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# Ecology of Feral House Mice (*Mus musculus*) on Wallops Island, Virginia

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ABSTRACT

The ecology of feral house mice (*Mus musculus*) was studied on Wallops Island, Virginia, during August 1981, March and May 1982, and March 1983. Small mammal populations were sampled on live-trapping grids and snap-trapping transects which encompassed a variety of habitats on the north end of Wallops Island: strand, primary dunes, interdunes, secondary dunes, old dunes, grass meadow, grass-shrub association, *Myrica* thickets, and woodland. Six hundred and seventy-two small mammals representing five species were collected: 85 least shrews (*Cryptotis parva*), 51 white-footed mice (*Peromyscus leucopus*), 519 house mice, 13 meadow voles (*Microtus pennsylvanicus*), and 4 rice rats (*Oryzomys palustris*). *Mus musculus* was the numerically dominant species, comprising 74.9% of 370 specimens in August 1981; 88.8% of 89 specimens in March and 90.3% of 124 specimens in May 1982; and 57.3% of 89 specimens in March 1983. There was minimal spatial overlap in the distribution of *Mus* and *P. leucopus*. *Mus* exhibited a non-random pattern of habitat utilization during all sampling periods and on all grids and transects. They evinced a significant preference for primary dunes and were never taken in woods. Their overall pattern of habitat distribution was consistent with a hypothesis that *Mus musculus* on Wallops Island select habitats which presumably resemble natural habitats in which ancestral populations of this species evolved.

Key words: small mammals, ecology, barrier island, habitat utilization, house mouse, *Mus musculus*, white-footed mouse, *Peromyscus leucopus*.

## INTRODUCTION

The introduced house mouse (*Mus musculus*) occurs throughout the United States, usually as a commensal with man but frequently as feral populations (Blair *et al.*, 1968; Hall, 1981). Very successful as a commensal, *Mus musculus* often does not do well in association with native North American species under natural conditions (Caldwell, 1964; Caldwell and Gentry, 1965; Lidicker, 1966; Sheppe, 1967; Whitaker, 1967; Briese and Smith, 1973). Feral *M. musculus* populations may reach substantial densities either in the absence of native American species (Lidicker, 1966) or in association with native species in unstable agricultural habitats (Stickel, 1979). Small mammal communities in which *Mus musculus* was the numerically dominant species have been studied by Hall (1927) and Pearson (1964) in California grasslands and by Dueser and Porter (1986) on Assateague Island, Maryland-Virginia. Because *M. musculus* can assume either a numerically subordinate or dominant position within individual small mammal communities, continued studies are needed to elucidate the conditions which determine its status within communities and its relationships with native species of small mammals.

In a survey of the mammals of the Virginia barrier islands, Dueser *et al.* (1979) collected *Mus musculus* on only 4 of 11 islands sampled. Although Bailey (1946) and Paradiso and Handley (1965) cite historical records of the occurrence of the native white-footed mouse (*Peromyscus leucopus*) on two Virginia barrier islands (Hog and Assateague), Dueser *et al.* (1979) failed to capture this species on any of the islands they sampled. Dueser and Porter (1986) subsequently captured *P. leucopus* on Cedar Island, which was not among those surveyed by Dueser *et al.* (1979). Another Virginia barrier island not sampled by Dueser *et al.* (1979) was Wallops Island, Accomack County. Preliminary sampling of small mammals on Wallops by the first author and his students during 1974 and 1975 confirmed the presence of both *Mus musculus* and *Peromyscus leucopus.* These two species appeared to exist in syntopy on the northeastern tip of Wallops Island. These preliminary observations suggested that Wallops Island was an appropriate site to study the spatial and numerical relationships of these two potential competitors, and in 1981 we initiated such a study. Our principal objectives were 1) to determine the ecological distribution of *M. musculus* on the north end of Wallops Island, and 2) to ascertain the numerical and spatial relationships between *M. musculus* and *P. leucopus* in the study area. In this paper we present data and results that are relevant to answering these two questions, and we propose a hypothesis to explain the observed pattern of habitat association evinced by *M. musculus* on Wallops Island.

