

Observations on Small Mammals in the Maple Flats Sinkhole Pond Complex, Augusta County, Virginia

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INTRODUCTION

The Big Levels area, consisting of a series of sinkhole pond complexes, provides a unique habitat for plants (Fleming & Van Alstine, 1999) and animals (Buhlmann et al., 1999). The largest Virginia population of the state endangered tiger salamander (*Ambystoma tigrinum*) breeds in these ponds (Mitchell & Buhlmann, 1999). The permanent ponds in Maple Flats also support the third richest site of dragonflies and damselflies currently known in Virginia (Roble, 1999). The unique flora and fauna of the area are directly associated with the sinkhole ponds and immediate terrestrial habitats. Efforts to document small mammal assemblages in the sinkhole pond area are previously unreported.

The forests around the sinkhole ponds are comprised of a variety of forest types including oak-hickory, oak-pine, pitch pine, and variations of these mixed forest types. These forests have been actively managed over the past 50 years and the age structure reflects management practices with stands ranging from early succession to mature forests. With the U.S. Forest Service designating the Maple Flats Sinkhole Pond complex as a Research Natural Area, future forest management within the complex is expected to be minimal and the forest should ultimately reach maturity. We sampled the small mammal community associated with maturing oak-hickory/pitch pine forests adjacent to several sinkhole ponds and report preliminary observations on small mammal species richness, diversity, and demography.

MATERIALS AND METHODS

In summer 1998, from mid-June to mid-August, 100 Sherman live traps were placed in two 5x10 grids with 15 m spacing between traps. Sherman live traps were run for 2 four-night periods at one grid and 3 four-night periods at the second grid for a total of 1,000 trap nights (TN). Traps were baited with a combination of peanut butter and oats wrapped in wax paper scented with oil of anise. Traps were checked daily during each trapping period. Individuals captured were toe-clipped and data were gathered on age, sex, reproductive condition, presence of parasites, and mass for both previously unmarked and recaptured animals. Three days after the final live-trapping session, snap traps were run for four consecutive nights (400 TN) in order to assess the effectiveness of live traps. Snap traps were baited with peanut butter and placed in the same location as the Sherman traps.

Fifty 2-L pitfall traps were placed in two 5x5 grids with 15 m spacing. Pitfalls were half filled with water. One grid was run for seven consecutive nights in early May, then closed and run from 30 June to 18 August. A second pitfall grid was run from 30 June to 19 August. Pitfall TN totaled 2,600. Traps were checked twice a week and age, sex, reproductive condition, presence of parasites, and mass were recorded for each mammal.

Shrews were dissected to determine reproductive condition. Based on tooth wear, individuals were assigned to one of three age classes: adult = upper incisors heavily worn with little red pigmentation showing, sub-

adult = upper incisors moderately worn with moderate amount of red pigmentation showing, and juvenile = upper incisors sharp with large amount of red pigmentation showing.

Based on pelage color, individual *P. leucopus* were assigned to one of three age classes: adult = brown dorsal and lateral pelage, sub-adults = brown dorsal and gray lateral pelage, and juveniles = gray dorsal and lateral pelage. Body mass was calculated using specimens from snap traps and the initial capture in each sample period for Sherman live traps. Individuals captured in pitfalls were not used in mass calculations due to deterioration and wet pelage. Mass is reported as the mean \pm one standard error. We calculated species diversity using the Shannon index (H') and evenness as (J') (Zar, 1996).

RESULTS AND DISCUSSION

A total of 91 individual small mammals was captured using all three trap types. Five species were represented; *Blarina brevicauda*, *Peromyscus leucopus*, *Sorex fumeus*, *Sorex hoyi*, and *Sorex longirostris*.

Peromyscus leucopus

The white-footed mouse occurs in many habitat types. Studies in the Virginia Coastal Plain (Mitchell et al., 1993), Piedmont (Pagels et al., 1992), and Ridge and Valley physiographic provinces (Mitchell et al., 1997) have documented *P. leucopus* as the most abundant rodent in all of these areas. We captured 15 individual *P. leucopus* a total of 39 times in Sherman live traps, 21 individuals in snap traps, and 4 individuals in pitfall traps. Of the 21 individuals captured in snap traps, 11 were originally captured in Sherman live traps, 9 were new captures, and one was partially consumed. Captures per unit effort are given in Table 1.

