AN ABSTRACT OF THE THESIS OF

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Title: Reproduction, Movement and Survival of the Eastern Woodrat

Abstract approved: Dwight L. Spencer

Live-trapping of eastern woodrats was conducted in Chase County, Kanaas, from 18 April 1984 through 8 November 1985. Animals were marked with numbered ear tags and released, and subsequently, attempts were made to recapture them.

Houses of some female woodrats were opened at the proper time in order to locate and mark nestlings.

Data regarding many aspects of the population were collected and analyzed and conclusions were drawn, as follows:

Population density had declined drastically since last studied in 1983, and many houses were found to be vacant.

Attempts to locate and mark nestlings were largely unsuccessful; only nine were recaptured.

Larger, well-protected houses were more likely to be occupied than smaller, less well-protected sites during the study.

Relocation from one house to another was common among both male and female woodrats, however, males were found to travel greater distances than females. Males were also found to relocate slightly more frequently than females.

Juveniles commonly established themselves in nearby houses following dispersal from the maternal house.

REPRODUCTION, MOVEMENT AND SURVIVAL OF THE EASTERN WOODRAT

A Thesis

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by

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Dwight L. Spence
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INTRODUCTION

The eastern woodrat (Neotoma floridana) and the southern plains woodrat (Neotoma micropus) are widely distributed throughout the central, eastern and southwestern United States. The eastern woodrat is a medium-sized cricetid rodent characterized by large, rounded and sparsely haired ears; tail covered with short hairs; large black eyes, and soft pelage (Rainey, 1956).

Two subspecies of N. floridana live in Kansas: N. f. campestris in the northweatern part of the state, and N. f. attwateri, the subject of this study, in the eastern half (Birney, 1973).

The habitat of the eastern woodrat has been described by Fitch (1958) as "primarily woodland, but extending also into various marginal situations". Rainey (1956) stated that "N. floridana occupies a wider range of habitats than any other speciea of woodrat and indicates a greater plasticity to respond to factors of the environment".

N. f. attwateri tends to favor house sites in brush piles, under fallen trees, around the bases of trees and less frequently in the branches of trees, while the western subspecies, N. f. campestris usually lives in the cracks and crevices of rock ledges (Cockrum, 1952). Osage orange (Maclura pomifera) hedgerows are the most common type of woodrat habitat in eaatern Kansas (Rainey, 1956). Hedgerows with low overhanging branches nearly touching the ground are favored by woodrats due to the protection they afford the animal when in and near the house.

Although each woodrat house is unique, most have many features in

common. The most common type of house rests on the ground and is dome-shaped (Fig. 1). The interior is divided into compartments such as nest and food cache chambers. Several entrances/exits are maintained in an occupied house, and feces are carried to and deposited outside of a particular opening. The presence of midden and fresh feces outside a house is often used as an indicator of occupancy.

The woodrat nest is usually located as low and as near the center of the house as possible. Nests are commonly cup-shaped and open at the top (Hall, 1955). Woodrats are intolerant of conspecifics and when an individual occupies a house, others are excluded (Fitch, 1958).

Fitch and Rainey (1956) listed five of the most formidable predators of N. floridana as follows: the horned owl (Bubo virginianus), prairie spotted skunk (Spilogale putorius), long-tailed weasel (Mustela frenata), Black rat snake (Elaphe obsoleta), and the timber rattlesnake (Crotalus horridus).

The food of the eastern woodrat is highly variable. Hall and Kelson (1959) stated that the food is almost any edible plant material and probably some animal matter. Osage orange fruits are a prime food source for woodrats in eastern Kansas, and the bark of tender twigs is eaten in winter.

Breeding in N. floridana occurs throughout the year over much of it's range, and from one to four young are produced per litter (Asdell, 1946). Although a great deal is known about eastern woodrat reproduction, some aspects of reproduction and survival following birth are little known.

Figure 1. Typical woodrat house.

A review of pertinent literature and personal communication with Dr. Dwight Spencer, Emporia State University, indicated that little was known about the degree of differential reproduction of female woodrats and differential survival of the young.

This study was initially patterned after McCarley (1966). He studied thirteen-lined ground squirrels (Citellus tridecemlineatus) and was able to associate the young with the mothers that produced them. McCarley reported no multiple litters of young in females approximately one year of age, however he noted the presence of a second litter in many older females. Mean litter sizes were significantly larger and survival until time of emergence from the burrow was higher among offspring of older females.

The primary objective of this study was to determine the degree of differential reproduction, that is, the degree to which the number of offspring varied among individual females. The study was also to determine if differential survival was present among litters of young produced by different females. Survival of the young could then be related to such factors as mothering care, house type and location of house.

Working hypotheses of this research can be stated as follows: there are significant differences among the number of young produced by various female woodrats on the ares. Additionally, there are significant differences in the survival rate of young woodrats on the study area. The null hypotheses that there were no significant differences in numbers of young produced and no significant differences in the survival rate of the young were to be tested. The

initial study methods were as follows:

1. To collect general population data.
2. To associate young with the females which produced them.
3. To associate each young woodrat with a particular house site.
4. To evaluate for differential reproduction among females.
5. To evaluate for differential survival among litters.
6. To speculate on the effects of house type and location on the survival rate of the young.

Initially, the study was to be conducted by live-trapping all woodrats on the study area, then at the proper time in accordance with reproductive cycles, retrap the females at the houses where they were initially caught. Each female would be examined in the trap and if it was determined she was nursing young, the house would be carefully opened and the young marked by toe clipping.

Due to the following factors, insufficient data were collected by the methods outlined:

1. The population density had declined drastically sometime following a study on the area which concluded in December, 1983, and prior to this study which began in April, 1984. Thus the population of N. floridana was at a low level.
2. The timing of the reproductive cycles varied somewhat from the "normal values" as noted by Rainey (1956), and others.
3. The timing of reproductive cycles varied to a degree within the population itself. The young must be caught at the correct stage of development; if these young are caught too early they are too small to mark, and if found too late they

will escape when the house is opened.

Study methods required tagging young within two weeks following birth and then retrapping them at intervals throughout the study. Data indicated a probable high mortality among young woodrats, and it seemed that long term trapping data from the young would have been difficult to obtain. Objectives of the study were changed somewhat as a result of the low population levels and the difficulty of catching the young at the correct developmental stage.

A previous study, conducted on the area by Riccio in late 1983, documented population levels prior to their drastic decline. Other studies including Agin and Crumb (1971), Brandt (1977), and Schupp (1980) also contributed to the recent history of the N. floridana population on the area. The objectives of the study were revised to the following:

1. Collect general ecological data on the N. floridana population, including population numbers, density, sex ratios and percent of juveniles in the catch.
2. Present the limited data regarding differential reproduction and survival, and relate the methods, problems, and techniques used in finding and marking young woodrats which may aid in future studies.
3. Review population data collected during several prior studies on the area, and compare earlier population levels with present levels.
4. Document the population decrease following the most recent prior study (Riccio, 1983).

5. Document rebuilding of the population, if it occurred.
6. Determine the degree of over-winter survival, and relate survival to house types and locations.
7. Present data on the relocation of animals from one house to another.
8. Present data on dispersal of the young following departure from the maternal house.

STUDY AREA

The study was conducted on the Chase County portion of the Ross Natural History Reservation, an 80-acre (32.4 ha.) tract located as follows: T18; R9; Section 12 (the E. half of the S.E. quarter) in Chase County, Kansas.

The area contained many different habitat types, most of which were occupied to some extent by the eastern woodrat. One type was native and non-native grassland bordered by Osage orange hedgerows. A hedgerow also divided the area from east to west. A large portion was covered by dense woodland, and some brushy areas were present. The area was heavily eroded and deeply gullied in several places. An old, abandoned, stone house and an overgrown catalpa (Catalpa speciosa), grove were present as well.

Woody vegetation on the study area was composed of trees of different sizes, as well as shorter, shrubby vegetation. Most woodrat habitat was provided by Osage orange hedgerows. Additional prominent woody species were: catalpa, fragrant sumac (Rhus aromatica), red cedar (Juniperus virginiana), dogwood (Cornus drummondi), American elm (Ulmus americana), green ash (Fraxinus pennsylvanica), hackberry (Celtis occidentalis), wild plum (Prunus americana), gooseberry (Ribes missouriense), and buckbrush (Symphoricarpos orbiculatus).

