SEX RATIOS, MORPHOLOGY AND CONDITION PARAMETERS OF MUSKRATS IN EAST TENNESSEE

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ABSTRACT

Muskrats (Ondatra zibethicus) *were collected from river and creek study areas in East Tennessee from July 1972 to June 1973. An imbalance in sex ratios was found to be seasonal and an overall sex ratio approaching 1:1 is likely the actual case.*

Significantly heavier body weights of river versus creek animals likely reflects the more abundant and/or higher quality food supply present on the river than on the small creek.

Adult male muskrats from the river tended to exhibit expected patterns of deposition and utilization of internal body fat, with increased fat levels from spring through fall and decreased amounts from winter to spring. Nonpregnant females exhibited a decrease in body fat from winter through summer while fat deposition occurred in pregnant females from spring to summer. Adults of the river contained more internal body fat than their creek counterparts over the winter, again indicating the better nutritional conditions on the river study area.

Adrenals of adult male muskrats reached maximum weights following the cessation of the breeding season. Adrenal weights of nonpregnant adult females were at maximum values during the early breeding season.

The distribution of the muskrat includes most of North America. Sixteen subspecies constitute the total range, with *O.z. zibethicus* Linnaeus being the only subspecies present in Tennessee (Hall and Kelson 1959). Previous studies on the muskrat cover a broad spectrum of subjects and objectives. Various aspects of trapping and tagging, external and internal sex determination, and aging techniques utilizing various skeletal and pelage characteristics have been researched in depth. Regionally, muskrat populations have been studied with respect to habitat preferences, food habits, reproduction, seasonal population movements and fluctuations, the limiting influence of decimating factors, and various aspects of management and reactions to environmental stress. However, studies performed in different continental locations involve different subspecies of the muskrat, each possibly with its own demographic, morphological and physiological characteristics.

Generally, previous researchers have relied upon trapper-supplied carcasses from late fall, winter, and early spring. The present study monitored sex ratios, physical characteristics, and condition parameters on a year-round basis. Winter data were compared to determine if differences exist between populations of river and creek muskrats in East Tennessee.

This study was supported by funds made available through McIntire-Stennis Project No. 11 of the Department of Forestry, Agricultural Experiment Station, and the Graduate Program in Ecology, The University of Tennessee, Knoxville.

METHODS AND MATERIALS

Muskrats (215) were obtained from the Holston River within Sullivan and Hawkins Counties from July, 1972 to June, 1973 (Table 1). Creek muskrats (145) were obtained from Knox and Blount Counties during the legal trapping season, 15 November 1972 to 15

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February 1973. Comparisons of sex ratios, physical measurements and condition parameters were made between the corresponding river and creek samples. Details of methods and materials are presented by Schacher and Pelton (1975).

Muskrats collected from the river were obtained as whole specimens; they were weighed on a Mettler P3 Analytical Balance to obtain total weight (TW). Body measurements included the standard taxonomic measurements (TL-T-E-HF). Animals were then skinned in the conventional manner and the pelt was stretched, dried, and used as an aging technique (Applegate and Predmore 1947). The above measurements could not be taken on the creek sample as the pelt was removed and the tail was severed by the trapper. Therefore, the carcass weight was obtained from the Mettler P3 Analytical Balance. Carcass weights were also recorded from the river muskrats during the December through February (winter) period for comparative purposes.

Upon dissection, sex and age determination was verified by examining the reproductive tract. The right and left adrenal glands were excised, weighed, and preserved in Mossman's AFA for future reference. For each specimen, internal body fat was recorded as high (3), medium (2), or low (1). Mean values for fat were calculated for each group of adults (i.e. segregated by sex and by season) on the basis of their fat value assignment (1, 2, or 3) to indicate the general condition of the sex for that season. High internal body fat was assigned when the adrenal glands were imbedded within fat in association with the kidneys. Medium internal body fat was assigned when the adrenal gland was visible, yet separated from the kidney by fat deposit, and low internal body fat was assigned when the adrenal gland was separated from the kidney by little or no fat.

Data from the river population were compiled and analyzed as monthly or seasonal samples and the means, and maximum and minimum ranges of all pertinent variables were plotted over the collection year. Winter data from river and creek animals were segregated into sex, age, and population units (i.e. adult male creek, adult male river, adult female creek, adult female river) for comparative purposes.

An "F Test" (Steel and Torrie 1960) was performed to determine any significant differences between the variances (σ^2) of appropriate creek and river variables. A pooled variance was used in the "t test" to compare means. For those comparisons with significantly different (5% probability level) sample means, an approximate t value was calculated for comparison. Statistical analysis of data within and between monthly age and sex categories could not be computed due to the restricted sample size for these monthly categories (Table 1).

