GENERAL NOTES

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STATUS AND HABITAT OF THE KEY LARGO WOODRAT AND COTTON MOUSE (*NEOTOMA FLORIDANA SMALLI* AND *PEROMYSCUS GOSSYPINUS ALLAPATICOLA*)

Key Largo, the largest and among the most mesic of the islands on the archipelago at the southern tip of Florida, is well known for its tropical, dry hardwood forest (Hilsenbeck, 1976) and a fauna somewhat distinctive from the mainland fauna. The purpose of this study was to evaluate the status and habitat use of two subspecies of omnivorous, terrestrial-arboreal rodents—the Key Largo woodrat (*Neotoma floridana smalli*) and cotton mouse (*Peromyscus gossypinus allapaticola*).

Though woodrat houses were reported on Key Largo by Small (1923), the first details and specimens were documented by Schwartz (1952). He noted that woodrats were common in the dense forest on the northern end of Key Largo but their prominent nests were absent from the southern part. However, he did capture two individuals on the southern end at Rock Harbor, where nesting might have been in cracks and holes in the limestone. Subspecific status of the Key Largo woodrat was established by Sherman (1955) and confirmed in a taxonomic review of *N. floridana* by Schwartz and Odum (1957).

The United States Department of the Interior (1973), based on surveys by Dr. Larry N. Brown, reported that populations of the Key Largo woodrat had been seriously depleted. According to this report, *N. f. smalli* was restricted to the northern one-third of Key Largo, in climax forest not exceeding 600 ha in extent. Based upon 1.25 woodrats per ha in a study plot, the population was estimated at 700 to 800 individuals. Rapid loss of habitat was noted, resulting from fires and bulldozing for commercial development. Layne (1974) stated that Key Largo woodrats appeared localized within the remaining patches of upland forest. In a study area selected for its high density of woodrat houses, Hersh (1978) found 2.2 woodrats per ha. She also commented on the ongoing reduction of forest vegetation on northern Key Largo. Brown (1978*a*), citing field studies from 1968 to 1973, stated that only 120 to 160 ha of mature upland forest suitable for woodrats remained on Key Largo.

The type locality of the Key Largo cotton mouse is 19.3 km northeast of Rock Harbor on Key Largo (Schwartz, 1952). Two specimens have been taken as far south as Planter, near Tavernier, by Osgood (1909, in Layne, 1974). Formerly the Key Largo cotton mouse was found throughout Key Largo (Brown, 1978*b*). However, fires and development have eliminated it from the southern portion of Key Largo, and it is now confined to the northern half of the Key (Layne, 1974; Brown, 1978*b*).

Peromyscus gossypinus allapaticola inhabits only mature tropical hardwood forests with deep leaf litter (Brown, 1978*b*) and is locally sympatric with the Key Largo woodrat. The mice construct nests in fallen logs, hollow tree stumps, and crevices in limestone outcrops. They are nocturnally active, feeding on seeds, fruit, and buds of tropical forest plants (Brown 1978*b*).

Recently, 19 Key Largo woodrats and 14 Key Largo cotton mice were introduced on Lignum Vitae Key (Brown and Williams, 1971), which is a State Preserve. Establishment of the woodrats was confirmed by Hersh (1978), who found a total of six active houses on the island in 1978. Based on the low density of houses, she suggested that the habitat was suboptimal for woodrats.

Livetrapping on Key Largo was conducted during the summer of 1979 in two tracts of forest, using Sherman livetraps placed in large 10 by 10 m grids and baited with oatmeal. The two sites were chosen for their difference in successional age, one being the most mature forest on Key Largo and the other being of intermediate maturity. The grid in mature forest contained 202 trap stations (6 by 34), and the other had 192 (8 by 24). Traps were run for 4 successive nights at each place. Sampling effort totalled 1,696 trapnights.

During January to August 1979, we estimated numbers of the stick houses that are built and maintained by woodrats. Censuses were done on 60 strip transects, each measuring 0.4 ha and spaced at intervals along state road 905, which bisects the upland forest of Key Largo. Transects with a width of 18.3 m began at the hammock edge near the roadside and covered a distance of 221.3 m along a compass line, usually perpendicular to the highway. In narrow strips of habitat in which upland forest graded into mangrove swamp before a transect was completed, we moved laterally and completed the transect by walking back toward the highway. Nests were judged to be actively used by woodrats if the houses were in good repair and their entrances were free of leaves, sticks, and spider webs. Size of forest tracts was estimated from Ruttenber and Weiner (1977) using a polar planimeter, after correcting their maps (based on 1973 photography) by deleting areas that had been burned or cleared by 1979.