The 80-acre study area was divided into eight 10-acre plots designated by letter and number (Fig. 2), and each plot was characterized as follows:

C34 - Small patches of predominantly native grasses and forbs, bordered on the west side by an Osage orange hedgerow

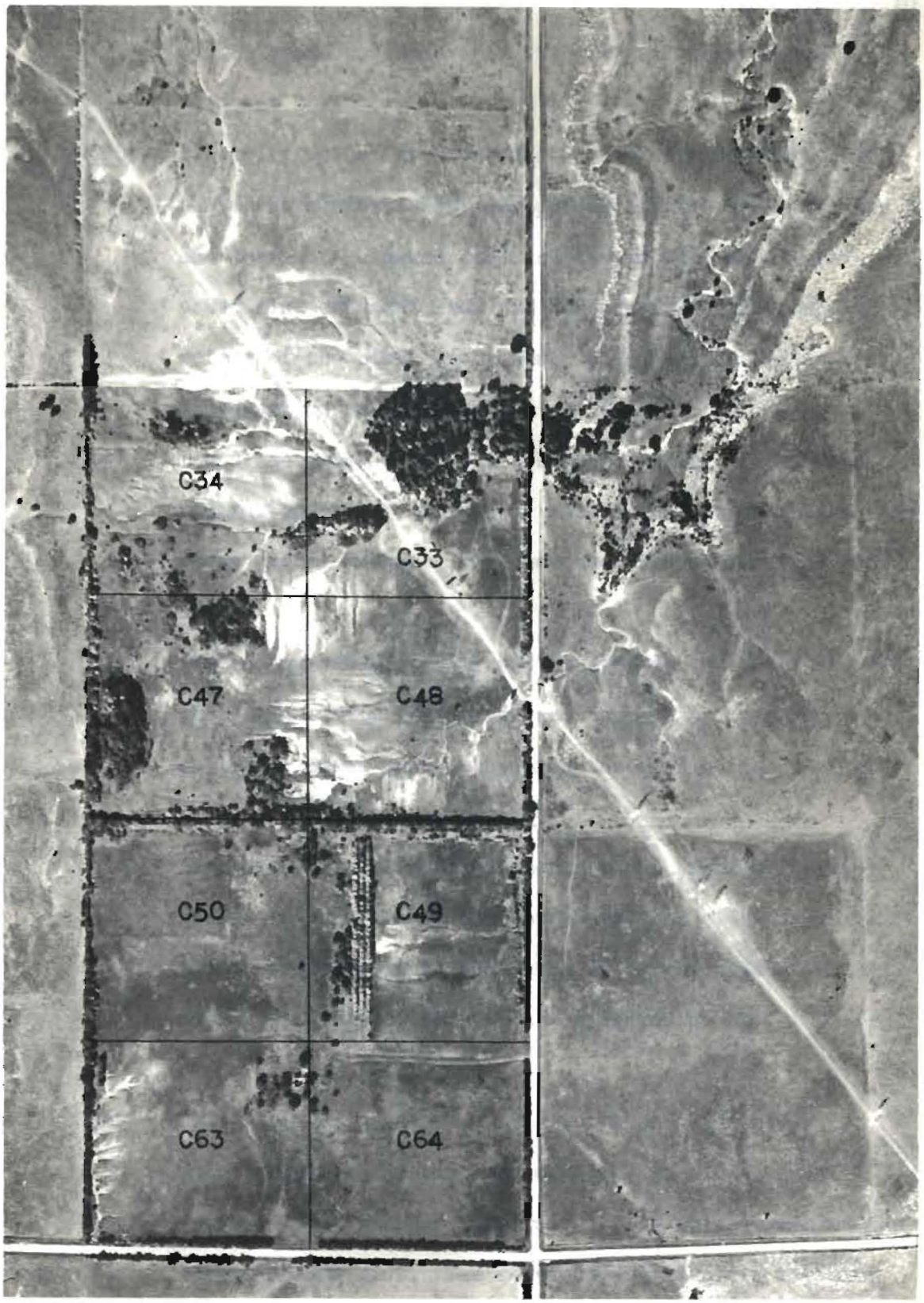


Figure 2. Study area divided into 10-acre grids.

and interspersed with dense thickets of dogwood and fragrant sumac.

C33 - A heavily wooded area covered much of the northern half while the southern half was predominantly native grasses and forbs. A cleared area associated with an electric power line extended from the northwest to the southeast corner of the plot, and a small pond was located in the southwest corner.

C47 - Trees and brush covered all but the center of the area. Vegetation was predominantly native grasses and forbs. An Osage orange hedgerow bordered the area on the west and south.

C48 - Vegetation was primarily native grasses and forbs and the plot was heavily eroded and cut through by deep rocky gullies. Osage orange bordered the grid on the east and south.

C50 - This area was primarily a smooth brome (Bromus inermis) grassland bordered on the north and west sides by Osage orange hedgerows. A small area of brushy vegetation had become established next to the hedgerow on the northern border.

C49 - This plot was bordered on the north and east sides by Osage orange hedgerows and contained an old stand of catalpa trees planted in parallel rows which extended the length of the plot. The remaining portions of the plot were predominantly smooth brome grassland.

C63 and C64 - Vegetation was primarily smooth bromegrass and each plot was bordered on two sides by Osage orange hedgerows. A small brushy area containing several red cedar trees was located on and overlapped the boundary between the two sreas. An abandoned stone house was located in the northwest corner of C64 amidst several red cedar trees. Area C63 was heavily eroded near the western edge, with deep, active gullies cutting into the surface.

METHODS AND MATERIALS

Trapping was carried out during aeven time periods beginning on 18 April 1984 and ending on 8 November 1985 as follows:

Period 1: 18 April 1984 through 21 May 1984

Period 2: 19 June 1984 through 10 July 1984

Period 3: 17 October 1984 through 16 November 1984

Period 4: 18 March 1985 through 29 March 1985

Period 5: 22 April 1985 through 9 May 1985

Period 6: 18 June 1985 through 22 June 1985

Period 7: 28 October 1985 through 8 November 1985

The first trapping period consisted of two parts. The initial segment was a general trapping session in which traps were set at all houses which appeared to be occupied. Capture data were recorded from the first segment, and all locations which had produced female wood-rats were re-trapped during the second segment. Houses at which a female was re-captured were opened in an effort to locate and mark the young, if any.

Period 2 was conducted less than one month following the conclusion of period 1 and included only those houses at which a female had been caught during the initial period.

Period 5 also included only those sites which had yielded females during previous trapping attempts.

All remaining periods, numbers 3, 4, 5 and 7, involved trapping at all houses which appeared to be active. In all cases, houses were given the benefit of the doubt, and, consequently, if there were any

signs of recent occupancy, traps were set at them.

Data recorded during all trapping sessions were the animal's tag number, the number of the house at which it was caught, when and at which house the animal was marked, by whom the animal was marked, sex, date, any special features or injuries, and also the animal's breeding condition.

All houses which were occupied were marked with a numbered tag and, subsequently, traps were set at each of these houses. Prior to and during the first trapping period, house tags consisted of lengths of plastic marking tape which were numbered and attached as near to the house as possible. Plastic tag numbers were eroded by rains and the tape was attractive to the woodrats. Many tags were removed and deposited inside houses by the rats.

Beginning with the fourth trapping period, the plastic tags were replaced with tags of wood lath cut into sections approximately four inches in length. These tags were numbered with a magic marker containing permanent ink, and securely wired above each house. These wooden tags were durable and required little maintenance.

Woodrat houses on the study area had been previously marked with numbered wooden tags, however only a small percentage remained intact when this study was begun. It was not possible to retain the old numbering system, however the old numbers were noted on data sheets along with the new numbers assigned during this study. Number one was established at the extreme southern edge of the catalpa grove and the numbering system progressed as shown in Fig. 3.

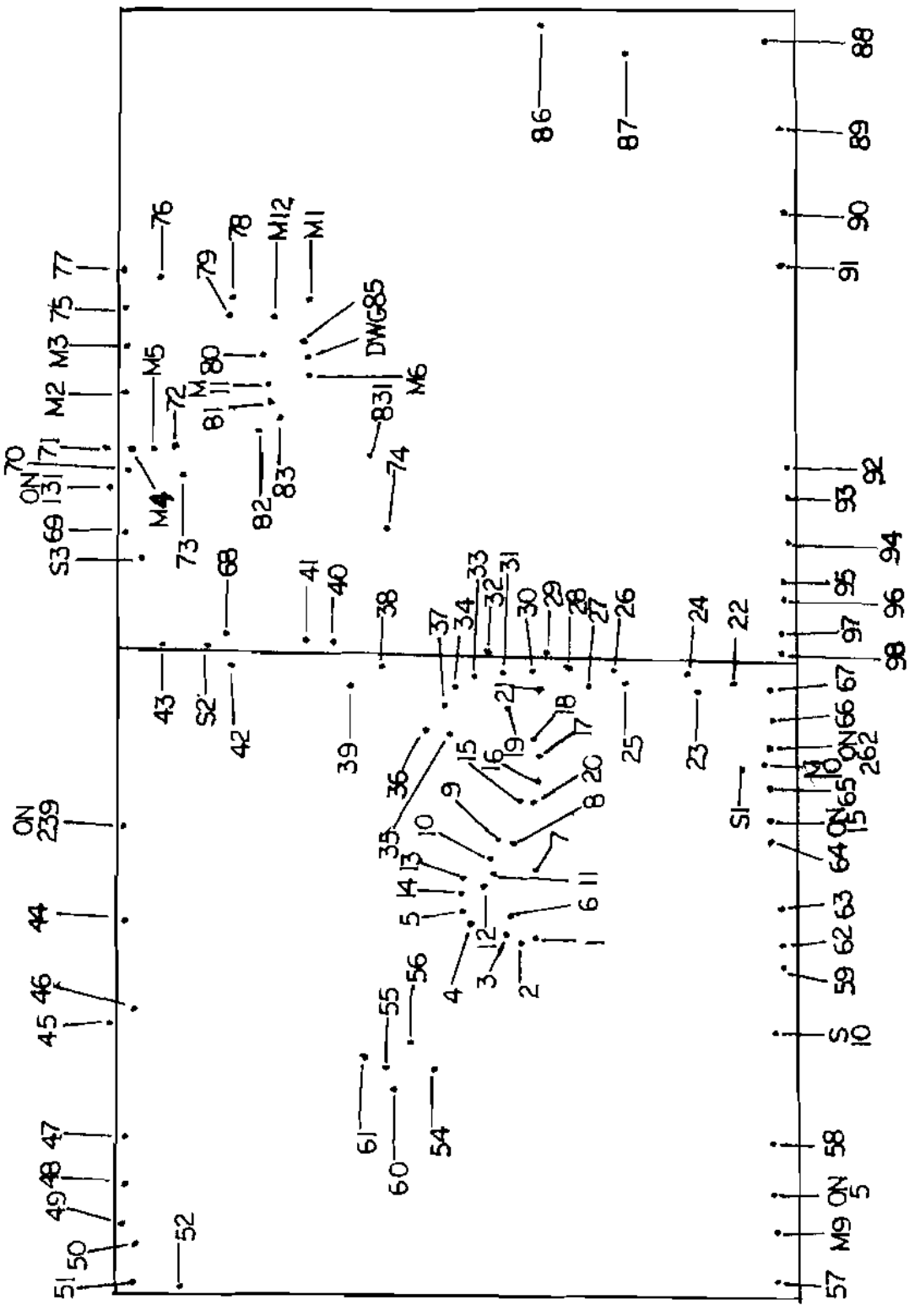


Figure 3. Numbering of woodrat houses on the study area.

