To the Graduate Council:

I am submitting herewith a thesis written by Tommy Ray Smith entitled "An Evaluation of Vertically Stratified Traps for Censusing Small Mammal Populations." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

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AN EVALUATION OF VERTICALLY STRATIFIED TRAPS FOR CENSUSING SMALL MAMMAL POPULATIONS

A Thesis

Presented for the

Master of Science

Degree

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ABSTRACT

The use of vertically stratified traps for censusing small mammal populations in Loblolly Pine Plantation and Oak-Pine-Mixed Hardwood Forest was evaluated. Trap types and placements included: pitfalls, snap and live traps set in excavated burrows, and snap and live traps set at ground surface. Combinations used for two removal trapping methods were: (1) one pitfall and one snap trap set at ground surface per station, and (2) one snap trap set in a burrow and one at ground surface per station. Live traps were placed in the latter manner.

Dominant species of small mammal communities in both habitats were *Peromyscus leucopus*, *Ochrotomys nuttalli*, *Blarina carolinensis*, and *Sorex longirostris*. Pitfalls did not appear effective for capturing *P. leucopus* and *O. nuttalli*, however, the design of this trap type herein may have allowed these rodents to escape capture, and interpretation was withheld. Neither of these species responded differently to snap and live traps set in burrows or at ground surface.

In removal trapping, *B. carolinensis* was captured with greatest efficiency by pitfalls and snap traps set in burrows when each was paired with snap traps set at ground surface. Trap-revealed densities indicated that setting traps in burrows was the most effective method for capturing this species. This trend was also observed in live trapping.

Higher numbers of *S. longirostris* were removed by pitfalls than by snap traps set in burrows or at ground surface. Response to the two placements of snap traps was variable and inconclusive while in live trapping distinctly more captures were made by traps set in burrows.

The three methods of vertical trap stratification produced uniform rates of capture for the four cohabiting species. Highest initial captures were observed in live trapping with indication that complete capture of resident populations was accomplished during a five-day trapping session. Small mammals were taken at lower rates in removal trapping with no indication that resident populations were totally removed. This was attributed to a shorter adjustment period of two days used in removal trapping compared to a five-day adjustment period used in live trapping.

Additional data were gathered on the distribution, density, standing crop biomass, diel activity, movement, home range, reproductive activity, and body measurements of the four common species.

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CHAPTER I

INTRODUCTION

Many important problems in contemporary ecological research are related to environmental protection, bioenergetics, and population ecology. Progress in these and other areas is dependent on accurate quantitative and qualitative assessments of the various components of biotic communities. One component which lends itself to censusing, responds readily to environmental fluctuations, and thus may provide indices to changes in other aspects of ecosystems is the small mammal fauna. The potentials for use of data on small mammal populations, however, have not been fully realized for lack of methods which routinely provide absolute estimates of density.

The delay in describing such methods has not been due to a paucity of interest or study. On the contrary, many investigators have evaluated methods of censusing small mammals (Bole 1939; Burt 1940; Calhoun 1959, 1964; Calhoun and Casby 1959; Gentry et al. 1966, 1968, 1971a, b, c; Golley et al. 1965; Grodzinski et al. 1966; Hyane 1949; Pelikan et al. 1964; Pucek 1969; Smith 1968; Smith et al. 1971; Stickel 1946, 1948, 1954; and others). These studies have shown that a variety of environmental conditions, intra- and interspecific interactions, and treatments (trap type, trap placement and spacing, bait, etc.) may influence the results of a census program and hinder delineation of the dynamics of a population and its role within the community and ecosystem.

One of the primary obstacles to developing a technique(s) which either counters or allows measurement of these biasing factors, thus permitting accurate density estimates, has been the inherent differences in the trap response and consequent probability of capture within and between cohabiting species. In recent years, removal trapping has generally been used due to its efficiency and feasibility in time and expense. By this method, density may be estimated by the linear regression method of Hayne (1949) provided a linear decline in the daily catch occurs. Variability in trap response results in different rates of capture, some species being taken at very low rates relative to their actual abundance during the first few days of trapping (Tanton 1965, Smith 1968). When lags in the capture of certain species occur, one of two problems generally arises: (1) either the lack of declines in daily catch prohibits fitting data to the linear regression model and density estimates cannot be made for all species in the community complex (usually fossorial and arboreal species) (Golley et al. 1968); or (2) the trapping period must be extended for several days (as many as 18 in the southeastern United States) before declines are observed or total removal is accomplished, and the major advantage of a short-term trapping period is lost.

Several explanations for this varying trap response in different species have been set forth. Calhoun (1963) hypothesized that lags in capture were due to community structure; the removal of dominant species having larger home ranges and greater exposure to traps allowed subordinate species to extend their movements and increased their probability of capture. This theory, however, has received strong criticism (Faust et al. 1971) and does not appear to be a valid explanation. Other authors (Fowle and Edwards 1954, Pucek 1969, Faust et al. 1971) have found that some of the "difficult to trap" species, particularly insectivores which often show a lag in capture, are readily taken in pitfalls and suggest that the lag is due to a "strange object reaction." Thus the pairing of conventional traps with other types such as pitfalls may be useful for equalizing the rate of capture for different species (Morris 1955, Buchalczyk and Pucek 1968).

In a more recent discussion Barbehenn (1973) presented limited evidence that the activities of various species are vertically stratified, movements of different species being concentrated at different vertical levels of the microhabitat. He suggested that positioning traps accordingly may reduce or eliminate lags in the capture of certain species and facilitate estimates of absolute density from short-term removal trapping.

The primary objective of this study was to evaluate the use of vertically stratified traps (including pitfalls) for censusing small mammal communities in two forest habitat types in the southeastern United States. Parameters of interest were trap response and rate of capture. A secondary objective was to gather baseline information on the population dynamics and biology of small mammal species occurring on the study area.

CHAPTER II

DESCRIPTION OF STUDY AREA

I. LOCATION AND TOPOGRAPHY

The study area was located in the northeast corner of Roane County, Tennessee, approximately 40 kilometers (25 miles) west of Knoxville and 16 kilometers (10 miles) northeast of Kingston. Bounded by White Wing Road (Highway 95) on the North, Bear Creek Road on the East and Oak Ridge Turnpike on the West (Fig. 1), this area is part of the Energy Research and Development Administration's (ERDA) Oak Ridge Reservation which encompasses 15,182 hectares (37,500 acres) in Roane and Anderson counties. The Reservation lies within a region known as The Great Valley of the Tennessee River which is in the Ridge and Valley Geologic Province. Situated East of the Cumberland Plateau and West of the Blue Ridge Mountains, this province is characterized by a series of alternating ridges and valleys oriented in a southwest-northeast direction.

The topography of the study area was typical of this province; the dominant feature is a steep ridge which transects the area along its long axis (Fig. 1). Elevation on the area ranges from 341 meters (1,119 feet) above mean sea level on Pine Ridge to 238 meters (781 feet) in the valleys on either side.

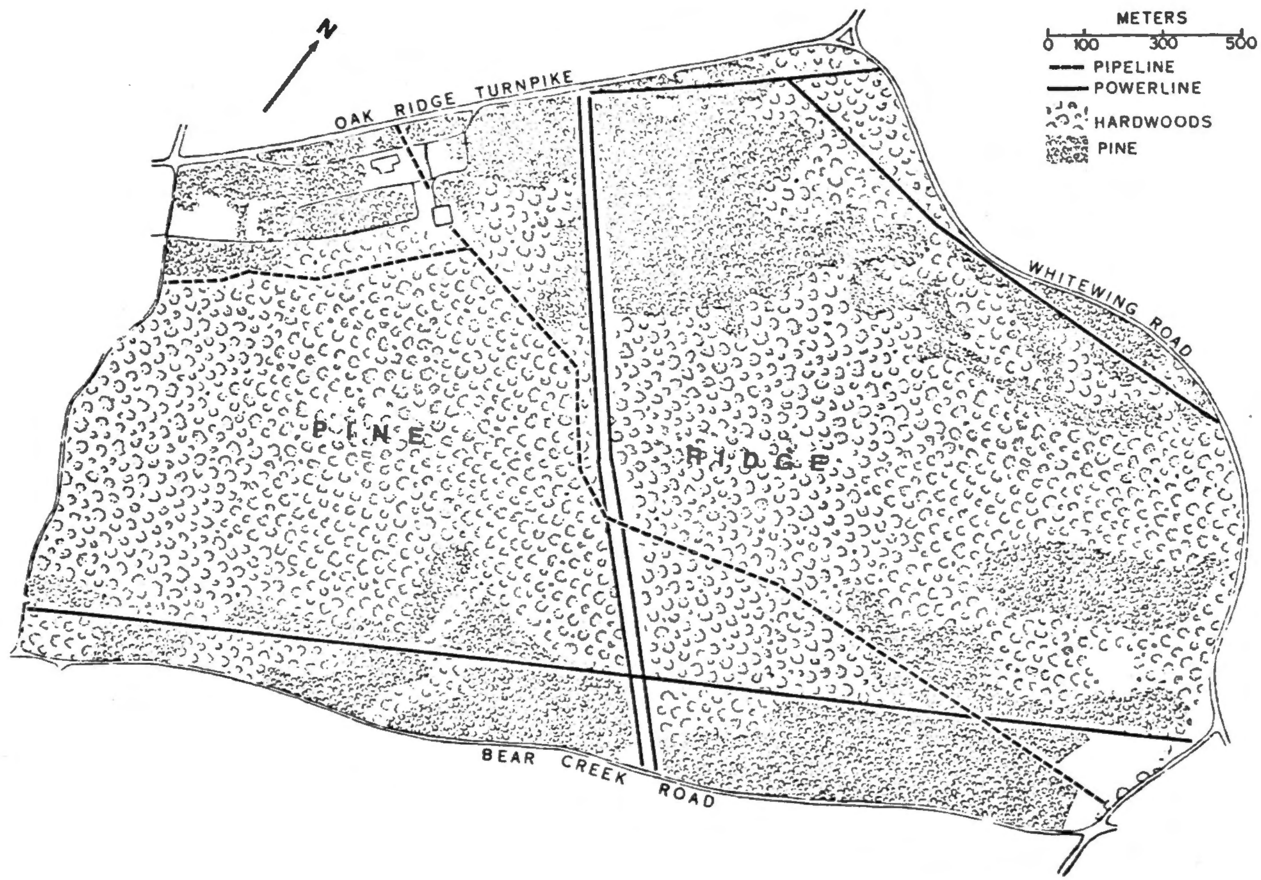


Figure 1. Map of the 400 hectare study area located on the Energy Research and Development Administration's Oak Ridge Reservation in Roane County, Tennessee.

II. GEOLOGY AND SOILS

Ridges of the "Great Valley" are characterized by sandstone, shale, and dolomite, while valleys are underlain by less resistant limestone and shale (Swann 1942). Soils developed from this substrate are of the utisol group which includes the red and yellow podzolic soils. These soils are moderately permeable and generally well-drained. Surface soils are gray, brown, or red silt loams, sandy loams, and silty clay loams.

Surface soils on the study area are generally of the sandy loam type. On uplands underlain by sandstone and shale, stony fine and very fine sandy loams occur. Uplands with limestone substrate have cherty silt loam (smooth phase) surface soils but are uncommon. Soils on colluvial slopes with sandstone or sandstone-shale substrate are gravelly fine and very fine sandy loam or in limited areas, silt loam. In bottomland areas, soils are lightly-colored, poorly-drained fine sandy loam which have been washed from uplands with sandstone and acidic shale substrate (Swann 1942).

III. CLIMATE

Climatic conditions on the Reservation were considered representative of the study area and are used herein.

The temperate climate of this area is humid, continental with moderate summers and winters. The mean annual temperature is 14.6°C, ranging from a summer mean of 25.1°C to a winter mean of 4.4°C (Curlin 1965). Fall and spring means are 15.5°C and 14.2°C respectively.

Annual precipitation averages 131.8 cm with rainfall evenly distributed throughout the year. Highest amounts of rainfall normally occur in January and lowest amounts in October. Snowfall does not represent a significant portion of the total precipitation, averaging 16.3 cm annually (Swann 1952).

IV. VEGETATION

Curlin (1965) reported six forest types from the Reservation: five are naturally occurring Appalachian types, and the sixth is managed Loblolly pine (*Pinus taeda*) plantations established between 1947 and 1956. McDonald (unpublished data) described three additional types, giving a total of nine for the area. Three of these, Loblolly pine, white oak-red oak-hickory (*Quercus alba*-*Q. falcata*-*Carya sp.*) and shortleaf pine-oak (*P. echinata*-*Q. sp.*) are significant, occupying approximately 25, 40, and 35 percent respectively of the total acreage of the area. Among these three cover types, stand density is greatest in Loblolly pine (23.2 m^2/ha), followed by white oak-red oak-hickory (17.4 m^2/ha) and shortleaf pine-oak (16.9 m^2/ha).

Other less significant types are: Virginia pine (*P. virginiana*) which occurs as successional forest, particularly on drier sites; sweet gum-yellow poplar (*Liquidambar styraciflua*-*Liriodendron tulipifera*); yellow poplar-white oak-northern red oak, a cove hardwood type occupying mesic well-drained sites; white pine (*P. strobus*); white pine-chestnut oak (*P. strobus*-*Quercus prinus*); and Loblolly pine-Hardwood. In addition to these a mixed bottomland forest consisting of Sweet gum, Sycamore

(*Platanus occidentalis*) and scattered clumps of mature Loblolly pine occurs on the North end of the study area in a small flood-plain associated with Bear Creek.

The small unforested portions of the study area are primarily maintained utility-rights-of-way. Periodic mowing of these areas prevents the development of forests. A few small fields occur on the area as a result of pine stands killed by the pine bark beetle. These open areas are currently being invaded by mixed hardwoods and will probably result in either oak-pine or mixed hardwood forest types.