TABLE 1.—*Estimates of size of forest tracts, woodrat densities, and number of nests. Numbers in parentheses are means of total nests seen along transect routes, including those beyond transect boundaries.*

Tract designation	Number of 0.4 ha transects	Estimated size of tract (ha)	Houses per hectare ($\bar{X} \pm SD$)	Estimated number of houses per tract	Estimate of woodrats in each tract
Key Largo					
L 1-5	1	8.8	2.5 (2.5)	22	4
L 1-6	1	7.6	7.4 (7.4)	56	10
L 1-9	1	16.7	4.9 (4.9)	83	15
L 1-10a	2	8.4	2.5 ± 3.5 (6.2)	21	4
L 1-10b	3	23.1	6.6 ± 3.8 (10.6)	152	27
L 1-11	13	111.5	11.8 ± 8.3 (22.8)	1,314	235
L 1-12	3	52.7	5.8 ± 2.9 (14.2)	304	54
L 1-13	3	19.1	13.2 ± 2.9 (19.8)	252	45
L 1-14	8	107.6	7.4 ± 3.5 (14.6)	798	142
L 1-15	4	42.2	5.6 ± 2.4 (15.4)	235	42
L 1-16	4	18.5	6.8 ± 5.1 (11.5)	126	22
L 2-1	6	35.4	6.2 ± 3.7 (9.9)	219	39
L 2-2b	1	11.3	7.4 (9.9)	84	15
L 2-2c	2	12.5	0 (3.7)	0	0
L 2-4	4	50.0•	0 (0)•	0	0
L 2-5	4	97.4•	0 (0)•	0	0
L 2-10	census	12.7•	— (0)•	0	0
L 3-7c	census	22.7•	— (0)•	0	0
Totals	60	475.4	7.7 ± 5.8	3,666	654
Lignum Vitae					
Key	10	89.9	5.3 ± 2.0 (10.0)	476	85

• Values not included in column totals.

Our livetrapping effort was insufficient to document the relation between the number of nests and individual woodrats. However, the intensive 17-month study of Hersh (1978) on 5.25 ha of hammock L 1-14 established that one individual was present for every 5.6 nests. This value proved to be reliable for Hersh's densely populated study area, for mark-recapture techniques showed a stable number of animals for a period of 10 months after all residents had been marked.

We evaluated the introduced population of woodrats on Lignum Vitae Key by censusing stick houses on 10 0.4 ha strip transects placed perpendicular to the circum-island nature trail. No attempt was made to determine the status of the introduced population of *P. g. allapaticola* on Lignum Vitae Key.

On Key Largo we captured 9 *N. f. smalli*, 38 *P. g. allapaticola*, 1 black rat (*Rattus rattus*), and 1 cotton rat (*Sigmodon hispidus*). These results provided little information about the abundance or habitat preferences of *N. f. smalli*, but the data were more instructive regarding *P. g. allapaticola*. In the mature forest, 36 individual cotton mice were captured a total of 93 times. Only three previously uncaptured individuals were taken on the last night of trapping, supporting the view that the data approached an accurate census of the population on the 1.65 ha grid. In the intermediate-age forest only two cotton mice were captured, with no recaptures. Grid size there was 1.61 ha. On this basis, population estimates were 21.8 individuals/ha in the mature forest and 1.2/ha in the intermediate seral stage.

The larger population of *P. g. allapaticola* had several distinctive features. A difference between the sexes in either sex ratio or trappability was suggested by individual and total captures. Of the individuals for which sex was recorded, 20 were males and 15 were females. Among recorded total captures, 52 were males and 35 were females. However, neither ratio was significantly different from the expected 1:1 ratio. No *P. g. allapaticola* in juvenile pelage were captured. Among the 15 adult females examined in June, none was pregnant or lactating, and six had perforate vulvae, indicating recent copulation. Most of the adult males (14 of 20) had descended testes in June. The observations indicate that breeding is highly seasonal; no signs of recent reproduction or recruitment of young were evident, and breeding had just begun.