Table 1. Sample sizes by months and seasons for muskrats collected from the creek and river study areas in East Tennessee.

	River samples					*Creek samples*			
Month	*Adult males*	*Nonpregnant adult females*	*Pregnant adult females*	*Subadult males*	*Subadult females*	*Adult males*	*Nonpregnant adult females*	*Subadult males*	*Subadult females*
December	2	3	—	6	5	11	2	7	10
January	6	5	—	—	—	37	21	4	6
February	15	5	—	—	—	29	17	—	1
March	18	4	—	—	—				
April	14	2	2	—	—				
May	9	6	6	1	—				
June	10	7	1	6	4				
July	4	3	3	5	3				
August	5	5	1	1	—				
September	3	7	—	8	2				
October	1	4	—	2	1				
November	7	2	—	8	2				

RESULTS AND DISCUSSION

Sex Ratios

The sex ratio for muskrats of the river was 156 males : 100 females. The adults in this sample exhibited a ratio of 142 males : 100 females, while the sex ratio among subadult muskrats was 206 males : 100 females.

The sex ratio of muskrats from the creeks was 154 males : 100 females. The adult sex ratio was 193 males : 100 females. The subadult sex ratio determined during the December to February (winter) trapping period was considered invalid because of the problem of accurately aging this group of transitional animals due to the approaching breeding season (Schacher and Pelton 1975). The combined muskrats of the creeks and river yielded an overall sex ratio of 155 males: 100 females with a combined adult sex ratio of 161 males : 100 females.

There is considerable speculation in the literature regarding the preponderance of male muskrats as a result of winter and early spring trapping. Buss (1941) quotes Errington (1940), "It has long been known that male muskrats may, to a considerable extent, be taken selectively by trapping in spring."

Donohoe (1966) suggests that the preponderance of males is due to differential mortality, heightened activity by the males, or trap-shyness of the females. Neal (1968) states that ". . . apparently differential mortality acts against the female before the age at which they are susceptible to trapping." In the opposite view, Hewitt (1942) and Smith (1938) indicate that females are more active in the late winter and spring, thus causing more of them to be captured.

Our data support the viewpoint that males are more frequently captured during the late fall, winter and early spring months. Sampling of both the creek and river areas resulted in a consistent imbalance in favor of males trapped throughout the legal trapping period in Tennessee, November through February (Table 1). However, the ratio of males to females over the remainder of the year (except June) illustrate that a larger percentage of adult females is consistently collected. It appears that the bias toward the selective trapping of males is a seasonal bias, reflecting a behaviorial change in the muskrats and not a true imbalance in the sex ratio of the population. The above data indicate that the sex ratio may indeed be much closer to 50:50 than is commonly inferred from the results of earlier workers.

Total Weights and Carcass Weights

In the present study the weights of the adult muskrats were analyzed according to the following seasons: winter (December, January, February), spring (March, April, May), summer (June, July, August) and fall (September, October, November) (Table 2). Mean weights ranged from 1221 g for nonpregnant adult females collected in winter to 1460 g for pregnant adult females collected in summer. The largest animal collected was an 1859 g adult male. Reports of the body weight of muskrats are abundant in the literature; the body weights of muskrats from our river area exceed most previously reported weights. Dozier (1945) described a mean weight of 3.6 pounds (1644 g) for muskrats collected on the Montezuma Wildlife Refuge in New York. However, Alexander and Radway (1951) followed up this series of weights on the refuge and noted a steady decline in average weights over a period of years, with eventual stability achieved at approximately 3 pounds (1361 g).

Table 2. Total body weights of river muskrats collected on the Holston River in East Tennessee.

	Pregnant adult females			*Nonpregnant adult females*			*Adult males*		
Season	*n*	$\bar{x}$ *Weight (g)*	*SE*	*n*	$\bar{x}$ *Weight (g)*	*SE*	*n*	$\bar{x}$ *Weight (g)*	*SE*
Spring	8	1422.9	±74.9	12	1288.4	±53.2	40	1305.8	±29.9
Summer	5	1460.0	±67.8	15	1352.1	±55.9	19	1336.6	±28.1
Fall	—	—	—	13	1241.3	±42.9	11	1307.5	±51.5
Winter	—	—	—	13	1221.3	±54.2	23	1325.8	±45.9

Since total body weight could not be obtained for the creek muskrats, carcass weights were recorded. Carcass weights were also determined for the corresponding river muskrats (December through February). The carcass weights were significantly different between areas (5% probability level) for both the adult females and adult males. Carcass weights of 23 males from the river averaged 986.9 g, compared to 825.5 g for a sample of 77 creek males. Similarly, 13 river females ($\bar{x}$ = 961.7 g) were significantly larger than the 40 creek females ($\bar{x}$ = 829.9 g). Highby (1943) reported a mean carcass weight of 923 g for adult males and 877 g for adult females; his data are intermediate between the values of the creek and river populations of the present study.