CHAPTER III

METHODS

I. HABITAT CLASSIFICATION

Loblolly Pine plantations on the study area were uniformly homogeneous with distinct boundaries. This forest type was considered a separate habitat type, hereafter referred to as Pine.

Two of the eight natural types, white oak-red oak-hickory and shortleaf pine-oak, comprised approximately 75 percent of the forested area. Acreage of the remaining six forest types was minimal. These eight forest types were considered one habitat type, hereafter referred to as Hardwoods.

II. VERTICAL STRATIFICATION OF MICROHABITAT

To test the hypothesis that by vertically stratifying traps the lag in capture of certain species may be eliminated (Barbehenn 1973), trapping methods were designed to place an equal number of traps at two vertical levels of the forest microhabitat (Fig. 2). Level 1 encompassed the area of wet litter (leaf mold) and surface soil. The depth and consistency of this level varied within and between habitat types, the wet litter being generally deeper in Pine. As a result, no limits were placed on the depth at which traps were positioned. Rather, Level 1 was considered that area suitable for and characterized by underground burrows constructed by fossorial species. Traps at this level should capture small mammals whose movements are concentrated below ground surface.

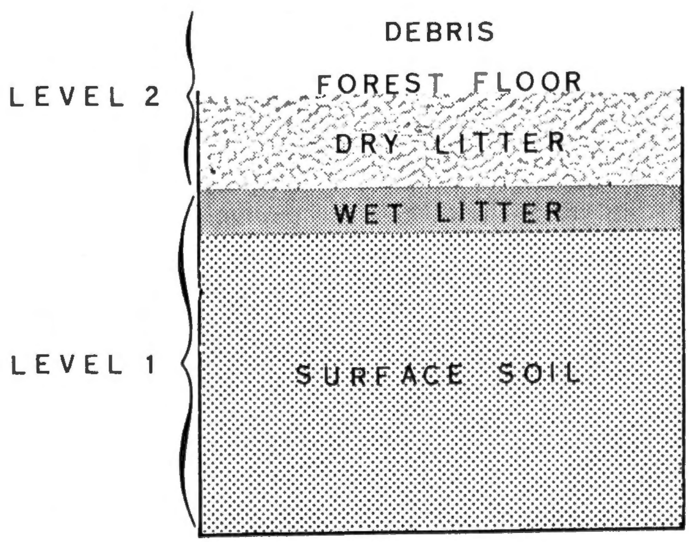


Figure 2. Profile of forest floor microhabitat indicating the vertical levels at which snap and live traps were placed.

Level 2 included the dry litter, the forest floor, and surface debris (logs, stumps, etc.). Traps at this level should be effective in capturing small mammals moving at ground surface.

III. REMOVAL TRAPPING

Sampling Intensity

The investigation was designed to census small mammals on 4.0 percent of the total acreage of each habitat by removal trapping. This effort was divided between two removal methods. Considering a border strip around removal trapping plots of 5 meters (one-half the distance between trap stations), the area encompassed by each removal plot was 0.5 hectare. Since the study area consisted of approximately 100 ha of Pine and 300 ha of Hardwoods, 8 removal sampling plots in the first and 24 in the second were needed to meet this objective (Fig. 3). Locations for these plots were randomly selected from a grid (with scaled coordinates of 150 meters) laid over a vegetation map of the study area.

The order in which removal plots were sampled was determined subjectively after grid coordinates were located, and gross habitat features (slope, slope aspect, dominant tree species, ground cover, and water supply) evaluated for each. Plot locations with similar features were assigned equally to the two removal trapping methods to reduce biases due to discrete habitat variables. This further helped minimize time and effort, allowing plots situated close to each other to be trapped during the same removal session. A total of eight sessions, working four plots during each session, were required to complete

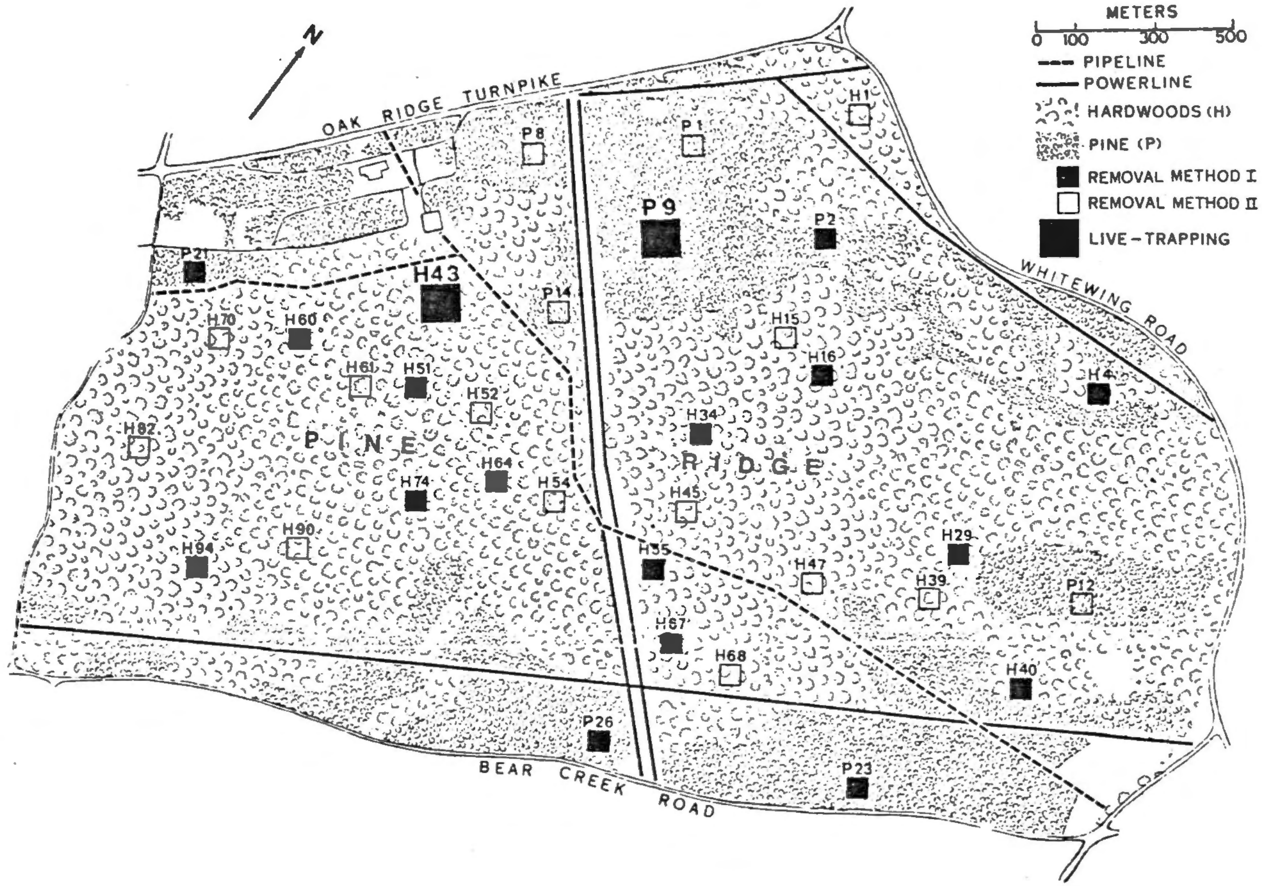


Figure 3. Locations of small mammal sampling plots on the study area on the ERDA's Oak Ridge Reservation in East Tennessee.

removal trapping. During these sessions two plots were trapped by Removal Method I and two by Removal Method II. Removal Session I began March 15, 1975, and Session VIII was completed July 20, 1975, sessions spaced irregularly through this four month period (Table I).

Trap Types and Methods of Trap Placement in Removal Trapping

Two types of traps were used in removal trapping: snap traps and pitfalls. "Museum Special" snap traps (70 x 140 mm) were employed, while pitfalls were constructed of aluminum cans (125 mm in diameter and 165 mm deep) sunk in the ground with the top just below ground surface (Fig. 4a). Two holes drilled in the sides of the can about 50 mm from the bottom allowed drainage of rainwater.

At each removal plot location, a square 7 x 7 grid was laid measuring 60 m per side and containing 49 trapping stations at 10 meter intervals. For Removal Method I, one snap trap and one pitfall were placed within one meter of each station (Fig. 5a). In this method snap traps were set at ground surface. The effect of pitfalls was to be tested against that of snap traps set across excavated burrows (Removal Method II) as both techniques have been found effective for capturing fossorial species (Barbehenn 1973, Briese and Smith 1974).

For Removal Method II, only snap traps were used, placing one trap across an excavated burrow and one at ground surface within one meter of each trap station (Fig. 5b). In original design, traps at ground surface were to be set on top of the dry litter, however, in order to stabilize traps, it was often necessary to brush aside the dry litter and place

TABLE I

SCHEDULE OF REMOVAL AND LIVE TRAPPING SESSIONS CONDUCTED DURING THE SMALL MAMMAL STUDY ON THE ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

Session	Trapping Method(s)	Plots Trapped	Inclusive Dates of Trapping
I	Removal Method I Removal Method II	H67&H94 H68&H90	3/15-3/19
II	Removal Method I Removal Method II	P21&H55 P8 &H45	3/26-3/30
III	Removal Method I Removal Method II	H40&H60 H47&H70	4/5-4/9
IV	Removal Method I Removal Method II	P2 &H16 P1 &H15	4/21-4/25
V	Removal Method I Removal Method II	H64&H74 H52&H54	5/23-5/28
VI	Removal Method I Removal Method II	P26&H51 P14&H61	6/11-6/15
VII	Removal Method I Removal Method II	P23&H29 P12&H39	6/24-6/28
VIII	Removal Method I Removal Method II	H4 &H34 H1 &H82	7/16-7/20
A	Live Trapping	P9&H43	3/2-3/6
B	Live Trapping	P9&H43	4/7-4/11
C	Live Trapping	P9&H43	5/16&5/20
D	Live Trapping	P9&H43	6/15-6/19
E	Live Trapping	P9&H43	7/16-7/20

(a)

(b)

(c)

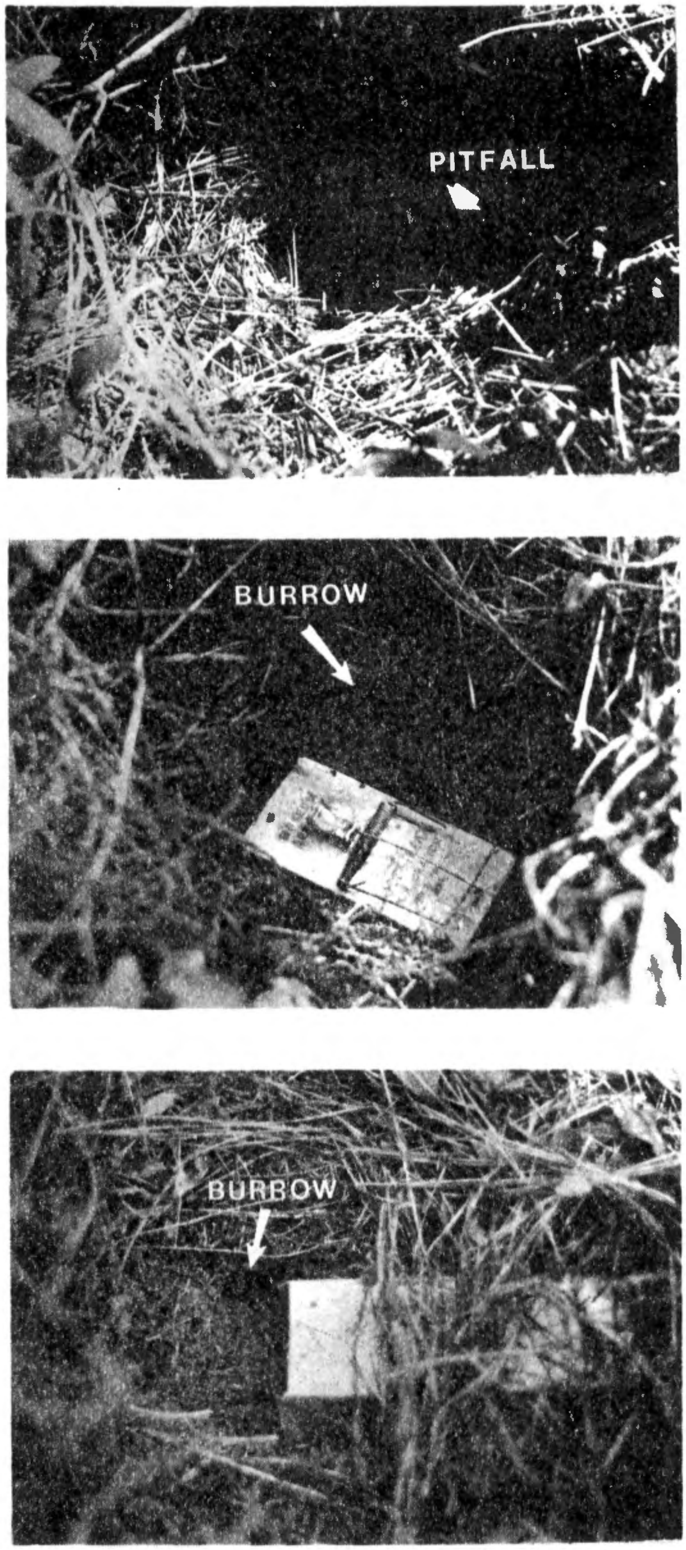
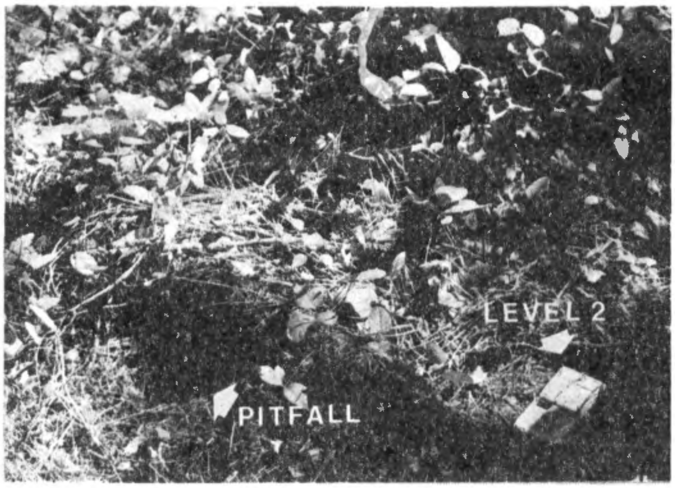
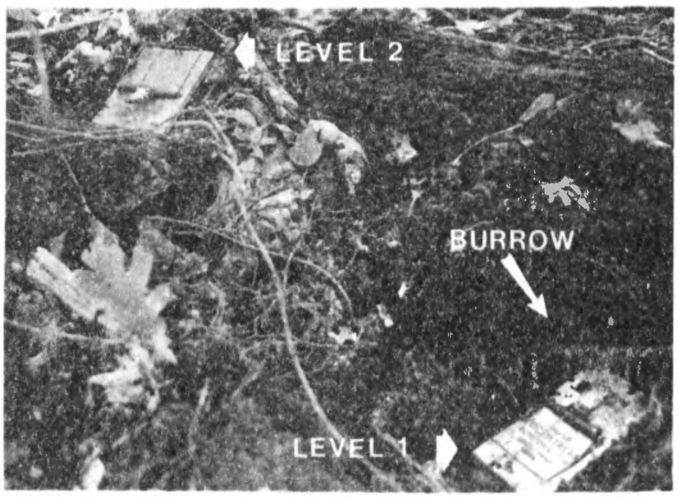


Figure 4. Types and placements of traps used at Level-1 and directed at capturing fossorial small mammals: (a) pitfall, (b) snap trap placed across an excavated burrow, and (c) live trap placed adjacent to an excavated burrow.

