Banisteria, Number 53, pages 3–10

Natural History of the Eastern Harvest Mouse in Southeastern Virginia

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ABSTRACT

The Eastern Harvest Mouse, *Reithrodontomys humulis*, has been studied extensively in southeastern Virginia since 1979, using a combination of live and pitfall trapping methods. This smallest rodent of eastern North America also is one of most versatile, occupying a range of habitats in southeastern Virginia from old fields in different stages of succession, brushy edges, and forests of different types. As with other species *of Reithrodontomys, R. humulis* often is associated with the Hispid Cotton Rat, *Sigmodon hispidus*, with both reaching modest densities in old fields. Two capture-mark-release studies of small mammal communities in southern Chesapeake lasting eight and nine years revealed that the Eastern Harvest Mouse was third in total abundance, behind Hispid Cotton Rat and Meadow Vole, *Microtus pennsylvanicus*, as old fields transitioned into forests. Multiple field studies using pitfall traps in a range of habitats in southeastern Virginia also indicated that harvest mice often arrive early in succession and stay later than other rodents.

Keywords: Coastal Plain, Eastern Harvest Mouse, habitat selection, *Reithrodontomys humulis*, small mammals.

INTRODUCTION

The Eastern Harvest Mouse, *Reithrodontomys humulis*, is a cricetid rodent with a distribution mostly in the southeastern U.S. (Stalling, 1997). With adults averaging about 8 g, this is the smallest rodent in the eastern U.S. Its small size alone distinguishes it from the 16-25 g White-Footed Mouse, *Peromyscus leucopus*, the native rodent with which adults are most comparable in coloration and body form; both have brownish backs, white or nearly white underbellies, and long tails. The other similar small mouse with which *R. humulis* might be compared is the House Mouse, *Mus musculus*, which has large and naked ears, a nearly hairless unicolored tail, and a gray or orangish underbelly. Their behaviors differ too; when placed in a bucket after removal from a live trap, an Eastern Harvest Mouse is likely to remain calm and groom itself or eat seeds, whereas a House Mouse is frenetic, running and leaping in its attempts to escape.

Much of the information in this report comes from the work of Old Dominion University graduate students conducting field research projects as part of their thesis research for the Master of Science degree. Jean Ferguson Stankavich, who conducted capture-mark-release (CMR) studies of small mammals in the northwest section of the Great Dismal Swamp National Wildlife Refuge, found Eastern Harvest Mice to be numerically dominant in two CMR grids. Sarah Crawford added an analysis of vegetation composition and structure to her study of small mammal communities with harvest mice. Michelle Cawthorn Chandler used a specially built trap, with a 2.1 by 2.1 cm opening, to exclude larger small mammals in an effort to study the smallest members of the small mammal community in an old field. These studies were conducted in habitats in early stages of succession, where densities of small mammals tend to be highest. Additional information about distribution and relative abundance comes from field studies using pitfall traps on dozens of 0.25 ha grids that enable comparisons

of relative densities among habitat types and from two long-term CMR studies of rodent communities.

GENERAL CHARACTERISTICS

The Eastern Harvest Mouse is grayish brown with a darker mid-dorsal stripe on the back, with lighter and sometimes rusty sides, and whitish feet (Fig. 1). The tail is about the same length as the head-body length; in a series of harvest mice from Isle of Wight County measured by the author, the tail was 47.8% of total length for 32 males and 47.6% of total length for 30 females. The underside of the tail is whitish, as is the belly. The eye is large and dark, suggesting nocturnal behavior. The vibrissae (whiskers) are numerous, long, and pale at the tips. Another feature that distinguishes the Eastern Harvest Mouse from other long-tailed rodents in southeastern Virginia is the groove in the upper incisor, which can be seen with the naked eye. The anterior face of the incisor is folded, giving it a corrugated appearance. The function of this feature is unknown, but the fold probably strengthens the tooth, thus reducing the likelihood that the tooth will break when opening hard-coated seeds. The sexes are similar in size (Dunaway, 1968), but when weighed with a 10-g Pesola scale (with 0.2 g calibrations) non-pregnant females from Chesapeake, Virginia ($\bar{x}$ = 8.20 ± 0.3 *SE* g, n = 35) weighed significantly ($p < 0.05$) more than male harvest mice ($\bar{x}$ = 7.04 ± 0.1 *SE* g, n = 42) (Cawthorn & Rose, 1989). The weight of males was relatively constant throughout the year but weights of females peaked in autumn, suggesting that as the season of greatest reproduction.

