

LITTER PRODUCTION OF COASTAL NORTH CAROLINA MUSKRATS

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Litter production studies of the Virginia muskrat (*Ondatra zibethica macrodon*) were made from 1951 to 1954 as part of a study of its ecology and management on the tidal marshes in Currituck and Dare counties, North Carolina. The Virginia muskrat inhabits the Atlantic Coast from the upper Delaware Bay to Pamlico Sound, North Carolina. Two color phases occur throughout its range, a black and brown, the latter in most sites being more abundant. During the years of normal yields, Currituck County, center of production in the State, produces about 40,000 muskrats; while in Maryland, more than a million pelts have been harvested. Except for work by Smith (1938) and Harris (1952) in Maryland, no other known litter production studies have ever been made of this race of muskrats.

Since the early 1940s, muskrat production in the tidal marshes of North Carolina has decreased annually. According to fur dealer's reports, trappers harvested about 50,000 muskrats from Currituck and Dare counties in 1941; but in 1954, fewer than 20,000 pelts were taken. Harvest records, kept by the writer for a 1,000-acre marsh owned by the Tice brothers on northern Currituck Sound, show decreases in yields from 958 muskrats in 1947 to 98 during 1951. Since then, no 'rat trapping has been done. Similar population drops occurred on marsh even where there was little or no trapping; namely, the 1,264-acre state-owned Northwest River Marsh — one of the principal study areas in this investigation. Why muskrats failed to increase under near refuge conditions remains an enigma. Food, cover, and water were, in general, plentiful; and investigations disclosed no epizootic. Finally, it was discovered that raccoon predation on litter populations was the factor responsible for the sharp drop in muskrat production. Before this discovery, however, reproduction studies had started. Since sterility was suspected, one of the main objectives of the investigation was to determine if muskrats were having young.

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BREEDING SEASON

Field investigations and weight and sex data obtained on about 12,000 muskrats since 1947 have provided general information on the breeding seasons of coastal muskrats. Uteri studies have also disclosed important facts. The data from these sources indicate that, except during unusually cold winters, some breeding occurs during every month in the year. Breeding activity is believed to be greatest during late winter and spring, usually from mid-February to mid-April, and some years to early May. Mating subsides during hot weather in June and July, but increases some from mid-August through September. Fall breeding appears to be largely

confined to young muskrats that have just attained sexual maturity and a few prolific females.

In Maryland, Smith (1938) concluded that muskrats "breed every month in the year, with the possible exception of November and December." He found that most young are born from mid-April to mid-September. This in general is true in coastal North Carolina. In Louisiana, O'Neal (1949) uncovered evidence of year-round breeding in muskrats. Errington (1937) in Iowa found that most breeding occurs from April to May, while in Maine (Gashwiler 1948) mating among muskrats extends from March through July with peaks in early May and mid-June.

UTERI STUDY

Muskrat uteri came from two sources: the fur shed in Moyock, North Carolina, and the Northwest River Marsh. All reproductive tracts were obtained from animals trapped during the 1952 - 53 and 1953 - 54 trapping seasons. Tracts obtained at the fur shed came from muskrats captured in marshes and ditches in Currituck County. A few uteri came from muskrats trapped in nearby Princess Anne County, Virginia. Professional skimmers at the fur shed received ten cents for each set of embryos, (found while gutting carcasses for shipment as meat to Baltimore, Maryland) placed in water containing 10 per cent solution of formaldehyde. This material was checked at two-week intervals for data on number of uteri and embryo counts. The trapping site and date were recorded for uteri from state marsh along with weight, color, and other pertinent data.

Most reproductive tracts with placental scars were examined when fresh; however, about a dozen were preserved in an 80:20 solution of grain alcohol and glucose. Scars on the uteri of freshly autopsied muskrats show up better than those on preserved material. Best scar counting results were obtained by holding each horn of the uterus in a stretched position in sunlight. The typical placental scar was quadrangular or funnel-shaped, 2 mm \times 3 mm in size and brownish-black in color (Fig. 1). Horns of the uterus in subadults were thin, translucent, and about 1 mm wide; in fertile adults, 2 mm \times 3 mm wide and whitish-gray with occasional tiny capillaries. Uterine horns of sterile adult muskrats were usually flesh-colored and about 2 mm wide. The uteri of animals approaching estrus (heat) were streaked with bloodshot and those in estrus or post estrus were often solid bloodshot. Placental scar on these uteri were too blotched or faded to count.