(a)



(b)



(c)

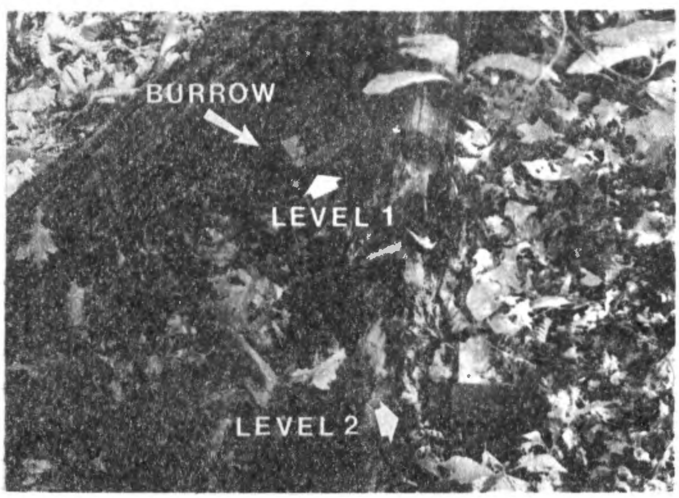


Figure 5. Typical conditions (trap type, spacing, and placement) of trap stations in (a) Removal Method I, (b) Removal Method II, and (c) live trapping.

the trap on top of the leaf mold. Occasionally a trap was placed on a decayed log or stump when found at a trap station.

The wet litter and surface soil were probed with a digging tool to locate burrows. When found, a burrow was partially excavated and the trap placed with the treadle across it (Fig. 4b). If a burrow was not located, the litter and surface soil were excavated in a similar manner, and the trap placed at a depth at which other burrows had been found in the plot. Generally, when burrows could not be located, traps were positioned under logs, stumps, tree roots, etc.

A two-day adjustment period was used prior to trapping at each removal plot. During this time snap traps were positioned but not set or baited, and pitfall holes dug without the cans inserted. The adjustment period was employed to reduce or eliminate "strange object reactions" by small mammals, particularly shrews (Brown 1967, Fowle and Edwards 1954, Pucek 1969, Faust et al. 1971). Traps were not prebaited for two reasons: (1) to avoid interference with normal movements by concentrating animals into baited areas (Babinska and Bock 1969); and (2) because there is some question of the ability of prebaiting to render all individuals in a population uniformly susceptible to capture (Grodzinski et al. 1966).

After two nights, pitfalls were completed and filled to a depth of 50 mm with water, and snap traps set and baited with a peanut butter-oatmeal mixture. Traps were checked daily for five consecutive days, replacing bait as needed. For each capture, species, session number, plot number, day of session, trap type and level, age, sex, reproductive condition, weight, and standard measurements were recorded.

IV. LIVE TRAPPING

Plot Description

In each habitat one site was selected for establishing a permanent live trapping plot (Fig. 3, page 12). Primary consideration in this selection was given to homogeneity of the habitat and juxtaposition to removal sampling plots (to avoid interference). At the two sites a square 10 x 10 grid, 90 m per side with 100 trap stations at 10 m intervals was marked.

Trap Types and Placement

Two sizes of Sherman-type, galvanized metal live traps were used; one measured 75 x 75 x 255 mm and the other measured 75 x 90 x 295 mm. Two traps were placed within one meter of each trap station, one trap adjacent to a burrow and one at ground surface (Fig. 5c, page 16). In both live-trapping plots, 155 small size and 45 large size traps were used, placing the large-size traps in a regular sequence.

The method of placing live traps was similar to that used for snap traps except that traps set in burrows were positioned with the door adjacent to the burrow (Fig. 4c, page 15). Traps were baited with a peanut butter-oatmeal mixture and supplied with absorbent cotton batting for bedding.

Beginning in March, one 5-day live-trapping session was conducted each month through July; sessions were conducted simultaneously in the two habitats. The mean interval between sessions was 30 days, ranging from 26 to 34. Session I was preceded by a 5-day adjustment period with traps positioned and set, leaving the back door open. No adjustment period was used thereafter as traps were left in the field between sessions. Traps were checked twice daily (early morning and late afternoon) removing animals and replenishing bait and dry cotton as needed.

Captured animals were handled by shaking them from the trap into a plastic bag and grasping them by the nape. For each capture, session number, date, time of day (a.m. or p.m.), trap number, trap level, species, age, sex, reproductive condition, and distance moved since last capture (for recaptures) were recorded. Animals were marked for identification by toe-clipping (Baumgartner 1940) and released at the point of capture. A record of the initial and all subsequent captures of each individual was kept. Animals found dead in traps were examined in the laboratory to verify sex (in the case of shrews) and record weight and standard measurements.

V. REFERENCES

Vernacular and scientific names of small mammals used in this report were taken from Jones et al. (1973). References used for identification of small mammals included: Hall and Kelson (1959), Golley (1962) and Burt and Grossenheider (1964). Vernacular and scientific names of plants were taken from Radford et al. (1968).

CHAPTER IV

RESULTS AND DISCUSSION

In removal trapping, a total of 142 small mammals representing six species was collected in 15,680 trap-nights. These included 44 white-footed mice (*Peromyscus leucopus*), 15 golden mice (*Ochrotomys nuttalli*), 37 southern short-tailed shrews (*Blarina carolinensis*), 41 southeastern shrews (*Sorex longirostris*), 4 woodland mice (*Microtus pinetorum*), and 1 eastern rice rat (*Oryzomys palustris*).

In live trapping, 199 captures of 85 individuals representing five species were made in 10,000 trap-nights. These included 21 *P. leucopus*, 10 *O. nuttalli*, 28 *B. carolinensis*, 25 *S. longirostris*, and 1 southern flying squirrel (*Glaucomys volans*).

I. TRAP RESPONSE

Due to the extremely low trap success presentation of trapping data by the conventional method (success/trap-night) was not believed to be effective for illustrating the efficiency of the various trap types and placements. Instead, empirical data are presented and discussed with trapping effort given in table headings. Trapping results by each method were pooled from all sampling plots sampled by individual methods.

Rodentia

Pitfalls did not appear to be effective for capturing the two common rodent species in either habitat. When paired with snap traps set at ground surface, 16 of 18 P. leucopus and 9 of 9 O. nuttalli were taken by snap traps (Table II). Sealander and James (1958) found that these species were captured with equal efficiency by pitfalls and snap traps, however, their sample size was very small and their method of pitfall construction was different. They used similar sized cans but filled them to a depth of six inches with water which prevented captured animals from escaping. Pucek (1969) found that rodents occasionally jumped from cone-shaped pitfalls 45-50 cm deep, but escape was considered uncommon. In the present study, the two pitfall captures of P. leucopus occurred on nights when heavy rain storms saturated the soil and filled these traps with water. Consequently, it appeared that, due to design, pitfalls utilized in this study may not have been effective in retarding escape and an unreliable picture of the response of P. leucopus and O. nuttalli to this trap type was produced.

In Removal Method II the response of P. leucopus to snap traps set across burrows and at ground surface varied between habitats. In Pine, ground surface traps were more effective accounting for 5 of 5 captures while in Hardwoods approximately equal numbers (10 and 11) were taken by burrow and ground surface traps (Table II).

In an evaluation of the responses of P. leucopus and B. brevicauda to snap traps set at ground surface, in burrows, and in ditches, Barbehenn (1973) reported 5, 1, and 10 captures of Peromyscus by the three placements respectively. These results disagreed with those in my study, however, in both cases, sample size was extremely small.

TABLE II

CATCH OF SMALL MAMMALS BY DIFFERENT TRAP TYPES AND PLACEMENTS IN PINE AND HARDWOODS HABITATS ON ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

		Removal Method I		Removal Method II		Live Trapping	
Species	Habitat	Pitfall (4,200 T.N.*)	vs Snap Trap at Ground Surface (4,200 T.N.*)	Snap Trap at Excavated Burrow (4,200 T.N.*)	vs Snap Trap at Ground Surface (4,200 T.N.*)	Live Trap in Excavated Burrow (5,000 T.N.*)	vs Live Trap at Ground Surface (5,000 T.N.*)
P. leucopus	Pine	0	3	0	5	29	20
	Hardwoods	2	13	10	11	18	20
	Total	2	16	10	16	47	40
O. nuttalli	Pine	0	4	1	4	15	8
	Hardwoods	0	5	0	1	6	4
	Total	0	9	1	5	21	12
B. carolinensis	Pine	3	0	11	2	29	7
	Hardwoods	4	2	13	2	12	2
	Total	7	2	24	4	41	9
S. longirostris	Pine	10	7	0	6	15	7
	Hardwoods	13	0	3	2	5	1
	Total	23	7	3	8	20	8

*T.N.—Trap Nights.

In Pine, trap response of O. nuttalli was greater to ground surface traps in which 4 of 5 captures were made. The number of captures by Removal Method II in Hardwoods was not sufficient for analysis (Table II).

Responses of rodents to live traps set at different vertical levels in Pine were not consistent with those to similarly placed snap traps in removal sampling; more captures of both P. leucopus and O. nuttalli were made by burrow placements than by ground surface placements. In Hardwoods captures of the two species were similar at the two levels (Table II). These data indicated that P. leucopus and O. nuttalli were isoresponsive to traps set in burrows and at ground surface.

Insectivora

B. carolinensis was captured more frequently by both pitfalls and snap traps set across burrows when paired with snap traps set at ground surface. In Removal Method I, 7 of 9 captures were made by pitfalls, and in Removal Method II, 24 of 28 by traps set in burrows (Table II). A greater efficiency by traps set in burrows was also observed in live trapping as 41 of 50 captures were made by this placement.

Similar results were reported by Barbehenn (1973) who found that snap traps set across burrows were more effective than traps set at ground surface for capturing Blarina. Briese and Smith (1974) reported a significantly higher catch of B. brevicauda by pitfalls when compared with live traps set at ground surface.

Although B. carolinensis was taken more readily by both pitfalls and traps set in burrows, the latter appeared to be the most effective method for capturing this species. The number of captures in plots sampled by Removal Method II were considerably higher than those sampled by Removal Method I (Table II, page 22). These differences were due to a consistently higher catch by snap-traps set in burrows as opposed to pitfalls.

Response of _S. longirostris_ to pitfalls and snap-traps at ground surface varied between habitats. In Pine the two were equally effective accounting for 10 and 7 captures respectively. In Hardwoods, however, response to pitfalls was significantly higher; 13 of 13 captures were made by this trap type (Table II).

Other investigators have verified the efficiency of pitfalls for capturing _Sorex_. After approximately 1,000 trap-nights effort by snap and live traps failed to catch _S. longirostris_, Tuttle (1964) successfully captured this species with pitfalls. Brown (1967) studying various _Sorex_ species in Montane habitats and MacLeod and Lethieq (1963) investigating _S. cinereus_ on an island in Newfoundland, reported that pitfalls were superior to snap traps. Likewise, Pucek (1969) found that the response of North-European shrews, primarily of the genus _Sorex_, was significantly higher to pitfalls than to snap traps.

The effectiveness of snap traps set in burrows and at ground surface for capturing _S. longirostris_ also varied between habitats. In Pine, 6 of 6 captures were made by traps set at ground surface compared to 2 of 5 by this placement in Hardwoods. It appeared that this species was readily captured by snap traps placed at ground surface in Pine but not in Hardwoods. This may have been related to the condition of the ground cover in the two habitats. Pine Plantations were characterized by a dense understory of honeysuckle (Lonicera japonica), providing nearly complete cover for small mammals moving at ground surface, while in Hardwood forest, ground cover was relatively sparse. Greater cover may have enhanced movements of Sorex at ground surface, thus increasing their exposure to traps set at this level as well as to pitfalls. Live trapping data, however, did not support this assumption as the number of captures was distinctly higher by traps in burrows than by traps at ground surface in both habitats (Table II, page 22).

