccupied
May 27	" "	"	"	0	22	76	0	"
May 27	" "	(Carex & (Typha	(Carex & (Typha	0	22	76	0	"
May 31	Lake Francis	Phragmites	(Typha, (Phragmites, (Scirpus fl.	23	13	66	1	Young present - 3 other similar houses found.
May 31	" "	"	" "	12	18	54	1	Occupied
May 31	" "	"	" "	22	11	54	0	Unoccupied - 1 other similar house found.
May 31	" "	"	Phragmites	11	18	66	1	Young present
May 31	" "	"	"	17	18	84	1	Unoccupied - 2 other similar houses found.
June 2	Delta Marsh	Phragmites	(Phragmites, (Scirpus vl.	19	26	82	1	Occupied
June 2	" "	"	Phragmites	8	24	88	1	"

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of Nests	Remarks
June 2	Delta Marsh	Phragmites	(Phragmites & (Scirpus vl.	20	24	86	1	Young present
June 2	" "	"	" "	10	22	65	1	" "
June 2	" "	"	Phragmites	2	25	67	1	Occupied
June 2	" "	"	(Phragmites & (Scirpus vl.	27	14	62	1	Young present
June 2	" "	Typha	Typha	26	22	86	1	" "
June 2	" "	"	"	24	12	69	2	Occupied
June 2	" "	Phragmites	(Phragmites & (Scirpus vl.	26	22	100	1	Young present
June 2	" "	"	" "	20	22	96	1	" "
June 2	" "	"	" "	14	18	70	2	Occupied
June 2	" "	"	(Scirpus vl. & (Typha	21	22	102	2	"
June 2	" "	"	" "	23	22	96	1	Young present
June 2	" "	"	" "	24	20	66	2	Occupied
June 2	" "	"	" "	18	24	66	1	"
June 3	" "	"	(Phragmites, (Scirpus vl. (& Typha	12	18	30	1	Young present
June 3	" "	"	" "	10	20	62	1	Occupied - 2 other similar houses found.
June 3	" "	"	Phragmites	6	22	66	1	Young present
June 3	" "	"	(Phragmites & (Typha	7	22	60	1	" "
June 3	" "	"	" "	13	16	66	1	" "
June 3	" "	Typha	(Typha & (Scirpus vl.	23	15	96	1	" "
June 3	" "	Phragmites	Phragmites	21	20	72	2	Occupied
June 3	2 "	"	"	20	18	66	1	Young present
June 3	" "	"	(Phragmites & (Scirpus vl.	11	17	42	1	" "

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
June 3	Delta Marsh	Phragmites	(Phragmites & (Scirpus vl.	23	28	110	1	Young Present
June 3	" "	"	" "	22	22	90	1	" "
June 3	" "	"	(Phragmites, (Scirpus vl. (& Typha	26	23	90	1	" "
June 22	Summerberry Marshes	Grasses	Grasses	15	18	84	1	Occupied
June 22	" "	"	"	16	18	84	1	"
June 22	" "	Phragmites	Phragmites	12	20	86	3	"
June 22	" "	(Willows & (Carex	(Carex & (Algae balls	18	16	98	2	"
June 22	" "	Phragmites	Phragmites	19	17	84	1	Occupation ?
June 22	" "	"	"	10	27	98	1	Young present
June 22	" "	Salix	(Carex, mud	0	32	58	1	Unoccupied - 4 similar houses found.
June 22	" "	Carex	Carex	8	22	60	2	Young present - 2 other houses found.
June 22	" "	"	"	1	20	64	1	Unoccupied - 2 other houses found.
June 22	" "	Phragmites	Phragmites	12	16	72	3	Occupied
June 22	" "	"	(Phragmites & (wood chips	11	16	60	1	"
June 22	" "	Carex	Carex	2	12	64	0	Unoccupied - 6 others found.
June 22	" "	Phragmites	Phragmites	10	16	78	1	Occupied
June 23	" "	"	"	7	24	72	2	Young present
June 24	" "	(Phragmites (& Typha	"	11	23	68	1	Occupied

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of Nests	Remarks
June 29	Netley Marsh	(Phragmites, (Scirpus fl.	(Phragmites & (Scirpus vl.	.5	36	124	3	Occupied
June 29	" "	Phragmites	(Phragmites, (Acorus, (Equisetem & (Scirpus fl.	.5	36	96	2	"
June 29	" "	(Salix & (Grasses	(Salix, Acorus, (Typha, Carex & (Scirpus fl.	0	32	72	1	Unoccupied
June 29	2 "	(Acorus, (Typha & (Carex	(Scirpus fl. (Acorus, Carex (& Algae	0	12	60	0	"
June 29	" "	(Acorus & (Carex	(Carex, Acorus, (& Scirpus fl.	.5	10	60	0	"
June 29	" "	"	(Scirpus fl. (& Carex	.5	22	90	1	"
June 29	" "	(Acorus, (Phragmites (Carex	(Algae balls, (Scirpus fl.	0	12	60	0	"
June 29	" "	Phragmites	(Phragmites, (Scirpus fl.	0	12	60	0	"
June 29	" "	Scirpus fl.	Scirpus fl.	0	10	60	0	"
June 29	" "	Acorus	(Phragmites, (Scirpus fl. (Algae balls	0	30	72	1	"
June 30	" "	Phragmites	Phragmites	6	12	45	1	Occupied
June 30	" "	(Phragmites, (Typha	(Phragmites, (Typha, Carex, (Algae balls	.5	13	52	0	Unoccupied - 20 similar houses found.
June 30	" "	Phragmites	(Phragmites, (Algae balls	10	56	108	3	Young present 3 similar houses found.