Arrangement of embryos on the uteri determines accuracy in scar counts. On numerous occasions, especially in prolific females, embryos, of the third or fourth litter became attached in near identical position of previous embryos. This condition causes overlapping of placental scars, makes accurate counting difficult and sometimes impossible. Placental scars on some uteri were faded while others were dark. Dark scars probably represented recent births; faded pigment, winter or early spring litters. Uteri collected from muskrats trapped in December to mid-January usually showed scars more distinctly than those from animals trapped during late January and February. During most winters, placental scars have faded so much by mid-February that they are difficult and sometimes impossible to count. During the unusually mild winter of 1952 - 53, six gravid muskrats were found with the placental scars of the previous year's birth. However, uteri with embryos approaching parturition never contained visible placental tissue. To

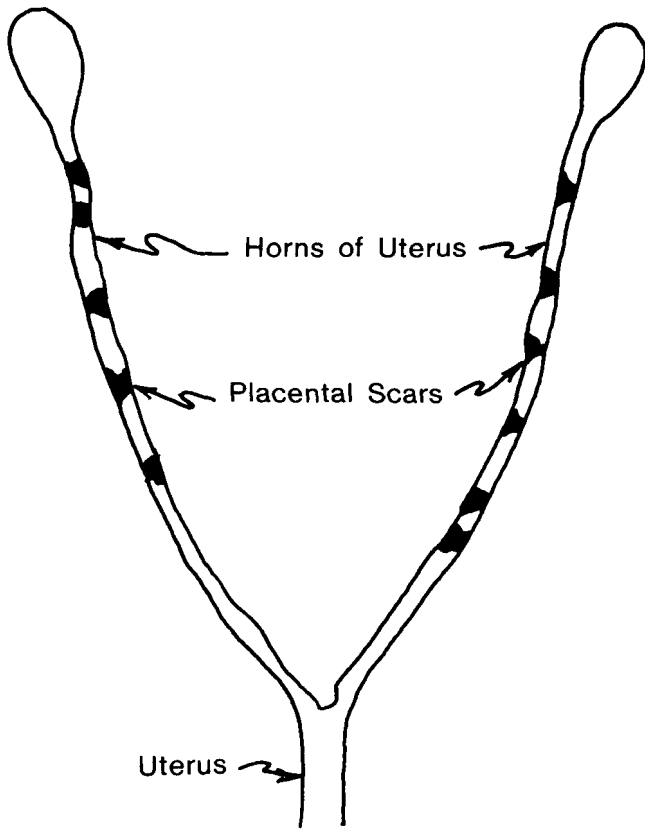


Fig. 1. Uterus of muskrat.

simplify tabulation and interpretation of data, all muskrats were classified under two-ounce weight groups.

Placental Scars

Placental data obtained in 1950 were not considered accurate enough to use. During the two-year study, reproductive tracts of 406 muskrats (weights ranging from 1 pound 4 ounces to 3 pounds 10 ounces) were examined for placental scars. Of this number 234 were adults and 172 were subadults. Of 172 adults autopsied at the fur shed during the winter of 1952 - 53, 140 or 81 per cent were breeders. Among 32 muskrats that did not bear young, 7 were apparently sterile. It is believed that the remaining 25 attained sexual maturity too late in the fall to mate. Uteri collected during the winter of 1953 - 54 contained material from the Northwest River Marsh and the fur shed. The 101 females from state marsh contained 60 subadults and 41 adults, 38 of which were breeders. Three large (2 pounds 14 ounces to 3 pounds 2 ounces) specimens had not borne young and were probably sterile. Forty-two muskrats from the fur shed contained 21 subadults and

21 adults, 16 of which had had young. Five adults without placental scars contained reproductive tracts slightly larger than those in subadults. Pelt primeness patterns, however, were those of mature animals. It is believed that these specimens reached adulthood in early fall, too late to breed. Of the total of 234 adult muskrats examined, there were 194 breeders, 30 non-breeders, and 10 were sterile (Table 1).

