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REPRODUCTIVE BIOLOGY OF BEAVER (*CASTOR CANADENSIS*) AT OLD HICKORY LAKE IN MIDDLE TENNESSEE

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ABSTRACT--Data on the reproductive biology of beaver (*Castor canadensis*) were obtained from animals taken in Wilson, Sumner, and Davidson counties in middle Tennessee from 1990 to 1992. One hundred fifty-three specimens (79 males and 74 females) were examined. Ages of trapped beaver ranged from 0.5 to 14.0 years; 37% of the beavers trapped were 0.5-1.0 year old. Earliest age of sexual maturity for both sexes was 1.5 to 2.0 years. Female beavers had an average litter size of 3.4 young (range = 1.0-7.0). For females, pregnancy rate was 66%, and prenatal mortality was 34%, with greatest productivity occurring in females ≥4.5 years. Reproductive measurements (testicular weight, volume, length, and width) of male beavers did not differ significantly among months (January through April).

Although the reproductive biology of the beaver (*Castor canadensis*) has been studied extensively in several states (see Hill, 1982; Wigley et al., 1983), information regarding productivity of beaver (number of young produced annually as a function of pregnancy rate, litter size, and number of litters per year following Payne, 1982) in Tennessee is lacking. *Castor canadensis* is an important species economically throughout its range. This is due primarily to its impact on habitat (Hill, 1982). Fur-harvest records (Tennessee Wildlife Resources Agency, 1992) indicate that numerous beaver are taken annually in Tennessee. However, management information in various regions of the state is sparse. The purposes of the present study were to examine beaver at a site in middle Tennessee to assess the productivity of female beaver of different ages, determine the peak breeding period for male beaver, and determine the age of sexual maturity for beavers of both sexes.

MATERIALS AND METHODS

Beavers were trapped and collected by authorized personnel for nuisance animal damage control through the United States Department of Agriculture Animal Damage Control and the Tennessee Wildlife Resources Agency in three counties (Davidson, Wilson, and Sumner) surrounding Old Hickory Lake in middle Tennessee. Specimens were collected from January through April in 1991 and January through March in 1992. Beaver were stored frozen until transported to Memphis State University where they were thawed and reproductive tracts were removed. Sex was determined when gonadal tissue was removed. Age classes were determined by the basal openings and cementum annuli of the cheek teeth in the lower jaw (van Nostrand and Stephenson, 1964; Larson and van Nostrand, 1968). In some instances when cheek teeth were unavailable, whole weight of the animal was used to differentiate between animals ≤2.0 years old and those >2.0 years old (Brenner, 1964; Payne, 1979).

Reproductive data for females consisted of counts of fetuses and placental scars (Leege and Williams, 1967) and number of corpora lutea. Number of placental scars and fetuses were combined to determine the average litter size (Wigley et al., 1984). Average number of corpora lutea and ranges of numbers of placental scars and corpora lutea also were determined. Prenatal mortality was calculated from the difference between the number of placental scars or fetuses and the number of corpora lutea (Provost, 1962; Wigley et al., 1983) as well as rate of pregnancy for beavers old enough to breed (Peterson and Payne, 1986). Females for which the ovaries were unavailable, yet placental scars or fetuses were present, were used to determine rate of pregnancy and average litter size but not prenatal mortality. Analysis of variance was used to test for temporal variation in litter size and number of corpora lutea across years and ages using the Statistical Analysis Systems (SAS Institute, 1990). Earliest age of sexual maturity of females as defined by Hill (1982) also was determined.

Reproductive parameters for males included paired testicular weight and volume as well as right testicular length and width. Volume was determined by displacement (Wigley et al., 1983). Sexual maturity in males was determined by presence of spermatozoa in the epididymis (Larson, 1967). Pearson's product-moment correlations between testicular measurements, age, and whole weight of the animal were calculated to determine the effects of age and body size on testicular size as suggested by Wigley et al. (1983). Temporal variation across months and ages to determine the age and period at which peak breeding occurred was tested by analysis of covariance with age and whole-animal weight as covariates using the Statistical Package for the Social Sciences (Norusis, 1990).

RESULTS

Reproductive tracts of 153 beaver (79 males and 74 females) were examined. Ages of trapped specimens ranged from 0.5 to 14.0 years. Of the animals examined, 37% were 0.5-1.0 year old.