Dozier (1950) states he found a "direct correlation between size and weight of muskrats and the quality and abundance of food present." The muskrats from the Holston River are among the heaviest of any previously reported in total body weight, exceeded only slightly by muskrats from the Montezuma National Wildlife Refuge of New York. Similarly, in the present study, the carcass weights of the river muskrats far exceed those of the creek muskrats. The adult males of the river area were 16 percent larger than their creek counterparts, and the adult females of the river area proved to be 14 percent larger than their creek counterparts. The above data indicate that the habitat of the Holston River is apparently superior in nutritive quality to that of the creek habitat (Schacher and Pelton 1975) and this is in turn reflected in body size of muskrats from the two areas. McCann (1944) substantiates the above in stating that carcasses collected in different areas varied considerably in weight, with river-bottom type habitat usually producing the largest carcasses in Minnesota. This condition, whereby man's influence causes artificial increases in fertility resulting in increased nutritive quality, and, hence, body size, may alter the expected relationship between body size and latitude (i.e. Bergmann's Rule). As man plays an increasing role in manipulating his environment, the relationships between such factors as soil-water fertility and genetics and body size become increasingly complex.

Internal Body Fat

The only previous quantitative measure of body fat for muskrats was presented by Dozier (1945). In describing his series of muskrats from the Montezuma Wildlife Refuge in New York, he states that as much as 8 oz (227.2 g) of fat were removed from the pelt and body. In the present study, subcutaneous fat was not measured quantitatively due to losses from skinning and fleshing, but a subjective evaluation of internal body fat was made.

The adult males from the river exhibited a trend toward an increase in fat from spring (1.1 ± 0.3) to summer (1.2 ± 0.4) to fall (2.0 ± 0.8), followed by a decrease during the winter (1.8 ± 0.7). The consistent increase in fat from spring to fall in adult males indicates the expected fat deposition during periods of abundant food. The decrease in fat from winter to spring indicates use of stored fat. Nonpregnant adult females from the river indicate a decreasing trend in internal body fat from winter (1.9 ± 0.8) to spring (1.4 ± 0.7) and through the summer (1.3 ± 0.6). Fat deposition occurred from summer to fall (2.2 ± 0.8), following the breeding season. The decrease in fat in the nonpregnant females from winter to summer is possibly due to the onset of the breeding season or energy expenditures involved in caring for current or preceding litters. In pregnant females, there was fat deposition from spring (1.4 ± 0.5) to summer (2.4 ± 0.9), which appears to discount the possibility presented for the nonpregnant adult females that fat is utilized merely due to the onset of breeding activity. However, the maternal expenditures of energy involved in lactation and litter care may account for the differences shown in the amount of internal body fat between the pregnant and nonpregnant adult females on the river area.

Data similar to the above were calculated for the creek sample over the winter season. Adult males had a fat index of 1.4 ± 0.7 which tended to be lower than that of the river males (1.8 ± 0.7). Similarly, females from the creek had a fat index value (1.5 ± 0.7) which tended to be lower than that of the river females (1.9 ± 0.8). The above trends again indicate the influence of the nutritionally superior habitat of the Holston River area versus that of the creek habitat. To further illustrate the seasonal trends in fat levels of adult muskrats, the seasonal percentages of animals in three fat categories are presented in Table 3.

Table 3. The percentage of adult muskrats from the creek and river study areas with high, medium, and low fat values by season in East Tennessee.

	Sample sizes		*High fat value*		*Medium fat value*		*Low fat value*	
Season	*Adult males*	*Adult females*	*Adult males*	*Adult females*	*Adult males*	*Adult females*	*Adult males*	*Adult females*
A. River sample								
Spring	41	20	0	5	10	30	90	65
Summer	19	20	0	20	16	15	84	65
Fall	11	13	27	38	45	38	27	23
Winter	23	13	13	23	52	38	35	38
B. Creek sample								
Winter	77	40	9	10	26	28	65	63

Table 4. Seasonal mean adrenal weights (g) by sex and age of muskrats from the river and creek study areas in East Tennessee.