## METHODS AND MATERIALS

Small mammals were sampled on the north end of Wallops Island in August 1981, March and May 1982, and March 1983. Both live and removal sampling were employed. Live-trapping was carried out in August 1981 on two grids, one 7 x 10 stations and the other 6 x 12 stations. Assuming a boundary strip having a width equal to one-half the interstation interval of 15 m, these two grids had effective sampling areas of 1.58 ha and 1.62 ha, respectively. The grids were oriented so that they would sample a diversity of habitats extending inland from the strand. At each station, two Sherman live traps (one large - 7.5 x 9.0 x 23.0 cm and one small - 5.0 x 6.5 x 16.5 cm) baited with rolled oats were set within 1 m of the station marker. Each grid was run for a total of seven days but not concurrently. In order to prevent trap mortality owing to exposure to high daytime temperature, we closed all traps each morning (0700-0830 h) as we checked them and reopened all traps in the afternoon (1500-1700 h). Specimens captured were numbered by toe-clipping, measured (total, tail, and hind foot lengths), weighed, sexed, and released at the site of capture. At each trap station, the following habitat variables were recorded: general habitat, percentage of open sand and dead ground cover, percentage cover and average height of herbaceous and woody plants within a 2 m circle centered on the station marker.

In May 1982 the 6 x 12 station grid was re-established at approximately the same position (est. 90%+ overlap) and was sampled for five days with the same methodology as employed in August 1981. For purposes of analysis, the May 1982 grid was considered to be coincident with the 6 x 12 station grid operated in August 1981. Accordingly, statistics such as the percentage of stations at which *Mus* and *Peromyscus* co-occurred on the live-trapping grids were based on a total of 142 stations (not 214).

Transects of snap traps (Museum Specials) were used during all study periods to augment data collected from the live-trapping grids. Transects varied from 33 to 50 stations with three traps set per station. Transects were oriented so as to sample the principal non-aquatic habitats on the northeast tip of Wallops Island. Each transect was operated for three days. At each trap station, the same categories of habitat data were recorded as at stations on the live-trapping grids. In March 1983, the 6 x 12 grid established in May 1982 was re-sampled using two Museum Special traps per station.

Population estimates for the live-trapping grids were calculated using the Schnabel technique (Smith 1980). The sample of *Mus musculus* was divided into three relative age classes using body mass as the aging criterion. Juveniles were defined as having body mass < 10 g; subadults, 10-18 g; and adults > 18 g. This represents a modification of the aging scheme of Rowe *et al*., (1964) who defined adult *M. musculus* as having a body mass > 17.6 g; subadults, 12.6-17.6 g; and infants/juveniles < 12.6 g.

## SITE DESCRIPTION

Wallops Island is located on the Atlantic side of the Delmarva Peninsula approximately 14 km south of the Maryland-Virginia border. The island is the site of a launch facility of the National Aeronautics and Space Administration (NASA). Buildings and other NASA structures are confined largely to the southern two-thirds of the island. An abandoned U.S. Coast Guard Station is located on the mainland side of the north end. At present, there is no resident human population on Wallops Island.