All traps were single-door, wire, Tomahawk-type live traps. Two different models were used; the main difference being trap size (Fig. 4).

The larger trap was 483 mm X 160 mm X 160 mm. The excessive length of this trap caused some problems with trap placement near woodrat houses as most were located in areas of dense vegetation. Only three of the large traps were used initially, and their use was later discontinued.

The smaller traps were 255 mm X 130 mm X 130 mm; they were easily placed and with the use of an aluminum pack frame, it was possible to carry up to 16 traps at one time.

Initially 17 of the smaller traps were used, however, beginning with period 4, 37 became available for use.

During the first three trapping periods only 20 traps, three large and 17 small, were used. This proved to be inadequate for the study area and resulted in prolonged trapping periods.

Beginning with period 4, 40 traps became available. This larger number was sufficient to cover the area quickly and efficiently.

Throughout the study, traps were placed as near to the house as possible and most were placed within one meter. If it was possible to do so, the trap entrance was aligned with a major entrance to the house.

Some trapping was conducted during cold weather, therefore it was necessary to take precautions to avoid cold stressing captured animals.

When it was necessary to trap while temperatures were below 50° F,

Figure 4. Traps used during the study.

all traps were initially covered on the sides, top, bottom, and back end with aluminum foil.

Aluminum foil covers made traps difficult to camouflage; also, woodrats removed foil from some traps. Soon after the study was begun, aluminum covers were abandoned in favor of newspaper which was wrapped around the trap with only the doorway uncovered. Paper covers proved to be effective and provided protection from rain and low temperatures. Even though paper covers became saturated with rain, they did not leak. Although somewhat difficult to handle when wet, the paper covers dried on traps and laated through several rainstorms. As they seemed to have no detrimental effects on trap operation, covers were allowed to remain on many traps throughout the study.

Cotton batting was provided inside the trap during cold weather and was shredded by the trapped animal and used for bedding. In a few instances, woodrats apparently carried bedding from traps into houses. In only one instance did an animal seem to be suffering from cold stress, and this was one of the occasions when bedding had been removed.

Peanut butter was used for bait throughout the study and supplemented with cracked milo during the hot, humid weather of period 6. Although somewhat subject to insect depredation during hot weather, the peanut butter was effective even after all visible traces had been removed.

Traps were checked each day, usually by 9:00 a.m. In a few instances it was necessary to check the traps later in the day due to road conditions or personal obligations. Traps were never left

untended for more than 30 hours. Trapping was conducted primarily on week days and traps were usually sprung but left in place on weekends.

Only those houses which appeared to be occupied were trapped. Traps were usually set at each house for two consecutive nights; some were allowed to remain longer if one or both nights were stormy or rainy. In this case, traps were left in place until two nights of relatively good weather ensued. Traps were also allowed to remain in place an additional night when a trap night occurred in which no traps were disturbed, even at houses which were almost certainly occupied. Traps were allowed to remain longer than two nights at houses which showed definite evidence of occupancy. Such evidence included the presence of fresh plant cuttings in openings of the house, or actually sighting the animal in proximity of the house. All traps left in place additional nights were re-baited.

Ear tags made by the National Band & Tag Company were used to mark adults, sub adults and some juveniles.

When caught, the animals were encouraged, by blowing on them, to run from the trap into a wire force cone approximately 450 mm in length. A rag was then inserted into the cone and pushed in tight behind the woodrat. The ear of the immobilized woodrat was pulled through the wire cone with forceps, and an ear tag was attached.

After all data were recorded, trapped animals were released near the house at which they were caught.

Initially the study included opening the houses at the proper time and marking young which were still in the nest. This required

the use of a four-tined digging fork and also a pair of heavy leather gloves.

Young were found on three occasions, and were marked as shown in Fig. 5. Marking consisted of clipping the toe or toes corresponding to the desired letter-number of the animal, i.e. RF2.

The woodrat house was repaired following the search for young. To repair houses, nest material was replaced where it had been found and the hole which had been created in the side of the house was filled in with the sticks and branches originally used in the house.

View from ventral side

Figure 5. Numbering system for marking of juveniles by toe clip method.

RESULTS AND DISCUSSION

Traps were in place for a total of 795 trap nights during the study. Trapping periods 1 through 7 consisted of 211, 58, 125, 113, 38, 94, and 156 trap nights respectively (Table 1). Periods 2 and 5 included only houses of previous female capture. A total of 106 individuals was captured during the study, of which nine were juvenile young found in the nest upon opening the house. One additional woodrat was found dead in a trap. The total number of captures was 183 with 50 captures during period 1, and 10, 36, 20, 9, 40, and 22 during subsequent periods, excluding young found in the nest.

Captures per trap night were .237, .172, .288, .177, .237, .426, and .141 respectively during periods 1 through 7 (Table 1). The total number of individuals captured during each trapping period was 39 during period 1, and 10, 27, 13, 6, 34, and 20 during the remaining periods, again excluding young found in the nest (Table 2). Periods 2 and 5 included only sites of previous female capture so numbers captured were low, as expected.

Total numbers of individuals caught during each period were lower than during any previous study on the area (Table 3). The lowest number captured previously was during 1969-1970 with 49 individuals, and the highest number recorded was 235 in 1977. The mean number of captured individuals per study based on totals in Table 3, was 120.5. The greatest number of individuals taken during this study was recorded for the first trapping period with 39, and the least, excluding periods 2 and 5, was 13 during period 4.

Table 1. Trap nights and trapping success.

Trapping period	Trap nights	Total number of captures	Percent success
1	211	50	23.7
2*	58	10	17.2
3	125	36	28.8
4	113	20	17.7
5*	38	9	23.7
6	94	40	42.6
7	156	22	14.1
Total	795	183	

* Only sites of previoua female capture were trapped.

Percent success = total captures/trap nights

Table 2. Numbers and types of individuals caught.

Trapping period	Individuals	Adults ♀	Adults ♂	Juveniles ♀	Juveniles ♂	Unsexed Juveniles
1	39	24	8			7
2*	10	6	2			2
3	27	13	12	2		
4	13	7	5	1		
5*	6	6				
6	34	14	7	4	5	4
7	20	13	6	1		

* Only sites of previous female capture were trapped.

Table 3. Number of woodrats captured each period of 16 trapping periods (adapted from Agin and Crumb, 1971).

Year captured	Total number	Year captured	Total number
1963-1964	143	1977	235
1964-1965	138	1978	no data
1965-1966	162	1979-1980	97
1966-1967	109	1981-1983	no data
1967-1968	132	1983	60*
1968-1969	79	Apr.-May 1984	39
1969-1970	49	Oct.-Nov. 1984	27
1970-1971	no data	March 1985	13
1971	61	June 1985	34
1972-1976	no data	Oct.-Nov. 1985	20

* Only central portion of area was sampled.