Fig. 1. An adult eastern harvest mouse, *Reithrodontomys humulis*. Photo credit to West Virginia University Wildlife and Fisheries Science study guide (Edwards).

DISTRIBUTION

The Eastern Harvest Mouse has a mostly southeastern distribution in the US, extending eastward from eastern Oklahoma and Texas to states lying south of the Ohio River, but also including southern Ohio, western Maryland, all of Virginia, and points southward. It may be absent from the southern tip of Florida. Some populations in Texas, Oklahoma, Arkansas, and Louisiana overlap in distribution with those of *R. fulvescens*, a larger species that has been studied extensively in the Texas coastal prairies by Cameron (1977).

Information on the distribution of *R. humulis* is accumulating as more community studies are being published, so the map of Stalling (1997), already an improvement of Hall (1981), continues to be revised. For example, before 1988, *R. humulis* was known from only three counties in Oklahoma and was considered a rare mammal, but by 2011, its presence had been recorded in six more counties (Braun et al., 2011).

Three subspecies are recognized. Howell (1940) described *R. humulis virginianus* based on specimens from Amelia County, located in central Virginia just one county southwest of Richmond. This subspecies, present in the eastern half of Virginia, is paler and more grayish, with a blackish-brown mid-dorsal stripe, and with white feet compared to *R. h. humulis,* the other subspecies east of the Mississippi River. *R. h. merriami* is present in the four western states. As presently understood, the northern distribution of coastal populations of *R. humulis* is in southeastern Virginia. Field studies of the Eastern Shore of Virginia by Rose and colleagues (e.g., Rose & March, 2013) have failed to record any *R. humulis* in either Northampton or Accomack counties, so its movement northward likely is blocked by the Chesapeake Bay. Pagels & Moncrief (2015) also consider *R. humulis* to be absent on the Eastern Shore.

FORM AND FUNCTION

Its small size and long tail suggest that this rodent can climb into even herbaceous vegetation, perhaps to glean seeds or capture insects. Relatively little is known about its diet, except that it eats some seeds. But *R. humulis* is not considered to be truly arboreal because its softball-sized grassy nests are placed in low herbaceous vegetation or on the ground rather than in tree holes, as truly arboreal rodents usually do.

The monthly mean weights of males from southeastern Virginia were relatively stable (Chandler, 1984). In Tennessee, unbred lab-reared adult harvest

mice of both sexes had identical weights, 8.2 g (Dunaway, 1968) and Kaye (1961) reported that lab-reared 50-day-old adult males and females weighed the same. By contrast, field-caught females were heavier than males in all but 3 of 21 months in Tennessee (Dunaway, 1968), suggesting that pregnancy accounts for most differences in weights of the sexes. As in southeastern Virginia, the weights of males were fairly constant throughout the year (Dunaway, 1968). In brief, adults are similar in size, about 8 g, and of equal body length.

Small body size means that, on a per gram basis, *R. humulis* has a higher metabolic rate, and thus relatively higher energy requirements, than larger mammals, a relationship recognized decades ago by Kleiber (1961). Furthermore, below the temperature zone of least energy cost, termed thermoneutrality, the energetic costs increase disproportionately. For example, the resting metabolism of the Eastern Harvest Mouse at 23° C is 4.35 ml of oxygen per gram of body weight per hour, but at 7° C the metabolic rate more than doubles, to 9.62 ml of oxygen per gram per hour; the comparable values for the twice-as-large White-footed Mouse are 3.04 and 5.68 (Dunaway, 1968). Also, because of its small size, it can neither reduce heat loss via long and dense insulative fur nor accumulate large fat reserves, two ways larger mammals can conserve or produce heat during periods of cold temperatures. These factors likely restrict the distribution of *Reithrodontomys*, a genus with tropical origins, to sub-tropical and temperate climate zones in the US.