The northeastern tip of Wallops Island supports a complex mosaic of vegetation (Klotz, 1986). Small mammals were sampled in nine habitats: strand, primary dunes, interdunes, secondary dunes, grass-shrub association, old dunes, *Myrica* thickets, grass meadow, and woodland. A foredune strand zone of variable width (10-40+ m) supports sparse vegetation, primarily sea-rocket (*Cakile edentula*), saltwort (*Salsola kali*), and seaside goldenrod (*Solidago sempervirens*). Inland the strand is bordered by primary dunes which are dominated by the grasses *Ammophila breviligulata* and *Panicum amarum* but also support some forbs, such as seaside goldenrod. Well-defined secondary dunes are present on the southern one-third of the study area. Vegetationally these are distinguished from primary dunes by denser living ground cover, the dominance of salt meadow cordgrass (*Spartina patens*), the presence of several woody species, most notably Virginia creeper (*Parthenocissus quinquefolia*) and poison ivy (*Rhus radicans*), and additional forbs, such as horsemint (*Monarda punctata*). Lying between the primary and secondary dunes, the interdune habitat is influenced by overwash during storms and supports an herbaceous community of grasses (*e.g., Ammophila breviligulata* and *Spartina patens*) and forbs, such as horsemint and seaside goldenrod. Towards the northern end of the study area, the interdune-secondary dune complex is absent and is replaced by a broad (100-200 m wide) level expanse of grassland, *Myrica* thickets, and admixtures of these two habitats (grass-shrub association). The grassland habitat is virtually devoid of woody species and is dominated by *Spartina patens* but also supports forbs such as sea-pink (*Sabatia stellaris*) and seaside goldenrod. Two species of *Myrica* are present, bayberry (*M. pensylvanica*) and wax-myrtle (*M. cerifera*); however, owing to their similarity, we did not attempt to distinguish between them in our habitat analysis. *Myrica* spp. occur either as scattered individuals interspersed with grasses (grass-shrub habitat) or in well-defined stands 3-5+ m across (*Myrica* thicket habitat). These thicket habitats are largely devoid of living ground cover, especially in comparison to the grassland and grass-shrub habitats. In the grass-shrub habitat, the *Myrica* spp. are generally 2-3 m in height, whereas in the *Myrica* thickets they are 3-5 m in height. Groundsel-tree (*Baccharis halimifolia*) is the other principal woody species in the grassland-thicket habitat. Old dunes are small unstable areas of fairly high relief within the grassland-thicket associations. Although old dunes support the same grasses as the primary dunes, they are characterized by sparser vegetation and the presence of bare sand caused by "blowouts." The interior of the northeast tip of Wallops Island supports woods dominated by loblolly pine (*Pinus taeda*), *Myrica* spp., cherry (*Prunus serotina*), and sassafras (*Sassafras albidum*). Common ground cover species in woodland habitats are poison ivy and greenbriar (*Smilax* spp.). The ecotone between the forests and open herbaceous habitats is characterized by dense stands of *Myrica* spp. and dwarf sumac (*Rhus copallina*).

## RESULTS

Five species of small mammals were collected in the study area: the least shrew (*Cryptotis parva*), white-footed mouse (*Peromyscus leucopus*), rice rat (*Oryzomys palustris*), meadow vole (*Microtus pennsylvanicus*), and house mouse (*Mus musculus*). The house mouse was by far the most abundant of the five species throughout the study. In the four sampling periods it comprised from 57.3 to 90.3% of small mammals, and overall, *Mus* constituted 77.2% of the 672 specimens captured (Table 1). The least shrew was the second most abundant small mammal on our study sites during August 1981, comprising 21.9% of the total sample; however, it declined dramatically in abundance over the winter of 1981-82 and was seldom taken during subsequent sampling (Table 1). The relatively high proportion of *Peromyscus leucopus* in the March 1983 sample (32.6%) reflects the sampling of two wooded sites, which yielded 28 of 29 *P. leucopus* taken during that period (Table 1). Marsh habitats were not extensively sampled, and this may explain the low numbers of *Oryzomys* and *Microtus* taken (Table 1). Both species are common to abundant in salt and brackish marsh habitats on Wallops Island and the adjacent mainland (Kirkland unpublished data) and on Assateague Island (Cranford and Maly, 1990).

In the three live-trapping samples, *Mus* had estimated densities of 48.5 to 59.9/ha and comprised 77.1 to 89.4% of the small mammals trapped (Table 2). The percentage of stations at which *Mus* were captured ranged from 53.8 to 88.4% during the three sampling periods. The clumped nature of the distributions of *Mus*

TABLE 1. Summary of small mammal captures (N) on Wallops Island, Virginia, based on live- and snap-trapping (1981 - 1983).

| SPECIES | AUGUST 1981 N | AUGUST 1981 % | MARCH 1982 N | MARCH 1982 % | MAY 1982 N | MAY 1982 % | MARCH 1983 N | MARCH 1983 % | OVERALL N | OVERALL % |
|---|---|---|---|---|---|---|---|---|---|---|
| Least Shrew *Cryptotis parva* | 81 | 21.9 | 1 | 1.1 | 1 | 0.8 | 2 | 2.3 | 85 | 12.7 |
| Rice Rat *Oryzomys palustris* | 1 | 0.3 | - | - | 2 | 1.6 | 1 | 1.1 | 4 | 0.6 |
| White-footed Mouse *Peromyscus leucopus* | 9 | 2.4 | 5 | 5.6 | 8 | 6.5 | 29 | 32.6 | 51 | 7.6 |
| Meadow Vole *Microtus pennsylvanicus* | 2 | 0.5 | 4 | 4.5 | 1 | 0.8 | 6 | 6.7 | 13 | 1.9 |
| House Mouse *Mus musculus* | 277 | 74.9 | 79 | 88.8 | 112 | 90.3 | 51 | 57.3 | 519 | 77.2 |
| Totals | 370 | | 89 | | 124 | | 89 | | 672 | |