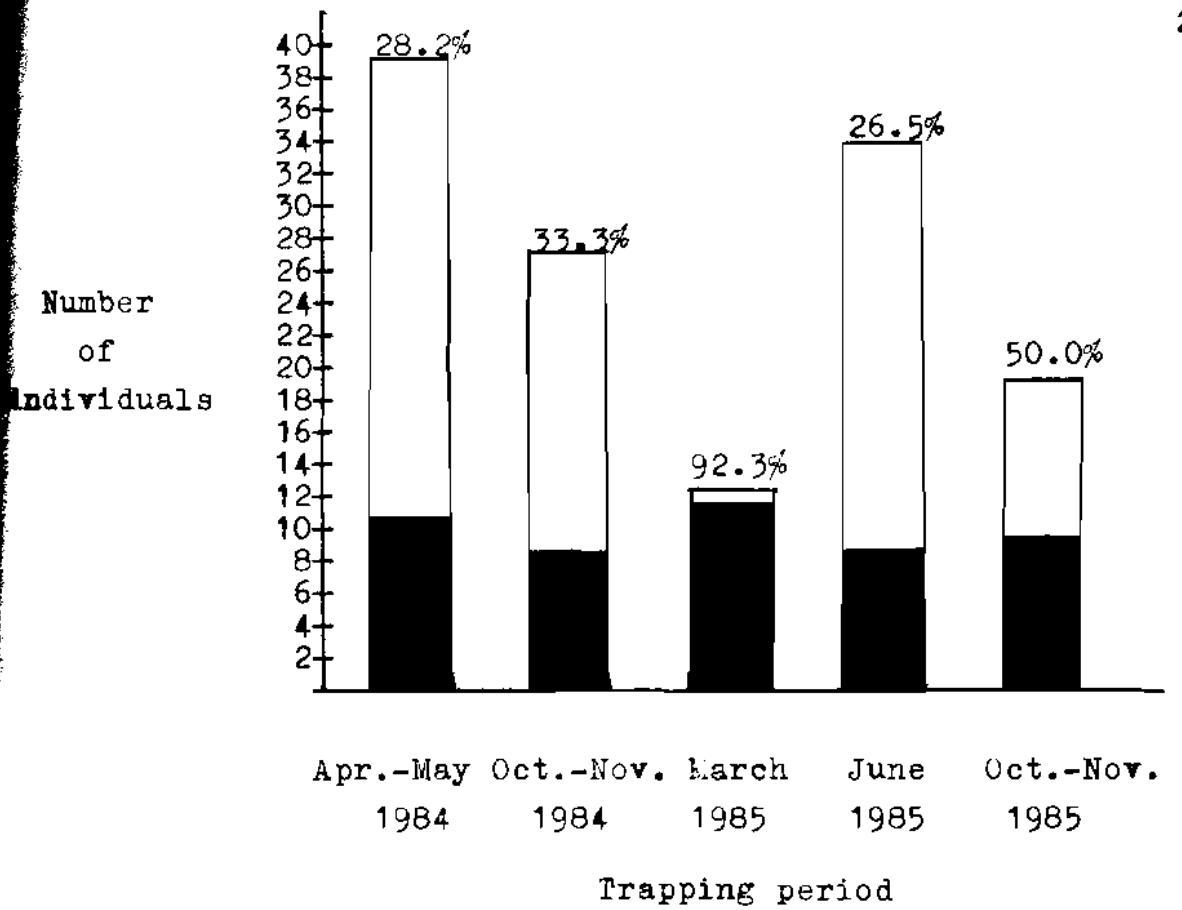
Ten juveniles were caught during period 1, and two, two, one, zero, 15, and one, respectively, during subsequent periods. Percentages of juveniles in the total catch were 25.6, 20.0, 7.4, 7.6, 0, 41.2, and 5.0, respectively, during periods 1 through 7.

During each of the seven trapping periods numbers of previously caught and marked rats were recorded. The percent of previously caught and marked rats of the total captured each period was also recorded. Results are as follows: Period 1, 11 (28.2 percent); Period 2, 8 (80.0 percent); Period 3, 9 (33.4 percent); Period 4, 12 (85.7 percent); Period 5, 0; Period 6, 9 (26.5 percent); and Period 7, 10 (50.0 percent), (Fig. 6).

More females than males were caught during all trapping periods (Fig. 7). The ratio of males per 100 females was 29.6, 33.3, 80.0, 62.5, 0, 66.7, and 42.9, respectively, during periods 1 through 7. Periods 2 and 5 included only sites of previous female capture so were biased toward females. Data from periods 2 and 5 do not appear in Fig. 7, as well as some other figures, due to the selectivity of trapping during these periods. No males were captured during period 5, however, two were caught during period 2.

Brandt (1977) reported 205.2 males per 100 females and a total population of 235 woodrats. Schupp (1980) reported a population of only 97 individuals and a ratio of 71.4 males per 100 females.

During a 1983 study on a portion of the area, Riccio caught 60 individuals but estimated the population to be twice that number. Even though the area sampled by Riccio was only a portion of the present study area, it included most of the area found to be inhabited



■ = woodrats caught and tagged previously.

□ = woodrats not captured previously.

Percentages indicate the number of previously tagged animals in the total catch.

Figure 6. Total number of individuals and number and percent of previously tagged animals during five trapping periods.

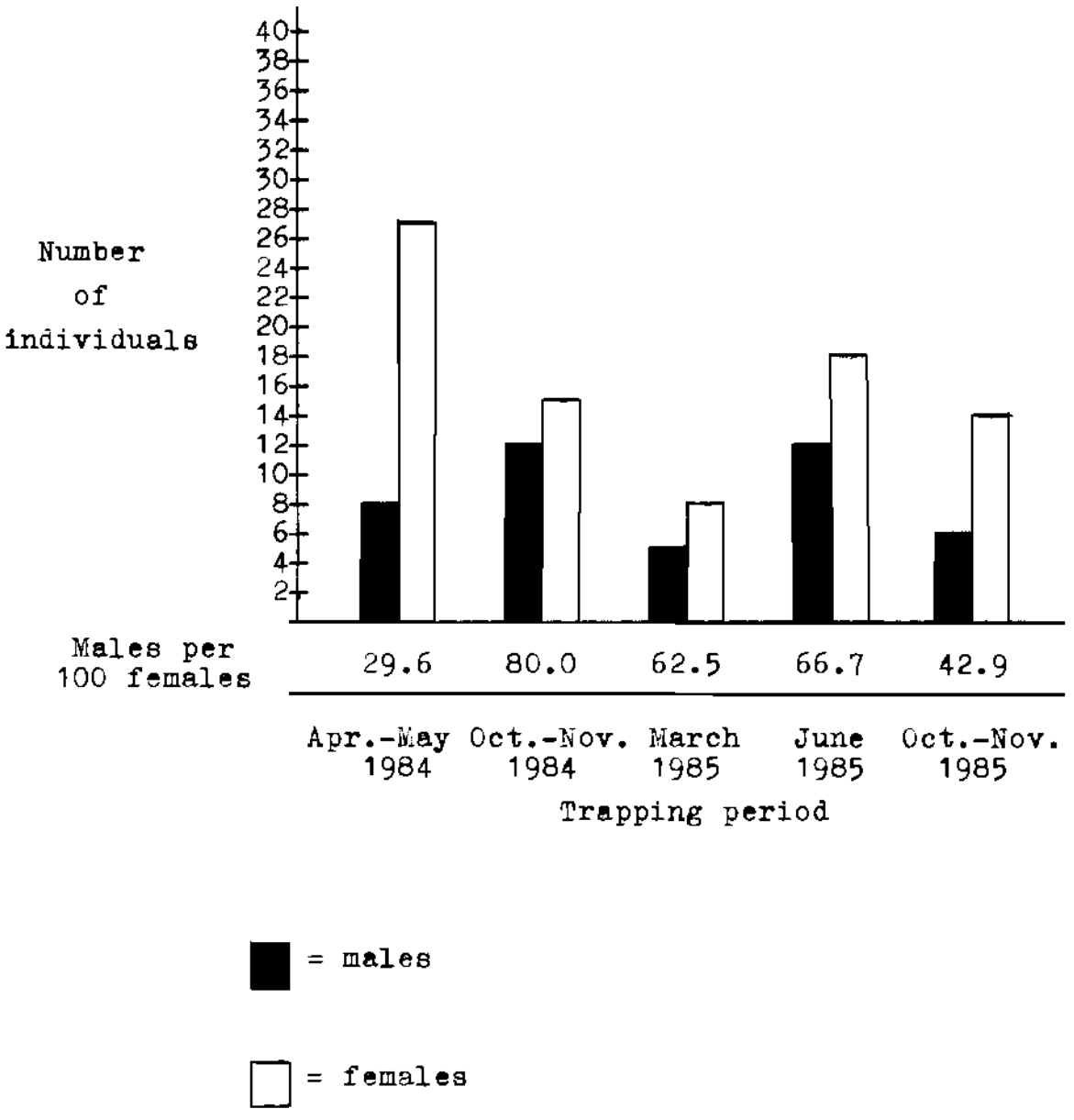


Figure 7. Ratio of males to females during five trapping periods.

