State of Maryland
Board of Natural Resources

MUSKRATS ON TIDAL MARSHES OF DORCHESTER COUNTY

VAN T. HARRIS

Publication No. 91

Chesapeake Biological Laboratory
Department of Research and Education
SOLOMONS ISLAND, MARYLAND

State of Maryland

DEPARTMENT OF RESEARCH AND EDUCATION

Commissioners:

Franklin D. Day, *Chairman*.....Centreville
Ernest N. Cory.....College Park
Earle T. Hawkins.....Towson
Fred Tresselt.....Thurmont
B. H. Willier.....Baltimore

Director:

R. V. Truitt.....Solomons

State Weather Service:

George N. Brancato, B. S., *Meteorologist in Charge*.....Baltimore

Chesapeake Biological Laboratory:

Byron L. Ashbaugh, M. Ed., *Education Assistant*
G. F. Beaven, M. A., *Biologist I, Oyster Investigations*
David G. Cargo, M.S., *Biologist II, Crab Investigations*
Harold J. Elser, Ph. M., *Biologist III, Fishery Investigations*
Adaline Gall, *Secretary*
George B. Gray, B. S., *Administrative Assistant II*
Harry A. Hensel, Jr., *Investigator*
Leah Belle Jones, *Senior Stenographer*
John R. Longwell, M.S., *Biologist III, Game Investigations*
Joseph H. Manning, B.S., *Biologist II, Oyster Investigations*
Romeo Mansueti, M.S., *Biologist II, Fishery Investigations*
Harvey Mister, Captain, *Fish Culturist, In Charge of Commercial Fish Hatcheries*
Rudolf S. Scheltama, B.S., *Chemist III*
Fred W. Sieling, B. S., *Biologist II, Oyster Investigations*
Richard E. Tiller, Ph.D., *Biologist I, Fishery Investigations*
R. V. Truitt, Ph. D., *Biologist*
R. D. Van Deusen, M. S., *Biologist I, In Charge, Natural Resource Inventory*
Craig D. Whitesell, B.S., *Biologist III, Forestry Investigations*
Betty Ann Woodburn, *Senior Typist*

INTRODUCTION

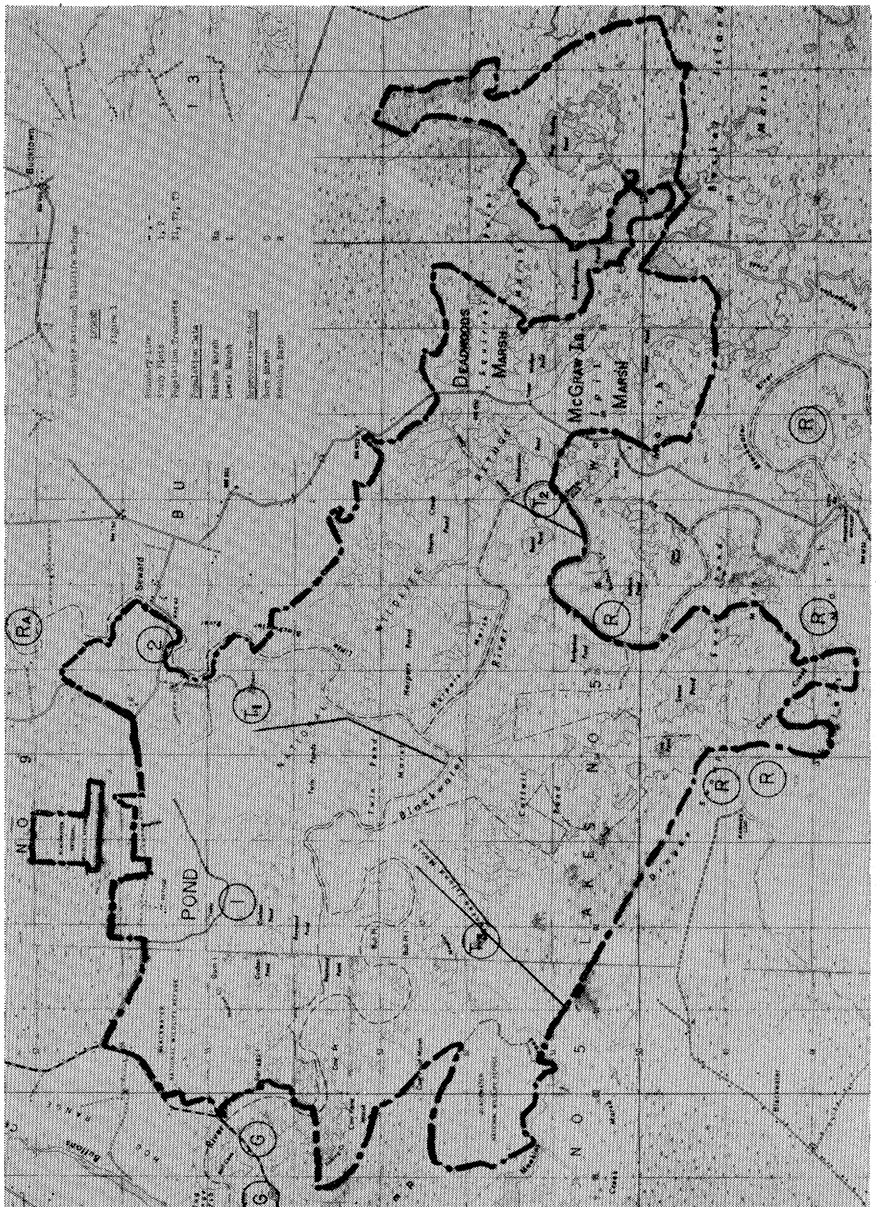
The muskrat is the most important fur-bearing animal in the United States. The Atlantic Coast, with its extensive tidal marshes, is one of the most important muskrat producing areas. The Virginia muskrat (*Ondatra zibethica macrodon*), which is considered in this report, occurs on the coast from the upper Delaware Bay to central North Corolina. Within this region, the State of Maryland provides 180,000 acres of tidal marsh, of which 77,500 acres occur in Dorchester County on the Eastern Shore of Maryland. Maryland has produced in some years well over a million pelts per year, over a fourth of which have come from Dorchester County.

The muskrat in Maryland and elsewhere along the Atlantic Coast has decreased in numbers to an alarming extent since 1939. Because many acres of marsh land are owned by individuals for the purpose of harvesting muskrats, this decrease is a matter of economic concern to the trappers and the land owners involved. It becomes necessary, therefore, to learn as much as possible about the muskrat in order to develop methods of maintaining and increasing its numbers.

This bulletin reports, in a non-technical manner, investigations on the Virginia muskrat, prevalent in Maryland, from July, 1949 to June, 1951. The investigations were limited to the Blackwater National Wildlife Refuge (Fig. 1) and surrounding areas in Dorchester County and concern the Virginia muskrat in more or less tidal marshes of brackish water. The ultimate purpose of the investigations, of which the present studies are a part, is to study the factors and conditions of the muskrat and its surroundings which affect its populations (abundance). Many factors (*e.g.* food, predation, salinity, breeding), some of which are not readily observable, act together to affect muskrats abundance, and important factors may be different from year to year. Further, factors may cause different reactions on the part of muskrat populations at different levels of abundance. Such a complex situation needs a number of years of study in order to evaluate different population levels under varying conditions imposed by the weather and by other factors of the habitat.

The immediate purpose of the present investigation was (1) to study the reproduction of the local or Virginia muskrat, (2) to assess the importance of predation to the muskrat population, and (3) to make a general evaluation of habitat (where the muskrat lives) factors.

Reproduction adds new individuals to the muskrat population, and, therefore, it is a primary factor in studies of abundance. A consideration of placental scars (see page 18) has proved to be a valuable general technique. This technique has given something of the amount and extent of reproduction. Together with an analysis of the population into young and adult muskrats, it gives an idea of reproductive success. Sex ratios are important in reproduction. A low proportion


DEADWOODS
MARSH
McGRAW IS.
MARSH
POND

of females limits the number of young produced. A low proportion of males may give the same result, for many of the females may not be bred. The weights of the muskrats will help to evaluate the relations between the muskrat and its habitat.

Predation by raccoons (*Procyon lotor*) is chief among the causes advanced for the muskrat decline in this region. For this reason, the raccoon-muskrat relationships were investigated. In order to know the effect of raccoons on the muskrat population, it must be possible to measure the numbers of raccoons and muskrats. Such studies would require a number of years to complete. Predation is a natural occurrence and has a fundamental place in nature's plan. It may even benefit the muskrat population by removing diseased and crippled animals and surplus animals above the number which the habitat can support. Biologists have no evidence of predators destroying a prey population over an extended area.

Although the study here reported has not solved the problems of the muskrat decline and methods of increasing the numbers of muskrats, it has given more information on muskrat reproduction and on the effect of predators on muskrats. It has, in a general way, evaluated some habitat conditions and has provided a basis for future work. Many muskrat studies have been made throughout the United States, and the fact that these studies are still being made shows that much is yet to be learned about the muskrat's relation to its surroundings. Wildlife studies are not unlike studies of humans in complexity. For example, much money and time of many individuals have been spent in studying cancer. Progress has been made, but cancer cannot yet be prevented nor can it always be cured.