Table 2 shows the number of muskrats in each of the twenty weight groups. None of 39 animals in the 1 pound 4 ounce to 1 pound 14 ounce groups bore young and every specimen was a subadult. Eighteen of 19 specimens in the 2-pound group were subadults. The one adult, lightest and smallest animal in the study samples, was a breeder (6 placental scars) while the uterus of the heaviest breeder, a 3 pound 10 ounce brown muskrat, contained scars too jumbled to count. Generally speaking, the number of animals bearing young increased in direct ratio to increases in weight. Of 193 muskrats in the 2 pound to 2 pound 8 ounce weight groups, only 56 (29%) had borne young while 137 (71%) had not. Most specimens in the latter group were subadults. Among 174 muskrats in the 2 pound 10 ounce to 3 pound 10 ounce groups, there were 138 (79%) breeders and 36 (21%) non-breeders. Data in Table 2 (winter, 1953 - 54) show an abnormally large number of non-breeders in the 2 pound 10 ounce to 2 pound 14 ounce weight groups. Of the 34 muskrats in these groups, only 22 (65%) bore young, 1 (3%) was sterile, and 11 (32%) were subadults. Most of the subadults were probably from litters born during the mild winter of 1952 - 53.

Accurate placental scars were made on the reproductive tracts of 149 muskrats; 116 from the fur shed, and 33 from the Northwest River Marsh. The smallest number of placental scars found on any uterus was 2, the largest 23. Fur shed material collected in January 1953 and the winter of 1953 - 54 averaged 10.9 scars and 10.7 scars per female, respectively. Scar counts made on the uteri of 33 animals from state marsh averaged 10.8 (Table 3). The 149 muskrats contained 1,617 placental scars, or an average of 10.9 young per female per year if all the young were born (Table 4). On the basis of weight in relationship to litter sizes, 36 muskrats weighing 3 pounds or more averaged 12.4 placental scars; 45 muskrats weighing from 2 pounds 12 ounces to 2 pounds 15 ounces averaged 11.7; 43 muskrats weighing from 2 pounds 8 ounces to 2 pounds 11 ounces averaged 10; 20 muskrats weighing from 2 pounds 4 ounces to 2 pounds 7 ounces averaged 9.2; and 5 muskrats weighing from 2 pounds 3 ounces averaged 6.6 placental scars (Fig. 2).

Embryos

A total of 206 sets of embryos was collected during the study. Of these, 181 (previous reports include only 180 sets of embryos) were obtained at the fur shed. All embryos were collected during the legal trapping season.

Fig. 3 summarizes data covering the two-year study. Five muskrats, probably first-litter females, contained only one embryo. Commonest litter size was 4. This number was found in 74 animals. Only two of the 206 sets contained six embryos.

Double embryos, i.e., twins, were found in five muskrats and an embryo on one uterus contained triplets. Specimen #1 carried what appeared to be two embryos, one much larger than the other. The smallest held one muskrat; the largest

Table 1. Placental scar data on 406 muskrats from Currituck County.

Source	Winter	Total examined	Adults	% Adults	Sub-adults	% Sub-adults	Adults with placental scars	Adults without placental scars						
								% Sterile	% breeders ^a	% Total				
Moyock Fur Shed	1952-53 ^b	263	172	65	91	35	140	81	7	4	25	15	32	19
Moyock Fur Shed	1953-54	42	21	50	21	50	16	76	0	0	5	24	5	24
Northwest River Marsh	1953-54	101	41	41	60	59	38	93	3	8	8	3	3	7
Total		406	234	58	172	42	194	83	10	4	30	13	40	17

^a Muskrats that reached maturity in late summer or early fall.

^b Placental data previously overlooked (not written up in quarterly reports) were included in this study material.

Table 2. Occurrence by weight groups of placental scars found on the uteri of muskrats in Currituck County.