The small sample sizes in this investigation limited conclusions concerning the effectiveness of the various trap types and placements. General trends, however, were observed: P. leucopus and O. nuttalli did not appear to respond differently to traps (snap and live) set in burrows and at ground surface; B. carolinensis was taken with greater efficiency by both pitfalls and traps set in burrows with the latter being the most effective method of capture; and S. longirostris was taken in much higher numbers by pitfalls, suggesting that this trap type gives more reliable density estimates for this species than other types of kill traps.

II. RATE OF CAPTURE

Two aspects of capture rate were of particular interest in this evaluation of vertically stratified traps: the uniformity of rates among cohabiting yet behaviorally different species, and the intensity of removal (or capture). Methods which produce uniform rates characterized by rapid removal and declining daily captures are essential for the accurate description of small mammal communities from short-term removal trapping.

Captures of each species were pooled for all trapping sessions and the combined data considered as one 5-day period. To compare capture rates of different species, the total number of captures of each over the 5-day period was taken as 100 percent. To illustrate the progression of captures through the trapping period, the cumulative percentages at successive days were plotted (Fig. 6). Tendencies of capture rates to increase, decline, or remain constant through the trapping period were illustrated by catch curves, constructed by plotting daily percentages of the total catch (Fig. 7).

Removal Method I

Capture rates by this method for the three most abundant species *P. leucopus*, *B. carolinensis*, and *S. longirostris* were relatively uniform (Fig. 6a). On day 1, 28, 33, and 20 percent respectively of the total catch of these species was made. Through days 2 and 3 rates varied, but by the fourth day of trapping from 89 to 93 percent had been captured. *O. nuttalli* was taken at a considerably higher initial rate, 67 percent captured on day 1 with the total catch made by day 3.

The intensity of removal varied between the four species, although each showed a similar trend (Fig. 7a). The daily catch of *O. nuttalli* and *B. carolinensis* declined sharply from day 1 to day 2, increased slightly at day 3 and then steadily dropped on days 4 and 5. The increase in daily catch for *B. carolinensis* after day 2 was due to the input of captures by snap traps at ground surface. If the catch of this species by pitfalls is considered separately, daily captures declined at day 2 and held constant through the remainder of the trapping period (Fig. 7d).

(a)

(b)

(c)

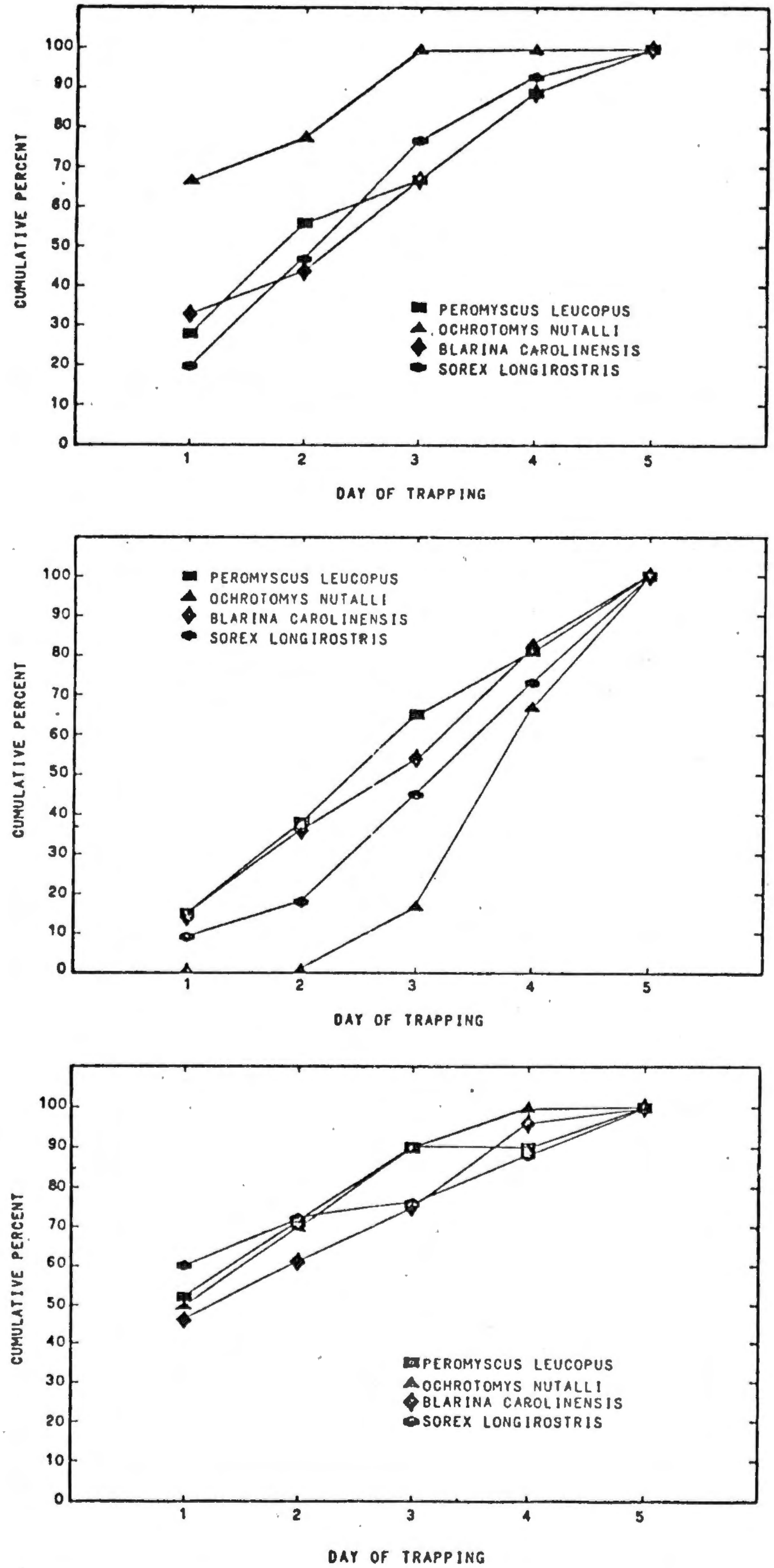


Figure 6. Rates of capture by: (a) Removal Method I, (b) Removal Method II, and (c) live trapping in Pine and Hardwoods habitats on the ERDA's Oak Ridge Reservation in Roane County, Tennessee, March-July, 1975.

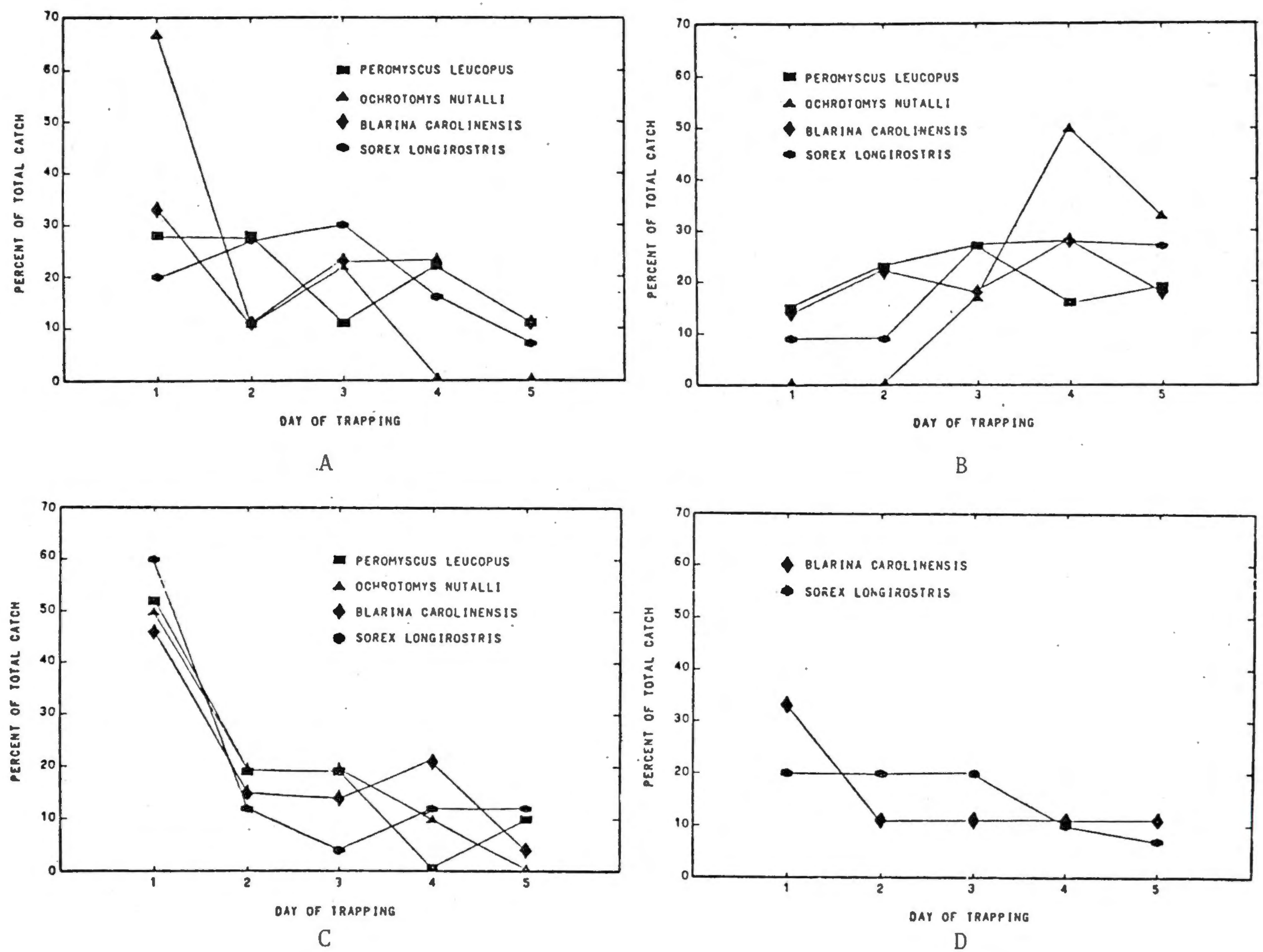


Figure 7. Catch curves of small mammals by: (a) Removal Method I, (b) Removal Method II, and (c) live trapping and (d) pitfalls only in Pine and Hardwoods habitats on the ERDA's Oak Ridge Reservation in Roane County, Tennessee, March-July, 1975.

P. leucopus showed a pattern similar to O. nuttalli and B. carolinensis but lagged behind by one day. The daily catch declined on day 3 after equal numbers were taken on days 1 and 2. An increase was observed at day 4 with the catch again falling off on day 5.

S. longirostris was the only species which showed an increase in daily catch during the initial days of the trapping period (Fig. 7a). A moderate rise occurred between days 1 and 3, with captures steadily declining thereafter. As in the case of B. carolinensis, the increase in daily catch during the second and third days of the trapping period resulted from captures by snap traps placed at ground surface. Considering only pitfall captures, the daily catch for this species remained constant from days 1 to 3 at which point a decline occurred (Fig. 7d).

Pucek (1969) found that North-European insectivores were removed at higher rates by pitfalls than by snap and live traps. A decrease in daily captures occurred only in the case of pitfalls which were equally effective for Rodentia. Although the removal of insectivores proceeded more slowly than rodents, even when pitfalls were used, accurate density estimates for Sorex by the linear regression method were made from trapping periods of 7 days or less.

In the present study, no substantial lag in capture rate was observed when pitfalls were paired with snap traps set at ground surface. Each species exhibited a decline in daily catch at some point during the 5-day trapping period. With the exception of O. nuttalli, however, these declines were not distinct or linear. Pitfalls captured the two insectivores, B. carolinensis and S. longirostris, at higher rates than snap traps at ground surface, supporting the earlier conclusion that this type was a more effective method for capturing these species.

Removal Method II

As in Removal Method I, capture rates of *P. leucopus*, *B. carolinensis*, and *S. longirostris* were similar (Fig. 6b, page 27). On the first day of trapping, 15, 14, and 9 percent respectively of the total catch of these species was made, the rates continuing in a uniform manner through the remainder of the period. The trend of capture for *O. nuttalli* approximated that of the other species, but lagged behind by two days. First appearing on day 3, the cumulative percentages for this species increased to 67 on day 4.

The intensity of removal by Removal Method II was considerably lower than by Removal Method I for all species. Daily catches increased during initial days of the trapping period and never showed a distinct decline (Fig. 7b, page 28). Consequently, there was no definite indication that resident populations were removed during the five days of trapping. However, by day 3 for *P. leucopus*, *B. carolinensis*, and *S. longirostris* and day 4 for *O. nuttalli*, substantial portions of the total catch had been made. Although they progressed rather slowly, capture rates of the four cohabiting species appeared uniform.

These results differed from those in a series of small mammal censuses in a lowland mesic hardwood forest in South Carolina (Gentry et al. 1971a). Placing two snap traps (1 Victor Mouse and 1 Museum Special) per station in a grid with 15 m trap station intervals and not prebaiting, these investigators found wide differences in the capture rates of _P. gossypinus_, _O. nuttalli_, and _B. b. carolinensis_. In each of two trapping periods (1969 and 1970), _P. gossypinus_ was captured at the highest rate, followed in order by _O. nuttalli_ and _B. b. carolinensis_. The rates of capture for the three species did not approximate each other until days 10 and 14 of the two trapping periods respectively. In the latter period, _O. nuttalli_ was not taken until day 4 with _B. b. carolinensis_ first appearing on day 13. Earlier studies on this grid employed a 5-day prebaiting period. In one case (1968), the three species were captured at highly uniform rates, while in the previous year, _P. gossypinus_ and _B. b. carolinensis_ were removed at a much higher rate than _O. nuttalli_ and _S. longirostris_, the latter two species not appearing until days 6 and 9. On the same study area in 1969, Kaufman et al. (1971) captured _P. gossypinus_ at a higher rate than _O. nuttalli_ and _B. b. carolinensis_ using similar traps set at 11 m intervals along octagon census lines.