This study also has pointed to several problems in carrying out muskrat investigations in Maryland.

(1) Time is required to learn how yearly variations of weather and marsh affect both low and high populations of muskrats, and how the populations of muskrats affect the marsh. For example, records of water level and salinity of the water have been taken on the marsh in the present investigation. These records of factors important to the muskrat are of little value unless they are continued over many years so that they can be correlated with muskrat abundance.

(2) Limited personnel decreased the scope of the present investigation. One investigator can study in a detailed way only a limited portion of the muskrat's relationship to its surroundings. He must develop a means of securing data on a particular muskrat relationship. He must collect data, analyze them to determine effects on the muskrat, and he must then prepare reports.

(3) Supporting studies of the muskrat, here considered, in nearby states are few and do not help in limiting the scope of the Maryland investigations. Studies of the **common** muskrat of Eastern United States (which is present in Western Maryland) are only generally ap-

plicable to our form since the two are different kinds (subspecies) of muskrats and live in different habitats. Observations show that the **Virginia muskrat** is the more nocturnal (active at night) animal. It is more wary and harder to study than the **common** muskrat. The extensive and densely vegetated marshes, which provide a home for the muskrat in Maryland, are not commonly found in inland areas of the United States.

(4) Techniques available for the study of the **common** muskrat do not always suffice for study of the local, (*i.e.*, Virginia muskrat) because of their different habitats and shyness. The use of techniques is important in obtaining sound information. As yet we have no good techniques for learning the numbers of muskrats, raccoons, or foxes on a given marsh in this area. The number of muskrats trapped on a marsh is determined by (a) weather, (b) economic needs of the trapper, (c) the trapper's skill, (d) the price of pelts, as well as by (e) the abundance of the muskrat. But records of muskrat catches, accurately kept over long periods, together with information on trapping conditions, number of traps used and number of trappers, may be valuable guides in muskrat investigations.

The investigation was supported by a two-year grant from the International Health Division of the Rockefeller Foundation. The grant was administered through the Division of Vertebrate Ecology, School of Hygiene and Public Health, The Johns Hopkins University. The Maryland Department of Research and Education and the Maryland Game and Inland Fish Commission cooperated in the study and supported the preparation and publication of this report. The Game and Inland Fish Commission provided funds for hiring assistants, defraying expenses, and obtaining raccoon stomachs. The United States Fish and Wildlife Service granted permission to use the Blackwater National Wildlife Refuge, Cambridge, Maryland, as a center of study and provided space for the storage of equipment.

ACKNOWLEDGMENTS

The study was carried out under the general direction of David E. Davis, School of Hygiene and Public Health, The Johns Hopkins University. C. Haven Kolb of Baltimore collected and classified plants from the marshes. Members of the Maryland Game and Inland Fish Commission and of the Department of Research and Education facilitated the investigation in many ways. The cooperation of the manager, Mr. Cornelius Wallace, and of the personnel of the Blackwater National Wildlife Refuge is greatly appreciated. The interest and suggestions of the personnel of the Patuxent Research Refuge, Fish and Wildlife Service, were helpful. William Stickel supervised and aided materially in the analysis of raccoon and fox droppings and stomaches. Special thanks are due Messrs. Gore, Linthicum, and Lewis, and the Robbins Brothers who made available much of the data from muskrat carcasses during trapping seasons. Other trappers have aided the writer in the study, and their help is appreciated.

THE BLACKWATER MARSHES

The extensive muskrat marshes of Dorchester County lie along the Chesapeake Bay and its tributaries. On the Blackwater marshes (Fig. 2), lying on the upper part of the Big Blackwater River and on the lower part of the Little Blackwater River, the tides are very irregular, being modified largely by the wind. Periods of high and low tides may last for several days to a week or longer. Generally the water level on the marshes averages higher during the summer than during the winter. The water of the marsh is brackish, varying, during the period of study, from two per cent to 42% of average sea salinity. The water level on these marshes is largely influenced by the irregular tides and by drainage from higher land.

Fig. 2. View of the Blackwater Refuge Marshes.

Relatively few species of plants characterize the vegetation of the Blackwater marshes. The characteristic species is the three-square sedge, *Scripus Olneyi* (Fig. 3), which occurs in stands of varying density over most of the area. This plant forms the main food of the muskrat. Cattail, *Typha sp.*, is another food plant of the muskrat, but it is not abundant on the Blackwater marshes, forming extensive stands on only a few areas.

The saltgrasses, *Spartina patens* and *Distichlis spicata*, form a zone of vegetation next to the higher land, and with saltmarsh cord-grass, *Spartina alterniflora*, occurs in patches along the two rivers (Fig. 4). Saltmarsh cord-grass (Fig. 5), together with the two salt-

Fig. 3. A Good Stand of Three-Square Sedge on the Blackwater Refuge.

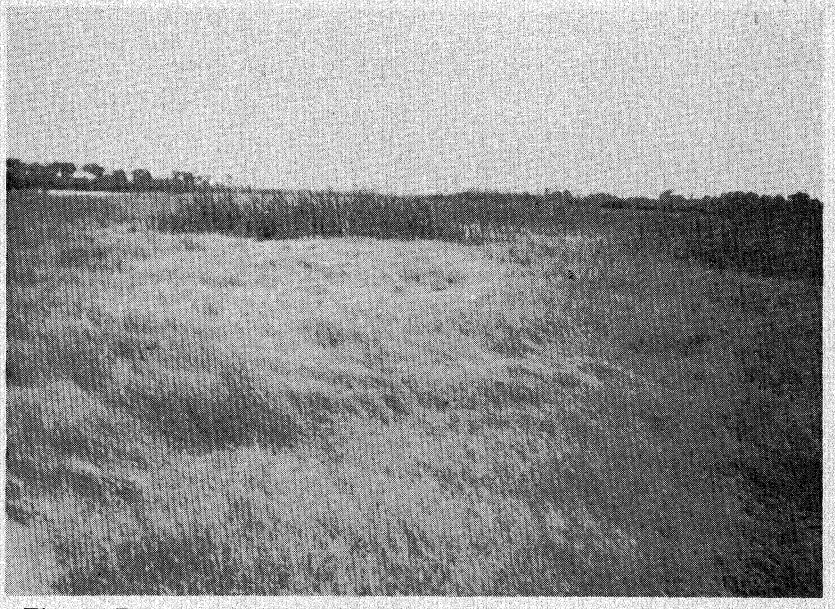


Fig. 4. Zone of Saltgrasses, *Spartina patens* and *Distichlis spicata* along the Big Blackwater River.

Fig. 5. A Stand of the Saltmarsh cordgrass, *Spartina alterniflora.*

grasses, form stands over large areas in the more saline marshes closer to the bay. With these grasses are stands of needle-grass, *Juncus Roemerianus.* These plants do not provide good food for the muskrat, and this type of marsh supports low muskrat populations.

SOME HABITS OF THE VIRGINIA MUSKRAT

The general habits of the muskrat here under study are well known, but certain habits, which make it more difficult to study than the common muskrat elsewhere, are of interest.

Muskrat houses, built in the fall for winter use, (Figs. 6 and 7), seem to be mostly deserted by the end of spring. During the summer and early fall, the muskrats seem to live in temporary, small structures (Fig. 8) or apparently in the open. Smith (1938) found three muskrats sleeping in open nests on the marsh. Two that were examined by him appeared to be diseased and injured. Trappers assured him that these open nests are always occupied by crippled or sick animals. The writer has frequently found these open nests or "forms" in tufts of three-square (Fig. 9). Only one of those found contained a sleeping muskrat which dashed away with the speed and manner of a healthy animal when disturbed. The writer has repeatedly found signs of muskrat activity hundreds of feet from any muskrat structure, and it appears that some muskrats, for a time at least, must live in the open. Such habits of a part of the population render the muskrat hard to study during the summer.

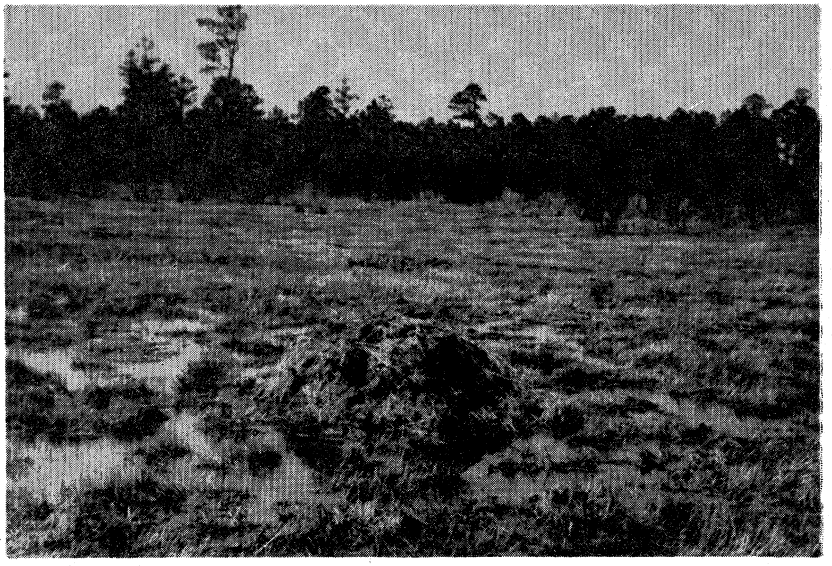


Fig. 6. A Winter Muskrat House on the Blackwater Refuge.