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
July 15	Delta Marsh	(Phragmites, (Typha	Phragmites	24	12	42	3	Occupied
July 15	" "	" "	"	20	18	40	2	"
July 15	" "	" "	"	21	15	48	1	Young present
July 15	" "	(Phragmites, (Scirpus vl.	"	24	16	52	1	" "
July 15	" "	(Phragmites, (Scirpus vl. (Typha	"	24	17	50	1	" "
July 15	" "	Phragmites	"	22	17	52	1	" "
July 15	" "	"	"	20	19	48	1	" "
July 15	" "	Typha	(Typha, (Scirpus vl.	20	12	42	2	Young present - 1 other house found.
July 15	" "	Phragmites	Phragmites	20	14	45	2	Young present
July 16	" "	"	"	19	20	60	1	" "
July 16	" "	"	"	17	18	56	2	Young present - 4 others of similar data located in area.
July 16	" "	"	"	16	20	48	1	Occupied - 5 houses of similar data located also.
July 19	Netley Marsh, Passwa	Carex	Carex	0	14	58	0	Unoccupied
July 19	" "	Phragmites	Phragmites	9	10	108	3	Occupied
July 19	" "	"	"	1	20	78	1	"
July 19	" "	(Carex, (Phragmites	"	3	21	80	1	"
July 19	" "	Phragmites	"	1	20	78	1	Occupation ?
July 19	" "	Scirpus fl.	Scirpus fl.	13	12	78	0	Construction

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
July 20	Netley Marsh, Section 1	Grasses	Salix	0	23	58	1	Unoccupied - 4 others found.
July 20	" "	(Phragmites, (Scirpus fl.	(Phragmites, (Scirpus fl.	.5	20	45	2	New construction
July 20	" "	" "	" "	5	32	55	1	Occupied
July 20	" "	Scirpus fl.	Scirpus fl.	8	32	95	3	New construction
July 22	Netley Marsh, Pruden Bay	" "	" "	2	12	23	1	Young present
July 22	" "	" "	" "	.5	24	110	3	Occupied
July 22	" "	" "	" "	6	10	30	1	"
July 22	" "	" "	" "	2	20	100	4	"
July 22	" "	" "	" "	5	18	50	1	Maternity nest
July 22	" "	" "	" "	5	10	48	0	Occupation ?
July 22	" "	" "	" "	4	38	110	1	Occupation ?
July 22	" "	" "	" "	11	18	48	1	Young present
July 26	Netley Marsh, Section 25	Carex	Carex	.5	24	64	2	Occupation ? - 5 other found.
July 26	" "	(Seedlings, (Carex	"	0	36	102	3	Occupied
July 26	" "	Carex	"	0	28	50	2	"
July 26	" "	"	"	0	17	64	2	Unoccupied - 8 others found
August 3	Netley Marsh, Pruden Bay	Scirpus fl.	Scirpus fl.	3	26	80	3	Construction proceeding.
August 3	" "	" "	" "	5	38	120	3	Occupied
August 4	Netley Marsh, L. Devil Lake	" "	" "	6	26	54	3	Newly constructed.
August 4	" "	" "	" "	0	30	50	3	" "
August 4	" "	" "	" "	6	26	108	2	" " - Young present.
August 4	" "	" "	" "	2	10	32	0	Under Construction.
August 4	" "	" "	" "	1	27	120	2	Young Present.