The numbers of red blood cells per unit volume were similar to those of larger rodents examined by Dunaway (1968). However, harvest mice had much higher concentrations of hemoglobin (g/ml) in the erythrocytes than in larger rodents, likely an adaptation to deliver sufficient oxygen to cells of a small mammal with high metabolic rate.

REPRODUCTION

The breeding season for *R. humulis* likely varies by geographical location, starting earlier in spring in southern than in northern populations. In southeastern Virginia, breeding peaks were observed in spring and autumn, with a lull in summer (Cawthorn & Rose, 1989). The higher body weights of females plus the many gray-backed juveniles indicate greater levels of reproduction in autumn than in spring.

Studies in the laboratory indicate that females in late pregnancy become intolerant of males and that males take no role in parenting (Kaye, 1961), the pattern seen in most mammals. Near the end of the 21-day gestation period, the female builds a birthing nest of dried grasses, in which the young are reared for about three weeks. Litter size averaged 2.2 for nine lab females in Florida (Layne, 1959) but was 3.2 for nine lab females from North Carolina (Kaye, 1961). Later, Dunaway (1962) reported finding three litters of three and three litters of four born in live traps in Tennessee; he also took a 17-g female into the lab where two days later it gave birth to eight young, the weights of which totaled nearly 8 g. Taken together, the litter size is about three; these are weaned near the end of the third week of life, at weights of about 5 g, the lightest animals trapped in most studies. On 16 December 2018, I recorded a 12-g pregnant female with partially open pubic symphysis and enlarged nipples, indicating that this female produced a late litter in southeastern Virginia. In my experience, females heavier than 10 g are pregnant.

Few details are known about reproduction in male eastern harvest mice, in part because indicators of reproduction are fewer than in females. During the breeding season the enlarged testes are descended into the scrotum, and such males are judged to be reproductive. In the winter non-breeding season, the testes of many mammals, including harvest mice, decrease dramatically in size, often losing 95% of their weight, and such males are non-reproductive. Cawthorn & Rose (1989) observed scrotal males in every month of the year, with lowest rates (10%) in winter. In the nearby Great Dismal Swamp, Stankavich (1984) also found some scrotal males in winter (24%), suggesting the possibility of occasional year-round breeding in southeastern Virginia. Coastal Virginia averages 10 cm of snow, 10–20 nights below 0° C, and short periods of frozen soil. By contrast, no scrotal males were observed in December, January, and February in Tennessee (Dunaway, 1968). These observations suggest that populations in southern states (or coastal locations in Virginia) might have year-round reproduction, although it was not observed by Layne (1959) in Florida. In South Carolina, highest numbers of captures were recorded in January, indicating that breeding levels were greatest in late autumn (Briese & Smith, 1974).

ECOLOGY

Much new information about *R. humulis* in southeastern Virginia has been published in recent decades by using CMR methods on small square or rectangular (row by column) grids with live traps placed at the coordinates. At monthly or twice-monthly intervals, the traps are baited and ‘run’ for three consecutive days. Each captured animal is given a unique number, usually with an ear tag, weighed, and its sex and reproductive condition are recorded. The animal is then released at the point of capture. The goal is to trap

such tagged animals in successive months and record the events of their lives: features such as their changes in body mass, levels of reproduction, rates of body growth and survival, area of use on the grid, among others. Also, the vegetation of the grid often is studied, both for its list of plant species but also for details of plant contacts at different heights in an effort to learn whether the vertical structure of the plant community is more or less important than the presence of certain plant species. For example, when grasses dominate the plant community, vertical structure is dense with stems and leaves below about 0.5 m. Later in biological succession, when shrubs and trees are common, the density of vegetation near the ground surface is much less, but vertical elements are more common, increasing vegetation complexity in a different way.

The first CMR study in southeastern Virginia was conducted under a 40-m wide powerline in the northwest section of the Great Dismal Swamp National Wildlife Refuge (Stankavich, 1984). Two study grids of Fitch live traps (Rose, 1994) were established in habitat dominated by plants typical of early successional stages in a swamp: grasses and forbs, and in wetter places, sedges, rushes, and spikerushes. Some deciduous trees and shrubs were present too, especially in the slightly higher places where winter flooding did not kill them. Harvest mice were the most common small mammal in this habitat, comprising 71 of 155 total individuals (Rose & Stankavich, 2008). In an 18-month CMR study, conducted in Suffolk just west of the Great Dismal Swamp National Wildlife Refuge, seven harvest mice were tagged, along with 47 *Synaptomys cooperi* (Southern Bog Lemming) and 110 *Microtus* (*Pitymys*) *pinetorum*; no other rodents were captured in this community where minor species dominated (Rose & Ford, 2012).