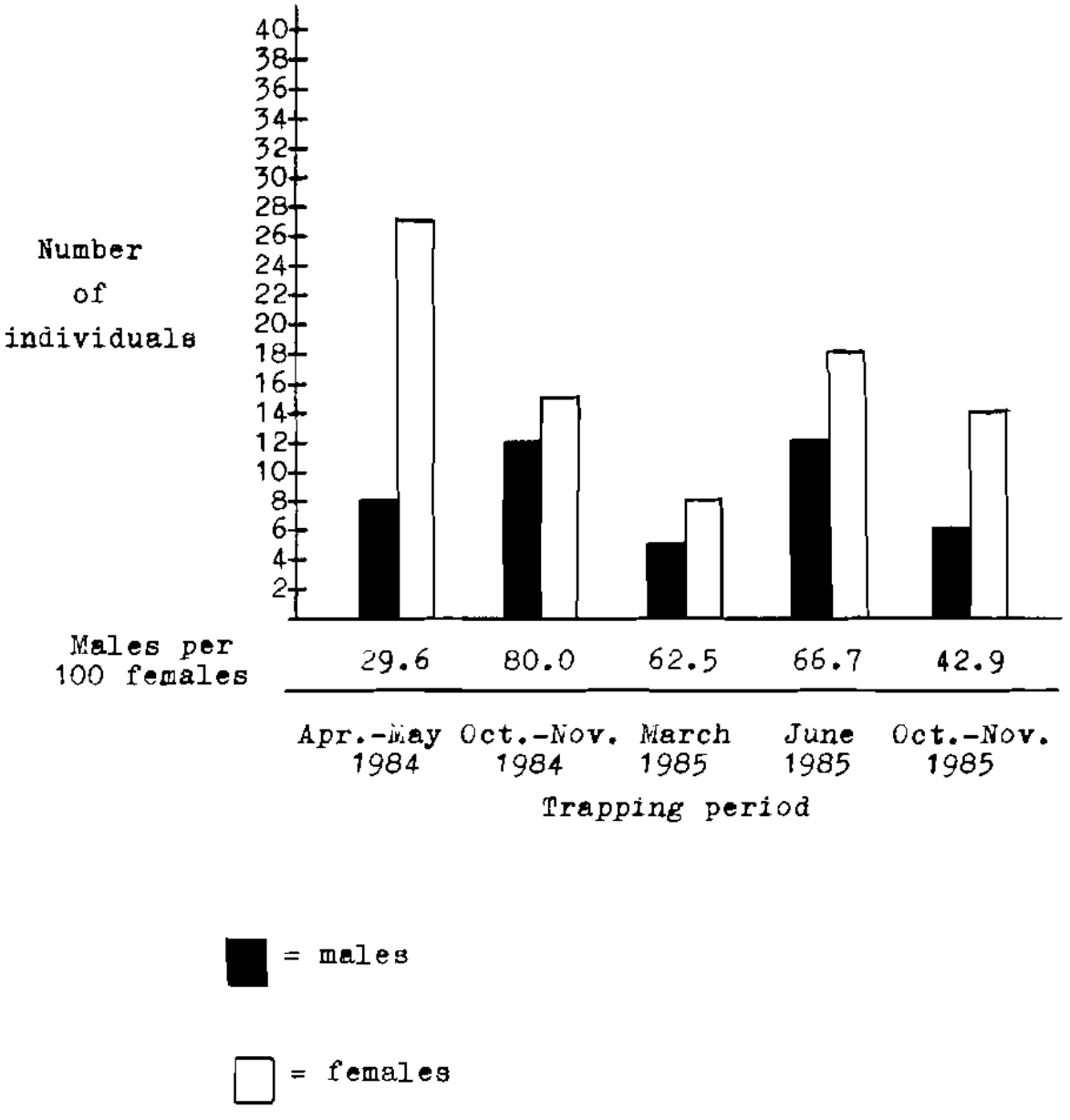


Figure 7. Ratio of males to females during five trapping periods.

by woodrats during this study. The population in 1983 would probably have been in excess of the 60 individuals captured, however, population density based only on these 60 individuals was 1.85 animals per hectare. The greatest density during the present study was 1.20 animals per hectare during trapping period 1. Riccio reported a sex ratio of 114 males per 100 females.

Movement by woodrats from one house to another was common during the study, and few individuals were taken at only one house. Many were taken at a different house with each capture, as may be seen in Tables 4 and 5.

The total number of captures for each individual during the study was divided by the number of houses at which it was caught. The resulting value was termed the "rate of relocation" and is shown for each individual in Tables 4 and 5. The mean rate of relocation for females was calculated to be 1.720 as opposed to 1.375 for the males. These data include only woodrats caught more than once, and the assumption was made that an animal caught at a house was actually living there. Attraction by traps or bait could possibly have resulted in the capture of an animal which was living at a nearby house.

Relocation from one house to another was common among both male and female woodrats as seen in Figure 8a-c. Capture locations for females versus males were analyzed using the Wilcoxon-Mann-Whitney test (Kruskal, 1957) and found to be not significantly different at the 0.05 level.

Table 4. Number of captures and capture locations and rate of relocation for individual females.

Animal No.	Number of captures	Number of capture locations	Rate of relocation*
450	2	1	2.00
222	3	3	1.00
220	7	5	1.40
451	3	3	1.00
234	3	2	1.50
452	11	3	3.67
298	3	3	1.00
454	2	2	1.00
457	2	2	1.00
459	2	1	2.00
460	3	2	1.50
462	2	1	2.00
463	3	2	1.50
465	2	1	2.00
473	3	1	3.00
403	4	4	1.00
406	3	3	1.00
410	5	3	1.67
413	3	3	1.00
415	4	2	2.00

Table 4. Continued

Animal No.	Number of captures	Number of captures locationa	Rate of relocation*
418	6	2	3.00
443	2	1	2.00
444	5	2	2.50
497	2	1	2.00
995	2	2	1.00
796	2	1	2.00

* Rate of relocation was calculated by dividing the number of captures for an individual by the number of houses at which it was caught.

Twenty-five additional adult female woodrats were captured only once and are not included in this table.

The mean rate of relocation for female woodrats was 1.72.

Table 5. Number of captures and capture locations and rate of relocation for individual males.

Animal No.	Number of captures	Number of capture locations	Rate of relocation
455	5	5	1.00
456	2	1	2.00
414	4	4	1.00
253	2	1	2.00
218	2	2	1.00
440	2	1	2.00
989	2	2	1.00
200	2	2	1.00

Twenty-six additional adult male woodrats were captured only once and are not included in this table.

The mean rate of relocation for male woodrats was 1.375.

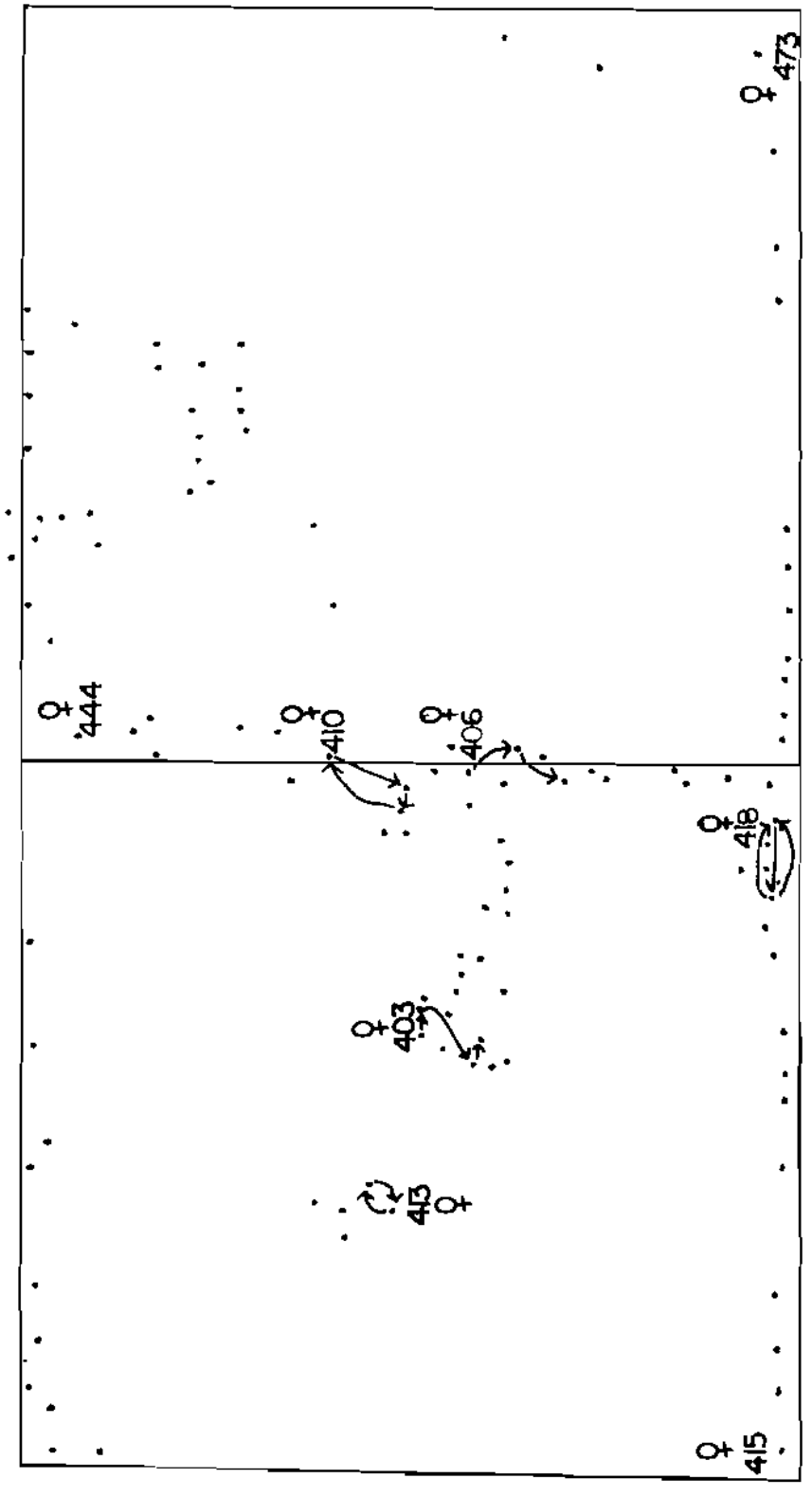


Figure 8a. Movements of individuals captured two or more times. Numbers and symbols represent tag number and sex of animals.