Weight groups (lbs.-oz.)	Winter 1952 - 53			Winter 1953 - 54			Grand Totals		
	Without scars	With scars	Total	Without scars	With scars	Total	Without scars	With scars	Total
1-4				4		4	4		4
1-6				3		3	3		3
1-8				2		2	2		2
1-10				4		4	4		4
1-12				7		7	7		7
1-14	9		9	10		10	19		19
2-0	131		13	5	1	6	18	1	19
2-2	8	3	11	7	1	8	15	4	19
2-4	21	6	27	12	1	13	33	7	40
2-6	26	14	40	10	4	14	36	18	54
2-8	24	17	41	11	9	20	35	26	61
2-10	11	22	33	4	6	10	15	28	43
2-12	5	24	29	5	7	12	10	31	41
2-14	2	21	23	3	9	12	5	30	35
3-0	2	11	13	1	8	9	3	19	22
3-2	2	10	12	1	6	7	3	16	19
3-4		6	6		1	1		7	7
3-6		5	5					5	5
3-8					1	1		1	1
3-10		1	1					1	1
Total	123	140	263	89	54	143	212	194	406

Table 3. Average number of placental scars per muskrat uterus in Currituck County, North Carolina.

Source	1953		1954	
	Total females	Average per female	Total females	Average per female
Moyock Fur Shed	105	10.9	11	10.7
Northeast River Marsh			33	10.8

Table 4. Placental scar data on muskrats from Currituck County, Winters 1952 - 53 and 1953 - 54.

Weight groups (lbs. - oz.)	No. muskrats with countable scars	Total number of scars	Average number scars
2-0	1	6	6.0
2-2	4	27	6.8
2-4	4	29	7.3
2-6	16	154	9.6
2-8	25	235	9.4
2-10	18	194	10.8
2-12	21	253	12.0
2-14	24	273	11.4
3-0	17	219	12.9
3-2	11	120	11.2
3-4	5	64	12.8
3-6	3	43	14.3
Totals	149	1,617	10.9

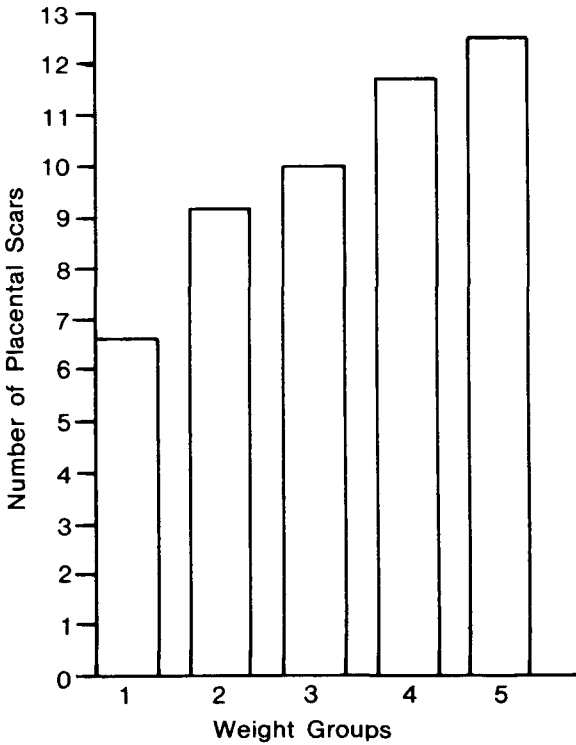


Fig. 2. Average number of placental scars found in 149 muskrats shown in relation to weight groups, Currituck County, winters of 1952 - 53 and 1953 - 54.

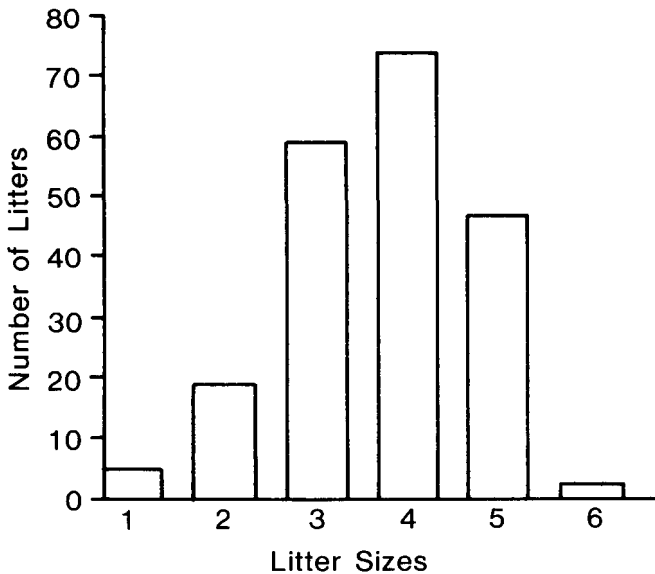


Fig. 3. Numerical sizes of 206 sets of embryos found in muskrats from Currituck County, North Carolina, and southeastern Virginia during the winters of 1952 - 53 and 1953 - 54.