Since there was no significant difference in any parameter examined between animals collected in different years, reproductive data for the 2 years were combined. The youngest age of sexual maturity in females was 1.5-2.0 years old. Of 47 sexually mature females, 31 had been or were pregnant within 1 year of their death. Overall litter size was 3.3 young/pregnant female with a pregnancy rate of 66%. Litter size

ranged from one to seven young. Females ≥4.5 years old had the largest litter size and highest rate of pregnancy while females 1.5-2.0 years old had the smallest litter size and lowest rate of pregnancy (Table 1). Prenatal mortality was highest for those 1.5-2.0 years old and lowest for those 3.5-4.0 years old. Prenatal mortality for beavers in middle Tennessee ranged from 0 to 60% with a mean across ages of 34% (Table 2).

In males, sexual maturity also occurred at 1.5-2.0 years of age. Spermatozoa was present in the epididymis of sexually mature males January through April. Beaver 0.5-1.0 year old were significantly smaller ($P < 0.01$) for all reproductive parameters than those ≥1.5 years old and were not included in other comparisons of temporal variation. High correlations were found between whole weight of beaver and age for all testicular measurements (Table 3). Since there was no significant difference in testicular measurements between the 2 years of collection ($P > 0.05$), data were combined, and analysis of covariance was conducted using data for the months of January through April. After removing age and whole-weight effects on the testicular measurements, there was no significant difference in these measurements among months (Table 4).

DISCUSSION

Relatively few studies on productivity or reproductive biology of beaver have been conducted in the southeastern United States: Texas (Miller, 1948); Alabama (Wilkinson, 1962); South Carolina (Woodward, 1977); Mississippi (Wigley et al., 1983). Although sample sizes in the present study were small, many of the animals examined were collected during the peak breeding season of January and February as determined by Bradt (1939). Therefore, the data in the present study should reflect the general patterns of reproduction for beaver at the study site.

Sexual maturity for beavers in the present study occurred at 1.5-2.0 years of age, which is similar to the results of Larson (1967) and others (see Hill, 1982). However, Osborn (1953) and Brenner (1964) found that sexual maturity occurs about a year later. Although sexually mature, not all beaver breed since they are monogamous (Bradt, 1938). If an older mate (either male or female) is killed or removed, a sexually mature 2-year-old could replace the lost mate (Svendsen, 1989).

Overall litter size for beaver in middle Tennessee was high, but prenatal mortality was about the same as previously reported for beaver in the Southeast (Asdell, 1964). Wigley et al. (1983) and Wilkinson (1962) indicated litter sizes of 2.6 and 2.5 young for beaver in Mississippi and Alabama, respectively. The smallest litter size (2.2) was reported by Woodward (1977) for beaver in South Carolina, whereas the largest litter sizes were found for beaver in more northern latitudes (e.g., Pennsylvania--Brenner, 1964; Alberta--Gunson, 1970; Wisconsin--Peterson and Payne, 1986). The smallest average litter size in the present study occurred in 1.5-2.0 year-olds which is consistent with the results of several other studies (Osborn, 1953; Henry and Bookhout, 1969; Payne, 1984; Peterson and Payne, 1986). Brenner (1964) noted that beavers ≥3.0 years old had a greater potential for larger litter sizes than those that were younger. Peaks in breeding ages for female beavers differ from region to region. In the present study, data suggest peak breeding age to be about 5.5-6.0 years, whereas Henry and Bookhout (1969) observed a peak at about 6.5-7.0 years for beaver in Ohio. Payne (1984) observed peak litter sizes in older animals (7.0-10.0 years old) in Newfoundland, although, in Wisconsin, 5.0 year-olds had the largest litter size (Peterson and Payne, 1986). This suggests that, although 1.5-2.0 year-olds may be physiologically able to breed, older animals (≥3.0 years old) are more capable of sustaining and nurturing fetuses during gestation.

Pregnancy rates for beavers ≥1.5 years old in middle Tennessee were higher (66%) than those reported in most other comparable studies (Hodgdon, 1949; Leege and Williams, 1967; Peterson and Payne, 1986). Only one study (Payne, 1984) showed a higher rate of pregnancy (70%), while Leege and Williams (1967) reported the lowest rate (41%). Henry and Bookhout (1969) reported a pregnancy rate (62%) for beaver in Ohio that was similar to the rate observed in the present study. No 1.5-2.0 year-old was found to be pregnant by Henry and Bookhout (1969) while 25% were pregnant in the present study. The rate of pregnancy for beavers in middle Tennessee increased as age increased to 4.5 years old (Table 1). This followed the general trends of other studies (Brenner, 1964; Henry and Bookhout, 1969; Payne, 1984; Peterson and Payne, 1986). Beaver 1.5-2.0 years old in middle Tennessee had the highest pregnancy rate for this age class among studies; this high rate for this age class may be the result of the loss of older females that were killed or removed (Svendsen, 1989) by trapping.