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
August 8	Netley Marsh, L. Devil Lake	Acorus	(Acorus, (Scirpus fl.	.5	24	70	1	Newly constructed
August 11	Whitewater Lake	Typha	Typha	19	12	36	2	Open nests - young present.
August 11	" "	"	"	18	16	45	1	Occupied
August 11	" "	(Scirpus vl. (Typha	Scirpus vl.	18	6	78	0	"
August 11	" "	" "	" "	18	18	54	1	"
August 12	Oak Lake	Carex	(Carex, (Scirpus vl.	18	18	54	0	Unoccupied
August 12	" "	Trash	(Scirpus fl. (Algae balls	24	16	40	0	Under construction
August 12	" "	Scirpus vl.	(Scirpus vl. (Algae balls	24	16	40	0	" "
August 12	" "	" "	" "	6	15	56	0	" "
August 12	" "	" "	" "	6	19	66	0	" "
August 16	Summerberry Marshes, Pakow Zone	Carex	Carex	8	16	84	2	Newly repaired
August 16	" "	(Phragmites, (Acorus, Typha, (Carex	(Phragmites, (Acorus	12	18	84	2	Occupied
August 16	" "	(Phragmites, (Acorus, Carex	(Phragmites, (Carex	18	12	40	0	Under construction
August 16	" "	Phragmites	(Phragmites, (Carex, Acorus, (Algae balls	12	24	60	1	Newly constructed
August 16	" "	"	" "	12	20	20	1	Occupied
August 16	" "	"	(Phragmites, (Carex	20	18	108	0	Unoccupied
August 16	Summerberry Marshes, Poplar Point Lake	(Carex, (Acorus	(Carex, (Acorus	.5	15	24	1	Occupied

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
August 16	Summerberry Marshes, Poplar Point Lake	(Phragmites, (Sparganium	(Phragmites	6	30	102	1	Occupied
August 16	" "	Phragmites	(Phragmites, (Algae balls	6	12	48	1	"
August 16	" "	(Phragmites, (Sparganium, (Sagittaria	(Phragmites, (Algae balls	6	14	50	2	"
August 16	" "	Phragmites	" "	7	26	48	2	"
August 17	Summerberry Lake 34 - Richard Zone	"	Phragmites	24	24	26	1	"
August 17	" "	"	" "	22	26	24	1	"
August 17	" "	"	" "	30	24	90	3	"
August 17	" "	(Typha, (Equisetum	Typha	30	20	66	1	"
August 17	" "	(Carex, (Typha	(Carex, Typha, (Algae balls	27	22	54	2	"
August 17	" "	"	" "	25	23	60	2	"
August 17	" "	"	" "	27	20	80	1	Occupied - 1 similar house
August 18	Summerberry, Lake 36 - Richard Zone	Phragmites	Phragmites	24	20	82	1	Newly constructed
August 18	" "	"	(Phragmites, (Algae balls	24	18	30	2	" "
August 18	" "	"	Phragmites	7	26	50	1	Young present- 1 other house.
August 18	" "	(Phragmites, (Scirpus vl. (Equisetum	(Phragmites, (Scirpus (Carex	12	20	84	2	Occupied
August 18	" "	(Scirpus vl. (Equisetum	(Scirpus, (Algae balls	14	16	60	1	"

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
August 18	Summerberry, Lake 36 - Richard Zone	(Acorus, (Typha	(Typha, (Scirpus vl. (Algae balls	30	22	54	1	Newly constructed- 5 other houses
August 18	" "	"	" "	16	20	30	1	Newly constructed
August 18	" "	Scirpus vl.	(Scirpus vl. (Algae balls	16	24	84	2	Newly repaired
August 18	" "	Phragmites	Phragmites	18	18	54	1	Newly constructed
August 18	" "	"	" "	19	17	53	2	" "
August 18	" "	"	" "	21	24	42	1	" "
August 18	Summerberry, Hill Island	(Salix, (Scirpus vl. (Typha	(Salix, (Carex	0	7	80	1	Occupied
August 24	Netley Marsh, Pruden Bay	Scirpus vl.	Scirpus vl.	2	28	96	2	Newly constructed
August 24	" "	"	" "	.5	21	64	1	" "
August 24	Netley Marsh, L. Devil Lake	Acorus	(Acorus, Carex, (Equisetum, mud	0	18	50	3	" "
August 24	" "	Scirpus fl.	(Phragmites, (Scirpus vl.	1	24	52	3	" "
August 24	" "	" "	Scirpus fl.	2	20	42	0	Under construction
August 24	" "	" "	" "	2	12	26	0	" "
August 24	" "	" "	" "	2	10	24	1	" "
August 24	Netley Marsh, West Channel, Red River	" "	" "	5	14	60	2	Newly constructed
August 24	" "	" "	" "	4	16	82	0	Under construction
August 24	" "	" "	" "	3	14	40	1	Newly constructed
August 24	" "	" "	" "	6	12	58	1	Young present
August 24	" "	" "	" "	3	22	90	0	Under construction
August 24	" "	" "	" "	0	14	63	0	" "