embryo, three muskrats. This raised the count from two to four embryos. Specimen #2 contained what appeared to be two embryos, one on each horn of the uterus. But when opened, two tiny young occupied the membrane of each enclosure. The double embryos raised this litter count from two to four. Specimen #3, typical of specimens #4 and #5, contained what appeared to be four embryos, but subsequent examination disclosed one embryo with twins. This raised the litter size from four to five. Embryo sizes ranged from tiny pea-like bumps to membraneous bodies 60 to 80 mm long. Since about one-third were too small to examine accurately (microscopic examination of small embryos would probably identify the presence of twins), it is possible that a few sets of twins and triplets were missed. What appeared to be resorption of embryos was detected once.

The average size of the 206 sets of embryos was 3.7 (Fig. 3). If adult females in the Currituck Sound locality have an average of three litters, each muskrat must give birth to 11 young per year. It appears that this figure is correct since breeding data on 149 muskrats disclosed an average of 10.9 placental scars or about 11 young per animal per year.

The number of embryos in 95 pregnant muskrats autopsied by Harris in Maryland averaged 3.9 per female. There was a noticeable increase in the average size of litters from 3.1 in January to 4.1 in March. This occurred in the North Carolina study. It was not considered significant, however, because the 3.7 average for 206 sets of winter embryos was larger than the average litter found in muskrat houses.

The uteri of 234 adult muskrats were examined for embryos during the study; 172 in January, 1953 and 62 during the winter of 1953 - 54. The winter of 1952 - 53 was mild, while the winter of 1953 - 54 was colder than average. And this fact

was reflected in the results. Uteri of the 172 specimens contained 19 sets of embryos or one pregnant animal for every eight adult muskrats. On the other hand, uteri of 62 specimens collected during the cold winter of 1953 - 54 contained only three sets of embryos or one pregnant animal for about every 21 adult muskrats (Table 5).

LITTER STUDY

All litters reported in this study were located in muskrat houses and most of the young were found on the Northwest River Marsh and Tice marshes in Currituck County and the Pea Island National Wildlife Refuge in Dare County on the "Outer Banks." Raccoon predation on nestling muskrat populations (associated with large-scale digging in houses) in 1951 and 1952 precluded systematic study on state marsh. Attempts were made to locate litters in 1953 when time could be spared from other duties and data gathered in 1954 were obtained on the writer's time or while engaged in other work.

An early study objective was to gather growth rate data on muskrats from birth to maturity. This work started on state marsh. During April, 1951, five houses containing recently born young were under observation. Subsequent examination for tagging of the young disclosed that all five houses had been dug open by raccoons and the young muskrats were missing (Wilson 1953). Additional attempts to tag and recapture young muskrats for growth data failed also because raccoons apparently ate them first. By May, 1951, raccoon damage to houses became even worse; and in June, for lack of litters to tag, the study was stopped (Table 6).

Despite raccoon depredations, periodic house checks for litters were continued. On state marsh from April through August, 1951, a total of eight litters was found in 89 occupied houses — more than 90 per cent of these houses had been previously ravaged by raccoons. Similar studies during the summer of 1951 on Tice marsh about six miles south on Northern Currituck Sound revealed three litters in 21 houses. Raccoon damage to dwellings equalled that on state marsh. Of 62 houses opened on state marsh in the spring and summer of 1952, only one contained a litter. An effective method of raccoon control was applied too late to save many litters. During the same year on Tice marsh, none of the 49 houses contained litters. By 1953, results of raccoon control on state marsh were evident in greatly increased muskrat populations. Only 14 houses were opened but three contained young. Of 21 houses opened late in April, 1954, five contained young. On April 15, 1953, none of ten houses on Tice marsh contained litters, but every one had been dug open by raccoons. Control measures were taken immediately. On April 28, thirteen days later, the same houses were opened again. Four contained litters. Only two dead raccoons were located, but not one house was damaged. During the spring of 1954, an examination of 90 houses on the same area revealed 19 litters (Table 6).