Fig. 7. An Exceptionally large winter Muskrat House. Litters of Young Muskrats are not usually found in Winter Houses.

Fig. 8. A Summer Muskrat Shelter. These and Similar Structures are usually built to protect young muskrats.

Fig. 9. Muskrat "form" in a Tuft of Three-Square Sedge. The object in the "form" is a mouse trap.

Our muskrat leaves little signs to attest to its activity during the hot summer monhs. This also is true of the Louisiana muskrat (Svihla an Svihla, 1931). In the marsh, occasional, scattered spots where muskrats have fed (Fig. 10), and freshly built or recently repaired houses are about the only evidence of their presence. Refuge personnel destroyed the muskrat houses on the No. 1 study area (Fig. 1, "I") just after the trapping season of 1949. During August of the same year, less than 10 muskrat structures, mostly of the summer type, were present on the area together with a little scattered sign of muskrat activity, yet in the late fall, 32 active houses were located.

Fig. 10. Muskrat feeding platform with remains of mussel shells.

The local muskrat appears, from this investigation, to be more shy and wary than the **common** muskrat. The last named muskrat has been live-trapped successfully for movement studies in a number of states. In Iowa, the young have been removed from houses and handled daily with little detrimental effect (Errington, 1939), although recent studies in Wisconsin suggest high mortality after handling. A study of the food habits of the **common** muskrat has been made in Pennsylvania (Grimm, 1941). In Maryland, the muskrat seems to be much more strictly nocturnal than the **common** muskrat (Dozier, 1948). It is rarely observed on the marsh during the daytime. In opening "occupied" muskrat houses, the writer has rarely seen any indication of adult muskrats leaving the houses. Nestling muskrats located in houses were never found at the second visit. In this investigation, a muskrat has never been caught with Rockefeller live-traps, despite the

use of bait, scent, and camouflage. The Gibbs live-trap, developed in Dorchester County, has been successful in trapping muskrats, but a large percentage of them die quickly in the trap. Both this and the family live-trap require special conditions for setting and are not suitable for live-trapping studies on the marshes investigated. In Louisiana, many kinds of live-traps were used, but it was found more practical to catch muskrats by stopping runs and breaking houses (O'Neil, 1949).

MUSKRAT POPULATIONS

The extent of the decrease in the muskrat population, since 1939, may be illustrated by trapping records from a few marshes. The number of muskrats trapped on a marsh from year to year, for reasons given in the introduction, may not reflect the actual muskrat population. However, trapping records will give an adequate index of the larger fluctuations in population level, such as those which have occurred in Maryland.

The catch on approximately 600 acres of three-square marsh bordering the Nanticoke River, given in Table I from the owner's records, reveals an almost continuous drop in the muskrat population after 1943. During 1950, an inexperienced trapper was employed. The marsh was not trapped in 1951. The owner beleives the marsh could have yielded from 400 to 500 muskrats per year during those two years.

TABLE I

MUSKRAT CATCH ON APPROXIMATELY 600 ACRES OF MARSH ON THE NANTICOKE RIVER, DORCHESTER COUNTY, MARYLAND.

Year	*Total Catch*	*Catch Per Acre*
1937	2417	4.0
1938	1875	3.1
1939	2531	4.2
1940	2283	3.8
1941	2065	3.4
1942	2228	3.7
1943	2050	3.4
1944	1370	2.3
1945	1314	2.2
1946 *	1010	1.7
1947	425	0.7
1948	853	1.4
1949	503	0.8
1950	150	0.2

* Marsh frozen much of the season.

Table II gives the catch on 36 acres of three-square marsh situated on the Little Blackwater River, north of the Blackwater Refuge (Fig. 1, "Ra"). The muskrat catch on this marsh has been high and has varied considerably from year to year, showing no definite down-

ward trend since 1940. There is no known reason why this marsh shows such a variable and sometimes high catch of muskrats.

TABLE II

MUSKRAT CATCH ON 36 ACRES OF MARSH (Fig. 1 "Ra") ON THE LITTLE BLACKWATER RIVER, DORCHESTER COUNTY, MARYLAND.

Year	*Total Catch*	*Catch Per Acre*
1940	716	19.9
1941	461	12.8
1942	451	12.5
1943	267	7.4
1944	343	9.5
1945	500	13.9
1946	518	14.4
1947	254	7.1
1948	383	10.6
1949	226	6.3
1950	194	5.4
1951	401	11.1

On the Blackwater National Wildlife Refuge, the yearly count of muskrat houses and the yearly muskrat catch both show the decrease in muskrat abundance (Dozier, 1947). Table III gives the total catch on the refuge (Fig. 1) and the catch per acre of trapped marsh taken largely from Dozier's table. It should be pointed out that from 1944 to the present, only the units with the higher muskrat populations were trapped. The drop in the muskrat population on the refuge has been almost continuous since 1939, and during the last five years trapping has been scarcely worthwhile economically.

TABLE III

MUSKRAT CATCH ON THE BLACKWATER NATIONAL WILDLIFE REFUGE, DORCHESTER COUNTY, MARYLAND.

Year	*Total Catch*	*Catch Per Acre*
1933	6039	1.2
1934	8580	1.6
1935	9290	1.8
1936	22454	4.3
1937	20499	3.9
1938	26286	5.0
1939	21876	5.2
1940	19310	3.7
1941	9895	1.9
1942	6730	1.3
1943 *	4169	0.8
1944 *	1061	1.3
1945 *	2268	2.7
1946 *	1845	2.3
1947 *	3645	1.1
1948 *	2049	1.1
1949	not trapped	
1950	not trapped	
1951 *	1836	2.1

* *Only a portion of the refuge area trapped.*

The house count on the Blackwater Refuge in December, 1949, revealed 1102 houses, the lowest number since records have been taken. Unfortunately, because of the wartime emergency, the U.S. Naval Air Station at Lakehurst, New Jersey, could not supply a helicopter for counting muskrat houses on the refuge as in the past several years. From a subjective survey of the marsh, it appeared that in the fall of 1950 the houses on the refuge were a little more numerous than in 1949. This was confirmed by house counts made on foot on five restricted areas in 1950. The 1950 counts were compared with 1949 counts made on foot and by helicopter on the same areas. These suggestions of a slightly increased muskrat population in 1950-1951 accord with reports from other marshes in the region.

DISTRIBUTION OF MUSKRAT HOUSES ON THE MARSH

There seemed to be relatively fewer muskrat houses in the center of the Blackwater marshes than around their landward edges during the 1949-1950 season. Reports of trappers confirmed this distribution on other marshes of Dorchester County. The division of the Blackwater Refuge since 1940 into sections or units of marshland to facilitate muskrat trapping provides a means of measuring this distribution of muskrat houses.

TABLE IV

DISTRIBUTION OF MUSKRAT HOUSES ON CENTRAL UNITS OF THE BLACKWATER NATIONAL WILDLIFE REFUGE

	Total Number (of houses)	*Percent of Houses (Central Units)*
1940	11179	44.8
1941	6560	36.7
1942	6250	32.7
1943	2575	27.9
1944	2482	26.1
1945	3055	23.9
1946	5185	30.4
1947	3481	31.6
1948	1569	30.0
1949	1437	30.8

Some of the trapping units lie around the edges of the marsh adjacent to high land, and others in the center of the marsh. Fifty-five percent of the original marsh area of the refuge was included in what may be considered as central units. After more marshland was added to the refuge in 1947, and divided into units, 52% of the total marsh area lay in central units. Table IV shows a progressive drop in the percentage of houses in the center units from 45%, in 1940, to 24% in 1945. The percentage increased a little during 1946, to 31%, when the total number of houses on the refuge increased, *i.e.*, and has remained approximately at that level through 1949, in spite of further decreases in the total annual house count.

Although the percentage for houses in the center of the marsh are not strictly accurate, since in some cases the edge units extend into the center of the marsh, they do indicate a progressive decrease in numbers of muskrats in the central portions of the marshes. The growth of three-square sedge is not as dense in the central portions of the marsh as around the edge. Also, more and larger unvegetated areas are present in the center.