Michelle Cawthorn (Chandler, 1984) conducted CMR trapping of small mammals every other week for a year on two grids in an old field in the Bowers Hill region of Chesapeake. The tiny specially built traps excluded adults of the common small mammals and thus she caught mostly Eastern Harvest Mice and House Mice, 51% and 39%, respectively, of 703 total captures (Cawthorn & Rose, 1989). Highest densities for *R. humulis* were achieved on both grids in autumn and winter, with 44 harvest mice per hectare; the average density was 21.9 and 21.8/ha on both grids across the study. The adult mortality rate of 6 percent per month was constant for the year-long study. Home range, the area of greatest use, was similar for both sexes, at about 1000 m^2. Lifespans, based on three or more captures, averaged about 10 weeks for both sexes, which if added to the 20–30 days for newborns to become trappable, equates to mean lifespans of about 100 days (Cawthorn & Rose, 1989), similar to those (90-120 days) in Tennessee (Dunaway, 1968).

Cawthorn/Chandler, (1984) recorded 29 plant species on Grid 1 and 27 species on Grid 2, 18 of which were present on both grids; asters dominated on Grid 1 but honeysuckles (*Lonicera*) on Grid 2. But height of vegetation was more important than species composition, a conclusion also reached by Crawford (2013), who used assessments of plant composition and measurements of structure while trying to understand the strong association of harvest mice with the Hispid Cotton Rat (*Sigmodon hispidus*), adults of which are mostly 80–120 g in southeastern Virginia. Numerous studies report that *S. hispidus* and the local *Reithrodontomys* species often occur together, regardless of the region. Both are tropical genera with populations in the US at the northern limits of distribution (e.g., Braun et al. [2011]; Brady & Slade [2001] for *R. megalotis* in eastern Kansas; Rose et al. [2018] for *R. humulis* in southeastern Virginia). Both genera reach highest densities in old field and other early successional habitats, but the reasons for their frequent coexistence remain unclear, whether by being active at different times of day, by mutual avoidance at the microhabitat level, or by differential use of resources (Crawford, 2013).

Using live-trapping records, Crawford (2013) found no evidence that either harvest mice or cotton rats avoided the other on either of two 1-ha grids, each trapped monthly for multiple years. A negative association between captures at each station was recorded for only one month over that period. Both species tended to occupy areas with few or no trees, and harvest mice were more likely than cotton rats to be present if the open sites were wet. Both species tended to use areas with dense vegetation near the ground surface, regardless of plant species composition. Crawford speculated that differential use of resources (harvest mice are primarily seed-eaters whereas cotton rats eat stems and leaves, mostly of monocots) and the broader habitat tolerances of harvest mice as the most likely reasons for the coexistence of these two species in southeastern Virginia.

In evaluating the changes in composition of the community of small mammals on the same two grids analyzed by Crawford (2013), Rose et al. (2018) found that harvest mice and cotton rats were early colonizers in grassy old fields in the third year after a farm field was abandoned and both species persisted while other community members came and went. Across eight years of study on one site and nine years on the other, *R. humulis* was third in total abundance on both grids, with cotton rats being most numerous on one grid and Meadow Voles (*Microtus pennsylvanicus*) numerically dominant on the other. Thus, although many investigators would consider harvest mice to be a minor

species in the community of small mammals, in southeastern Virginia they are early arrivals, third in abundance during succession, and they are still present at the point when the forest small mammals, such as White-footed Mice and Golden Mice (*Ochrotomys nuttalli*), arrive and become the dominant rodents.

In field studies using pitfall traps on 0.25 ha grids, the results were similar. For example, *R. humulis* was present on 13 of 14 grids in Isle of Wight County, more than any other species, and was second in abundance to Least Shrew (*Cryptotis parva*) (Rose, 2005). Similar results were found in 19 pitfall grids in Virginia Beach, Chesapeake, and Suffolk (Rose, 2016).