Live Trapping

Capture rates of each species in live traps were based on captures of new individuals. The results of Live Trapping Sessions I-V from both habitats were combined. The assumptions were made that neither the occupancy of traps by captured individuals nor the return of live-trapped animals to the environment affected the probability of capturing unmarked members of the populations.

Rates of capture for _P. leucopus_, _O. nuttalli_, _B. carolinensis_, and _S. longirostris_ were relatively uniform throughout the trapping period (Fig. 6c, page 27). Percentages of the total catch of these species on day 1 ranged from 46 for *B. carolinensis* to 60 for *S. longirostris*. At day 4, from 88 to 100 percent of the total catch of all species had been made. Similar rates of capture for *P. leucopus* by live trapping were reported by Morris (1955) and Getz (1961).

Live trapping results of my study indicated that all or nearly all of the resident population of each species had been captured by the third or fourth day of trapping. This intensity of capture was distinctly higher than that by removal methods, particularly Removal Method II. The daily catch for each species exhibited a sharp drop at day 2 with more moderate declines occurring through day 5 (Fig. 7c, page 28). Differences in capture intensity between removal and live trapping were believed to be due to differences in the length of adjustment periods used for each. Removal trapping sessions were preceded by a two-day adjustment period while in live trapping, traps were positioned five days prior to the commencement of Trapping Session I and remained in the field through the course of the study (5 months). The longer adjustment period may have allowed the breakdown of neophobic reactions to live traps while the two-day period utilized in removal trapping may not have been long enough to accomplish this.

In the present study, it appeared that by vertically stratifying traps uniform capture rates for different species of the small mammal community were produced. No distinct lag in the capture of insectivores was observed.

In contrast, Gentry et al. (1971a), as well as many other investigators who have used conventional trapping methods, found that capture rates of cohabiting species varied considerably. Rodents were generally taken at higher rates than insectivores which showed a definite lag in capture. In some cases, species in the latter group were not captured until several days into the trapping period. On the other hand, Pucek (1969) found that insectivores were captured by pitfalls at high rates during initial days of trapping. The effectiveness of this type trap for capturing insectivores has been verified by other authors as well (Briese and Smith 1974, Tuttle 1964, Brown 1967, MacLeod and Lethieq 1963). This evidence, like that presented by Faust et al. (1971), draws question to Calhoun's (1964) theory that lags in the capture of certain species are due to social organization. It appears likely that lags which were observed resulted in part from using ineffective methods of trapping.

The lack of declines in the daily catch of small mammals by removal methods was believed to result from insufficient periods allowed for the animals to adjust to snap traps. Pitfall captures, which occur when the animal accidentally falls into the trap, would not have been affected by the length of adjustment periods. The daily catch of *B. carolinensis* and *S. longirostris* by this trap type showed a declining trend through the trapping period.

Although the evidence of this study was limited by small sample sizes, it clearly demonstrated the potentials of vertically stratified traps (including pitfalls) for investigating small mammal communities. Further evaluation of these methods using longer adjustment periods and possibly prebaiting appear warranted.

III. POPULATION ECOLOGY OF THE SMALL MAMMALS

Low trap success in both removal trapping (0.01 captures/trap-night) and live trapping (0.02 captures/trap-night) in this study resulted in extremely small sample sizes. Interpretations of population dynamics are therefore made with reservations under the assumption that the limited data collected represented true trends of the small mammal populations.

Distribution and Relative Density

Five of the 7 small mammal species occurring on the study area, *P. leucopus*, *O. nuttalli*, *B. carolinensis*, *S. longirostris*, and *M. pinetorum*, were captured in both Pine and Hardwoods habitats. The lone specimens of *O. palustris* and *G. volans* were taken in Hardwoods, the first in a bottomland flood plain in a snap trap and the latter in a mature oak-pine stand in a live trap. *M. pinetorum* did not appear to be common as only two specimens were collected in each habitat type. These latter or uncommon species are not considered further. Frequencies of occurrence and relative densities of the four common species varied between habitats indicating that the requirements of each were met at different degrees in Pine and Hardwoods.

Removal Trapping

P. leucopus was taken in a higher percent of the removal sampling plots in Hardwoods (66.5 percent) than in Pine (50 percent) (Table III). In the latter habitat this species appeared to be the dominant small rodent as *O. nuttalli* was taken in only 16.6 percent of the plots sampled.

TABLE III

FREQUENCY OF OCCURRENCE, RELATIVE DENSITY, AND RANGE IN RELATIVE DENSITY OF SMALL MAMMALS CAPTURED IN REMOVAL SAMPLING PLOTS IN PINE AND HARDWOODS HABITATS ON THE ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

	Frequency of Occurrence		Relative Density		Range in Relative Density	
Species	Pine	Hardwoods	Pine	Hardwoods	Pine	Hardwoods
P. leucopus	50.0%	66.5%	1.00	1.50	0-3	0-4
O. nuttalli	75.0	16.6	1.13	0.25	0-2	0-4
B. carolinensis	87.5	54.4	3.25*	1.25*	0-6	0-5
S. longirostris	87.5	34.4	4.25**	1.08**	0-6	0-5
M. pinetorum	12.5	8.3	0.13	0.13	0-1	0-2
O. palustris	0.0	4.2	0.00	0.04	0	0-1

*Based on results of Removal Method II

**Based on results of Removal Method I

However, in Pine _O. nuttalli_ occurred at a 75 percent frequency at a mean relative density comparable to that of _P. leucopus_.

Habitat selection by the two common insectivores was similar to that of _P. leucopus_ and _O. nuttalli_ yet not as pronounced; _B. carolinensis_ was captured with greater regularity in Hardwoods than _S. longirostris_, the two taken in 54.4 percent and 34.4 percent of the sampling plots respectively. In Pine both were captured in 87.5 percent of all removal plots (Table III).

In removal trapping there was no indication that resident small mammal populations were completely removed from sampling plots. The total catch per plot, therefore, could not be considered representative of absolute density. Also, since distinct linear declines in daily captures were not observed in removal trapping, estimates of absolute densities could not be made by the linear regression method of Hayne (1949). Instead, relative densities were compared using empirical data (# of captures/sampling plot) as sampling effort was replicated in each removal plot.

Relative densities of species in both habitats varied widely between sampling plots and were not normally distributed about relative density means for the habitats. Rather these densities were generally distributed in Poisson fashion. The transformation $\sqrt{X} + \sqrt{X+1}$ (Mosteller and Youtz 1961), where X = the number of captures of a species in an individual removal sampling plot, proved to be effective for stabilizing variances and allowed comparisons by one-way analysis of variance.

P. leucopus occurred at a higher relative density in Hardwoods (1.5/plot) than in Pine (1.0/plot) ($.50 < P < .25$) (Table III). In contrast, relative densities of _O. nuttalli_ were higher in Pine (1.13/plot) than in Hardwoods (0.25/plot) (.005 < P < .001). Golley (1966) and Goodpaster and Hoffmeister (1954) reported that this semiarboreal species prefers thickets of honeysuckle and greenbriar (_Smilax_ sp.) which provide nesting sites. Pine plantations on the study area were characterized by such vegetation and supported higher numbers of _O. nuttalli_.

Relative densities of the two insectivores, _B. carolinensis_ and _S. longirostris_ varied according to trapping method, some trap types or placements being more effective for capturing these species. The mean relative density of _B. carolinensis_ was 3 to 4 times higher by Removal Method II as a result of a greater catch by snap traps set across burrows. On the other hand, the relative density of _S. longirostris_ was distinctly higher by Removal Method I, apparently due to the efficiency of pitfalls for capturing this species. Tuttle (1964) reported that _S. longirostris_ appeared to be more prevalent than _B. brevidauda_ in areas trapped by pitfalls. A similar observation was made in the present study. The higher relative densities of these species were obviously more representative of actual population numbers and were used for analysis.

Both insectivores were more abundant in Pine than in Hardwoods. The mean relative density of _B. carolinensis_ (by Removal Method II) was higher in Pine (3.25/plot) than in Hardwoods (1.25/plot (.10 < P < .05). Similarly the mean relative density of _S. longirostris_ (by Removal Method I) was higher in Pine (4.25/plot) than in Hardwoods (1.08/plot) (.01 < P < .005). According to Golley (1966) both of these species prefer moist situations such as damp forests rich in invertebrate prey. The availability of food for these species in the two habitats was not determined in this study, however, the leaf litter and surface soils were consistently more moist in Pine plantations than in Hardwood forests. This condition in Pine was associated with higher relative densities of insectivores.

Live Trapping

Estimates of absolute density by methods based on the probability of recapture could not be made due to the low number of captures in live trapping. This was compounded in the case of *Blarina* and *Sorex* by high trap mortality. Considering actual numbers captured, live trapping data followed density trends observed in removal trapping.

P. leucopus densities were similar in the two habitats with this species clearly the dominant small rodent in Hardwoods. *O. nuttalli* was more abundant in Pine, occurring in numbers similar to *P. leucopus* (Table IV).

Greater numbers of *B. carolinensis* were captured in Pine than in Hardwoods, but the difference was marginal, whereas *S. longirostris* was distinctly more abundant in Pine.

One observation of note was made in the Pine plantation live trapping plot during March (Live Trapping Session B). In the first two days of this trapping period, 14 *S. longirostris* were captured, 13 on day 1 and 1 on day 2. No other captures of this species were made during days 3-5 indicating that all of the members of the population had been removed. Three of the animals captured on day 1 were marked and released, one being recaptured 35 m distant from the initial point of capture

TABLE IV

MEAN NUMBER AND RANGE IN NUMBERS OF INDIVIDUALS IN SMALL MAMMAL POPULATIONS OCCURRING IN LIVE TRAPPING PLOTS IN PINE AND HARDWOODS HABITATS ON THE ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

Species	Pine		Hardwoods	
	Mean	Range	Mean	Range
P. leucopus	2.0	(1-3)	2.2	(0-6)
O. nuttalli	1.8	(1-4)	0.6	(0-2)
B. carolinensis	2.8	(0.9)	2.2	(0-4)
S. longirostris	4.2	(0-14)	1.2	(0-3)

approximately 10 hours later. Using this distance between captures as the width of the border zone around the live trapping grid from which animals were taken, and assuming that the actual number captured represented the total population, a conservative estimate of the *S. longirostris* population density was 5.5/ha. Using the same border strip width around removal trapping plots in Pine, and assuming the 5-day catch as total removal, *S. longirostris* densities were as high as 6.7/ha.

Although these interpretations are made with reservations, it appears that under certain conditions this species is less rare than suspected (Golley 1966).

Standing Crop Biomass

The standing crop biomass of each species in Pine plantation and Hardwood forest was examined to determine the potentials of the two habitats for supporting small mammal populations. Such data may also prove useful for future interpretations of energy flow through these or similar ecosystems.

Using the criteria set forth by Adamczyk and Ryzkowski (1968), the "area of effect" around removal trapping plots was considered to be approximately 25 m. This resulted in a sampling area per removal plot of 1.21 ha. Biomass figures were transformed to grams/hectare, which served as the unit of measurement for comparisons by chi-square analysis.

Standing crop small mammal biomass was distinctly higher ($P > .995$) in Pine (63g/ha) than in Hardwoods (38g/ha) (Table V). For only one species, *P. leucopus*, was the standing crop biomass higher in Hardwoods.

TABLE V

STANDING CROP BIOMASS (GRAMS/HECTARE) OF SMALL MAMMALS OCCURRING IN PINE AND HARDWOODS HABITATS ON THE ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

	Pine		Hardwoods	
Species	Standing Crop Biomass (g/ha)	Percent of Total	Standing Crop Biomass (g/ha)	Percent of Total
P. leucopus	16	25%	23	61%
O. nuttalli	18	29	4	10
B. carolinensis	21	33	9	24
S. longirostris	8	13	2	5
Totals	63g/ha	100%	38g/ha	100%

The percent which each species contributed to the total biomass varied between the two habitats. In Pine, P. leucopus represented 25 percent of the total, while in Hardwoods the significance of this species was much higher (61 percent). O. nuttalli, on the other hand, appeared to fill a niche in Pine that was lacking or limited in Hardwoods, representing 29 percent and 10 percent of the two totals respectively. B. carolinensis was a major component of the small mammal standing crop biomass in both habitats, accounting for 33 percent of the total in Pine and 24 percent in Hardwoods.

S. longirostris represented a relatively small percentage of the total standing crop biomass in both habitats. In Pine, this species constituted 13 percent of the total and in Hardwoods 5 percent. The impact of S. longirostris, as well as B. carolinensis, was probably much higher than biomass figures indicated considering the high energy requirements of these species (Morrison 1948, Morrison et al. 1957, Pearson 1947, 1948).

These findings are of particular interest considering that Pine plantations, which are often referred to as "sterile monocultures" supported a much higher small mammal standing crop biomass than the Hardwoods habitat.

Diel Activity

Information which is presented on the diel activities of small mammals was based on the time of capture in live trapping. Data from Live Trapping Sessions I-V and of all individuals of a species were pooled (Table VI).

TABLE VI

DIEL ACTIVITY OF SMALL MAMMALS IN PINE AND HARDWOODS HABITATS ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE RESERVATION IN EAST TENNESSEE, MARCH-JULY, 1975

	Pine				Hardwoods			
	Diurnal Movements		Nocturnal Movements		Diurnal Movements		Nocturnal Movements	
Species	#	%	#	%	#	%	#	%
P. leucopus	14	28	36	72	10	26	29	74
O. nuttalli	1	5	21	95	3	30	7	70
B. carolinensis	12	38	20	62	2	14	12	86
S. longirostris	5	25	15	75	1	17	5	83

Note: Figures represent observed movements based on the time of capture in live traps.