Of 112 houses opened on state and Tice marsh during 1951, 11 supported litters; and in 1952, only one litter was found in 121 houses. During this two-year period, practically every occupied house was ravaged by raccoons. Effective racoon control in 1953 and 1954 stopped the destruction. Among 34 houses opened in 1953, 4 (21%) contained litters; and in 1954, 111 houses held 24 (22%) litters. These house-litter ratios compare favorably with similar data for Pea Island where almost no raccoons occur. Tracks of at least two raccoons were seen in May, 1954 on the Pea Island National Wildlife Refuge.

Table 5. Pregnancy ratios for 234 adult muskrats from Currituck County. Data in this table represented only by visible embryos.

Winter	Number pregnant	Number not pregnant	Total number examined	Pregnant non-pregnant ratio	Comments
1952-53	19	153	172	1 to 8	Mild winter except for week or two in December
1953-54	3	59	62	1 to 21	Coldest winter in three years, Northwest River froze over once; coldest in January — no snow all winter.

Table 6. Number of muskrat litters found in houses on marsh in Currituck County before and after raccoon control. Ten random litters were found on other marsh in the county to bring the total to 53.

Year	Season or month	No. of houses opened	No. of houses with litters	% houses with litters		Comments
				Before raccoon control	After raccoon control	
Northwest River Marsh						
1951	Spring and Summer	89	8	9		Scores of houses dug open by raccoons.
1952	Spring and Summer	62	1	2		Raccoon damage to houses worse than in 1951.
1953	Spring	14	3		21	Found litters in May. Noticeable increase in muskrat sign. No raccoon damage to houses.
1954	Spring	21	5		24	Litters located late in April. Raccoon damage to houses almost nil.
Tice Marsh						
1951	Summer	23	3	13		Raccoon damage to muskrat houses as bad as on state marsh; 2 of 3 litters found on Bray Island where no houses were damaged.
1952	Spring and Summer	49	0	0		Heavy raccoon damage to muskrat houses.
1953	April 15	10	0	0		All of 10 houses ravaged by racoons. Initiate raccoon control measures immediately.
	April 28	10	4		40	On 13th day following start of raccoon control a check of same houses revealed no damaged houses, 2 dead racoon and 4 litters of mice-size young.
1954	Spring	90	19		21	Big increase in muskrat populations. No racoon damage to houses. Most litters found between April 15 and 30.

During the four years covered by this study, accurate counts were obtained on 108 litters of muskrat: 53 from Currituck County and 55 from Pea Island. Among the Currituck County material, the commonest litter size was three. This occurred 14 times. Litters with one young were found three times. Seven litters contained six young and one litter held seven. The average litter size was 3.6 (Fig. 4). Of the Pea Island litters, seven contained one, 10 contained two, 19 held three, and 12 litters had four young. The largest litter size was five, found seven times. Average size of the 55 litters was three (Fig. 5). Over-population (the refuge is not trapped), relatively sterile soil, and a general lack of high quality foods probably contribute to the small size of litters (Table 7).



Fig. 4. Numerical sizes of 53 litters of muskrats from Currituck County, North Carolina.

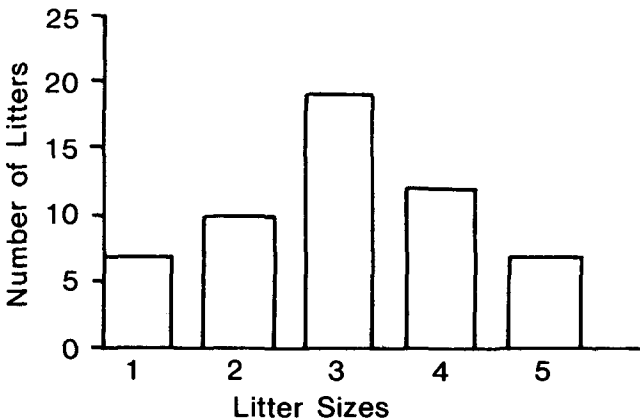


Fig. 5. Numerical sizes of 55 litters of muskrats from the Pea Island National Wildlife Refuge, Dare County, North Carolina.