	Adult males			*Nonpregnant adult females*			*Pregnant adult females*			*Subadult males*			*Subadult females*		
Season	*n*	$\bar{x}$	*SE*	*n*	$\bar{x}$	*SE*	*n*	$\bar{x}$	*SE*	*n*	$\bar{x}$	*SE*	*n*	$\bar{x}$	*SE*
A. River sample															
Spring	41	.1839	±.006	12	.1947	±.012	7	.2409	±.015	1	.0335	±.000	—	—	—
Summer	19	.1601	±.009	15	.1880	±.008	5	.1934	±.018	10	.0448	±.006	7	.0345	±.008
Fall	10	.2151	±.019	12	.2117	±.009	—	—	—	18	.1222	±.024	4	.0765	±.005
Winter	20	.1613	±.009	12	.1437	±.014	—	—	—	4	.1420	±.045	5	.0721	±.009
B. Creek sample															
Winter	77	.1432	±.006	40	.1553	±.008	—	—	—	11	.1073	±.009	16	.1205	±.008
Combined sample															
Winter	97	.1469	±.005	52	.1527	±.007	—	—	—	15	.1166	±.013	21	.1090	±.009

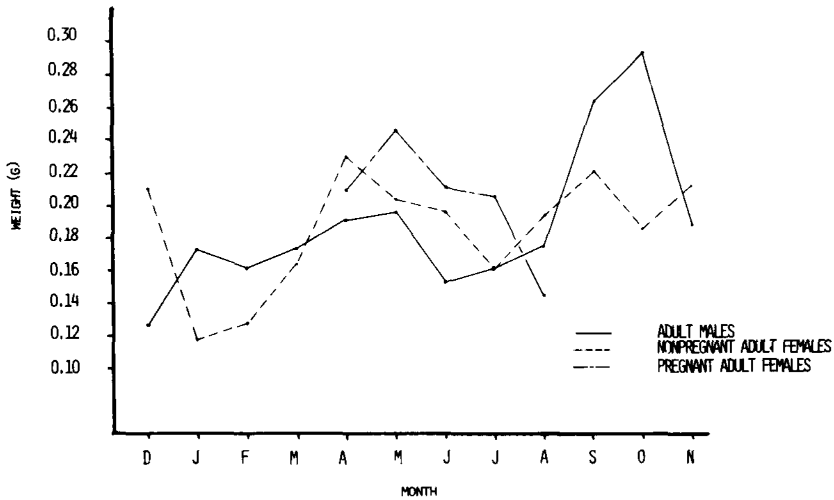

Figure 1. Weights of adrenal glands by months for adult river muskrats in East Tennessee.

Weights of Adrenal Glands

Data on the mean weights of adrenal glands were assembled seasonally by sex, age, and study area (Table 4). Weights of adrenal glands of muskrats from the creek and river samples were not significantly different (5% probability level) over the winter season.

Beer and Meyer (1951) refer to changes in the adrenal glands in their study of endocrine organs and muskrat behavior. In the adult male, the weights of adrenal glands began to increase in February, exhibited a minor peak in April, then reached a maximum in October. From October, the adrenal weights decreased and reached a minimum in January and February. The above authors state that female adrenal weights begin to increase in February, achieve minor peaks in March and April, attain maximum values in October and then decrease until the following February. The above authors include no reference to statistical analysis of their data. Selye (1946) states that "the adrenal reacts rapidly to increased stress and that this reaction is reflected by the increased weight of the organ."

In the present study adrenals from adult male muskrats exhibit maximum weights during September and October, following the cessation of the breeding season (Fig. 1). The above data agree with Beer and Meyer (1951). Adrenal glands of nonpregnant, adult females are heaviest in April and remain high throughout the early months of the breeding season (March to June); this coincides with follicle maturation and early births of litters in East Tennessee (Schacher and Pelton 1975). Beer and Meyer (1951) state that increased levels of estrogens and androgens affected adrenal weight, the estrogens being the more effective. The above period of intense reproductive activity could be the major reason for these peaks in adrenal weights. The decrease in weights of adrenals in July is unexplained, as June is a month of low prevalence of pregnancy and July is a month of maximum prevalence of pregnancy (Schacher and Pelton 1975); this may indicate that factors other than reproduction contribute to an increase in weights of adrenals. Adrenal weights remain high throughout the fall and into winter probably due to the more harsh environmental conditions and/or maximum population densities achieved at this time of the year. The maximum adrenal weight for the pregnant females occurs in May. However, there is a steady decrease through the remainder of the litter-bearing period (June through August); this could indicate that initial estrogen production and/or breeding activities contribute to increased adrenal weight in pregnant females, while subsequent pregnancies do not. No significant differences were found when adrenal weights of adult river muskrats were compared to creek muskrats during the winter season.

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