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
August 24	Netley Marsh, West Channel, Red River	Scirpus fl.	Scirpus fl.	0	20	66	2	Newly constructed
August 25	Netley Marsh, Passwa Lake	" "	" "	15	18	54	1	" "
October 7	Netley Marsh, Pruden Bay	" "	" "	0	34	84	1	Kits present
October 7	" "	" "	" "	0	30	72	3	" "
October 7	" "	" "	" "	2	40	88	2	" " - 8 similar houses
October 7	" "	" "	" "	.5	16	34	x	Kits present - 4 similar houses
October 7	" "	" "	" "	2	40	108	x	Occupied
October 8	Netley Marsh, Passwa	" "	" "	.2	42	144	x	Kits present
October 8	" "	" "	" "	.5	30	90	x	" "
October 8	" "	" "	" "	.5	36	110	x	" "
October 8	Netley Marsh, Section 18	" "	" "	10	28	90	x	Kits present - 10 similar houses
October 9	Delta Marsh	Phragmites	(Phragmites, (Algae balls, (mud	10	24	40	1	Occupied
October 9	" "	Grasses	Grasses	10	40	72	x	"
October 9	" "	"	"	18	26	54	x	"
October 9	" "	Phragmites	Phragmites	8	28	50	x	"
October 9	" "	Grasses	Grasses	6	32	60	x	"
October 9	" "	"	"	7	12	45	0	Occupation ?
October 9	" "	"	"	8	28	58	x	Occupied
October 9	" "	"	"	3	28	78	x	"
October 9	" "	"	"	10	36	60	x	"
October 9	" "	"	"	10	24	32	x	"
October 9	" "	"	"	6	32	90	x	"

Date	Location	Cover	Construction	Water Depth	Height	Average Diameter	No. of nests	Remarks
October 9	Delta Marsh	Grasses	Grasses	10	42	78	x	Occupied
October 9	" "	"	"	12	12	24	x	"
October 9	" "	"	"	9	26	54	x	"
October 9	" "	Phragmites	Phragmites	8	20	42	x	"
October 9	" "	"	" "	8	30	78	x	"
October 9	" "	"	" "	12	24	90	x	"
October 9	" "	Grasses	Grasses	12	20	39	x	"
November 11	Netley Marsh Transect	(Scirpus vl. (Typha, (Seedlings	(Typha, (Scirpus fl. (Scirpus vl.	.5	28	65	1	Occupied - 2 similar houses in vicinity.

TABLE X

SUMMARY OF THE RESULTS OBTAINED FROM THE HOUSE DATA

AREA	OCCUPIED WITH YOUNG	OCCUPIED MINUS YOUNG	UNOCCUPIED LODGES	OCCUPATION DOUBTFULL	TOTAL NUMBER RECORDED	PERCENTAGE OF OCCUPIED LODGES
Whitewater Lake	20	3	0	0	23	100.0%
Oak Lake	9	0	127	1	137	6.6%
Lake Francis	1	5	5	0	11	54.5%
Delta Marsh	37	31	0	1	69	100.0%
Summerberry Marsh	42	7	16	1	66	75.4%
Netley Marsh	122	24	107	19	272	57.7%
TOTALS;	231	70	255	22	578	54.1%

	PREFERRED COVER	PREFERRED CONSTRUCTION
Whitewater Lake	Typha latifolia	Typha latifolia
Oak Lake	Scirpus validus	Scirpus validus
Lake Francis	Phragmites maximus	Phragmites maximus
Delta Marsh	Phragmites maximus	Phragmites maximus
Summerberry Marsh	Phragmites maximus	Phragmites maximus
Netley Marsh	Scirpus fluviatilis	Scirpus fluviatilis

The factors which determine the location of muskrat lodges

The following four factors all influence the location

(a) building materials

(b) cover vegetation

(c) food vegetation

(d) water depths.

(a) Building materials

Muskrats construct houses from any material which is available in a suitable concentration. However the construction material is usually derived from the cover or food vegetation. Thus the following plants are used extensively:

(a) *Scirpus fluviatilis*

(b) *Scirpus validus*

(c) *Typha latifolia*

(d) *Phragmites*

These plants do not only furnish building materials but also the cover and food elements. Therefore, if plants which are suitable as muskrat food are present, there will be no deficiency of construction materials.

(b) Cover vegetation

If the lodges are constructed over water, they are anchored on stalks of dead or living plants and are usually surrounded by some type of cover vegetation. This ensures the stability of the lodge and prevents the surrounding waters or mud from freezing deeply by the coating of snow which is held by the cover plants during the winter months.

Generally muskrats do not leave their cover vegetation unless water is absent. Therefore during drought conditions the lodges are built in an exposed manner. This causes deep freezing of the surrounding waters and mud which cause difficulties during entrance and exit from the lodge in order to procure food. Also with the coming of the spring, these houses are usually carried off by the swift flowing run-off waters. Usually the muskrat finds a location where water is present among some type of cover vegetation which is usually utilized to a great extent as food. Therefore, if the suitable food vegetation is present together with some water, the muskrats usually build in the food vegetation. This location is very satisfactory because building cover, and food materials are all together and are easily accessible.

(c) Food vegetation

The lodge is generally located near suitable food, especially during the winter months. If suitable food plants are present, the muskrat builds the lodge there. This statement applies even though water is completely absent. However, with the deficiency of water, some types of food plants do not offer easy accessibility of their underground root systems due to severe freezing unless the stems furnish enough cover so that a sufficient blanket of snow is captured. Snow prevents deep freezing of the underground root systems. However, for optimum conditions of food accessibility, water as well as sufficient cover plants must be present. Such considerations are essential because the muskrat does not hibernate or store a sufficient quantity of food to last more than a few days.