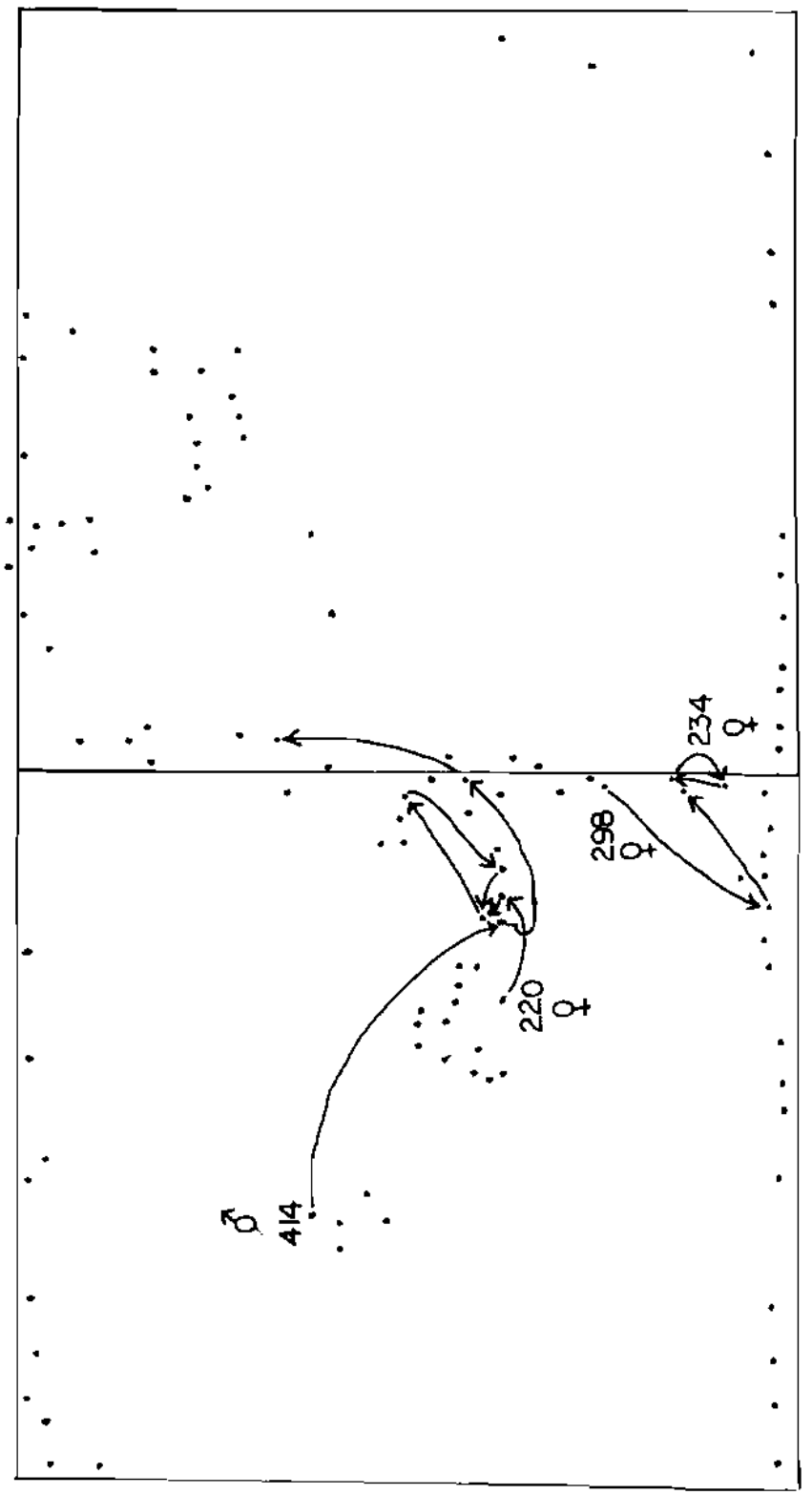


Figure 8b. Movements of individuals captured two or more times. Numbers and symbols represent tag number and sex of animals.

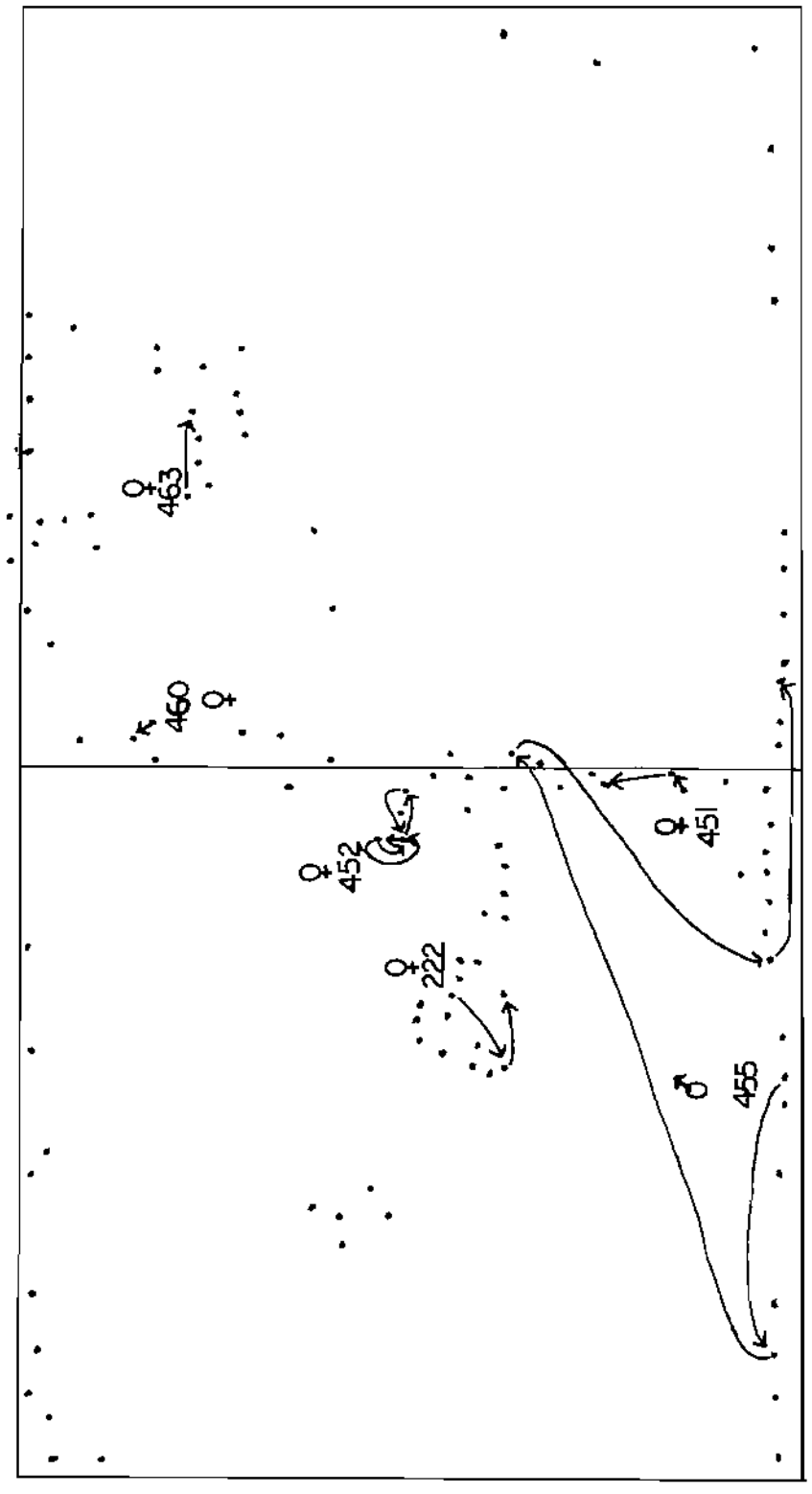


Figure 8c. Movements of individuals captured two or more times. Numbers and symbols represent tag number and sex of animals.

Distances traveled during relocation seemed to be greater with males. Rainey (1956) reported that males have more of a tendency to wander while females tend to be captured repeatedly at one house. As seen in Figure 8a-c, females captured during this study were often captured at any one of several houses in a closely spaced group, rather than at the same house each time. Most females seemed to alternate occupancy among houses in this group. Low population levels and the subsequent abundance of houses may have contributed to this short range movement of females.

A study on the dusky-footed woodrat (Neotoma fuscipes) by Linsdale and Tevis (1956) concluded that old dominant individuals tended to maintain and control several houses from which they excluded all other members of the colony. They stated that long residence in the same house was rare, and that the rats often shifted their headquarters to a different dwelling within their area of influence. The study also stated that woodrats would occasionally abandon their territory and move to an area which had been vacated by another individual.

Some houses were often occupied by woodrats while others seemed to be seldom used. Table 6 groups houses by common features and shows the degree of occupancy by woodrats throughout the study.

The "well protected" houses were large and associated with low, overhanging branches, earth banks or hollow trees or were located at the base of stone walls or rock ledges. The other houses tended to be smaller and less well protected. As may be expected, woodrats occupied the larger, better protected houses more frequently. The

Table 6. Frequency of house occupancy prior to winter (Period 3) and following winter (Period 4). Pre-Period 3 and Post-Period 4 occupancy of house used during periods 3 and 4 is also shown.

House number	Trapping period						
	1	2*	3	4	5*	6	7
	Large, well protected houses						
1	X		X	X			X
5			X				
9			X				
15			X			X	
16			X	X		X	
17			X	X	X		
22	X		X			X	X
29			X	X			
31				X		X	X
34	X		X	X		X	
35				X	X	X	X
36	X	X	X				X
37	X	X	X	X		X	
38			X				X
40	X		X			X	

Table 6. Continued.