REPRODUCTION OF MUSKRATS

The importance of breeding in maintaining a muskrat population has been mentioned. No very exact data have been published on the breeding of our native muskrat. A small amount of breeding occurs during most of the year since embryos may be found in muskrats trapped during January, February, and March. Smith (1938) concludes that most of the young are born from mid-April to mid-September in Dorchester County. Forbes (1942) found that male muskrats collected

Fig. 11. A litter of muskrats a few days old.

from the Blackwater marshes during several years produced sperm in large numbers from the beginning of January until October. The females produce egg cells in numbers from the latter part of February until late October. One trapper indicated that there are three breeding seasons during the year, peaks of breeding occuring during April to June, again in August, and a third in December.

The number of young muskrats per litter is also not well known. Smith (1938) records that 27 litters of muskrats born in pens in Dorchester County averaged three young per litter. Embryos from 10 muskrats trapped in Dorchester County averaged four and four-tenths per female. According to Smith, a marsh owner in Dorchester County found an average of five young in 25 muskrat houses, opened on May 15.

The number of embryos in 95 pregnant muskrats taken in Dorchester County during January, February, and the first half of March of 1950 and 1951 averaged three and nine-tenths per female. There is a significant increase in the average number of embryos per female from January to March. Such an increase in litter size from early in a breeding season to its height is known to occur among many mammals. These data, together with data cited, indicate that usually an average of four to five young per litter my be expected of muskrats in Maryland.

TABLE V

AVERAGE NUMBER OF EMBRYOS PER PREGNANT MUSKRAT TAKEN DURING THE TRAPPING SEASONS OF 1950 AND 1951 IN DORCHESTER COUNTY, MARYLAND

Month	*Number of Females*	*Average Number of Embryos per Female*
January	14	3.1
February	37	3.8
March	44	4.3

The present investigation has supplied no field data on the number of litters produced in a year. Most trappers report that three litters per year are born, but only two per year were produced by captive animals in a study by Smith (1938).

The place where the unborn muskrat is attached by the placenta to an internal sex organ of the female, the uterus, is marked, after the birth of the young, by a dark spot of pigment. These spots, called placental scars, can be seen on the internal sex organ of the female muskrat. Each placental scar indicates that a young muskrat began to develop in the female. Placental scars give an estimate of the extent of breeding that has occurred. Although no experimental evidence has been reported, the general opinion seems to be that placental scars are visible on muskrats during the winter following the breeding season when they were formed. Apparently they fade away gradually, but some may last for longer than a year.

The reproductive tracts of 921 female muskrats were taken from the Gore (Fig. 1, "G") and Robbins marshes, (Fig. 1, "R" indicates a portion of Robbins marshes) during the trapping season of 1950. During the season of 1951, 1709 reproductive tracts were obtained from the Gore, Robbins, and Blackwater marshes. These reproductive tracts were examined for the presence of reproductive scars from which data are given in Table VI.

The female muskrats from which the data were obtained, were grouped by weight, each weight class including about three and one-half ounces. It is noted that in most of the weight classes from comparable areas, more females had reproductive scars in 1951 than in 1950. This indicates that more female muskrats produced young during the summer of 1950 than during the summer of 1949.

TABLE VI

PRESENCE OF PLACENTAL SCARS IN MUSKRATS TAKEN FROM JANUARY 1 TO MARCH 15 IN DORCHESTER COUNTY, MARYLAND.

	COMPARABLE AREAS				ALL AREAS	
	1950		1951		1951	
Approx. Midpoint of Weight Class	*Total Females*	*% with Scars*	*Total Females*	*% with Scars*	*Total Females*	*% with Scars*
1 lb. 10½ oz.	63	6	91	1	160	2
1 14	71	3	94	6	175	6
2 1½	171	15	187	18	312	21
2 5	180	32	152	41	304	50
2 8½	184	56	169	68	303	73
2 12	77	71	75	92	168	93
2 15½	69	91	65	100	113	99
3 3	26	96	14	100	26	96
3 6½	5	100	1	100	4	100
3 10	0	.....	1	100	2	100
3 13½	1	0	1	100	1	100

All of the reproductive tracts obtained in 1950 and those obtained from the Robbins marsh in 1951, were preserved in Bouin's solution, and the placental scars were studied from the preserved tracts. The study of 442 reproductive tracts in 1951 while fresh and again after preservation, revealed that preservation obscured some of the scars. The figures for preserved tracts have been corrected by weight class according to the percentage loss of female tracts with scars in the series of 442 tracts after preservation.

The increase in breeding during the summer of 1950 as compared with the summer of 1949 again is shown by the percentage of adult females with placental scars (Table VII). The females were separated into adults and young according to the development of their reproductive tracts. The data in Table VII show a significant increase in the number of estimated adult female muskrats that reproduced during the summer of 1950 as compared with those that reproduced during 1949. According to the data, there was no unusual number of female muskrats that failed to breed in 1950.

TABLE VII

PROPORTION OF ADULT FEMALE MUSKRATS WITH PLACENTAL SCABS FROM DORCHESTER COUNTY, MARYLAND.

	1950		1951	
	Total Adult Females	*% with Scars*	*Total Adult Females*	*% with Scars*
Gore Marsh	161	81.4	193	94.8
Robbins Marsh	240	87.5	196	95.9
Blackwater			420	93.3

The number of scars per female muskrat also gives some indication as to the extent of reproduction. Since the reproductive tracts sometimes contained much blood in their walls, it was not possible to count scars on all the tracts. The average number of scars per female (Table VIII) were counted on reproductive tracts which afforded good scar counts. The Gore marsh shows a significant increase in the average number of scars per female uterus from 1950 to 1951.

TABLE VIII

AVERAGE NUMBER OF PLACENTAL SCARS PER MUSKRAT UTERUS IN DORCHESTER COUNTY, MARYLAND.

	1950		1951	
	Total Females	*Average per Female*	*Total Females*	*Average per Female*
Gore Marsh	48	7.7	161	10.2
Robbins Marsh	74	8.2	95	8.7
Blackwater	.....	.....	281	9.8
All Marshes	122	8.0	537	9.7

The average for the number of scars per preserved reproductive tract was corrected on the basis of the difference between the average number of scars found in 143 reproductive tracts counted when fresh and again after preservation.

If our evidence of four to five young per litter, and the suggestion of three litters per year are correct, we might expect an average of 12 to 15 scars per female muskrat. The average of approximately 10 scars per female from the Gore and Blackwater Refuge marshes is lower than that expected, and would suggest an average of only two litters per year. It is also possible that the lower than expected number of scars might be due to an average litter size smaller than four or five young, or to a loss of scars during trapping season.

It is well known that when a female muskrat produces young, either she repairs her house and keeps it in repair, or she builds a new house. Thus the selection of houses which contain litters of young muskrats is not entirely a random procedure. Smith (1938) reports a marsh owner of Dorchester County finding 25 litters in one day during May. In Louisiana, O'Neil (1949) found young in 31% of 242 houses opened throughout the year.

As indicated by Table IX, attempts to find litters in houses on the Blackwater marsh gave poor results. Litters (Fig. 11) were found in 12.5% of the repaired houses, or in 7.1 % of all the houses opened. This is a low percentage as compared with the examples cited above. With one exception, all of the litters examined were estimated to be little over a week old. The number of young in 22 litters found in muskrat houses averaged two and four-tenths per litter, with four young, the greatest number, occurring three times. This is a low number compared with the average number of embryos of four or five given above. Some of the young in these litters may have fallen down the plunge hole or may have been dragged down by the mother.

Attempts to recover such young were made as often as practical. The low number per litter may not be completely due to a high death rate among embryos and nestling muskrats.

TABLE IX

NUMBERS OF MUSKRAT LITTERS FOUND IN HOUSES ON THE BLACKWATER REFUGE

	Total Houses Opened	*Houses Freshly Repaired*	*Number Litters Found*	*% of Total Houses with Litters*
April, 1951	135	47	4	3.0
May, 1951	49	17	3	6.1
June, 1950-51	83	74	6	7.2
August, 1951	10	10	1	10.0
Sept., 1950	20	20	7	35.0
Totals:	297	168	21	7.1

All the data presented on reproduction indicate that on the marshes of Dorchester County, the extent of reproduction is somewhat less than that expected for the Virginia muskrat in Maryland. It also indicates that reproduction during 1950 was somewhat greater than that during 1949. Apparently, as a result, more muskrats were caught in 1951 than in 1950.

SEX AND AGE RATIOS OF THE MUSKRAT POPULATION

Of the 6,465 muskrats taken during the trapping seasons, January 1 to March 15, of 1950 and 1951 in Dorchester County, 58% were males. In the five trapped populations during the two years (Robbins, Gore and Blackwater marshes), the proportion of males varied from 52.1% to 64.0%. These data are within the range of sex ratios reported for common muskrats taken during trapping seasons from a number of states (Petrides, 1950). The sex ratio of muskrats taken in Dorchester County does not indicate an unbalanced ratio of male and female muskrats.