In his pitfall-trapping study of small mammals in and near the Great Dismal Swamp National Wildlife Refuge, Everton (1985) found *R. humulis* on 10 of 21 one-quarter hectare grids, and fourth in overall abundance behind two shrews (Southeastern Shrew, *Sorex longirostris,* and Least Shrew) and Southern Bog Lemmings (*Synaptomys cooperi*). In the analysis of vegetation structure, Everton found that *R. humulis* was associated with high values for stem densities from ground level to 40 cm and for average height of herbaceous vegetation, indicating a strong preference for dense cover of plants, mostly grasses, near the surface. In a summary of studies of small mammals conducted across the range of habitats in the Great Dismal Swamp, using all trapping methods (live, pitfall, and break-back traps [used in the late 19th century]), *R. humulis* was third in total abundance, behind Short-tailed Shrews (*Blarina* spp.) and White-Footed Mouse (Rose et al., 1990, Table 4).

Thus, in southeastern Virginia at least, *R. humulis* is the most versatile rodent in the small mammal community. For example, one was caught on a tall sand dune at Little Creek Amphibious Base in Norfolk, along with House Mice and White-footed Mice (Rose & Sweitzer, 2013).

More commonly, *R. humulis* arrives early in old fields dominated by grasses and forbs, sometimes sharing early arrival status with house mice. Soon other species, such herbivores as cotton rats, meadow voles, and rice rats, arrive and some of these become dominant species for months or years. But when the herbaceous vegetation thins and eventually is shaded out by shrubs, saplings, and trees, the herbivorous rodents disappear, often quickly. Based on studies of two old fields going through succession, cotton rats and harvest mice often were still present before forest rodents come to dominance. Eastern Harvest Mice are much less common in the forests of southeastern Virginia than in earlier stages of succession, but often they are present in small numbers (e.g., Everton, 1985). Others also have found *R. humulis* in forests, such as in wetland forests in Tombigbee National Forest in Mississippi (Edwards & Jones, 2014), and rarely in pine forests (Dolan & Rose 2007). In their pitfall trapping study in the upper coastal plain of Virginia, Bellows et al. (2001) found *R. humulis* to be more abundant in old field habitats than in other macrohabitats; harvest mice were present in oak-hickory forest and young pine forests, but not in older pine or oak-pine forests. In a four-year study in the North Carolina coastal plain, *R. humulis* had good recruitment and survival in all five treatments that provided varying amounts of structure (woody debris, pine seedlings, switchgrass), and by year four it outnumbered the other three colonizing species (Homyack et al., 2014). In brief, numerous studies reveal *R. humulis* to be versatile by occupying a range of habitat types.

BEHAVIOR

Harvest mice are primarily nocturnal, and thus are active during the coldest part of the day, enabling them to benefit from the heat generated during foraging and other activities. At thermoneutrality (22° C), *R. humulis* shows an innate increase in metabolic rate at the approach of darkness, as if foretelling the beginning of nocturnal behavior (Baker, 1974). Baker, who measured CO_2 production rather than oxygen consumption, also recorded a doubling of metabolic rate when harvest mice were housed at 9° C.

Nocturnal behavior means that owls are their main avian predators, as recorded by Klippel & Parmalee (1982) in their study of pellets from a wintering Long-eared Owl (*Asio otus*) in the Nashville Basin of Tennessee. *R. humulis* was second in abundance ($n = 78$) to Prairie Vole (*Microtus ochrogaster*, $n = 129$) among 71 complete pellets. In a study conducted near Williamsburg, Virginia, Rosenburg (1986), who followed tagged Barn Owls (*Tyto alba*) via radio-tracking, found small numbers of Eastern Harvest Mice in their pellets in most seasons. The Meadow Vole, also common in old fields in early succession, was the main food of these owls.