House number	Trapping period 1	2*	3	4	5*	6	7
			Large, well protected houses				
54	X	X	X			X	X
61	X		X	X	X	X	X
64	X		X	X		X	
65	X		X	X	X		
80	X		X			X	
239			X			X	
			Smaller, less well protected houses				
14				X		X	X
24	X	X	X				
25	X	X	X				
27			X	X			
43				X	X		X
57			X	X	X		
81			X			X	
84	X		X			X	X
86	X		X			X	
96				X		X	X

Table 6. Continued.

House number	Trapping period 1	2	3	4	5	6	7
ON5			X				
S2			X	X			
S3			X				
S11			X				
S14			X				

* Trapping included only sites of previous female capture.

X = occupied house

larger physical size of a well placed house might be the result of it's being occupied more frequently, as woodrats tend to repair and add to houses which they are using. Table 6 includes only houses which were occupied during trapping period 3 or period 4 or both. Period 3 was conducted before the winter of 1984-1985 and period 4 immediately following. Many additional smaller, less well protected houses were occupied only occasionally or not at all.

Winter survival is a determining factor of woodrat population density. In a prior study on the area in October-December 1983, Riccio captured 60 individuals and estimated the population to be larger than 60. Thirty-nine individuals were captured during the first trapping period of this study in April-May 1984. Thus it is possible to assume that the population dropped from more than 60 to about 39 individuals, primarily during the winter period. The third trapping period of this study was conducted in October-November 1984; 27 woodrats were captured. During March 1985, only 14 individuals were caught. The population was higher in June 1985, when 34 individuals were captured, however, only nine were animals which had been captured before. From these data it seems that low winter survival had a dramatic effect on this already depleted population.

Of the 60 individuals captured by Riccio in October-December 1983, only 14 were captured again in April-May 1984. One individual captured by Riccio was captured three additional times with the final time being the last trapping period in June 1985.

Some animals were not captured during a particular trapping period but were captured again during a subsequent period, as seen in

Table 7. This was especially prevalent during periods 2 and 5 which included only sites of previous female capture.

Seventy-one woodrats were caught only once, including nine which were caught initially during the final trapping and, thus, there was no possibility of recapture. Seventeen woodrats were caught twice, nine were captured three times, three were captured four times, three five times, one six times, and one woodrat wss captured 11 times (Fig. 9).

Young woodrat survival seemed to be low during this study. A total of 29 juveniles was captured initially during the study, including those which were nestlings and the larger, blue-colored young which were live-trapped. Of the 29 young, only six were recaptured, however, one of the six was captured a total of four times (Fig. 10).

Initial study methods included opening woodrat houses at the proper time in accordance with reproductive cycles, and marking young which were in the nest. Three young were found in one house and four in another during trapping period 2 and two additional young were found at one house during period 5.

One of the four nestlings taken at the house during the second period was recaptured once during period 3 and twice during period 4. None of the other eight individuals initially found in nests were recaptured.

Rainey (1956) in a study on N. floridana, initially captured 27 young on his study area; only six were caught one additional time (six reached adult size), three seemingly did not survive long enough to

Table 7. Longevity of individual woodrats. Dashed lines indicate time animals were known to be alive.

Animal number	Time periods during which animals were caught							
	Oct–Dec 1983 Period	Apr–May 1984 1	June–July 1984 2	Oct–Nov 1984 3	March 1985 4	Apr–May 1985 5	June 1985 6	Oct–Nov 1985 7
220	X	X		X	X	X	X	
222	X	X		X				X
450		X*						
451		X	X					
234	X	X	X					
455		X		X	X			
452		X	X	X	X	X	X	X
298	X	X						
454		X		X				
456		X		X				
457		X*						
459		X	X					

Table 7. Continued.

Animal number	Time periods during which animals were caught							
	Oct-Dec 1983 Period	Apr-May 1984 1	June-July 1984 2	Oct-Nov 1984 3	March 1985 4	Apr-May 1985 5	June 1985 6	Oct-Nov 1985 7
460		X----------X----------X						
462		X----------X						
463		X----------X						
465		X*						
473		X----------X----------X						
403				X----------X----------X----------X				
406				X----------X				
410				X----------X----------X----------X				
413				X----------X				
414				X----------X----------X				
415				X----------X----------X----------X				
253	X----------X							

Table 7. Continued.

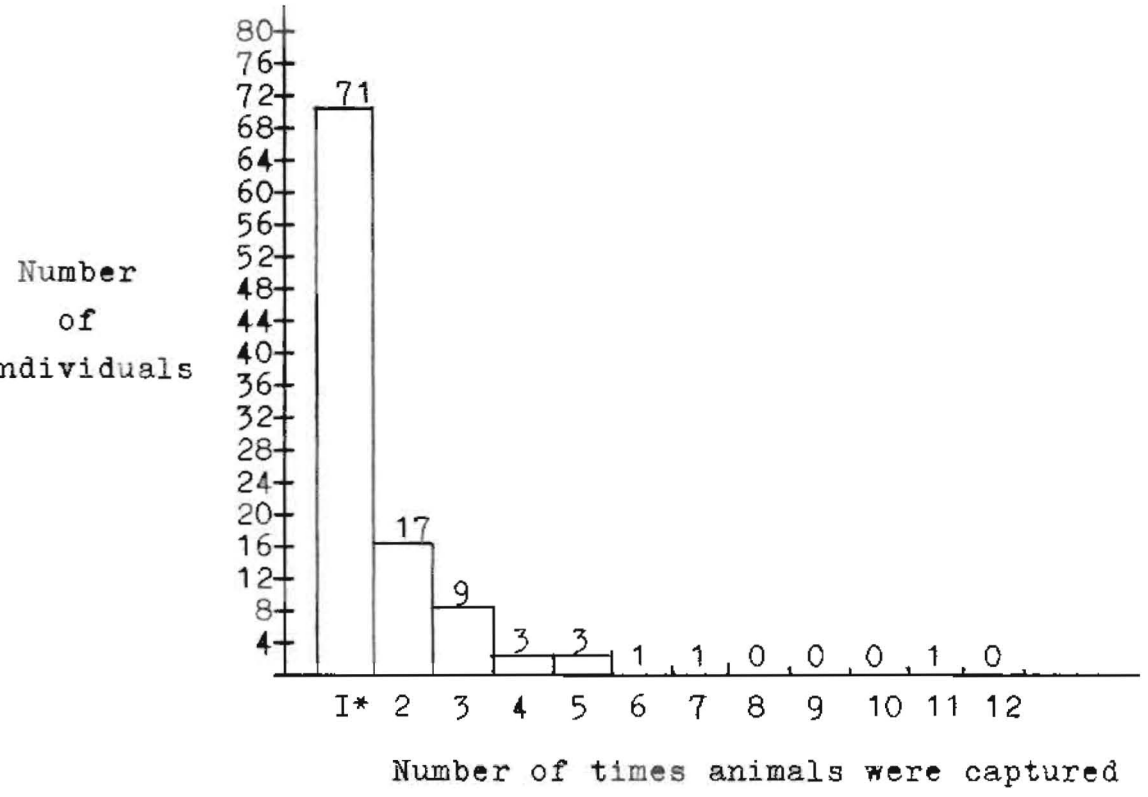
Animal number	Time period during which animals were caught							
	Oct-Dec 1983 Period	Apr-May 1984 1	June-July 1984 2	Oct-Nov 1984 3	March 1985 4	Apr-May 1985 5	June 1985 6	Oct-Nov 1985 7
418				X	X	X	X	
218	X				X			
443					X	X		
444					X	X		
497							X	X
440							X	X
989							X	X
995							X	X
944							X*	
796							X	X

Table 7. Continued.

Animal number	Time periods during which animals were caught							
	Oct-Dec 1983 Period	Apr-May 1984 1	June-July 1984 2	Oct-Nov 1984 3	March 1985 4	Apr-May 1985 5	June 1985 6	Oct-Nov 1985 7
200							X----------X	
245	X----------X							
281	X----------X							
252	X----------X							
273	X----------X							
231	X----------X							
232	X----------X							
283	X----------X							
243	X----------X							

X = captures of individual.

* Animals which were captured more than one time within the same trapping period, but were not captured during any other periods.



igure 9. Numbers of woodrats captured from one to 12 times during the study.