The age ratio, the proportion of young of the previous season to older adults, gives an insight into the state of the population. Generally speaking, unless there is high mortality of adults, an increasing population contains a higher proportion of the younger age groups than a stationary or a decreasing population. According to Errington (1940), a low breeding density of muskrats results in high productivity per muskrat. By lowering the population and making room for more muskrats, trapping will produce the structure of an increasing population.

Female muskrats taken in Dorchester County during the 1950 and the 1951 trapping seasons were separated into adult and young age groups according to the development of their reproductive tracts. Methods in use for aging male muskrats in this manner were not

successful in this region. Descriptions of the reproductive tracts (uteri) of young and adult female muskrats have been given by Errington (1939). Uteri of adult females are enlarged and the walls are thickened and contain remnants of groups of blood vessels. Uteri of young females are small, not thickened, and show no remnants of blood vessels.

The figures in Table X show a low proportion of young muskrats in populations trapped in Dorchester County. Proportions recorded by Petrides (1950) for the common muskrat vary from 65% to 88% young in the trapped populations from a number of states. The effect of trapping on the age ratio of a muskrat population may be seen in Table X. The age ratio of the Blackwater population, which had not been trapped for two years, shows a significantly lower proportion of young than the two trapped (Gore and Robbins) marshes for the same year. These data indicated a lower trapping pressure on Maryland marshes than is usually reported for the **common** muskrat on inland marshes and streams, because "harder" trapping would leave room for more young muskrats in the population. In comparison with the **common** muskrat, the local form is a more wary animal and lives in a much more extensive habitat with less opportunity to build bank burrows. For these reasons, it is possible that a high proportion of the population is not usually trapped on tidal marshes in Maryland.

TABLE X

AGE RATIOS OF FEMALE MUSKRAT POPULATIONS TRAPPED IN DORCHESTER COUNTY, MARYLAND.

		Total Females	*% Young Females**	*Estimated Total Young per Adult Females*
Gore Marsh,	1950	346	50.6	2.2
Gore Marsh,	1951	442	56.3	2.7
Robbins Marsh,	1950	582	54.5	3.0
Robbins Marsh,	1951	487	59.1	4.0
Blackwater,	1951	796	47.2	2.0

* Number of young males estimated from percent of young females and from sex ratio.

The low age ratios indicated in Table X are not wholly due to low trapping pressure. They also suggest that mortality other than trapping may be proportionally high for young muskrats in Dorchester County. The total number of young per adult female was calculated from the age ratios (Table X). For the Gore marsh in 1951, the population contained approximately three young per adult female. Table VIII shows that breeding females taken in 1951 from the Gore marsh had an average of 10 placental scars each. The difference between the 10 possible young per female, produced in the breeding season of 1950, and the actual number of three per female in the trapped population of 1951, indicates a mortality of seven young muskrats per adult, breeding female. This mortality is from all causes, including mortality of young before birth as well as after birth.

WEIGHTS OF MUSKRATS

All the muskrats handled, during the 1950 and 1951 trapping seasons, were weighed, usually on the day they were caught. Those damaged by mice, vultures, raccoons, or other animals were not included. The average weights of muskrats obtained in this study are recorded in Table XI.

TABLE XI

AVERAGE WEIGHTS OF MALE AND FEMALE MUSKRATS

		Total Males	*Average Weight*	*Total Females*	*Average Weight*
Gore Marsh,	1950	406	2 lb. 8.2 oz.	350	2 lb. 5.7 oz.
Gore Marsh,	1951	491	2 5.7	449	2 3.6
Robbins "	1951	878	2 6.5	494	2 3.5
Robbins "	1950	789	2 5.8	501	2 2.8
Blackwater,	1951	984	2 5.9	790	2 3.2

The average weight of 13,421 males taken from 1941 to 1945 on the Blackwater Refuge was two pounds and four and three-tenths ounces, and of 10,090 females, was two pounds and one and nine-tenths ounces (Dozier *et al,* 1948). These weights were taken during the drop in muskrat abundance. The average weights for both male and female muskrats taken on the refuge in 1951 are somewhat higher than those reported by Dozier. This may be due to an increased number of older and larger muskrats on the marsh as a result of not trapping for two years, or it may be due to increased food available to the muskrats because of the lower population. Dozier's (*loc cit*) figures do not show a definite trend toward increased average weights during the period, but the weights for 1944 and 1945 were higher than those for 1941 to 1943.

The average weights in this study support the contention of Dozier *et al* (1948) that male muskrats in Dorchester County weigh significantly more than female muskrats.

RELATIONSHIPS OF MUSKRATS WITH RACCOONS AND FOXES

Observations that raccoons commonly travel the marshes and tear into muskrat houses are responsible for the opinion that they have caused the decrease in abundance of muskrats. Many trappers point out that the decrease in muskrats has been accompanied by an increase in raccoons. Other trappers feel that raccoons have always been present and could hardly be a major factor in the muskrat decline. Nevertheless, it seems well establishd that raccoons have increased in numbers during recent years.

During the winter and spring of 1950 and 1951, many areas on the Blackwater Refuge were surveyed to determine the extent of raccoon damage to muskrat houses (Figs. 12, 13 and 14). Table XII

gives, by months, the total number of muskrat structures observed and the proportion of these that were disturbed.

TABLE XII

MUSKRAT HOUSES DISTURBED BY RACCOONS AND OTHER PREDATORS ON THE BLACKWATER NATIONAL WILDLIFE REFUGE.

	Total Houses	*% Disturbed*
March, 1950	327	54
April "	271	58
May "	93	65
December, 1950 & January, 1951	358	19
February, 1951 ...	243	55
March "	213	42
April "	366	67
May "	23	78

No attempt was made to distinguish between the damage to houses caused by raccoons and that caused by other predators. Observations indicate that by far a greater part of the damage was done by raccoons. For this reason, the damage will be mentioned as raccoon damage in this discussion. Structures believed to have been made before the previous fall were not included. Structures were counted as disturbed only if they showed definite signs of being disturbed. Many structures were unoccupied by muskrats at the time the surveys were made. Structures that had been opened by raccoons and recently patched by muskrats could be detected, but those with older patching could not. Hence, the percentages given in Table XII are believed to be minimal.

Fig. 12 Muskrat house showing a number of small holes presumably made by raccoons.

Fig. 13. Muskrat house from which a raccoon was captured.

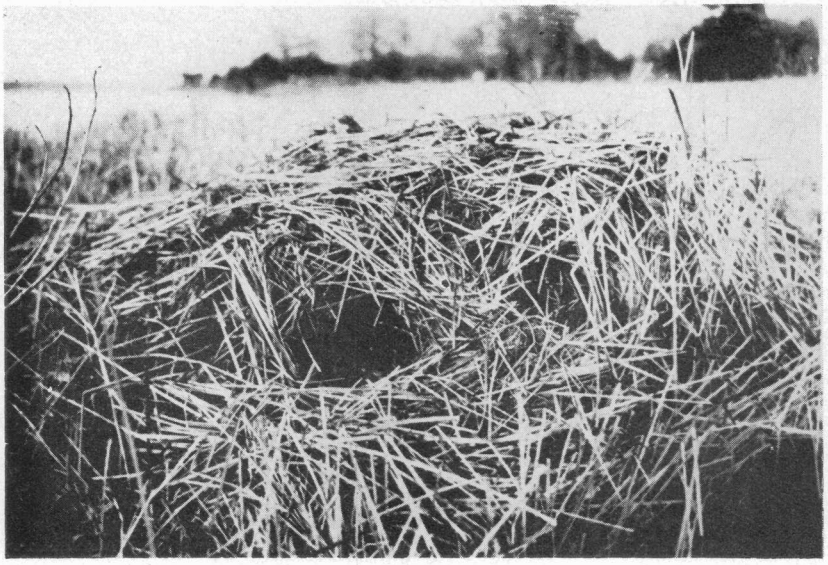


Fig. 14. A resting chamber was made by a raccoon in this muskrat house.

Disturbance occurred to 57% of the structures counted in 1950 and to 46% of the structures counted in 1951. An almost continuous increase in the percentage of disturbed structures is shown from winter to spring, especially for the 1951 figures. This increase parallels the expected increase in the birth of young as the main breeding season is approached.

Some examples of the surveys are interesting. During April, 1951, an area of about 140 acres was surveyed. This area was completely surrounded by water, which at the narrowest point was about 10 feet wide. On the area, 75% of the 55 estimated fall houses had been disturbed, and an estimated 60% of the disturbed houses were severely damaged. Raccoon tracks indicated that the disturbance must have occurred within a period of several nights previous to the survey. The tracks led from one house to the next and did not suggest the presence of more than one raccoon. On one house was found evidence of recent muskrat predation (Fig. 15).

Fig. 15 Muskrat skin on a house in the marsh. Both raccoons and vultures sometimes leave the skin inside-out after feeding on muskrats.

During early May, 1951, a search was made for litters on another refuge area. Most of the few small freshly built houses, in which young muskrats are often found, had been broken into by raccoons.