DISCUSSION

Breeding data for Currituck County are believed to represent the true potential productivity for coastal North Carolina muskrats, i.e., an average litter of about 3.7, three litters and about 11 young per female per year. Production data obtained by Harris in Maryland for the same race of muskrat "suggests an average of little more than two litters per year." This conclusion appears to be partly based on placental averages, 8 and 9.7 per female for 122 and 537 muskrats, respectively, and other data that suggest an average litter of four to five young. Twenty-seven pen-raised litters recorded by Smith (Maryland) average three young per litter and a maximum of two litters per year. In Louisiana, embryo counts made by Arthur (1931) on 1,058 pregnant muskrats (*Ondatra rivalicia*) averaged 3,185 per litter. O'Neal, from the same state, located 75 litters that averaged 3.22 young. In Iowa, 158 litters of *Ondatra zibethicus zibethicus* handled by Errington (1939) averaged 6.5 young. Sixty-two litters studied by Gashwiler in Maine averaged 5.4 muskrats. O'Neal in Louisiana "estimated that the adult female have approximately five to six litters of young each year and is evidently capable of having seven to eight litters." Errington in Iowa and Gashwiler in Maine found that most muskrats average two litters annually, though a few specimens have three litters. According to these sources of information, North Carolina muskrats have fewer litters than Louisiana muskrats, though litter sizes are about the same. Iowa and Maine muskrats have fewer litters, but total average production is slightly larger than that for North Carolina. Raccoon depredation on nestling muskrat populations in Maryland handicapped Harris and his data on production are not conclusive.

Harris' placental study on Maryland muskrats gives data on the average number of scars per female but no details for individual animals. Uteri data on 194 North Carolina muskrats revealed five specimens with between 20 and 23 placental scars. The latter number of scars was found on the uterus of a 3 pound 2 ounce black muskrat. To have had 23 young from three matings, litters containing seven, eight, and eight would have been necessary. Since only one of 311 sets of embryos and litters contained seven young, this was not likely. The muskrat with 23 scars and the other prolific females probably had four or five litters. Since breeding occurs during every month of the year, it is possible that some of these animals gave birth to six litters. It bears repeating that during the winter of 1952 - 53 the writer found visible scars of the previous season's births on the uteri of pregnant muskrats. No scars were ever found, however, on the uteri of animals where fetuses approached parturition.

O'Neal found muskrats in the kit stage (six to eight weeks old) carrying embryos (1949, p. 60). It is assumed, though the author does not say so, that most young females are breeding at six months. Errington (1939) in Iowa found no evidence of litters in kits and noted that muskrats nearly seven months old were sexually immature. Each year in North Carolina, a few subadult female muskrats are found weighing up to 2 pounds 12 ounces. These animals have never been examined histologically but were judged sexually immature by the appearance of genital organs and pelt primeness patterns. The number of months between birth and sexual maturity is not known for male or female muskrats. It is believed, however, that very few females breed or have young before one year old.

Gashwiler was not sure how long placental pigment remained visible on the uteri of Maine muskrats and Harris in Maryland suspected that the scars in some muskrats disappeared during the trapping season, January 1 - March 15. Placental studies of 175 North Carolina muskrats disclosed only a small amount of scar fading during cold winters, but a considerable amount during mild winters. The winter of 1952 - 53 was mild. Every one of 50 reproductive tracts examined between January 1 to January 12, 1953 contained countable scars. But of 54 muskrats with countable scars examined from January 19 to January 31, 22 or 41 percent were to faded or blotched to count. It is recalled that during this winter one of every eight adult females examined was pregnant. Weather during the winter of 1953 - 54 was consistently cool from mid-December through February. The scars of two December uteri were too faded to count; but all of 13 uteri from February rats contained countable scars (Table 8), though most of them were in various stages of retrogression. No reproductive tracts of muskrats taken in late February and March were examined. If material had been available, it is doubtful that the placental data would have been clearly defined enough to count.