The observation of multiple captures in live traps suggests some degree of sociality in harvest mice. In southeastern Virginia, 6.4% of total captures were as multiple captures, with more male-male pairs and fewer female-female pairs than expected (Cawthorn & Rose, 1989). Others have reported huddling, especially during winter months. For example, Dunaway (1968) reported that only 3 of 18 eastern harvest mice were alone in the nest cans of traps on a late January day; the others were in groups of 6, 4, 3, and 2. I have observed similar social groupings in *R. megalotis* in eastern Kansas, instances in which up to 11 adults shared grassy nests in gallon-sized nest chambers. Similar social groupings were observed

in *R. fulvescens* in the Texas coastal plain (Spencer et al., 1982). Formation of social groups is especially important for tiny mammals, enabling them to share the costs of staying warm together in their well-insulated grass nests. In his analysis of spacing behavior among individuals of *R. humulis*, Dunaway (1968) found little evidence of territoriality: territorial individuals are anti-social.

One consequence of social groupings is the potential for the 'sharing' of ectoparasites. Clark & Durden (2002) found 10% prevalence both of fleas (*Polygenis gwyni*) and of ticks (*Amblyoma maculatum*) in Eastern Harvest Mice in Mississippi. In southeastern Virginia, of nine small mammal species evaluated for ticks over a period of years, harvest mice had the lowest proportion of infestation; 18.3% had ticks, mostly on the ears (17 of 93; H. Gaff, pers. comm.). By contrast, another benefit of social groupings is allogrooming, i.e., the removal of ectoparasites by other members of the group. There is no direct evidence of allogrooming in *R. humulis*, but the low percentage of ticks on harvest mice is consistent with this hypothesis.

The killing of young by siblings or mother seems to be a common behavior, at least in captivity; sometimes this unexplained behavior is followed by cannibalism (Dunaway, 1962; Kaye, 1961).

GENETICS

Information on the chromosomes of *R.* and its congers is mostly derived from studies conducted nearly 30 years ago. Carleton & Myers (1979) reported that *R. humulis* had a diploid number of 2n = 51 for two females (no males were assessed); the chromosomes were mostly small-to-medium acrocentrics plus five pairs of larger and bi-armed chromosomes. The unpaired element was a small metacentric chromosome. The 2n = 51 was confirmed by Robbins & Baker (1980), and although they determined the FN to be 78, they could not determine the origin of the unpaired element. Much remains to be learned about the genetics of *R. humulis* and others in this genus.

CONSERVATION STATUS

The 2016 International Union for the Conservation of Nature Red List of Threatened Species lists *R. humulis* as "Least Concern," and with stable populations. However, a map on the same website indicates that Oklahoma considers the species to be "critically imperiled," but this statement conflicts with Braun et al. (2011), which adds six counties to their known locations in the state. The map also lists the species as "possibly extirpated" in West Virginia and "not ranked" or "under review in Mississippi, South Carolina, and Florida. The Ohio Department of Natural Resources website states that *R. humulis* is a "Threatened" species in their state, despite Harder et al. (2014). The other states, including Virginia, assess their populations to be "secure" or "apparently secure."

REMARKS

The name *Reithrodontomys humulis* was given in 1841 by John James Audubon and his son-in-law, John Bachman, based on specimens collected near Charleston, South Carolina. Early in the next decade, these same authors, far better remembered for their studies of and naming of many North American birds, published *Quadrupeds of North America*, the first comprehensive book on New World mammals. They chose the genus name, *Reithrodontomys*, derived from three Greek words (Lowery, 1974), because of the grooved incisor: *reithron* (groove), *odous* (tooth), and *mys* (mouse). The specific name *humulis* may be a misspelling of *humilis*, which means "little harvest mouse." In their Quadrupeds book, the authors used the latter spelling. The tiny mouse of western Europe and the British Isles is also called "harvest mouse," but it is in a different genus, *Micromys*, literally "tiny mouse."

ACKNOWLEDGMENTS

I gratefully acknowledge the assistance of many former students while conducting small mammal studies in southeastern Virginia, especially Michelle Cawthorn (Chandler) and Sarah Crawford, both of whom focused their MS theses on understanding the ecology of *Reithrodontomys humulis.* Thanks also to other students who participated in field studies, including James Dolan, Jana Eggleston, Roger Everton, Jean Ferguson (Stankavich), Linda Ford, Heather Green (Salamone), Jay Kiser, Robyn Nadolny, Thomas Padgett, and John Rose.

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