(d) Water depth

In the fall, most of the lodges are located as close as possible to moderately deep water providing cover, building material, and food vegetation are within reach. For optimum over-wintering conditions, water is one of the essentials. Water from 10 to 24 inches in depth seems to be quite satisfactory. This depth prevents severe freezing of the mud around the underground root systems and enables the animals to travel more easily. It has been found from both summer and winter observations that the muskrat lodges are never more than a few hundred feet away from water. This fact illustrates the muskrat's inherent desire for water. Therefore water cannot be entirely eliminated from an optimum muskrat habitat.

If the desirable muskrat food plants are present together with some water, no difficulty will be encountered by the animals in building lodges. It would be desirable in most cases to raise the fall water levels if at all possible. In many of the Netley Marsh areas, the lodge location is a compromise between existing food, cover, and construction vegetation, and the optimum water level obtainable. These are the conditions as evidenced from this winter's observations. More information on houses and the suitability of their location would be desirable through the winter months for at that time they are subjected to the severe test of their suitability in overcoming the extremes of low temperatures.

IV Survival Potential

The survival potential of muskrats is quite high because of their various protective habits. The survival of the young animals is very great because of the great parental nutritian and protection. As long as there is no great population pressure, the survival rate of the adults and sub-adults appears to be quite high also. But as soon as the population increases to a certain magnitude, the survival rate of the animals decreases rapidly because of any one or all of the following factors:

(a) intraspecific predation
(b) epizootics
(c) starvation
(d) interspecific predation

It is the duty of the game managers to keep all of these factors at a minimum by suitable trapping programs. These programs should allow a certain breeding stock which will not produce a population in excess of the carrying capacity. It is highly probable that even if the carrying capacity is not exceeded, the populations may become too large and some of the above mentioned factors will commence. The population densities have not as yet been determined for any of the Manitoban areas. This means that no definite information can be brought forward as to the limiting number of muskrats for any certain type of vegetation in order to keep these undesirable factors at a satisfactory minimum. Nevertheless, this one fact is obvious and has been proved many times.

The population must not exceed a certain density otherwise the habitat will be destroyed by the increased coaction. The population in such a denuded area will diminish rapidly until all the animals perish or only a minute fraction of the former population will remain in a precarious state.

At certain periods of time, the muskrat population seems to lose its resistance to certain diseases which rapidly establish themselves in epidemic proportions. As yet, there is no experimental proof to support this assumption. These epizootics seem to sweep across great areas and destroy most of the muskrat population during certain years which seem to be uniform in their periodicity of occurrence.

Recorded Field Cases of Muskrat Mortality

Eight different cases of muskrat mortality were encountered during the summer of 1949. These were composed of 26 individuals. Two deaths were the result of intra-specific predation. The remaining 24 mortalities were due to disease, starvation, or suffocation. A female and her litter of seven young were found dead in a house at Netley Marsh (Fig. 42). No external wounds could be found on any of the specimens. On dissection of the adult animal, some form of enteritis (Errington's ?) seemed to be present because of the hemorrhagic condition of the intestine. Since a total of 590 muskrats were examined during the summer, the known mortality rate was determined to be:

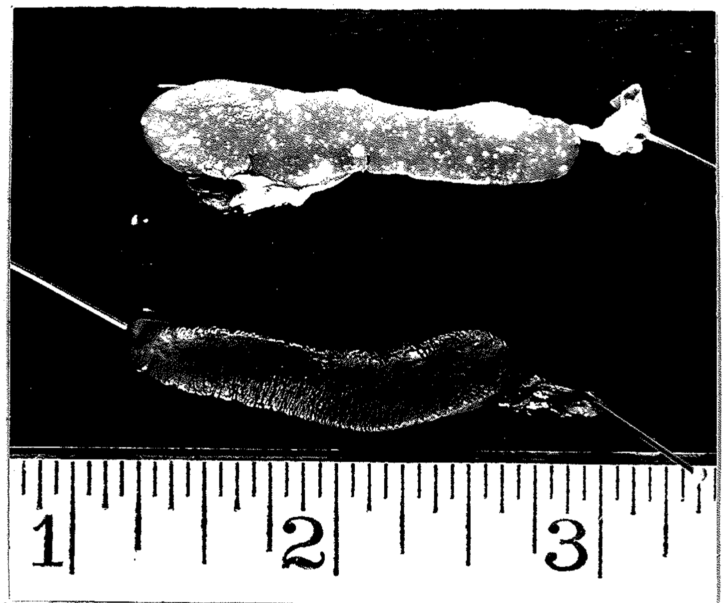
$$26/590 \times 100 = 4.4\ \%$$

This figure represents a minimum value which is probably far below the actual mortality rate.

Figure 42.--- Adult female and her litter of seven young found dead in a house at Netley Marsh, 10/6/49. Dissection of the adult revealed a hemorrhagic condition of the intestine probably produced by some form of enteritis.