Two study areas were selected on the Blackwater Refuge (Fig. 1, "1" and "2") to follow closely muskrat activities. The records from these study areas permit some estimation of the effect on muskrats

caused by raccoon disturbance to muskrat houses. Table XIII summarizes the disturbance to muskrat houses on the study areas.

TABLE XIII

DISTURBANCE OF MUSKRAT HOUSES BY RACCOONS ON STUDY AREAS OF THE BLACKWATER REFUGE.

Study Area	*Dates*	*Total Structures*	*Percent Disturbed*	*Average Disturbance Per Structure*
No. 1	Dec.-Aug, '49	90	76	2.0
No. 2	Dec.-Aug, '49	64	56	1.7
No. 1	*Nov.-May,'50	55	75	3.0
No. 2	Dec.-May, '50	61	69	1.7

* Trapped for muskrats during trapping season.

The longer period of observation and the chance to record repeated disturbances accounts for the greater proportion of disturbed houses on the study areas than on the other areas surveyed. Trappers believe that constant human activity on the marshes will drive the raccoons away from the affected sections of the marsh. This seems to be true since very little damage occurred on No. 2 study area (Unit 9), while the marsh was traversed daily by a muskrat trapper during the 1951 season. Less frequent visits seem to have less effect on raccoon activity. Visits were made to No. 1 study area (Unit 3) about every two weeks during 1950, and about every week during 1951, without greatly changing the amount of raccoon disturbance.

Raccoon activity on the study areas seemed to be periodic. On some occasions only a few houses would be opened by the raccoons, but on other visits it appeared that the raccoon had gone from house to house. The evidence from the signs indicated that the disturbances on an area were caused by one or, at most, a few raccoons which covered the area periodically in search of food.

Table XIV suggests some aspects of raccoon disturbance to muskrat houses. The data in the table should be considered with caution, since a muskrat house cannot always be judged as "occupied" or "unoccupied" by muskrats at each visit. However, the data will give a rough estimation of the effect on muskrats of raccoon disturbance to muskrat houses. Raccoons will break into "occupied" muskrat houses more often than into "unoccupied" houses. During a two week period when No. 2 study area was not visited after the trapping season, raccoons disturbed 78% of the "occupied" houses but only 12% of the "unoccupied" houses. A house that is broken into once or more will be deserted by the muskrat somewhat less than half the time. The unknown here is the amount of shifting about from house to house the disturbances might cause. It is apparent that raccoon disturbance to muskrat houses must upset the muskrats at least to some extent, and may have some effect on the population by lowering muskrat reproduction.

TABLE XIV

THE EFFECTS OF RACCOON DISTURBANCE ON OCCUPATION OF MUSKRAT HOUSES.

		Relation of Disturbances (to Occupation of House)		*Relation of Desertion (to Disturbance)*	
		Total Disturbances	*Per cent in Occupied Houses*	*Total Occupied Houses*	*Per cent of Houses Deserted*
No. 1	1950	139	68	44	55
No. 2	1950	61	74	19	42
No. 1	1951	123	75	43	33
No. 2	1951	71	76	35	46

Predation involves another relationship between muskrats and raccoons and foxes. The food habits of raccoons have been studied by the analysis of raccoon droppings and stomachs. Of 219 stomachs secured largely by trapping from July, 1949 to June, 1951, 150 contained food. Fig. 16 records the food items found in these stomachs. Each item of food found in a stomach is recorded as one occurrence, and the proportion of the 150 stomachs containing an item is recorded as the per cent of occurrence of that item. Certain of the food items found as remains in 551 raccoon droppings collected on the marsh are shown by the same method in Fig. 17. Droppings containing no hair or bone were roughly analyzed in the field, hence some food items and traces were not recorded and a complete analysis of the droppings cannot be given.

The difference between the occurrences of muskrat in the stomachs (Fig. 16) and in the droppings (Fig. 17) is noted at once. The low occurrence of muskrat in the raccoon stomachs may be explained, at least partly, by the source of the raccoons. A large share of them was brought in for special bounty. Fish and crabs occur less frequently and corn more frequently in the stomachs than in the droppings that were collected on the marsh. This would indicate that the raccoons from which stomachs were obtained, came from areas close to farms and fields. Even though close to marshes, their food habits would reflect more of an upland diet. Also, raccoons are far more easily trapped along the edge of the marsh than in the marsh, and, thus, are caught approaching as well as leaving the marsh. Trapped animals are not a good source of specimens for food habits study. Unless the traps are promptly attended, the trapped animal may lose the contents of its stomach. There is a tendency for trapped animals to ingest all sorts of dirt and debris in their attempts to get out of the trap.

Trappers frequently ask why the raccoon is found on the marsh if it is not preying on muskrats. Figs. 16 and 17 record items, other than muskrats, that are found on the marsh which form a substantial and probably attractive part of the raccoons diet. Crabs and fish are presumably easily taken by the raccoon in small pools where they can be found after the tide goes down. Other foods, such as snakes, turtles, frogs, birds, and insects also occur in the marsh.

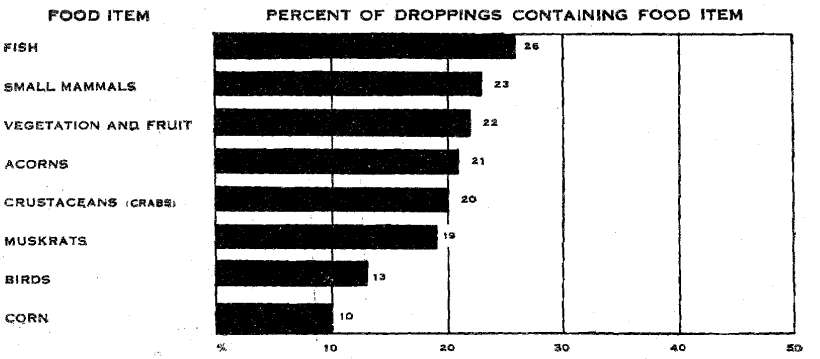


Fig. 16. Percent of occurrence of food items in 150 stomachs of raccoons taken 1949 to 1951, mostly from Dorchester County, Maryland.

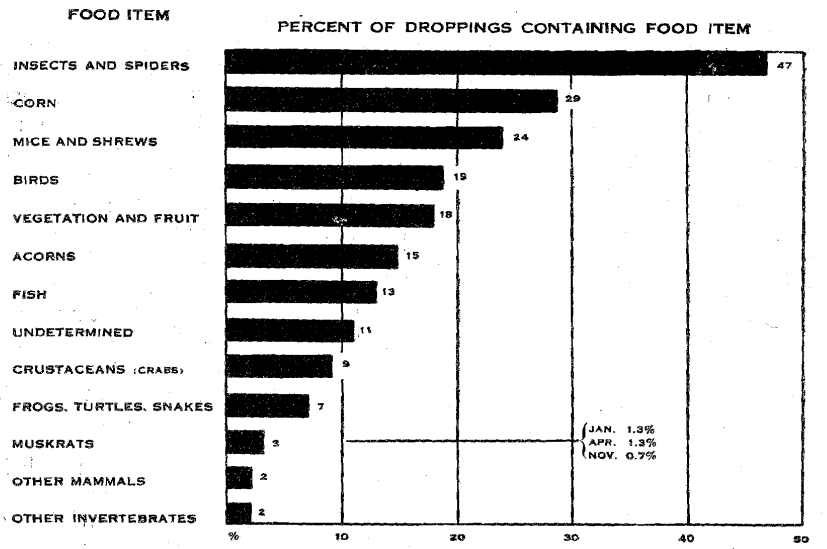


Fig. 17. Percent of occurrence of certain food items in 551 raccoon droppings collected, 1949 to 1951, mostly from the marshes of the Blackwater National Wildlife Refuge, Dorchester County, Maryland.

Small mammals form a food item of the raccoon that is closely linked with the muskrat. Both meadow mice (*Microtus pennsylvanicus*) and rice rats (*Oryzomys palustris*) live in "occupied" and "unoccupied" muskrat houses, meadow mice being the more abundant species. Seventy-one different muskrat structures were trapped for periods of a few days during January, March, and June of 1950. Mice of both species were caught at 48% of these structures. Mice are readily taken by raccoons (Fig. 16 and 17), and may account for much of the latters disturbance in both "occupied" and "unoccupied" muskrat houses.

The 150 raccoon stomachs were taken during the year as follows: 31 in January, 10 in February, 8 in March, 16 in April, 11 in May, 2 in June, 6 in July, 9 in August, 8 in September, 8 in November, 15 in December, and 26 during the winter. Two of the raccoons with muskrats in their stomachs were caught during the muskrat trapping season, and could have taken the muskrats from traps. The other three occurrences of muskrats in raccoon stomachs represent predation or feeding on carcasses since two of the raccoons were taken in April and one in November. It is estimated (because the droppings cannot be accurately dated) that 29% of the 106 droppings containing muskrat remains could have represented scavenging on trapped muskrats.