Initial captures included 26 males and 13 females, yielding a sex ratio of 2.0 males/female. Of the adults captured, 16 were males and 9 were females, yielding an adult sex ratio of 1.8 males/female. Total sub-adult captures included 6 males and 4 females, yielding a sub-adult sex ratio of 1.5 males/female. Four juvenile males and no juvenile females were captured. In each age group, males were captured more frequently than females. The overall sex ratio of 2.0 males/female is statistically different from 1:1 ($\chi^2 = 4.3$, $P < 0.5$) and suggests that males were more abundant or more likely to be captured than females.

Based on pelage color, 25 of the *P. leucopus* were adults, 10 were sub-adults and 4 were juveniles. Of the

adults, 10 were females, yielding a juvenile to adult female ratio of 0.4 juveniles/adult female.

Based on enlarged testes, 8 of 20 adult male *P. leucopus* were reproductively active. Six of 10 adult females were reproductively active based on perforate vaginae. Reproductive activity was first observed in males in August and in July for females. The vaginal condition of females in July suggested that males were potentially active at or before this period also.

Body mass of adult males was 23.8 ± 2.26 g ($n = 19$, range = 19.9 - 27.7) and for adult females was 24.4 ± 5.58 g ($n = 7$, range = 15.5 - 32.6). Some of the variance in adult female mass may be attributed to weight gains associated with pregnancy. Body mass of sub-adult males was 19.0 ± 4.4 g ($n = 5$, range = 12.1 - 23.8) and for sub-adult females was 18.7 ± 2.09 g ($n = 4$, range = 16.3 - 21.4). Body mass of juvenile males was 15.5 ± 2.14 g ($n = 4$, range = 13.1 - 17.9). No juvenile females were captured.

Five of the 15 *P. leucopus* captured showed signs of botfly (*Cuterebra* sp.) parasitism. All were observed between 12 and 19 August. Hensley (1976) found botfly parasitism to peak in August for *P. leucopus* from Rockingham, Shenandoah, and Augusta counties, Virginia.

Sorex hoyi

Until the late 1980s, the pygmy shrew was considered one of the rarest shrews in Virginia. Pagels (1987) extended the known localities to 22. Since then the pygmy shrew has been collected in numerous localities, and in some instances has been found to be relatively abundant.

We captured 15 individual *S. hoyi* in pitfall traps. The capture ratio was 0.56/100 trap nights (Table 1). Of the total captures, 3 were males, 10 were females, and 2 were unidentified, yielding a sex ratio of 0.3 males/female. Although females were more abundant or more likely to be captured than males, the observed sex ratio was not statistically different from 1:1 ($\chi^2 = 3.77$, $P > 0.05$).

Of the total individuals captured, 5 were adults, 8 were sub-adults, and 2 were juveniles, based on tooth wear. Of these, 3 were adult females yielding a juvenile to adult female ratio of 0.67 young/adult female. Reproductive condition could only be determined for one individual, a reproductively active male.

Due to the small sample size, we calculated mean mass by age class only. Body mass for adults was 3.1 ± 0.16 g ($n = 5$, range = 2.9 - 3.3), 2.8 ± 0.4 g for sub-adults ($n = 8$, range = 2.0 - 3.4), and 2.5 ± 0.07 g for juveniles ($n = 2$, range = 2.0 - 2.1).

Table 1. Species, individuals captured, and trap success (number/100 trap nights in parenthesis) by trap type and species richness at Maple Flats Sinkhole Pond complex, Virginia, 1 May - 19 August, 1998.

Species	Trap Type		
	Sherman Live	Snap	Pitfall
<i>Peromyscus leucopus</i>	15 (3.9)	21 (5.3)	4 (0.15)
<i>Sorex hoyi</i>	----	----	15 (0.56)
<i>Sorex longirostris</i>	----	----	7 (0.26)
<i>Sorex fumeus</i>	----	----	1 (0.037)
<i>Blarina brevicauda</i>	----	3 (0.75)	1 (0.037)
Total (#/100 Trap Nights)	39 (3.9)	24 (6.0)	28 (1.05)
Richness	1	2	5

Sorex longirostris

Like the pygmy shrew, the distribution of the southeastern shrew was little known until the 1980s. Pagels et al. (1982) summarized records from the District of Columbia, Maryland, and Virginia and reported 11 observations in the Coastal Plain, 24 in the Piedmont, and two in the Ridge and Valley Province. Additional work by Pagels & Handley (1989) increased the range of this species in Virginia to include the Blue Ridge and Cumberland Plateau Physiographic Provinces. Today, the southeastern shrew is known to have a statewide distribution below 600 meters, except for the Eastern Shore where it has not been reported.