The study failed to pinpoint all the year-round dates of peak production. Embryo data obtained at the fur shed proved that young are born during the winter and early spring. Too few houses were opened during this time of year, however, to find any litters. From mid-April through May is the period of heaviest production annually (Tables 6 and 7). Parturition during the summer apparently drops off sharply. This was especially noticeable on Pea Island during early summer 1952. On May 27 of that year, 16 of 67 houses contained litters. One month later on June 27, 57 of the same houses were broken again. This time only one litter was found. In July, 1951, 17 houses opened on Pea Island contained only two litters. There is evidence (mostly obtained from placental, muskrat weights, and pelt primeness data) of a minor peak production in September and early October and a few litters during remainder of the fall.

SUMMARY

Production studies of the Virginia muskrat were conducted from 1951 to 1954 in Currituck and Dare counties, North Carolina.

Except during unusually cold winters, coastal muskrats breed the year-round. Period of greatest breeding activity is from mid-February to early May. Another but smaller breeding peak occurs in August and September. April 15 through May is the period of heaviest production.

Among 406 female muskrats, 234 were adults and 172 were subadults. Of the adults, 194 produced litters, 30 matured too late to have young, and ten were sterile. Smallest specimen with placental scars weighed 2 pounds, the largest 3 pounds 10 ounces. Production increased in direct ratio to weights; from an average of 6.6 young in the 2 pound to 2 pound 2 ounce weight groups to 12.4 young per muskrat weighing 3 pounds or heavier. Scar counts on 194 uteri averaged 10.9 or about 11 young per muskrat per year if all the young were born.

The average litter size of 206 sets of embryos was 3.7. Smallest and largest litter sizes were 1 and 6, commonest litter size 4.

Among 108 litters of muskrats, 55 came from the Pea Island National Wildlife Refuge, Dare County, on the "Outer Banks," and 53 from Currituck County. Pea Island litters averaged three and Currituck County litters, 3.6.

Table 7. Number of muskrat litters found in houses on marsh in Dare County void of raccoons. Tracks of at least two raccoons seen on May 11, 1954.

Year	Month	Number of houses opened	% houses with young	Number of houses with young	Comments
Pea Island					
1951	July	17	2	12	Very hot in late spring and early summer. Production down.
1952	May	67	13	20	Litters found May 27. About ten houses contained young. I could not catch or count.
1953	June	57	1	2	Same houses one month before contained 15 litters.
	Feb.	26	0		Litter of young 3 or 4 weeks old scrambled from a nest in one house.
	April	50	5	10	Litters found April 2 and 3. Period of heavy production ahead.
	May	74	21	27	Houses opened May 7. About half the litters appeared to be 10 to 14 days old and born late in April.
1954	May	64	13	20	Houses opened on May 11.

Table 8. Comparative rates of placental fading in muskrats trapped during mild and cold winters. Uteri of pregnant muskrats not included.

Date examined	Total number uteri	Number of uteri with countable scars	%	Number of uteri with non-countable scars	%	Comments
1952 - 53 ^a						
1/6	25	25	100			All scars distinct.
1/9	13	13	100			
1/12	12	12	100			
1/19	13	12	92	1	8	A few uteri streaked with capillaries.
1/26	45	33	74	12	26	Some fading. Counted scars on all but one uterus.
1/31	18	9	50	9	50	Most of the uteri in these study samples showed some placental fading or bloodshot; this was especially apparent in the Jan. 31 material.
Total	126	104		22	17	
1954 - 54 ^b						
12/23	13	11	85	2	15	Scars clear and distinct.
1/1 - 1/15	10	10	100			
1/16 - 1/31	13	10	77	3	23	Scars on most uteri show little or no sign of fading.
2/1 - 2/15	13	13	100			First stages of fading seen on about half these uteri.
Total	49	44		5	10	

^a Winter mild.

^b Winter cold.

Muskrat tagging and growth studies were abandoned in 1951 on state marsh because of severe raccoon depredation to nestling populations. Raccoon control during 1953 and 1954 has restored muskrat populations on the Northwest River Marsh and Tice Marsh, but populations in the remainder of Currituck County continue to remain low.

Litter production data proved that muskrats in coastal northeastern North Carolina are not sterile and that the current low yields from tidal marsh in Currituck County are the result of raccoon predation on nestling muskrat populations.

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