(Photo taken by J. A. McLeod)

Figure 43.--- A comparison of a normal and a pathological spleen. The latter is characteristic of Errington's Virus Enteritis. Note the numerous, small, white spots and the swollen condition.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ENVIRONMENTAL RESISTANCE

The sum total of the factors tending to decrease the muskrat numbers constitutes what is referred to ecologically as the animals' environmental resistance. These factors are external and characteristic of the habitat in which the animals live. The environmental resistance will be discussed under three main divisions:

I Climatic Factors

II Physiographic Factors

III Biotic Factors

I Climatic Factors

Light

Muskrats do not seem to require light directly. In fact exposure to strong sunlight will produce injury which frequently results in death of young muskrats, devoid of hair, if they have been subjected to a sufficient dosage of such rays. Most of the individuals are protected from such an exposure by being raised in a covered nest. However, a few litters were found where no such protection was present due to the open character of the nest. Such litters may perish quite easily. Light does have an effect on the behavior of the animals in view of the fact that they do most of their feeding at night. Indirectly, muskrats cannot live without sunlight as they are primarily dependent upon those plants which require sunlight.

Solar light is never constant but changes quantitatively and qualitatively from day to day, from season to season, and from year to year. These fluctuations may affect the occurrence and quantity of certain essential amino acids and vitamins which are essential for optimum conditions of growth and health of the individual and consequently of the whole population.

Moisture

The muskrat, a semi-aquatic animal, requires free water as a compenent of its optimum habitat. Indirectly water levels play an irreplaceable role in their control of the types of vegetation in the marsh. The carrying capacity of an area for muskrat production is dependent upon the condition of the reed-swamp sere which is affected by water depth and fluctuation of water levels. Free water covering an area constantly for a number of years produces stagnation among the emergent vegetation. In order to allow seedling reproduction and to prevent plant degeneration, it is essential to drain areas for a certain period of time. Only in this way can the reed-swamp sere be maintained at its optimum carrying capacity. Therefore, water levels are one of the major factors in the environmental resistance of muskrat populations.

Temperature

The muskrats are homiothermic animals and can survive wide temperature fluctuations because of the protection offered by their warm fur and their habit of house-building. However the temperature does exert a decided influence on the growth and reproductive rates. These latter rates determine animal numbers. Young muskrats cannot survive the temperature fluctuations unless they are closely protected by the adult female. They are sheltered in a fine-lined nest and receive supplemental heat from the body of the parent. Some of the young were found in open nests. These individuals would have little chance of survival during storms.

During the winter season, low temperatures are often fatal to the animals unless the effects of temperature are modified in the following way:

(a) sufficient plant cover

(b) sufficient snow cover

(c) sufficient depth of water

(d) sufficient concentration of nutritive, easily-available food.

When these conditions are realized, the animals are able to obtain a sufficient quantity of food. When temperature effects are not modified, high mortality occurs due to death by freezing because of partial starvation. Temperature limits the winter distribution of muskrats because only a very small portion of the general marsh area offers optimum protection against the severity of the long cold season.

II Physiographic Factors

Nature of the Soil

The character of the soil determines largely the nature of the vegetation and the types of animals that can maintain themselves upon it. Soils vary in respect to:

(a) origin

(b) formation history

(c) texture

 (1) clay

 (2) sand

 (3) silt

(d) porosity (aeration)

(e) moisture

 (1) bound water

 (2) free water

(f) chemical nature

 (1) pH

 (2) relative quantities of inorganic substances

 (3) relative quantities of organic compounds.

The physical and chemical nature of the soil limits muskrat distribution because of the type of vegetation it produces and because of other factors which have been mentioned previously.

Contours

The contours of the marshes are generally such that only a small portion can support the vegetation of the reed-swamp sere. This portion can be altered if the water levels are brought under control. Therefore, contours act as limiting factors by determining the size of the habitat which is suitable for the raising of muskrats.

III Biotic Factors

Intraspecific Relations

Muskrats compete among themselves for the following:

(a) cover, food, and shelter

(b) mates

(c) territorial rights ?

Muskrats will attack one another during critical shortages of food or space or because of a general feeling of insecurity. Intraspecific competition and actual warfare are the result of adverse environmental conditions or excessive population densities. The animals increase their own environmental resistance. This produces a great increase in the mortality rate which now exceeds the natality rate. The population decreases until the environmental resistance is lowered. In order to keep intraspecific strife at a minimum, the following conditions are not to be exceeded:

(a) maximum population density at which there is no competition for space, and

(b) carrying capacity.

Figure 44.--- A muskrat lodge which had been opened by bears. No trace of the muskrats belonging to this house could be found (Summerberry Marsh).

Figure 45.--- The results of bear predation. The house was almost completely leveled and most of the young of the litter which was present were destroyed. Note the one surviving muskrat (Summerberry Marsh).