TABLE 2. Summary of live-trapping results from Wallops Island, Virginia.

| SPECIES | August 1981 7 x 10 Grid | August 1981 6 x 12 Grid | May 1982 6 x 12 Grid |
|---|---|---|---|
| *Cryptotis parva* | 6 | 25 | 0 |
| *Oryzomys palustris* | 0 | 0 | 2 |
| *Peromyscus leucopus* | 3 | 4 | 7 |
| *Microtus pennsylvanicus* | 0 | 0 | 1 |
| *Mus musculus* | 76 | 101 | 63 |
| Totals (Individuals Captured) | 85 | 131 | 73 |
| % House Mice | 89.4 | 77.1 | 86.3 |
| # Stations at which House Mice Captured | 50 | 64 | 42 |
| % Stations at which House Mice Captured | 71.4 | 88.4 | 53.8 |
| $S^2/\overline{X}$-Ratio House Mice | 1.78 | 1.71 | 1.71 |
| Density: House Mice/ha | 48.5 | 59.9 | 55.4 |

on the three grids was further evidenced by variance/mean ratios of captures at trap stations that ranged from 1.71 to 1.78 (Table 2). A similar pattern of clumping of captures was evident in the snap-trapping data. Excluding data from two forest transects which yielded no house mice, *Mus* were taken at 108 of 250 or 43.2% of the stations on the six transects. The variance/mean ratios for *Mus* captures on these transects ranged from 1.49 to 2.72.

These clumped patterns of dispersion suggested that *Mus* preferred some habitats and were captured in these at higher frequencies than expected by chance while they tended to avoid other habitats. To ascertain this, we analyzed the habitat association of *Mus* in the eight habitats present on the live-trapping grids based on 825 total captures of 240 individuals. Chi-square analyses, comparing the observed captures of house mice in individual habitats versus expected captures based on the proportional sampling effort in each habitat, revealed highly significant deviations from the expected in the entire sample of *Mus musculus,* as well as in each of three relative age classes (Table 3). The data for the entire sample, as well as the individual age classes, revealed a higher than expected percentage of captures in the primary dunes. Although there was some variation among the age classes in the proportional catch in each habitat (Table 3), a Kendall Coefficient of Concordance ($W = 0.824$; Siegel 1956) revealed significant agreement among the rankings ($p < 0.02$) of the three age classes.

Spatial overlap between *Mus musculus* and *Peromyscus leucopus* on the study area was minimal. On the live-trapping grids, both species were taken at 12 of 142 or 8.5% of the stations. On eight snap-trapping transects having a total of 300 stations, both species were taken together at only two or 0.67% of the stations. Of the 14 total stations at which both species were taken (combined live- and snap-trapping), their distribution by habitat was: myrtle thickets (7), grass-shrub (5), grass meadow (1), and old dune (1). *Mus* and *Peromyscus* were segregated largely on the basis of wooded versus non-wooded habitats. On Wallops Island, *Mus* were never taken in the wooded habitats sampled, while 31 of 38 *P. leucopus* taken in the snap-trapping transects were from wooded habitats. The positive association between *Peromyscus* and woody habitats extended to the live-trapping grids, where the 31 captures of 14 individuals were limited to 12 stations, 7 of which were in myrtle thickets. On the live-trapping grids, only 12 of 142 stations (8.5%) were characterized by myrtle thickets. Thus, *Peromyscus* were taken at 58.3% (7 of 12) of the stations at which this spatially limited habitat occurred.