P. leucopus appeared to be primarily nocturnal but often moved during daylight hours as well. Approximately 25 percent of the captures of this species were made between morning and afternoon trap checks. These findings agreed with those of Golley (1962, 1966), Johnson (1926), and Sumner and Swarth (1924) who reported this species to be nocturnal.

O. nuttalli appeared more active at night, particularly in Pine where only 1 of 22 observed movements were diurnal. Similar observations were made by Goodpaster and Hoffmesiter (1954) who found that this species stayed in the nest during light hours, inferring that movement occurred at night.

The diel activity of both insectivores was concentrated during dark or twilight hours. This behavior was less pronounced in Pine where 12 of 32 B. carolinensis captures and 5 of 20 S. longirostris captures occurred between morning and afternoon trap checks. Lyon (1936) and Jackson (1961) stated that B. brevicauda was more nocturnal than diurnal but may be active both day and night. No information concerning activity patterns of S. longirostris was found in the literature, however, this species, like Blarina, has an extremely high metabolic rate (Morrison et al. 1957, Pearson 1947, 1948) and likely seeks food during all hours of the day. However, on my study area, since few insectivores were captured during daylight hours, and from these captures there was no indication that these species confined their activity to burrows at this time, it was assumed that the majority of their activity was nocturnal.

Average Distance between Captures

Knowledge of the average distance between captures (ADBC) may be useful for: (1) determining the relative activity of individual animals and their spatial use of home range areas; and (2) predicting home range area from a limited number of recaptures. Home range data are particularly important for calculating the area of effect of trapping grids. Faust et al. (1971) found a linear relationship between home range, as measured directly by various methods, and ADBC and were able to reliably predict home ranges of P. gossypinus, O. nuttalli and B. brevicauda from the first recapture as well as subsequent recaptures. Since long trapping periods are generally required to obtain ample data for estimating home range, the development of this method holds great potential.

Low relative densities of small mammals on the study area offered limited information on the ADBC and home range of the various species. This was compounded in the cases of B. carolinensis and S. longirostris by high trap mortality. Consequently, home range predictions could not be made based on ADBC, and the two parameters were considered separately.

The ADBC of P. leucopus was similar in Pine (31 m) and in Hardwoods (33 m) (Table VII). Movements of males (29 m) approximated those of females (33 m) in Pine, while in Hardwoods, females moved greater distances (42 m) than males (24 m). Brandt (1962) found no consistent difference in movements of male and female Peromyscus, while Faust et al. (1971) reported that male P. gossypinus tended to move farther than females.

The magnitude of Peromyscus movements observed in this study varied from previous observations. Shure (1970), using a 3 x 8 grid with 20 m

TABLE VII

AVERAGE DISTANCE BETWEEN CAPTURES (ADBC) AND HOME RANGES (AS MEASURED DIRECTLY BY THE MINIMUM AREA METHOD, AND EXCLUSIVE AND INCLUSIVE BOUNDARY STRIP METHODS) OF SMALL MAMMALS LIVE-TRAPPED FIVE OR MORE TIMES IN PINE AND HARDWOODS HABITATS ON THE ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

Species	Habitat	Age	Sex	# Captures	ADBC	Min. Area	Excl. B.S.	Incl. B.S.
P. leucopus	Pine	Ad	M	16	39 m	0.20 ha	0.26 ha	0.37 ha
P. leucopus	Pine	Ad	F	20	33 m	0.19 ha	0.29 ha	0.38 ha
P. leucopus	Hardwoods	S-Ad	M	6	37 m	0.07 ha	0.12 ha	0.17 ha
P. leucopus	Hardwoods	Juv	M	8	15 m	0.015 ha	0.05 ha	0.055 ha
O. nuttalli	Pine	Ad	F	8	26 m	0.06 ha	0.14 ha	0.17 ha
B. carolinensis	Pine	Ad	M	7	40 m	0.09 ha	0.15 ha	0.20 ha
B. carolinensis	Pine	Ad	M	11	26 m	0.04 ha	0.08 ha	0.11 ha

intervals between trap stations, reported an ADBC of 15-18 m for *P. leucopus*. In contrast, Faust et al. (1971) found that *P. gossypinus* moved an average of 54.9 m between captures on a 26 x 26 grid with 15 m trap station intervals. These latter authors also found that longer movements were observed on larger grids, in which case the differences between the ADBC of *Peromyscus* in this study and those in previous investigations were explicable.

O. nuttalli moved longer distances in Hardwoods (26.5 m) than in Pine (16.5 m). Linzey (1968) reported ADBC's of 31 m and 32 m for male and female *O. nuttalli* on a 5.1 ha study plot with traps spaced at 7.6 m intervals. On a larger grid (14.1 ha) with 15 m intervals, Faust et al. (1971) reported an ADBC of 72.8 m for this species. Again, the size of the trapping grid appeared to influence the observed magnitude of movement.

ADBC data were available only for male *B. carolinensis*. Average distances moved were similar in Pine (26 m) and in Hardwoods (20 m). Faust et al. (1971) reported movements four to five times greater than this, but the difference may have been due to their larger sampling plot. These investigators also observed that *B. brevicauda* moved longer distances than both *P. gossypinus* and *O. nuttalli*, while in the present study, the ADBC for *B. carolinensis* was not significantly different from *P. leucopus* and *O. nuttalli*.

Only one recapture of *S. longirostris* was made in which case the individual moved 35 m between trap stations in Pine during daylight hours.

Home Range

A sufficient number of captures for directly measuring home range was made for 4 P. leucopus (1 adult male, 1 adult female, 1 subadult male, and 1 juvenile male), 1 O. nuttalli (adult female), and 2 B. carolinensis (adult males). All of these animals except the two immature P. leucopus were inhabitants of the Pine plantation study plot P9. For each of these individuals, home range size was calculated by the minimum area method (Mohr 1947) and the exclusive and inclusive boundary strip methods (Stickel 1954). The inclusive boundary strip method was considered the most reliable and comparisons between sexes, species, and habitats were made using this measurement.

Home ranges of adult P. leucopus were distinctly larger than those of immatures of this species. The adult male ranged over 0.37 ha and the adult female over 0.38 ha, while the subadult male had a home range of 0.17 ha and the juvenile male a range of 0.06 ha (Table VII, page 46). These figures generally agreed with previous reports of home range calculated by the inclusive boundary strip method. Morris (1955) observed a range of 0.51 ha for adult P. leucopus, while Linzey (1968) reported ranges of 0.45 ha and 0.34 ha for adult males and females respectively. Howell (1954) found a range size of 0.12 ha for an immature female. Other authors (Blair 1940, Stickel and Warbach 1960, Stickel 1968, Gashwiler 1971) reported that male Peromyscus move longer distances and have greater home ranges than females. The limited data of the present study did not exhibit this trend.

The lone adult female O. nuttalli had a home range size of 0.17 ha which was approximately one half the size for adult P. leucopus.

McCarley (1958) and Faust et al. (1971) reported significantly larger ranges of 0.59 ha and 0.34 ha for the golden mouse. A relatively small home range size of 0.11 ha (calculated by the minimum area method) (Dunaway 1955) approximated the home range estimate for one individual by this method in the present study (0.06 ha).

The two adult male *B. carolinensis* had ranges of 0.20 and 0.11 ha. Faust et al. (1971) reported a significantly larger range of 1.2 ha for this species.

The relationship between average movement and home range size varied between species. Average distances moved by adult *P. leucopus*, *O. nuttalli*, and *B. carolinensis* were not significantly different, while their range sizes were. It appeared that the latter two species used their home ranges more intensely which may have been the result of habitat requirements being met more efficiently in Pine.

Sex Ratios

Sex ratios were calculated for *P. leucopus*, *O. nuttalli*, *B. carolinensis*, and *S. longirostris* in the two habitats (Table VIII). Data from removal and live trapping were pooled. Variations from a 1:1 ratio were determined by chi-square analysis.

Distinctly more *P. leucopus* males were caught than females in Pine ($.05 < P < .01$) while in Hardwoods the ratio was close to 1:1. Conditions similar to that in Pine have been reported (Calhoun and Casby 1958, Stickel 1960, Nicholson 1941, Gashwiler 1971, Kaufman et al. 1971) for *Peromyscus*. These authors and others concluded that male *Peromyscus*

TABLE VIII

SEX RATIOS OF SMALL MAMMALS IN PINE AND HARDWOODS HABITATS ON THE ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

Species	Pine				Hardwoods			
	Male		Female		Male		Female	
	#	%	#	%	#	%	#	%
P. leucopus	11	73	4	27	26	56	20	44
O. nuttalli	5	28	13	72	1	12	7	88
B. carolinensis	13	50	13	50	13	44	16	56
S. longirostris	24	60	16	40	17	77	5	23

have larger ranges exposing them to more traps and thus increasing their probability of capture.

A higher number of female than male _O. nuttalli_ were captured in both Pine and Hardwoods (.1 < P < .05 in Pine and .05 < P < .025 in Hardwoods) (Table VIII). Gentry et al. (1968) captured more females (15) than males (10), while Kaufman et al. (1971) found a closer fit to the 1:1 ratio.

Sex ratios for _B. carolinensis_ were very close to the expected (Table VIII). Similar results were obtained by Kaufman et al. (1971) while Gentry et al. (1968) captured significantly more females.

In Hardwoods more male than female _S. longirostris_ were taken (.025 < P < .01) (Table VIII). A higher percentage of males was also observed in Pine, however, variance from the expected was much less distinct (.5 < P < .01). These findings were in direct contrast to those of Gentry et al. (1968) who caught significantly more females. Similarly, Manville (1949) found 68 percent females in a _Sorex_ population. Pelikan et al. (1964) reported relatively equal numbers of male and female _Sorex_ in northwest Poland.

In the present study, there was no indication that variances in sex ratios were associated with reproductive activity.

Reproduction

Definite peaks in reproductive activity were observed in populations of the two rodent species on the area (Fig. 8). Pregnant or lactating _P. leucopus_ were captured each month from March through June, the percent gradually increasing to a high in May, then declining in June.

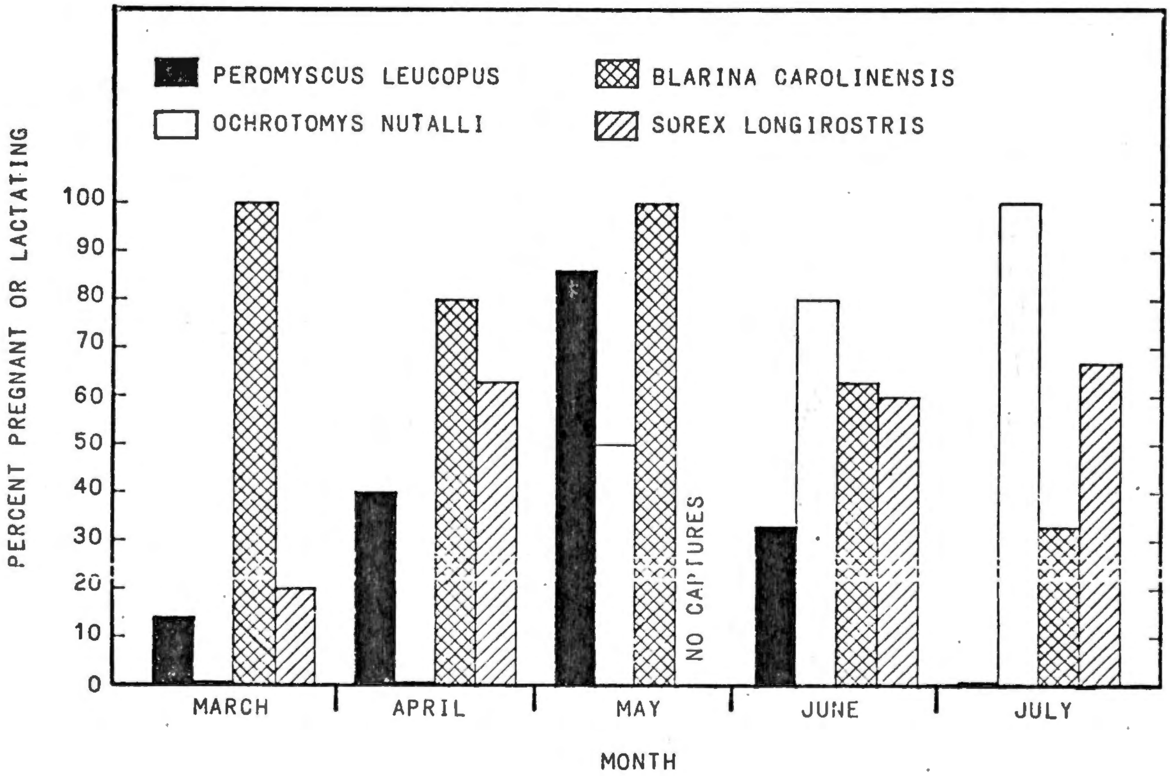


Figure 8. Reproductive activity of small mammals occurring in Pine and Hardwoods habitats on the ERDA's Oak Ridge Reservation in Roane County, Tennessee, March-July, 1975.

The only female observed in July showed no signs of pregnancy. This individual, however, had earlier delivered a litter on May 18 in Plot P9. One subadult P. leucopus was captured on March 16 indicating that breeding had occurred in late December or early January. Immatures were not taken again until late May (5 individuals) and early June (3 individuals). Svihla (1932) reported that the gestation period of Peromyscus ranged from 27 to 37 days. Considering this, heights in breeding activity of P. leucopus on the study area were reached during late March. Observations of females in June and July were too few to make inferences as to the course of reproductive activity through the summer months.

The highest percentage of pregnant or lactating female O. nuttalli was observed in July (Fig. 8). In March and April no reproductively active females were taken, but in May two of four and in June, four of five showed signs of pregnancy. The peak in reproduction apparently occurred one to two months later for this species than for P. leucopus. Goodpaster and Hoffmeister (1954) reported that breeding extends from March to October in Kentucky. Layne (1960) found at least an eight month breeding season in Florida, while Gooley (1966) stated that reproduction may occur throughout the year in South Carolina. One subadult specimen was taken in June and a live-trapped female appeared close to parturition on July 17. These findings indicated that breeding occurred from April through June and probably continued through the summer.