Overall prenatal mortality rate for beavers in middle Tennessee was much higher (34%) than rates previously reported for beaver in the Southeast (Woodward, 1977; Wigley et al., 1983). The highest prenatal mortality rate previously noted for beaver was >27% (Wyoming--Osborn, 1953). A high prenatal mortality rate for beavers in middle

TABLE 1. Litter size and rate of pregnancy for female beaver (*Castor canadensis*) from Old Hickory Lake in middle Tennessee, 1990 through 1992.

Age class (years)	No. of females examined	No. of pregnant females	No. of placental scars or fetuses present	Litter size (range)	Pregnancy rate (%)
1.5-2.0	12	3	6	2.0 (1-3)	25
2.5-3.0	14	9	26	2.9 (1-5)	64
3.5-4.0	13	11	38	3.4 (1-7)	85
4.5-5.0	3	3	12	4.0 (2-5)	100
5.5-6.0	1	1	6	6.0	100
6.5-7.0	2	2	7	3.5 (2-5)	100
9.5-10.0	1	1	4	4.0	100
11.5-12.0	1	1	4	4.0	100
Combined	47	31	103	3.3 (1-7)	66

TABLE 2. Prenatal mortality in beaver (*Castor canadensis*) from Old Hickory Lake in middle Tennessee, 1990 through 1992.

Age class (years)	No of females examined	No. of placental scars or fetuses present	Corpora lutea			Prenatal mortality (%)
			No. present	Mean no./individual	Range	
1.5-2.0	3	6	13	4.3	4-5	54
2.5-3.0	7	18	28	4.0	2-6	36
3.5-4.0	9	30	42	4.7	2-7	29
4.5-5.0	2	7	11	5.5	5-6	36
6.5-7.0	1	2	5	5.0		60
9.5-10.0	1	4	4	4.0		0
11.5-12.0	1	4	5	5.0		20
Combined	24	71	108	4.4	2-7	34

Tennessee could be related to high activity of the ovaries during pregnancy which was noted by Zurowski and Doboszynska (1975) to occur in rare cases in the European beaver (*Castor fiber*).

Brenner (1964) found that beavers whose testicular weights were >6 g would be physiologically capable of reproduction during February and March. Testicular weights of beaver in Saskatchewan (Rock et al., 1992) and in Mississippi (Wigley et al., 1983) were greatest from January through May with a peak of spermatogenesis and sperm volume occurring simultaneously. Since all sexually mature males examined in the present study had testicular weights >6 g (Table 4) and had spermatozoa present, these animals could be capable of reproduction from January through April. Wigley et al. (1983) suggested that beavers may be capable of reproduction for most of the year in Mississippi. Lack of data from other seasons prevents any final conclusions regarding the reproductive biology of male beaver in middle Tennessee.

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TABLE 3. Pearson's product-moment correlation coefficients for age (n = 77) and whole weight (n = 78) correlated with dependent testicular variables for beaver (*Castor canadensis*) from Old Hickory Lake in middle Tennessee, 1990 through 1992. All correlation coefficients were significant ($P < 0.01$).

Dependent variable	Simple r	
	Age	Weight
Paired testicular weight	0.71	0.85
Paired testicular volume	0.72	0.85
Right testicular length	0.69	0.85
Right testicular width	0.68	0.86

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TABLE 4. Means (±1 *SE*) of testicular parameters from January through April in adult beaver (*Castor canadensis*) from Old Hickory Lake in middle Tennessee, 1990 through 1992. There was no significant difference among months ($P > 0.05$).

Month	No. of males examined	Testicular parameter			
		Weight (g)	Volume (ml)	Length (cm)	Width (cm)
January	15	13.47 ± 1.15	13.00 ± 1.13	3.49 ± 0.13	2.07 ± 0.08
February	22	15.03 ± 0.99	14.64 ± 0.99	3.74 ± 0.09	2.19 ± 0.49
March	2	14.60 ± 0.70	14.50 ± 0.71	3.65 ± 0.15	2.20 ± 0.10
April	7	10.81 ± 1.04	10.57 ± 0.87	3.37 ± 0.12	2.06 ± 0.08
Combined	46	13.86 ± 0.65	13.48 ± 0.64	3.60 ± 0.07	2.13 ± 0.04

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