Interspecific Relations

Their is little competition with other species of animals for cover, food, building materials, or space. However, muskrats are preyed upon by other animals to some extent. The most common predators in manitoba are:

(a) bears

(b) mink

(c) hawks

(d) owls

(e) wolves

During the summer survey, evidence was uncovered on bear and wolf predations. Both instances occurred at the Summerberry Marsh. A wolf was seen digging into a lodge on June 23rd. On June 24th, an adult bear with two cubs was seen performing the same act. A thorough investigation of that area revealed over a dozen muskrat lodges in a disrupted condition (Fig. 44). One house had only the remains one young muskrat. In general, predation does not constitute a very serious factor and it can easily be controlled.

Parasites

A, parasitological survey of the intestinal tracts of 78 muskrats was undertaken. The data on pages 87 and 88 shows the detailed results.

LAB. NO.	Plagiorchids	Amphistomes	Notocotylids	Echinostomes	Tapeworms
1	9	1		2	
2			4		
3	7	2			
4		3			
5	10	2			
7	38	11	3		
8	23	3			
11	3	7	3		
12		13	6		
13	2	8	11	8	
14	458			6	
15	569	4		2	
16	252	5	127	7	
18		8	105	103	
19		11	11	27	
20	13		152		
22	910	3			
23	4	7	43	4	
24	730	8	379	3	
25	16	12		55	
27	14	6			
29	7	2	3		
31	29	5			
33	45	30	60		
34	72			6	
35		3	848	44	
36	28	5			
32		5		12	
40	60	8	160		
41	6	2			
42		98	480	5	
43	17	5	58	5	1 adult
44	592	15	227	18	
46		8		13	
48		6	13	65	
49	63	2		2	
53		8	14	32	
55		20		81	
57	46	3	38		

LAB. NO.	Plagiorchids	Amphistomes	Notocotylids	Echinostomes	Tapeworms
58		7		4	
59	6	15			
60		4	2		
61				6	
62	3				
63	9	3		9	
64	104	15			
65	2		1o3		
66	143	19		4	
67	9	3	9	1	
70	5	16			
73	28	11	39	41	
74		6	20	1	
76	24	3			
80		12	135		
81		21	16	44	
82		9	7	53	
83		2		59	
84		14			
85	21	8			
87		2			
88	32	3	87		
91	73	13			
92	3	18			
93		24		56	
94	33	4	2		
95	59	1	4	3	
97	118				
100	37				
103	8	6		6	
124	218			1	
129		14	23	2	
142	31	8	17		
182	2	4	5	1o	
194	75	2	40		
202	38	7	259		larval cyst
207	167				
1S			3	2	adult stage
B4	---------------	24 Adult	Acanthocephalids	--------------	

The parasites belonged to the following groups:

TREMATODES

1. Family Notocotylidae Lühe, 1909.

Notocotylus urbanensis (Cort, 1914) Harrah, 1922.

Notocotylus quinquiserialis (Barker and Laughlin, 1911) Harrah, 1922.

Percentage of individuals infested: 48.7%.

2. Family Paramphistomidae Fischoeder, 1901.

Pseudodiscus zibethicus (Barker and East, 1915) Fukui, 1929.

Percentage of individuals infested: 83.3%.

3. Family Plagiorchidae Lühe, 1909.

Plagiorchis spp.

Percentage of individuals infested: 66.6%.

4. Family Echinostomidae Looss, 1902.

Species were not identified.

Percentage of individuals infested: 48.7%.

CESTODES

Taenia spp. (not positively identified)

2.6% infestation with adult stages.

1.3% infestation with larval stages.

ACANTHOCEPHALA

Only one muskrat specimen was infested with a number of parasites belonging to this group and apparently all of the same species. Intestinal perforation by these thorny-headed worms was the probable cause of death of the animal.

Two types of mites (Liponyssid and Dermanyssid) are known to infest muskrats. This year mites occurred on many of the young animals and were present in great numbers on some of them. During the June observations of Summerberry Marsh, a few young muskrats were found to be covered with such an abundance of mites that the animals' grey color was obscured. Mites are important vectors of pathogenic organisms which they transmit to their hosts by inoculation. Therefore, a detailed consideration of the possibility that mites are responsible for transmission of epidemic muskrat diseases should be undertaken.

All of the muskrat specimens which had been examined during this entire year showed varying degrees of parasitic infestations. Heavy concentrations of these parasites would certainly hinder the development and general well-being of their hosts. Ectoparasitic infestation varies over a number of years. It has been proved that there is a definite relation between the number of parasites and the degree of avitaminosis. Consequently, the mites, etc. may only be indicators of a deficient diet. Also, heavy parasitic infestation may cause a lowering of the host resistance and render them more susceptable to infection with other disease-producing organisms.