## DISCUSSION

Our results, with respect to the abundance and ecological distribution of *M. musculus*, differed substantially from those of Shure (1970), who studied small mammals on an Atlantic coastal island in New Jersey. In that study, *Mus* comprised only 2.7% (29 of 1069) of the specimens collected in a five-species community which also included *P. leucopus* (489), *M. pennsylvanicus* (317), *Zapus hudsonius* (196), and *Sorex cinereus* (38). Although *Mus* were most frequently captured in herbaceous habitats on the New Jersey island, they were not most abundant in dunegrass habitat. *Mus* were largely absent from mixed herb-shrub habitats in Shure's study, whereas they were common to abundant in these habitats on Wallops Island (Table 3). In New Jersey, all of these habitats supported large populations of *P. leucopus*. The difference between Shure's and our results may be related to habitat differences between the two study areas and the impact these may have had on the abundance and interspecific relationships of resident species. For example, in view of the relatively high moisture requirements of *M. pennsylvanicus* and *Z. hudsonius*, and their preference for sites characterized by high soil moisture and rank vegetation (Getz, 1961*a*, 1961*b*), the presence of large numbers of these

TABLE 3. Analysis of habitat distribution of house mice on live-trapping grids on Wallops Island, Virginia. Chi-square analysis was performed on numbers of captures in each habitat, with expected values based on sampling effort in each habitat.

| HABITAT | Percent Sampling Effort | Percent Total Catch of House Mice Overall | Juveniles | Subadults | Adults |
|---|---|---|---|---|---|
| Strand | 17.0 | 15.2 | 12.8 | 19.6 | 10.8 |
| Primary Dunes | 16.4 | 28.6 | 19.8 | 36.6 | 25.5 |
| Interdunes | 5.8 | 5.1 | 10.3 | 4.5 | 0.4 |
| Secondary Dunes | 4.2 | 1.9 | 3.7 | 1.7 | 0.4 |
| Grass/Shrub Assoc. | 33.0 | 31.9 | 37.2 | 25.0 | 36.8 |
| Old Dunes | 8.2 | 5.5 | 4.5 | 3.4 | 9.5 |
| *Myrica* Thicket | 7.4 | 5.5 | 2.5 | 4.5 | 10.0 |
| Grass Meadow | 8.0 | 6.4 | 9.1 | 4.5 | 6.5 |
| Totals (Captures) | | 825 | 242 | 352 | 231 |
| $X^2$ | | 101.41* | 26.45* | 121.55* | 40.45* |

* $P < 0.001$

species at the New Jersey site suggests that it was substantially moister than our study areas on Wallops Island, which yielded only 13 *M. pennsylvanicus* (and no *Zapus*). Also, as reported by numerous authors, *Mus musculus* tends to be uncommon to absent in wooded habitats (Whitaker, 1968; Zejda, 1975). One conspicuous exception is New Zealand, where *Mus* is common in southern beech (*Nothofagus*) forests (King, 1982).

Research by Porter and Dueser (1982) and Dueser and Porter (1986) on habitat selection and competition in small mammals on Assateague Island permit comparison of our results with those of another island in the Maryland-Virginia barrier island complex. Cranford and Maly (1990) provide additional insights into the habitat relationships of small mammals on Assateague Island, which lies approximately 2 km NNE of Wallops and from which it is separated by Chincoteague Inlet. With a length of about 60 km and an approximate area of 7029 ha (Porter and Dueser, 1982), Assateague is about five to six times the size of Wallops, which is 11 km long (Klotz, 1986) and encompasses 1214 ha (ca. 3000 ac.; Turgeon and Turgeon, 1980). Owing to the larger size of Assateague, it is not surprising that it supports at least one additional species of native small mammal, the meadow jumping mouse (*Zapus hudsonius*), which comprised 16.7% of the individuals collected by Dueser and Porter (1986) but only 4.6% of the individuals in Cranford and Maly's (1989) sample of 567 small mammals. Although *Mus* was also the numerically dominant small mammal in Dueser and Porter's (1990) sample from Assateague, it constituted only 43.1% of the total (196 of 455) compared to 77.2% in our Wallops sample (Table 1). In Cranford and Maly's study, *Mus* was the third most abundant species (after *Microtus pennsylvanicus* and *Oryzomys palustris*) and comprised 22.6% of their sample. This variation may reflect differences in proportions of habitats sampled in these studies. Nevertheless, these studies reveal similar results regarding habitat selection by *Mus* and the potential interspecific interactions of *Mus* and *P. leucopus*. The negative spatial and numerical relationships between *Mus* and *P. leucopus* observed in our Wallops Island data were also evident on Assateague. Cranford and Maly (1990) found limited spatial overlap of *Mus* and *Peromyscus* and a preference in the latter for wooded habitats. Porter and Dueser's (1982, Fig. 1) depiction of the habitat of *Mus* in discriminant space on Assateague suggests a preference for sites having low herbaceous cover and relatively low shrub cover. In our study, sites yielding *Mus* had mean herbaceous cover of 52.5% within 2 m of the trap and only 2.7% shrub cover. Sand (39.3%) and organic litter (5.2%) formed the remainder of surface area at such sites. The discriminant habitat profile of *P. leucopus* on Assateague showed it to be differentiated from *Mus* in terms of its preference for sites with dense shrub cover (Porter and Dueser, 1982). In addition to exhibiting a pattern of spatial segregation on Assateague, *Mus* and *Peromyscus* also evinced significant competition coefficients (Porter and Dueser, 1982).