Pregnant or lactating B. carolinensis were captured in each month of the study (Fig. 8). Highest percentages occurred in March and May. A moderately lower figure was observed in April but may have been an artifact of the small sample size. One female which was found dead in a live trap on May 16 carried five early-stage embryos. The highest number of immature *B. carolinensis* (6 individuals) was taken in June after only one had been captured in each of April and May. Four immatures were caught in July. These findings indicated that breeding occurred as early as late February, reaching a peak during April and May. Golley (1966) reported that pregnant females were taken in South Carolina from February to November, while in Georgia (Golley 1962) females with embryos were captured from April to October. In Wisconsin, sexual activity of *B. brevicauda* began in late February and peaked during late March and early April (Jackson 1961).

Highest percentages of reproductively active female *S. longirostris* were observed in April, June, and July. No females were taken in May. Four immature specimens were captured during the course of the study: 1 in April, 3 in May, and 1 in June, indicating that breeding had occurred between late February and May. No information on the reproductive ecology of this species was found in the literature. Jackson (1961) reported that female *S. c. cinereus* carrying embryos were collected in Wisconsin from March to September.

Measurements and Weights

Head and body length, tail length, hind-foot length, and weight were recorded for animals collected during removal trapping and found dead in live traps. These figures are given in Appendix B, Table XI. In general, measurements and weights followed those reported by Golley (1962, 1966), Hamilton (1963), and Hall and Kelson (1959). It appeared, however, that *S. longirostris* on the area were shorter yet heavier than those collected in other southeastern states.

CHAPTER V

SUMMARY AND CONCLUSIONS

The primary objective of this investigation was to evaluate the use of vertically stratified traps for censusing small mammal populations. Two methods of removal trapping and one method of live trapping were tested in Loblolly Pine plantations and Mixed Hardwood forests. For Removal Method I, one pitfall and one snap trap set at ground surface were placed within one meter of each trap station. For Removal Method II, the ground surface snap trap was paired with one set in an excavated burrow. In live trapping Sherman-type live traps were positioned as in Removal Method II.

Small mammals were sampled on 2.0 percent of the total acreage of each habitat by each of the two removal methods. Sampling plots consisted of 7 x 7 grids (49 trap stations) with stations spaced at 10 meter intervals. A two-day adjustment period, with traps positioned but not prebaited, was used prior to five consecutive days of trapping on each grid. A 10 x 10 meter live trapping grid was established in each habitat and one 5-day trapping session conducted monthly from March to July. A 5-day adjustment period was used prior to Session I with traps remaining in the field between live trapping sessions thereafter. A peanut butter-oatmeal bait was used for snap and live traps. Pitfalls were not baited.

The effectiveness of pitfalls for capturing the two common rodents, *Peromyscus leucopus* and *Ochrotomys nuttalli*, could not be evaluated due to a trap design which may have allowed them to escape. These two species appeared to be isoresponsive to traps set in burrows and at ground surface.

Blarina carolinensis was captured with greater regularity by pitfalls and traps set in burrows than by traps set at ground surface. Burrow placements were clearly the most effective method for taking this species as trap-revealed densities were three to four times higher when this trap type was utilized. From these findings, it is recommended that investigations of Blarina populations in forest habitats employ traps set in burrows rather than the conventional placement at ground surface.

Sorex longirostris was taken in higher numbers in plots sampled by Removal Method I (pitfall + ground surface snap trap) due to the effectiveness of pitfalls. In live trapping, traps placed in burrows were superior to those set at ground surface, while the efficiency of snap traps at the two levels varied between habitats. The greater response of S. longirostris to pitfalls in this study coupled with similar evidence from previous investigations, indicated that this technique produces the most reliable density estimates for this species. Consequently, the use of this method when feasible appears vital to studies of Sorex populations.

The three methods of vertical trap stratification produced relatively uniform rates of capture for the four common species with no distinct lag observed in the capture of insectivores. The rate at which animals were removed, however, varied between the three methods. Distinct declines in the daily catch of all species were observed in live trapping with all members of resident populations apparently captured by the third or fourth day of trapping.

Of the two removal methods, intensity of capture was greatest by Method I, in which a decline in the daily catch occurred at some point during the 5-day removal period. By Method II, the daily catch of each species increased during initial days of trapping and fell off only moderately during the latter days. Neither of these methods appeared to accomplish complete removal of resident populations, and estimates of absolute density could not be made by the linear regression method of Hayne (1949). The inability of removal methods to produce a high initial capture was attributed to insufficient adjustment periods of two days.

The observation, however, that these methods rendered each species equally susceptible to capture differed from previous studies which utilized conventional trapping methods and generally found lags in the capture of certain species. Methods of vertical trap stratification hold great potential for increasing the reliability and use of short-term removal studies and should be tested using longer adjustment periods and/or prebaiting.

A secondary objective of this investigation was to gather baseline information on the population ecology of small mammal species occurring on the study area. A total of 142 individuals representing six species was collected in removal trapping, and 199 captures of 85 individuals representing five species were made in live trapping.

P. leucopus, *O. nuttalli*, *B. carolinensis*, and *S. longirostris* were the most abundant species on the area and occurred in both habitats. *Microtus pinetorum* was also taken in the two habitats but appeared to be uncommon as only two specimens were taken in each. One subadult *Oryzomys palustris* was collected in a snap trap in a bottomland hardwood floodplain and one *Glaucomys volans* was live-trapped in a mature oak-pine stand.

P. leucopus was clearly the dominant small rodent in Hardwoods habitat. This species occurred in 66.5 percent of the plots sampled at a mean relative density of 1.5 individuals/plot as opposed to a 16.6 percent frequency of occurrence for *O. nuttalli* at a mean relative density of 0.25/plot. The relationship between these species was reversed but less distinct in Pine. *O. nuttalli* occurred at a frequency of 75 percent and mean relative density of 1.13/plot while *P. leucopus* was taken in 50 percent of the sampling grids at a mean relative density of 1.0/plot.

The two insectivores, *B. carolinensis* and *S. longirostris*, were more common in Pine Plantation each occurring at a frequency of 87.5 percent as opposed to 54.4 percent and 34.4 percent respectively in Hardwoods. The mean relative densities of these species varied distinctly between trapping methods, *B. carolinensis* taken at higher numbers by traps set in excavated burrows and *S. longirostris* by ptifalls. Densities estimated by these methods were considered more representative of actual population size.

The mean relative density of *B. carolinensis* was higher in Pine (3.25/plot) than in Hardwoods (1.25/plot) ($.1 < P < .05$). *S. longirostris* was also more abundant in Pine (4.25/plot) than Hardwoods (1.08/plot) ($.1 < P < .005$).

Estimates of absolute density based on the probability of recapture could not be made from live trapping due to small sample sizes.

Considering the actual number of individuals occurring in live trapping plots, densities of the four common species approximated those observed in removal trapping.

Standing crop biomass was calculated for the four most abundant species on the area. Total small mammal standing crop biomass was distinctly higher in Pine plantation (63g/ha) than in Hardwood forest (38g/ha) ($P > .995$). The percentage which each species contributed to total biomass varied between habitats and followed trends observed in density. Due to its small size, biomass figures for *S. longirostris* were probably unrepresentative of the significance of this species. Based on total small mammal biomass, Pine plantation appeared to be the most productive of the two habitats.

Data on diel activity, average distance between captures (ADBC), and home ranges were gathered in five 5-day live trapping sessions. All species appeared to be primarily nocturnal, but movements were not uncommon during daylight hours. *P. leucopus* and *B. carolinensis* were often active between morning and afternoon trap checks with approximately 25 percent of their captures made during this time. *O. nuttalli* and *S. longirostris* were less active diurnally.

Considering all recaptures of adults, ADBC was greatest for *P. leucopus* (31 m), followed by *B. carolinensis* (23 m) and *O. nuttalli* (19 m). Only one recapture of *S. longirostris* was made, the individual moving 35 meters during daylight hours.

Home range size of these species was more variable than their average movements. Calculated by the Inclusive Boundary Strip Method, one adult male and one adult female P. leucopus had home ranges of .37 ha and .38 ha respectively. One adult female O. nuttalli had a range of .17 ha and two adult male B. carolinensis ranged over .20 ha and .11 ha. These data indicated that O. nuttalli and B. carolinensis either used their home range area more intensely or were less prone to exploratory movement than P. leucopus.

Variations from the expected 1:1 sex ratio were not distinct in populations of P. leucopus or B. carolinensis. More female than male O. nuttalli were captured while the opposite was observed for S. longirostris.

Since this study was conducted from March through July, reproductive activity of small mammals could be determined directly for this time interval and indirectly for a one to two month period prior to this. Reproductive activity of P. leucopus was greatest in May with indirect sign that breeding occurred from late December or early January through the early summer. Highest percentages of pregnant or lactating O. nuttalli were taken in late June and early July with breeding occurring from April through June. Reproductively active B. carolinensis were captured during all months of the study with highest percentages of pregnant or lactating females taken in March and May. Indirect sign indicated that breeding occurred as early as late February and continued into the summer months. Highest percentages of reproductively active female S. longirostris were taken in May. Based on the appearance of immatures, breeding occurred in this species from late February to May.

Standard measurements and weight were recorded for all individuals collected during the course of the study. These measurements generally followed published standards for these species, however, *S. longirostris* on the area appeared to be shorter and heavier than specimens taken in other southeastern states.

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APPENDICES

APPENDIX A

TABLE IX

NUMBERS OF SMALL MAMMALS COLLECTED IN REMOVAL TRAPPING PLOTS IN PINE AND HARDWOODS HABITATS ON THE ERDA'S OAK RIDGE RESERVATION, IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

Plot	Session	Habitat Type	Removal Method	P.l.	O.n.	B.c.	S.l.	M.p.	O.p.
H67	I	2	I	4	3	1	1	0	0
H90	I	2	II	4	0	1	0	2	0
H68	I	2	I	2	1	0	0	0	0
H94	I	2	II	3	0	0	0	0	0
P21	II	1	I	0	0	1	6	0	0
P8	II	1	II	2	1	1	4	0	0
H55	II	2	I	2	0	0	5	0	0
H45	II	2	II	1	0	1	0	0	0
H60	III	2	I	1	0	0	0	0	0
H40	III	2	I	0	0	0	1	1	0
H47	III	2	II	2	0	0	3	0	0
H70	III	2	II	0	0	0	0	0	0
P2	IV	1	I	2	0	0	3	1	0
P1	IV	1	II	3	1	6	0	0	0
H16	IV	2	I	3	0	0	0	0	0
H15	IV	2	II	3	0	3	0	0	0
H74	V	2	I	1	0	0	2	0	0
H64	V	2	I	0	1	1	0	0	0
H52	V	2	II	3	0	1	0	0	0
H54	V	2	II	4	0	1	0	0	0
P26	VI	1	I	0	2	1	5	0	0
P14	VI	1	II	0	1	5	1	0	0
H51	VI	2	I	0	0	1	3	0	0
H61	VI	2	II	1	0	2	0	0	0
P23	VII	1	I	1	2	1	3	0	0
P12	VII	1	II	0	2	1	1	0	0
H29	VII	2	I	1	0	0	0	0	0
H39	VII	2	II	1	0	1	0	0	0
H4	VIII	2	I	0	1	2	1	0	1
H34	VIII	2	I	0	0	1	0	0	0
H1	VIII	2	II	0	0	5	2	0	0
H82	VIII	2	II	0	0	0	0	0	0
			Totals	44	15	37	41	5	1

Habitat 1—Pine; Habitat 2—Hardwoods

P.l.—*Permoyscus leucopus*; O.n.—*Ochrotomys nuttalli*; B.c.—*Blarina carolinensis*; S.l.—*Sorex longirostris*; M.p.—*Microtus pinetorum*; O.p.—*Oryzomys palustris*.

TABLE X

SMALL MAMMAL CAPTURES ON CONSECUTIVE DAYS OF 5-DAY REMOVAL TRAPPING SESSIONS CONDUCTED ON THE ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

				P. leucopus Day					*O. nuttalli* Day					*B. carolinensis* Day					*S. longirostris* Day				
Plot	Session	Habitat Type	Method	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
P21	II	1	I	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2	2	1	0
P2	IV	1	I	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
P26	VI	1	I	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	3	0	1
P23	VII	1	I	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	0	1	1	1
			Total	0	1	0	2	0	2	1	1	0	0	1	1	0	1	0	1	5	7	2	2
H67	I	2	I	2	1	0	0	1	3	0	0	0	0	0	0	1	0	0	0	0	1	0	0
H94	I	2	I	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H55	II	2	I	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	1
H60	III	2	I	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H40	III	2	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
H16	IV	2	I	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H74	V	2	I	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
H64	V	2	I	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
H51	VI	2	I	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	1	0	0
H29	VII	2	I	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H4	VIII	2	I	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0
H34	VIII	2	I	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
			Total	5	4	2	2	2	4	0	1	0	0	2	0	2	1	1	5	3	2	2	1
P8	II	1	II	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	1	2
P1	IV	1	II	1	0	0	1	1	0	0	0	1	0	1	1	1	3	0	0	0	0	0	0
P14	VI	1	II	0	0	0	0	0	0	0	0	1	0	0	0	2	0	3	0	0	1	0	0
P12	VII	1	II	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0
			Total	2	0	0	1	2	0	0	1	3	1	1	1	3	4	4	1	0	2	1	2

TABLE X (continued)

Plot	Session	Habitat Type	Method	*P. leucopus* Day 1	2	3	4	5	*O. nuttalli* Day 1	2	3	4	5	*B. carolinensis* Day 1	2	3	4	5	*S. longirostris* Day 1	2	3	4	5
H90	I	2	II	0	0	3	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
H68	I	2	II	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
H45	II	2	II	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
H47	III	2	II	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
H70	III	2	II	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H15	IV	2	II	1	2	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0
H52	V	2	II	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
H54	V	2	II	0	0	3	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
H61	VI	2	II	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
H39	VII	2	II	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
H1	VIII	2	II	0	0	0	0	0	0	0	0	0	0	0	2	1	2	0	0	0	1	1	0
H82	VIII	2	II	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Total	2	6	7	3	3	0	0	0	0	1	3	5	2	4	1	0	1	1	2	1

Habitat 1—Pine; Habitat 2—Hardwoods

Method I—One pitfall and one snap trap at ground surface per station.