Disease

Four disease-producing organisms are known to cause severe fluctuations in muskrat populations. They are the following:

(a) Bacterial types

(1) *Micrococcus pyogenes* var. *aureus*

(2) *Pasteurella tularense* (Tularemia)

(3) *Salmonella typhimurium*

(b) Virus type

(4) Errington's Virus Enteritis

Some of the known pathogens, such as the virus enteritis exist in the Manitoba marshes continuously in an endemic form. Periodically, the organisms assume epizootic proportions causing the death of the majority of the muskrats in those regions. The question: "Why does the disease take up an epidemic existence at certain periods of time?", has not yet been solved. It is probable that avitaminosis, decrease in animal vigor, general malnutrition, high population density, or the increase in the disease vectors and the pathogenicity of the organism itself, all may have some bearing on this extremely complex problem.

A few muskrat carcasses bearing huge abscesses under the neck regions were obtained from Loon Lake, Saskatchewan, in December of 1949. Evidently, a localized epidemic of some type was taking place in this area for many houses contained dead or dying animals. Laboratory investigation revealed the presence of the above mentioned Micrococcus species. A very virulent strain of this organism can produce death of the individual very rapidly and also it can cause epidemics because of its easy transmission by carcasses or faecal materials possessing the disease by contaminating the food and water supplies.

Epidemics of this type are not new. During the late summer of 1903 on Seton's estate in Conneticut, an epidemic occurred among the varying hares. Preble in 1908 reported a similar epidemic among the hares and rabbits along the Hay River and Lower Athabaska river in the summer of 1903 (MacLulich, 1937).

Pasteurella tularense, the causative organism of tularemia, was found to be widespread among such mammals as the beaver and the muskrat both in Canada and in the United States during the past years. This organism was found to be transmitted by the following vectors:

(a) Chrysops discalis .... deer fly (seen biting young muskrats)

(b) Dermacentor spp. .... ticks

(c) Haemodipsus ventricosus   rabbit louse

(d) Polyplox serratus .... mouse louse

(e) Ceratophyllus acutus .... squirrel flea

(f) Stomoxys calcitrans .... stable fly

(g) Cimex lectularius .... Bed bug

Since this pathogen is transmitted by biting and sucking insects, mites may also act as vectors. Infection is also produced by direct contact with the infected animal. Once tularemia does become established in endemic proportions, it soon reaches epidemic proportions in the form of a devastating epizootic. The liver and spleen of an animal subjected to this disease possess large lesions which are general over one half of an inch in diameter. No trace of this disease was found during the 1949 survey.

Salmonella typhimurium has been reported in Minnesota and probably occurs in Manitoba. It is transmitted in the same manner as tularemia. No cases were identified in 1949 by the survey.

Errington's Virus Enteritis has been identified in quite a few localities in Manitoba in 1949 and in the previous years. The exact nature of this disease has not as yet been determined. The pathological effects are quite similar to tularemia. Both the liver and the spleen are affected and characteristically smaller lesions are formed (Fig. 43).

The disease produced by the discussed organisms are of major importance in connection with muskrat production on a sustained yield basis. Large populations are periodically almost completely destroyed by epizootics. Such epizootics can be checked to some extent by destroying endemic centres and by preventing excessive population densities.

SUMMARY AND CONCLUSIONS

The study of the biology of the muskrat has revealed the following points:

1. There are approximately one million acres of marsh lands in Manitoba which, at the present time, can be utilized only for the production of wild-fur-bearers.

2. The muskrat is of the highest economic importance because of its abundance, wide distribution, and pelt quality.

3. This animal's habitat is specific, being confined, almost entirely, to the reed-swamp stage of hydrosere succession.

4. The vegetation of the reed-swamp sere is very unstable. At present, it is generally at the mercy of fluctuating water levels.

5. In order to prevent plant stagnation and to allow seedling regeneration, recession of water is necessary during the late spring or early summer.

6. The muskrat possesses a very high biotic potential because of its fecundity, parental care, house-building habits, and others.

7. This potential can be realized only if the carrying capacity of the habitat is at or near an optimum.

8. However, disease seems to be the limiting factor of the environmental resistance and tends to keep the population in check.

RECOMMENDATIONS

In order to realize the potentialities of the muskrat, the following techniques are recommended:

1. Water level control should be set up wherever conditions will permit. The levels are adjusted so as to favor the existence of the largest possible area of reed-swamp vegetation. At first, complete drainage may be necessary in order to allow Scirpus and Typha seedlings to become established. After the seedlings have undergone sufficient growth, the water level is raised in order to prevent the introduction of Carex vegetation. The area is periodically drained so as to preserve plant vigor.

2. The muskrat population is balanced so that it does not exceed: (a) a certain density above which population pressures are established and intraspecific strife results, (b) the carrying capacity of the area which would cause the destruction of the habitat and the starvation of the population. These factors can be controlled by allowing only the desirable breeding stock after the spring trapping season or by salvage trapping when emergencies arise.

3. Endemic disease centres can be salvage trapped if the marshes are patrolled at regular intervals. In this manner, epizootics can be prevented or at least reduced in their rapid spread.

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