It was sometimes possible to estimate the size of the muskrat eaten from the remains in the droppings. Of 117 individual muskrats represented in the 106 droppings, 44% were half-grown or smaller.

The extent of predation on muskrats indicated by the present analysis of raccoon food habits has an effect on the numbers of muskrats. The problem is – how much effect? Is the effect so great that it accounts for almost all of the young muskrats born? The marsh is able to provide living conditions for a certain number of muskrats. If more muskrats are produced than the marsh can support, the excess will die in some manner, or will leave the marsh. Predators may feed onlv on the excess muskrats which would be lost to the trapper anyway. Thus, one muskrat saved from a predator does not necessarily mean one more muskrat for the trapper. To determine how greatly raccoon predation effects the muskrat population, we must know how many muskrats and how many raccoons are present on a marsh. An adequate estimate of the numbers of raccoons and muskrats for this purpose would not be a short, easy task. Yet it is necessary definitely to learn the effect of raccoon predation on the muskrat population. A detailed knowledge of raccoons' habits will greatly aid in evaluating their relationships with muskrats.

The analysis of red fox (*Vulpes fulva*) stomachs and of fox droppings indicate a higher degree of predation on muskrats than in the case of raccoons. In a total of 17 red fox stomachs taken from July, 1949 to April, 1951, 10 or 58.8% contained muskrat remains. One fox containing muskrat was taken in July, and nine were taken in May. The 17 foxes included six adults and 11 young of the year.

Muskrat remains were found in 51.9% of 106 fox droppings collected during the period of the investigation. In addition, 26 fox droppings were collected at one time from Bull Point "Island" (Fig.1) in the Blackwater marsh. An estimated 73% of these droppings contained muskrat remains, which composed by bulk 82% of the droppings. The remains in the fox stomachs and droppings were almost entirely those of adult-sized muskrats. The percentages found in this study are somewhat higher than those found by Heit (1944) in the same region. Thirty-nine percent of 95 red fox droppings that he collected from March through August, 1939, contained muskrat.

Although red fox is indicated as a serious predator of muskrats, again we cannot estimate the total effect of this predation on the muskrat population unless the populations of the mammals involved are known.

During the period of this study, 141 barn owl (*Tyto alba*) pellets were examined and one was found to contain muskrat remains. Of 79 pellets, believed to be those of the marsh hawk (*Circus cyaneus*), only one contained muskrat fur. This pellet was taken in a trapped marsh soon after trapping season and probably represented scavenging on a trapped muskrat.

MUSKRAT HABITAT

WEATHER

Climatographs were drawn for each year from 1933 to 1950 by plotting the monthly average temperature against the monthly total rainfall for the Cambridge, Maryland region. No trend or consistent variations corresponding to the changes in the muskrat population could be seen from the climatographs.

WATER LEVELS

As a part of the planned long-term study of muskrats, 24 water depth stations were established on the Blackwater marshes. Water depths have been recorded almost weekly from December, 1949 to June, 1951. These records would have value if continued over a long period of time.

The water level of the Little Blackwater River at refuge headquarters has been taken weekly from 1940 to 1942, and daily since 1943. These records have been graphed, but they show no significant trend in water level fluctuations during that period.

SALINITY

Water samples were taken from the water depth stations on the marsh from April, 1950 to June, 1951. Again, these records have their greatest value over a long period of years.

An objective analysis of salinity records suggest the possibility that salinity of the water in the marsh may be greater in recent years

than earlier. Past records of salinity cover too brief a period to indicate more than a possibility.

VEGETATIONAL CHANGES

Ten permanent quadrats and transects and three long transects (Figs. 1, T1, T2, and T3), were established on the Blackwater marshes. The quadrats and transects will be used for a long term study of vegetational changes.

Dozier, Hotchkiss, and others established 12 permanent quadrats on the Blackwater Refuge, in 1938. Preliminary notes on the plants of these quadrats were made by Mr. Hotchkiss in 1938, and he kindly made them available for the present study. The quadrats were surveyed during the summer of 1950, and show no great change over the period of years.

Comparison of aerial photographs show that non-vegetated areas have increased in extent on the Blackwater Refuge largely between 1938 and 1945. This change was measured by placing a transparent grid over the photographs for 1938 and 1949 and counting separately the dots that touched vegetated areas and non-vegetated areas. Table XV gives the results of these measurements.

TABLE XV

COMPARISON OF PROPORTION OF VEGETATED AREAS AS ESTIMATED FROM 1938 AND 1949 AERIAL PHOTOGRAPHS.

Area	*Aproximate Acres*	*% of area vegetated* 1938	1949
Gore Marsh			
West Hwy. #335	200	97.9	98.2
East Hwy. #335	70	65.7	57.6
*Units 3 and 4	300	65.9	56.2
*Units 10	175	58.8	41.7
*Units 15	200	67.2	53.6
*Unit 9	110	92.4	81.0
*Unit 13B	170	83.0	59.3
Upper Little Blackwater River	75	91.8	76.8
TOTAL	1300	72.6	62.3

* Blackwater Refuge Trapping Unit Numbers.

Although the extent of vegetated area on the Blackwater Refuge has decreased, especially in the center of the marsh, this fact alone might not account for the decrease in the muskrat population. The population decrease has been greater than the decrease in vegetated areas would suggest. Many apparently good stands of three-square sedge, especially around the edges of the marshes, appear now to be relatively underpopulated with muskrats. However, other changes, not readily visible, may have accompanied the changes in extent of vegetated areas. These other changes may have affected the whole marsh, lowering its capacity to support a good muskrat population. Such a factor might be found in a gradually increasing tidal action brought about by ditch-

ing for mosquito control that was carried out on the refuge in the 1930's. One trapper claims that many areas have been opened in this manner and some of the original ditches have been enlarged by tidal action. In this connection, it is interesting to note that the heights of tides in relation to land surface at Baltimore have increased about four inches between 1930 and 1947, according to Marmer (1948).

"Eat-outs" (Fig. 18), caused by the excessive muskrat populations of 1938 and 1939 (Dozier *et al*, 1948), contributed to the decreased extent of vegetated areas. The McGraw Island, Deadwood, and Sunken Island marshes (Fig. 1), extensively destroyed during the high population, have showed little evidence of "coming back" to their original condition.

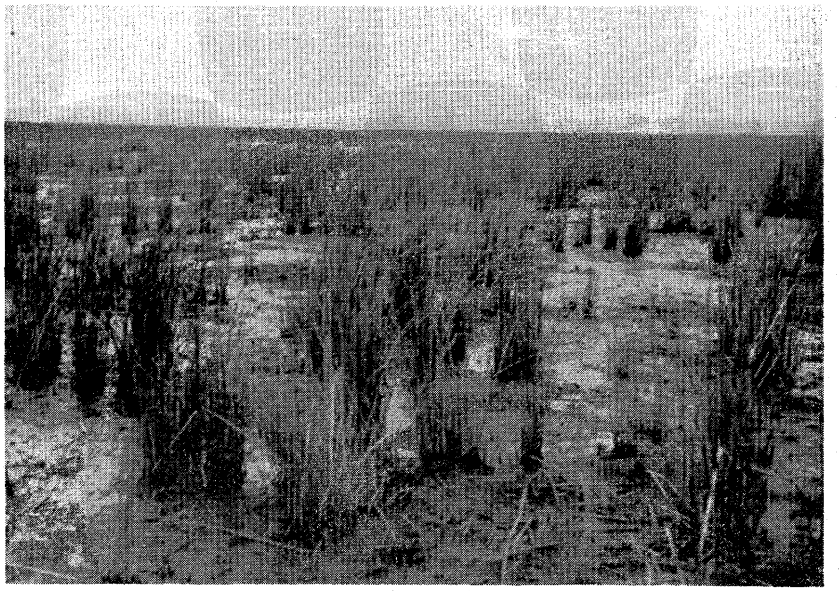


Fig. 18. Open stand of three-square sedge resulting from a local over population of muskrats.

DISEASE

There has been no evidence of epidemic disease among the muskrats of Dorchester County during the period of study, 1949 to 1951. No sick animals have been found. The muskrats examined during trapping seasons appeared to be in good health, and only a few individuals were in a poor condition. Very few external parasites were noted.

DISCUSSION

The muskrat populations that existed on the Blackwater Refuge during 1938, 1939, and early 1940 were excessively high. Trappers state that one could "almost walk across the marshes on muskrat houses." One trapper, who lived in a shack on the marsh during trapping season, claimed that before breakfast he could kill a number of muskrats with a stick in the vicinity of the shack. Other trappers mention that almost every trap would contain a muskrat day after day. Trapping did not, and probably could not, reduce such a population to a safe level. Trappers remember the peak muskrat populations and high catches as a desirable situation again to be attained. However, the high populations were neither desirable nor stable, and according to Dozier (1947), the decline in muskrat numbers was brought about by disease. The greatest catch during this peak population on over 7200 acres of the Blackwater Refuge yielded five muskrats per acre.