Mehotd II—One snap trap set in an excavated burrow and one snap trap at ground surface per station.

APPENDIX B

TABLE XI

MEASUREMENTS AND WEIGHTS OF SMALL MAMMALS COLLECTED ON THE ERDA'S OAK RIDGE RESERVATION IN ROANE COUNTY, TENNESSEE, MARCH-JULY, 1975

Plot	Habitat	Month	Age	Sex	Head & Body	Tail	Hind Foot	Weight
Peromyscus leucopus								
H67	2	Mar	Ad	M	--	76mm	18mm	22.6g
H94	2	Mar	Ad	M	--	56	19	15.6
H68	2	Mar	Ad	M	--	68	19	20.4
H67	2	Mar	Ad	M	--	64	20	17.4
H90	2	Mar	Ad	M	88mm	71	20	21.9
H90	2	Mar	Ad	M	--	55	18	17.6
H90	2	Mar	Ad	M	82	66	19	18.1
P1	1	Mar	Ad	M	82	76	19	14.3
H67	2	Mar	Ad	M	--	70	19	--
H43	2	Mar	Ad	M	78	63	19	13.5
P8	1	Mar	Ad	M	84	67	19	17.4
H45	2	Mar	Ad	M	91	75	22	21.0
H43	2	Mar	Ad	M	83	65	20	14.3
H60	2	Apr	Ad	M	80	63	20	20.1
H47	2	Apr	Ad	M	84	78	20	18.5
P1	1	Apr	Ad	M	83	64	20	17.3
H16	2	Apr	Ad	M	73	64	20	--
P2	1	Apr	Ad	M	92	79	21	20.0
H15	2	Apr	Ad	M	91	69	21	20.7
H16	2	Apr	Ad	M	88	76	21	21.9
P1	1	Apr	Ad	M	78	63	20	19.3
P1	1	Apr	Ad	M	85	72	20	20.1
H54	2	May	Ad	M	94	72	20	21.0
H52	2	May	Ad	M	83	70	20	17.2
P23	1	Jun	Ad	M	82	71	21	15.0
$\overline{X}$					84	68.5	20	18.5
H54	2	Jun	SAd	M	73	66	20	11.0
H67	2	Mar	Ad	F	--	65	19	16.2
H68	2	Mar	Ad	F	--	62	19	15.5
H90	2	Mar	Ad	F	97	80	19	24.1
H55	2	Mar	Ad	F	89	69	21	23.1
P8	1	Mar	Ad	F	82	--	20	16.3
H43	2	Mar	Ad	F	79	61	20	12.8
H47	2	Apr	Ad	F	78	63	20	17.5
H15	2	Apr	Ad	F	93	77	21	18.8
H16	2	Apr	Ad	F	84	68	20	20.0
H15	2	Apr	Ad	F	94	73	21	23.5
P2	1	Apr	Ad	F	88	74	21	23.1

TABLE XI (continued)

Plot	Habitat	Month	Age	Sex	Head & Body	Tail	Hind Foot	Weight
H52	2	May	Ad	F	81mm	67mm	19mm	15.8g
H54	2	May	Ad	F	85	73	20	17.9
H54	2	May	Ad	F	91	59	21	19.2
H52	2	May	Ad	F	85	82	21	15.5
H29	2	Jun	Ad	F	88	78	20	20.7
H39	2	Jun	Ad	F	80	75	21	16.9
$\overline{X}$					86.3	70.4	20.2	18.6
H94	2	Mar	SAd	F	--	62	18	14.9
H74	2	May	SAd	F	68	70	19	12.3
Ochrotomys nuttalli								
H67	2	Mar	Ad	M	--	76	18	22.6
P8	1	Mar	Ad	M	94	76	18	24.5
P9	1	Apr	Ad	M	83	71	19	14.4
P26	1	Jun	Ad	M	86	73	17	18.3
P14	1	Jun	Ad	M	94	77	20	22.3
$\overline{X}$					89.25	74.6	18.4	20.4
H67	2	Mar	Ad	F	--	68	18	17.5
H67	2	Mar	Ad	F	--	65	18	16.2
H68	2	Mar	Ad	F	--	65	16	14.3
P1	1	Apr	Ad	F	84	70	19	20.0
H64	2	May	Ad	F	77	71	18	15.1
P26	1	Jun	Ad	F	88	76	19	21.2
P23	1	Jun	Ad	F	92	74	18	21.1
P23	1	Jun	Ad	F	85	77	18	20.5
P12	1	Jun	Ad	F	87	74	18	18.5
H4	1	Jul	Ad	F	93	77	19	25.5
$\overline{X}$					86.6	71.7	18.1	19.0
P12	1	Jun	SAd	F	60	55	16	7.1
Blarina carolinensis								
H43	2	Mar	Ad	M	81	21	13	15.7
H45	2	Mar	Ad	M	89	20	13	17.2
H43	2	Mar	Ad	M	82	26	14	14.8
H15	2	Apr	Ad	M	82	19	13	17.6
P1	1	Apr	Ad	M	88	23	14	16.9
H15	2	Apr	Ad	M	88	27	14	16.6
P1	1	Apr	Ad	M	77	25	14	13.3

TABLE XI (continued)

Plot	Habitat	Month	Age	Sex	Head & Body	Tail	Hind Foot	Weight
P1	1	Apr	Ad	M	90mm	27mm	14mm	18.9g
P1	1	Apr	Ad	M	77	23	12	11.8
P9	1	May	Ad	M	81	23	13	12.0
P9	1	Jun	Ad	M	76	26	14	11.5
H51	2	Jun	Ad	M	75	22	14	12.4
P26	1	Jun	Ad	M	79	25	13	11.5
P14	1	Jun	Ad	M	78	27	13	13.0
H39	2	Jun	Ad	M	85	25	13	15.5
P9	1	Jul	Ad	M	83	26	13	10.7
P9	1	Jul	Ad	M	77	22	13	11.0
H1	2	Jul	Ad	M	80	23	13	11.7
$\overline{X}$					81.6	23.9	13.3	14.0
P9	1	May	SAd	M	79	24	12	9.6
P9	1	Jun	SAd	M	74	23	12	9.8
H43	2	Jun	SAd	M	75	25	14	9.5
H61	2	Jun	SAd	M	76	25	14	9.3
P23	1	Jun	SAd	M	73	27	13	8.9
H1	2	Jul	SAd	M	82	26	14	9.1
H34	2	Jul	SAd	M	77	23	13	9.1
H4	2	Jul	SAd	M	76	25	13	9.7
$\overline{X}$					76.5	24.8	13.1	9.4
H90	2	Mar	Ad	F	--	--	--	15.3
H43	2	Mar	Ad	F	79	19	14	12.5
H67	2	Mar	Ad	F	--	--	--	14.6
H43	2	Mar	Ad	F	77	23	12	11.9
P8	1	Mar	Ad	F	72	27	14	11.8
H43	2	Mar	Ad	F	86	23	13	14.6
P1	1	Apr	Ad	F	72	21	13	11.2
P9	1	Apr	Ad	F	81	25	14	16.2
P1	1	Apr	Ad	F	77	20	13	13.5
H15	2	Apr	Ad	F	81	22	12	10.7
P9	1	May	Ad	F	72	23	12	14.6
H52	2	May	Ad	F	83	24	13	14.7
H54	2	May	Ad	F	79	20	12	11.9
H64	2	May	Ad	F	80	23	13	12.4
P9	1	Jun	Ad	F	82	26	13	14.6
H43	2	Jun	Ad	F	90	25	14	13.9
H61	2	Jun	Ad	F	84	22	13	11.2
P14	1	Jun	Ad	F	85	24	13	14.8
P14	1	Jun	Ad	F	85	24	14	14.2
P12	1	Jun	Ad	F	77	24	14	12.3

TABLE XI (continued)

Plot	Habitat	Month	Age	Sex	Head & Body	Tail	Hind Foot	Weight
H1	2	Jul	Ad	F	87mm	25mm	14mm	14.6g
H1	2	Jul	Ad	F	82	24	13	11.3
H1	2	Jul	Ad	F	77	25	13	10.6
$\overline{X}$					80.4	23.3	13.1	13.2
H43	2	Apr	SAd	F	72	22	13	8.3
P9	1	Jun	SAd	F	71	20	13	9.4
P14	1	Jun	SAd	F	68	25	13	8.6
P14	1	Jun	SAd	F	78	25	13	9.2
H4	2	Jul	SAd	F	76	24	13	8.9
$\overline{X}$					73.0	23.2	13.0	8.9
Sorex longirostris								
H67	2	Mar	Ad	M	--	--	--	3.0
H55	2	Mar	Ad	M	50	31	9	2.8
P21	1	Mar	Ad	M	52	35	10	3.6
P21	1	Mar	Ad	M	50	25	9	2.7
P21	1	Mar	Ad	M	49	29	9	2.6
P21	1	Mar	Ad	M	49	31	9	2.9
P8	1	Mar	Ad	M	49	29	10	3.4
H55	2	Mar	Ad	M	53	29	10	3.4
H55	2	Mar	Ad	M	53	31	10	3.4
H55	2	Mar	Ad	M	53	30	9	3.2
P8	1	Mar	Ad	M	57	29	9	3.7
P9	1	Apr	Ad	M	49	29	9	3.1
P9	1	Apr	Ad	M	49	30	9	2.9
P9	1	Apr	Ad	M	50	30	10	3.1
P9	1	Apr	Ad	M	48	30	9	2.8
P9	1	Apr	Ad	M	50	30	10	2.8
P9	1	Apr	Ad	M	48	30	9	2.8
P9	1	Apr	Ad	M	47	31	10	2.7
P9	1	Apr	Ad	M	49	28	10	2.6
H40	2	Apr	Ad	M	52	31	9	2.8
H47	2	Apr	Ad	M	50	27	9	3.2
P2	1	Apr	Ad	M	49	30	10	3.3
H43	2	Apr	Ad	M	46	28	9	2.5
P9	1	Jun	Ad	M	50	31	10	2.8
H51	2	Jun	Ad	M	52	26	8	2.2
H51	2	Jun	Ad	M	51	31	10	3.3
P26	1	Jun	Ad	M	52	32	10	3.2
H51	2	Jun	Ad	M	56	32	10	3.2
P26	1	Jun	Ad	M	54	29	9	3.4

TABLE XI (continued)

Plot	Habitat	Month	Age	Sex	Head & Body	Tail	Hind Foot	Weight
P26	1	Jun	Ad	M	51mm	30mm	9mm	3.4g
P26	1	Jun	Ad	M	48	27	10	2.9
P23	1	Jun	Ad	M	49	34	9	2.1
P23	1	Jun	Ad	M	50	27	9	3.0
H4	2	Jul	Ad	M	48	32	9	2.4
H1	2	Jul	Ad	M	53	28	9	3.7
H1	2	Jul	Ad	M	53	28	9	3.6
P9	1	Jul	Ad	M	47	31	10	2.6
$\overline{X}$					50.4	29.75	9.4	3.0
H55	2	Mar	Ad	F	54	--	9	3.4
P21	1	Mar	Ad	F	51	30	10	3.5
P8	1	Mar	Ad	F	54	30	10	2.8
P21	1	Mar	Ad	F	54	31	10	3.6
P8	1	Mar	Ad	F	59	31	10	3.3
P9	1	Apr	Ad	F	50	33	10	2.9
P9	1	Apr	Ad	F	52	31	9	2.8
P9	1	Apr	Ad	F	48	31	10	2.7
H47	2	Apr	Ad	F	58	27	7	2.4
H47	2	Apr	Ad	F	52	30	9	2.6
P2	1	Apr	Ad	F	49	33	10	3.3
P2	1	Apr	Ad	F	--	29	10	---
H43	2	Apr	Ad	F	49	27	9	2.6
P9	1	Jun	Ad	F	50	30	9	2.7
P14	1	Jun	Ad	F	51	26	10	3.3
P26	1	Jun	Ad	F	51	31	10	4.6
P12	1	Jun	Ad	F	46	35	9	2.1
P23	1	Jun	Ad	F	47	32	10	2.3
H43	2	Jul	Ad	F	48	28	9	3.3
P9	1	Jul	Ad	F	50	33	10	3.4
P9	1	Jul	Ad	F	46	30	10	2.4
$\overline{X}$					50.95	30.4	9.5	3.0
H74	2	May	SAd	F	43	28	7	1.4

Habitat 1—Pine; Habitat 2—Hardwoods

VITA

Tommy Ray Smith, son of Otis Spencer Smith and Margaret Lee Brooks Smith, was born in Memphis, Tennessee, on October 6, 1946. He attended Snowden Elementary and Junior High School and was graduated from Central High School in Memphis in 1964. In September of that year he entered Memphis State University from which he was graduated in January 1969, receiving the Bachelor of Science degree in Zoology.

After two years of teaching in public secondary schools, he entered graduate school at Memphis State University and received the Master of Education degree in Science Education in December 1972. In March 1973, he entered The University of Tennessee at Knoxville and began graduate study in wildlife biology. He received the Master of Science degree in Wildlife and Fisheries Science in March 1976. He is a member of The Wildlife Society, The American Society of Mammalogists, The National Audubon Society, and Xi Sigma Pi, national forestry honorary.