Given the fact that house mice on Wallops Island appear to select certain preferred habitats and reduce their utilization of others, we are faced with the question of why they exhibit the pattern they do? As noted above, avoidance of wooded habitats by *M. musculus* is typical. Whether this represents inherent habitat selection or is the result of competitive interactions with native forest-dwelling small mammals cannot be determined on the basis of our Wallops Island data. B. J. Fox (pers. comm.) notes that although *Mus musculus* occurs throughout Australia, it is absent from rainforest habitats. Strahan (1983) suggests that the absence of feral populations of *Mus musculus* in northern tropical Australia may be the result of the competitive superiority of larger native forest-dwelling species of *Rattus* and *Melomys*. However, during our field work on Wallops Island, the abundance of *P. leucopus*, the principal potential native competitor of *Mus* in the wooded habitats, was low, averaging 3.1 captures/100 trap nights. Given the relatively low numbers *of P. leucopus* in wooded habitats on Wallops during our study, the overwhelming numerical dominance of *Mus musculus* in non-wooded habitats on the island is inconsistent with their being forced into such habitats as a result of interspecific competition with *P. leucopus*. The fact that Dueser and Porter (1986) determined that *P. leucopus* was competitively superior to *Mus* on Assateague Island suggests that site characteristics of individual study areas may influence the perceived competitive interactions between species.

In contrast to most populations of house mice which live in close association with man and his structures, the Wallops Island population is truly feral and free-ranging. It provides us with an opportunity to observe habitat selection in this species under conditions of minimal influence by man. We propose that the observed habitat distribution of *Mus musculus* on Wallops Island can be explained on the basis of its evolutionary history prior to becoming a commensal with man. *Mus musculus* presumably originated in the semi-arid regions east of the Caucasus Mountains of Asia and physiologically is well adapted to survive arid conditions (Watts and Aslin, 1981). Schwarz and Schwarz (1943) reported that all wild forms of *Mus musculus* are typically residents of dry regions, inhabiting savannahs, steppes, and occasionally deserts. Watts and Aslin (1981) note that like many small desert rodents, house mice avoid the heat of the day by living in burrows and becoming active principally at night, thus conserving water. On Wallops Island, the vast majority of snap-trapped *Mus* were taken during the night. On the live-trapping grids, released *M. musculus* frequently ran immediately to and entered burrows which they shared with ghost crabs (*Ocypode quandratus*). Thus, in some aspects of their behavioral repertoire, Wallops Island house mice resemble desert-dwelling *Mus musculus*.

The principal habitat of *Mus musculus* on Wallops Island was primary dunes. Based on a sample of 82 trap stations, primary dunes on Wallops were characterized by means of 53.8% living ground cover, 41.3% sand cover, and 4.9% organic litter, with herbaceous species dominated by grasses which comprised 95.3% of the living ground cover. We propose that of the available habitats on the north end of Wallops Island, primary dunes are the most similar to those of ancestral wild forms of *Mus musculus*, and we therefore hypothesize that on Wallops Island, the habitat distribution of *Mus musculus* reflects a preference for that habitat which most closely resembles the ancestral habitats of this species.

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LITERATURE CITED

Bailey, J. W. 1946. The mammals of Virginia. Williams Printing Co., Richmond, Va. 416 pp.

Blair, W. F., A. P. Blair, P. Brodkorb, F. R. Cagle, and G. A. Moore. 1968. Vertebrates of the United States. 2nd ed., McGraw-Hill Book Co., New York. 616 pp.

Briese, L. A. and M. H. Smith. 1973. Competition between *Mus musculus* and *Peromyscus polionotus*. J. Mammal. 54:968-969.

Caldwell, L. D. 1964. An investigation of competition in natural populations of mice. J. Mammal. 45:12-30.