We captured 7 individual *S. longirostris* in pitfall traps. The capture rate was 0.26/100 trap nights (Table 1). Total captures included 5 males and 2 females, yielding a sex ratio of 2.5 males/female. Similar to *P. leucopus*, these data suggest that males were more abundant or more likely to be captured than females. The observed sex ratio was not statistically different from 1:1 ($\chi^2 = 1.29$, $P > 0.25$).

Based on tooth wear, one individual was an adult, three were sub-adults, and three were juveniles. Reproductive activity was not evident for any of the specimens.

Due to the small sample size, we calculated mass by age group only. Individual adult mass was 3.9 g. Mean

body mass for sub-adults was 3.4 ± 1.01 g ($n = 3$, range = 2.2 - 4.0), and mean body mass for juveniles was 2.9 ± 0.35 g ($n = 3$, range = 2.5 - 3.1).

Sorex fumeus

The smoky shrew is a common and relatively abundant shrew in the mountains of Virginia. In our study, we captured only one *S. fumeus* in a pitfall trap. This individual was a sub-adult female with a mass of 5.6 g.

Blarina brevicauda

The northern short-tailed shrew is considered one of the most abundant small mammals in Virginia and it inhabits most terrestrial habitats. We captured four *B. brevicauda*, one in a pitfall trap and three in snap traps. All four animals were adults, two males and two females yielding a 1:1 sex ratio. None of the individuals was reproductively active. Mean body mass of the three captured in snap traps was 15.7 ± 1.7 g (range = 13.7 - 16.7).

Other Mammals Observed

Several other mammal species observed during our study, included white-tailed deer (*Odocoileus virginianus*), gray squirrel (*Sciurus carolinensis*), and runways

of a mole species. The gray squirrel is a common mammal of oak-hickory forests in the eastern U.S. Surprisingly, we observed only one *S. carolinensis* during our field activity. This may be a reflection of a low population, annual variation, or poor site quality to support gray squirrels. Mist netting for bats was conducted on three nights in conjunction with an education program. *Eptesicus fuscus* (big brown bat) and *Pipistrellus subflavus* (eastern pipistrelle) were captured on two of the three nights.

Species Richness, Diversity, and Evenness

Five species of small mammals were captured in the Maple Flats Sinkhole Pond complex. Species richness varied among trapping techniques, pitfall traps captured all 5 species, snap traps captured 2 species, and Sherman live traps captured 1 species (Table 1). Species diversity (H') and Evenness (J') were computed for pitfall captures at 0.699 and 0.744, respectively.

Several studies have described differences in capture success among pitfall traps, Sherman live traps, and/or snap traps (Williams & Braun, 1983, Mitchell et al., 1993, Kalko & Handley, 1993). Our use of all three methods was intended to increase capture success and species diversity. Pitfall traps provided the greatest diversity and species richness while snap traps had the highest capture rate (Table 1). Sherman live traps captured only one species, and the capture rate was intermediate between those for pitfall and snap traps.

Although a direct comparison of capture success, diversity indices, and species richness from other Virginia small mammal studies may not be statistically valid due to differences in sampling efforts, time, habitat differences, and geographical differences, a subjective comparison suggests the Maple Flats Sinkhole Pond complex contains low species richness, diversity, and numbers. Jackson et al. (1976), sampling with snap traps, reported an overall capture rate of 9.4/100 trap nights at Presquile National Wildlife Refuge and observations of 22 mammal species. Painter & Eckerlin (1993), using snap traps, Sherman, and Hav-a-Hart live traps, did not report capture success, but observed 22 mammal species at the George Washington Birthplace National Monument. Pagels et al. (1992), sampling with pitfall traps, reported species diversity indices greater than 2.0 and species richness greater than 10 for two mixed forest sites in Cumberland County, Virginia. With a species richness of five species, a diversity index of 0.699 and a capture success of 1.05 individuals/100 trap nights (for pitfall traps), the Maple Flats Sinkhole Pond small mammal community appears less rich, diverse, and populated compared to other areas in Virginia. Additional trapping efforts could add to the

species list of small mammals occurring in the Maple Flats Sinkhole Pond complex.

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