The high muskrat population resulted in damage to the marsh, the more severe damage occurring as "eat-outs" on which vegetation has not yet grown back. "Eat-outs" and possibly other factors, such as increased tidal action, have resulted in decreased areas of vegetation on the Blackwater marshes. It is possible that areas not "eaten-out" could have been damaged by high muskrat populations and other causes to an extent that they cannot now support good muskrat populations. This could be true even though these areas, to human eyes, have the appearance of good muskrat marshes. Hence, even the better muskrat areas now existing may have lost some of their ability to support high muskrat populations.

The decreased proportion of houses in the center of the marshes bears out the suggestion of a greater deterioration of habitat there than around the edge. During the 1949-1950 season, muskrats occurred more commonly in the better habitats around the edges of the marsh. These edges support a better stand of three-square sedge, and the water levels are apt to be more stable and the water less saline. The evidence strongly suggests that decreased ability of the marsh to support muskrats is in part responsible for the present low population. Studies by O'Neil (1949) point out that in Louisiana low muskrat populations are a result of previous overpopulation and under trapping.

Data from the present investigation does not permit a measurement of the effect of predation on the muskrat population. Evidence bearing on the problem is presented. Betwen nine and ten embryos per female muskrat were produced during the breeding season of 1950. The high proportions of adults in the trapped populations of 1951 suggest a high mortality among the young muskrats. Relatively few litters of young muskrats were found in houses on the marshes. During periods of low tides, the marshes can be easily travelled by predators, and predators, largely raccoons, disturb and damage a large number of muskrat houses. There has been no evidence that the raccoons are after

dead muskrats in the houses. Raccoons often visit one house after another, paying more attention to the inhabited ones. Certainly if young muskrats are present in a house which has been opened, the raccoon will feed on then. Tearing into such a large proportion of houses would cause a considerable disturbance to the muskrats, and might result in the suggested reduced breeding as well as in mortality to the young through predation and perhaps desertion. All this evidence suggests that raccoons do have an effect on the muskrat population, mainly through young muskrats. The amount of this effect is a problem which needs further study.

Raccoons are probably not responsible for the drop in the muskrat population. Raccoon predation alone is probably not severe enough to hold the population at a low level. However, predation on young muskrats during a low population, together with unfavorable habitat conditions, might prevent a rapid increase in the muskrat population.

SUMMARY

Studies of the local muskrat (*Ondatra zibethica macrodon*) were made from July, 1949 to June, 1951 on the marshes of Dorchester County, Maryland, to learn something of the factors which affect their populations. These extensive marshes are brackish and are subjected to irregular tidal action. The vegetation of the marshes is largely dominated by the three-square sedge.

During a peak population of muskrats in 1938, five or more muskrats per acre were trapped over extensive areas of marshland. The muskrat population has decreased to a point that many marshes could not be trapped profitably since 1939. The proportion of houses in the center of the marsh decreased 20% during the muskrat decline. The drop in the muskrat population was greater in the center of extensive marshes than around their edges next to higher land. There is evidence of a slight increase in the muskrat population during 1950.

The number of embryos in 95 female muskrats taken during two trapping seasons, 1950 and 1951, increased significantly from 3.1 per female in January to 4.3 per female in the first half of March. This and previously reported data suggest that an average of four to five young per litter are born to a female muskrat in this region. The reproductive tracts of 1709 females trapped from three marshes during the season of 1951 were studied for placental scars. The proportions of adult female muskrats on these marshes showing scars varied from 93.3% to 95.9%. The average number of scars per female varied during 1950, these figures represent an increase in breeding during the summer of 1950 as compared with the summer of 1949.

The breeding data collected in 1951 suggests an average of little more than two litters per year. Other possible explanations of the

data may be—fewer than four or five per litter, or a disappearance of scars during the winter.

Few litters were found in houses on the marsh since only 21% occurred, or 7.1% of the 297 muskrat houses opened. The number of young in 22 litters averaged 2.4 per litter.

The proportion of males found in five populations trapped in 1950 and 1951 varied from 52.1% to 64.0%. These percentages are within the range usually reported for the muskrat. The female muskrats trapped in the five populations were divided into young and adults by noting the development of the uterus. The proportion of young in populations, ranging from 346 to 796 females, varied from 47.2% to 59.1%. The figures indicate a low proportion of young muskrats in the population and, together with the number of scars, suggest a high mortality of young.

The average weights of the five populations of muskrats are given. The weights of male and female muskrats on the Blackwater Refuge were significantly higher in 1951 than during the peroid 1941 to 1945. This could be due to (1) increased numbers of larger and older muskrats because the refuge was not trapped during the two previous years, and (2) increased food per muskrat due to lower muskrat populations. The weights of female muskrats were significantly lower than those of male muskrats by two to three ounces.

During the winter and spring of 1950 and 1951, fifty per cent of 1892 muskrat structures were disturbed by predators, largely raccoons, at the time of survey. Studies of marked houses indicate that some muskrat houses may be damaged several times. Approximately 75% of the houses disturbed were "occupied" by muskrats and somewhat under half were deserted after one or more disturbances by raccoons. Raccoons seem to appear on the marsh periodically and one raccoon travels a large area.

Muskrat remains occurred in 19.2% of 150 raccoons stomachs taken during the study. From comparison with droppings it is believed that the stomachs represent more of an upland than a marsh diet. Muskrat remains occurred in 3% of 551 raccoon droppings collected on the marsh. Small mammals of the marsh, fish and crabs were present in the diet of the raccoon in equal or greater frequency than muskrat. Muskrat remains were found in 59% of 17 red foxes stomachs, and in 56% of 132 fox droppings.

The species and relative abundance of plants have changed little on 12 plots established on the Blackwater National Wildlife Refuge in 1938. There has been some increase in the extent of patches of three-square sedge during the last two years in the more saline marshes.

Aerial photographs of the Blackwater Refuge show a decrease in the area of vegetated marsh mainly between 1938 and 1945. This decrease varied from 0% to 24% of representative areas measured on

1938 and 1949 aerial photographs. Damage to the marsh by the previously high muskrat population accounts for at least part of the decrease in vegetated areas. Other factors may also be involved.

Evidence from an analysis of the muskrat population, from the disturbance of muskrat houses, and from the study of food habits indicate that raccoons and foxes affect the muskrat population. The extent of this on the muskrat abundance was not measured in the short time allotted for the study. The combination of predation and a reduced capacity of the marsh to support muskrats may prevent a rapid increase in the muskrat population.

The present study has not solved the problem of the muskrat decline. It has pointed out the complexity of muskrat populations and has formed a working basis for future study. Problems involved in muskrat investigations in this region have been discussed. They are: (1) A long time is required to study adequately the muskrat; (2) More than one person is needed for the studies; (3) Supporting studies from nearby states are few; and (4) More techniques must be developed for the study of the muskrat. The report indicates that future studies of the msukrat should develop practical techniques to measure the effect of predators on the numbers of muskrats and on changes in the marsh which may effect the muskrats.

LITERATURE CITED

DOZIER, HERBERT L. 1947. Salinity as a factor in Atlantic Coast tidewater muskrat production. Trans. 12th N. A. Wildlife Cong., pp. 398-421.

1948. Estimating muskrat populations by house counts. U. S. Dept. Interior, Fish and Wildlife Service, Wildlife Leaflet 306, 17 pp.

DOZIER, HERBERT L., MERLE H.MARKLEY, and LEONARD M. LLEWELLYN. 1948. Muskrat investigations on the Blackwater National Refuge, Maryland, 1941 - 1945. Journ. Wildlife Mgt., 12: 177 - 190.

ERRINGTON, PAUL L. 1939. Observations on young muskrats in Iowa. Journ. Mammalogy, 20: 465 - 478.

1940. Natural restocking of muskrat-vacant habitats. Journ. Wildlife Mgt., 4: 173 - 186.

FORBES, THOMAS R. 1942. The period of gonadal activity in the Maryland muskrat. Science, 95: 382 - 383.

GRIMM, W. C. 1941. The muskrat in northwestern Pennsylvania. Penn. Game News, May, pp. 6-7.

HEIT, WILLIAM S. 1944. Food habits of red foxes of the Maryland marshes. Journ. Mammalogy, 25: 55 - 58.

MARMER, H. A. 1948. Is the Atlantic coast sinking? The evidence from the tides. Geogr. Rev., 38: 652 - 657.

O'NEIL, TED. 1949. The muskrat in the Louisiana coastal marshes. New Orleans, La., La. Dept. of Wild Life and Fisheries. 152 + xii pages. Illus.

PETRIDES, GEORGE A. 1950. The determinination of sex and age ratios in fur animals. Amer. Midl. Nat., 43: 355 - 382.

SMITH, FRANK R. 1938. Muskrat investigations in Dorchester County, Maryland, 1930 - 34. U. S. D. A. Circ. No. 474. 24 pp.

SVIHLA, ARTHUR and RUTH DOWELL SVIHLA. 1938. The Louisiana muskrat. Journ. Mammalogy, 12: 12 - 28.