_____. and J. B. Gentry. 1965. Interactions of *Peromyscus* and *Mus* in a one-acre field enclosure. Ecology 46:189-193.

Cranford, J. A. and M.S. Maly. 1990. Small mammal population densities and habitat associations on Chincoteague National Wildlife Refuge, Assateague Island, Virginia. Virginia J. Sci. 41(4A):321-329.

Dueser, R. D., W. C. Brown, G. S. Hogue, C. McCaffrey, S. A. McCuskey, and G. J. Hennessey. 1979. Mammals of the Virginia barrier islands. J. Mammal. 60:425-429.

Dueser, R. D. and J. H. Porter. 1986. Habitat use by insular mammals: relative effects of competition and habitat structure. Ecology 67:195-201.

Getz, L. L. 1961*a*. Factors influencing the local distribution of *Microtus* and *Synaptomys* in southern Michigan. Ecology 42:110-119.

_____. 1961*b*. Notes on the local distribution of *Peromyscus leucopus* and *Zapus hudsonius*. Am. Midl. Nat. 65:486-500.

Hall, E. R. 1927. An outbreak of the house mouse in Kern County, California. Univ. California Publ. Zool. 30:189-203.

_____. 1981. The Mammals of North America. 2nd ed., John Wiley and Sons, New York. 1181 + 90 pp.
King, C. M. 1982. Age structure and reproduction in feral New Zealand populations of the house mouse (*Mus musculus*), in relation to seedfall of southern beech. New Zealand J. Zool. 9:467-480.
Klotz, L. K. 1986. The vascular flora of Wallops Island and Wallops Mainland, Virginia. Castanea 51:306-326.
Lidicker, W. Z., Jr. 1966. Ecological observations on a feral house mouse population declining to extinction. Ecol. Monogr. 36:27-50.
Paradiso, J. L. and C. O. Handley, Jr. 1965. Checklist of mammals of Assateague Island. Chesapeake Sci. 6:167-171.
Pearson, O. P. 1964. Carnivore-mouse predation: an example of its intensity and bioenergetics. J. Mammal. 45:177-188.
Porter, J. H. and R. D. Dueser. 1982. Niche overlap and competition in an insular small mammal fauna: a test of the niche overlap hypothesis. Oikos 39:228-236.
Rowe, F. P., E. J. Taylor, and A. H. J. Chudley. 1964. The effect of crowding on the reproduction of the house mouse (*Mus musculus* L.) living in corn ricks. J. Anim. Ecol. 33:477-483.
Schwarz, E. and H. K. Schwarz. 1943. The wild and commensal stocks of the house mouse, *Mus musculus* Linnaeus. J. Mammal. 24:59-72.
Sheppe, W. 1967. Habitat restriction by competitive exclusion in the mice *Peromyscus* and *Mus*. Canadian Field-Nat. 81:81-98.
Shure, D. J. 1970. Ecological relationships of small mammals in a New Jersey beach habitat. J. Mammal. 51:267-277.
Siegel, S. 1967. Nonparametric Statistics. McGraw-Hill Book Co., New York. 312 pp.
Smith, R. L. 1980. Ecology and Field Biology. 3rd. ed. Harper & Row, Publ., New York. 835 pp.
Strahan, R. 1983. Complete Book of Australian Mammals. Angus and Robertson, Publ., Sydney. 530 pp.
Turgeon, D. D. and K. W. Turgeon. 1980. A preliminary floristic and vegetative survey of vascular plant communities on Wallops Island, Virginia, a barrier island-salt marsh system. Final Report, Contract No. P-76, 356 by NASA to the Marine Science Consortium, Wallops Island, Virginia.
Watts, C. H. S. and H.J. Aslin. 1981. The Rodents of Australia. Angus and Robertson, Publ., Sydney. 321 pp.
Whitaker, J. O., Jr. 1967. Habitat relationships of four species of mice in Vigo County, Indiana. Ecology 48:867-872.
_____. 1968. Relationships of *Mus*, *Peromyscus*, and *Microtus* to major textural classes of soils in Vigo County, Indiana. Proc. Indiana Acad. Sci. 77:206-212.
Zejda, J. 1975. Habitat selection in two feral house mouse (*Mus musculus* L.) lowland populations. Zool. Listy 24:99-111.