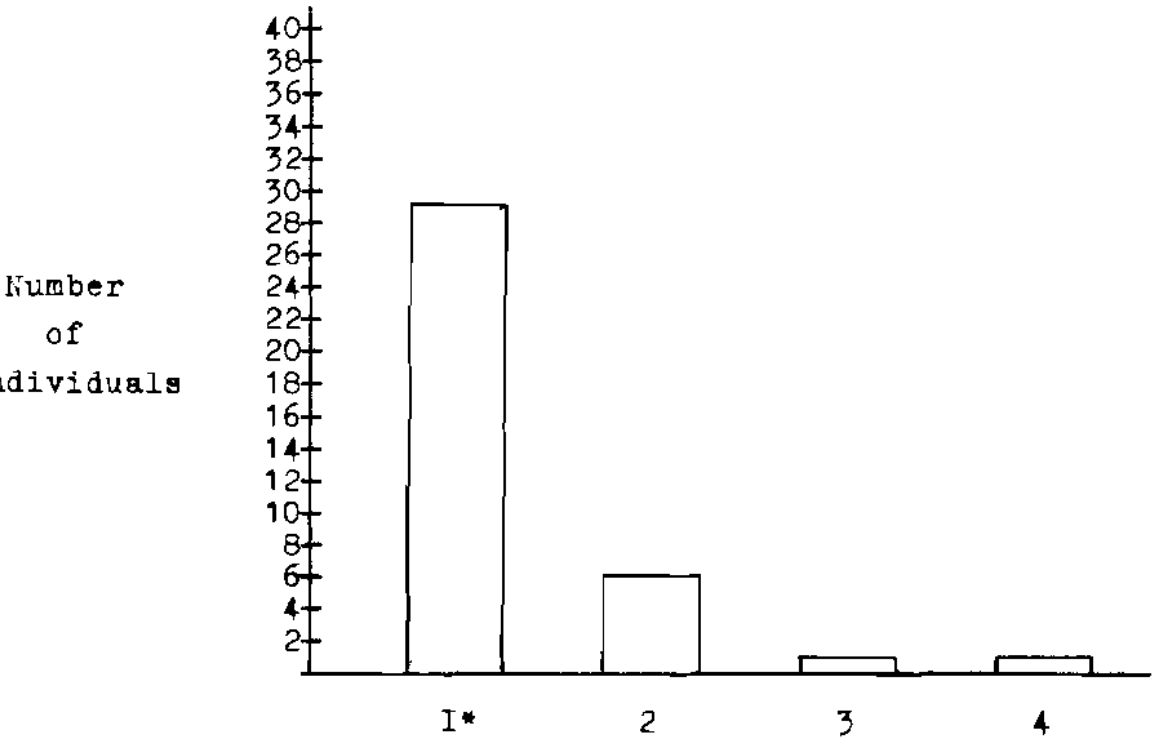


Figure 10. Numbers of woodrats captured from one to four times which were initially captured as juveniles.

breed. He said, "So far as was known of 27 young, only 11.1 percent survived to contribute to the maintenance of the population". He also reported that the minimum number of young that should have been produced from known pregnancies greatly exceeded the number caught in traps. "Most of those unaccounted for probably did not survive until weaning" (Rainey, 1956).

Although few young were found in nests during the study, a total of 29 was captured while small and in the blue coloration phase, presumably at the maternal house. On several occasions two, three or four juveniles were caught in one trap, sometimes with the mother in the trap as well. When a juvenile woodrat was captured with the mother, with another juvenile of approximately the same age, or at a house known to be occupied by an adult female, the house was assumed to be the maternal house.

Young woodrats were expected to disperse only a short distance from the maternal house due to the abundance of unoccupied houses on the area. It seemed that most were in fact moving only a short distance, however recapture, and presumably survival, was so low that only a small amount of recapture data regarding the young was collected.

Of the six woodrats initially captured at what was presumed to be the maternal house, one remained at that house while all others moved. All but one individual moved into an unoccupied house within a few meters of the maternal house. The other individual, number 406, was one of the animals found in the nest and marked by toe clipping. This woodrat was captured a total of four times and moved a greater

distance than the others (Fig. 11).

Insufficient data were collected regarding differential reproduction and differential survival to support the working hypotheses, as previously stated. The problems connected with locating and marking nestlings were compounded by the low population density during this study. A future study attempting to mark nestling woodrats might prove successful if a larger population were available.

In addition to objectives concerning differential reproduction and differential survival of young, other objectives (Pg. 6) were attained. Those stated objectives were:

The collection of general ecological data on the population of N. floridana, including population size, density, sex ratio and percent of juveniles in the total catch; to compare previous population levels with present levels and to document the population decrease following the last study (Riccio, 1983); to determine the degree of over-winter survival, and relate survival to house type and location; to present data on relocation of animals from one house to another and dispersal of the young following departure from the maternal house. An additional objective was to document the rebuilding of the population to previous levels, however, no rebuilding was recorded.

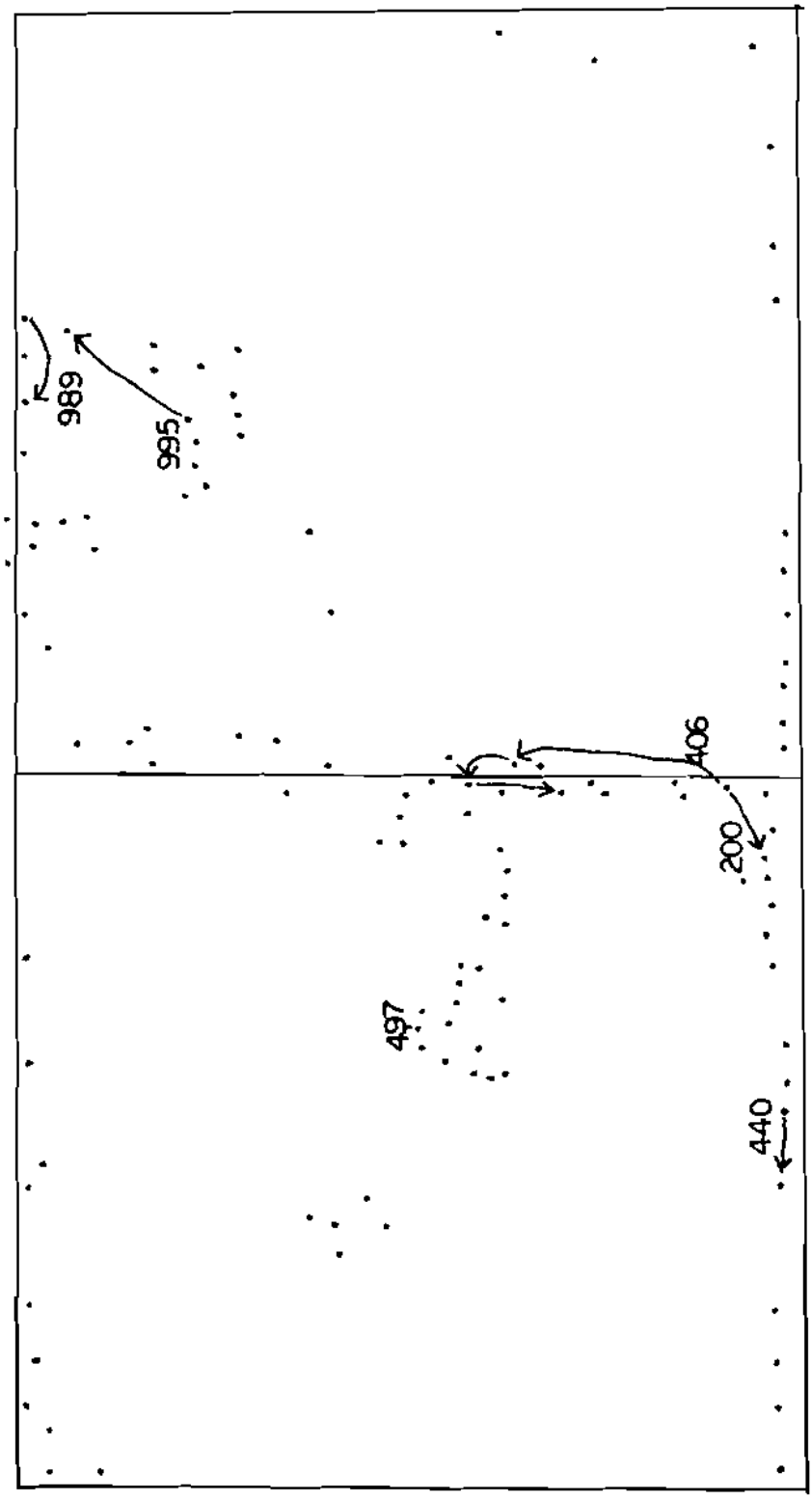


Figure 11. Movements of individuals initially captured as juveniles; numbers represent animal tag numbers.

SUMMARY

Live-trapping of eastern woodrats was conducted on an area in eastern Chase County, Kansas, from 18 April 1984 through 8 November 1985. Trapping was carried out during seven time periods for a total of 795 trap nights. Animals were marked with numbered ear tags and released.

Total captures during the study was 183 with a total of 106 individuals being captured. The ratio of males per 100 females ranged from 29.6 to 80.0, with a mean value of 56.3.

Houses of some female woodrats were opened, at the proper time in accordance with reproductive cycles and the observed breeding condition of the trapped female, in an effort to locate and mark nestlings.

Data were collected and analyzed regarding population size, survival, survival and dispersal of young, movements, and occupancy and preference among houses by woodrats. Additionally population densities and structure were compared with several prior studies conducted on the same area. Population density was found to have declined from greater than 1.85 animals per hectare when last studied, (Riccio, 1983) to 1.20 animals per hectare at the highest point during this study. The population density was the lowest ever reported on the area and many vacant houses were present.

Survival of juveniles was low throughout the study. Of 29 animals initially captured as juveniles only six were recaptured, indicating low survival.

Attempts to locate and mark nestlings were largely unsuccesful, however, nine were found. Of the nine, one was recaptured. The difficulty of catching nestlings at the correct stage of development combined with low population levels were the primary obstacles to marking of nestlings.

Larger, better protected houses were occupied more frequently during the study, while the majority of smaller houses were rarely occupied.

Relocation from one house to another was common among both male and female woodrats. Females tended to alternate occupancy between houses within a closely spaced group, while males tended to move greater distances.

A "rate of relocation" value was established for both males and females, by dividing the total number of captures for an individual by the number of houses at which it was caught. The mean rate of relocation value was 1.72 for females as opposed to 1.375 for males, indicating greater frequency of relocstion in males.

Upon dispersal from the maternal house, juveniles commonly established themselves in vacant houses nearby.

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