When released, most *P. g. allapaticola* escaped by running a short distance across the forest floor on direct routes to small holes under logs or roots. Rapid entrance into these holes indicated that they were familiar shelters. A few individuals escaped by climbing trees or shrubs.

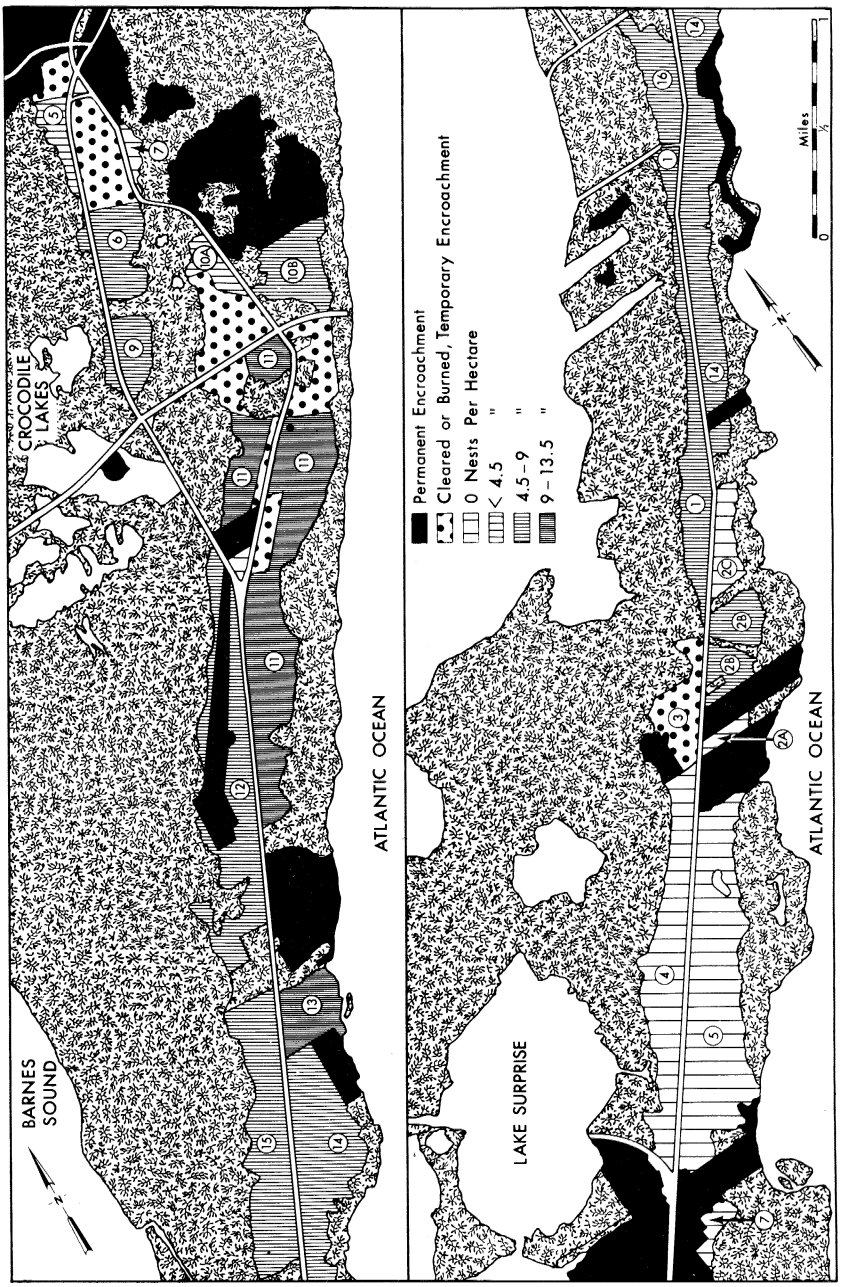

FIG. 1.—Relative abundance of woodrat nests on northern Key Largo. Encircled numbers refer to tracts of forest identified in Ruttenber and Weiner (1977).

Counts of woodrat houses on 60 transects, plus complete censuses in two forests, were conducted on northern Key Largo. Censuses farther to the southwest in two relictual forests among urban and suburban developments showed these forests to be unoccupied by *N. f. smalli*, unless animals were living in rock crevices without aboveground nests. Examination from roads showed that most of the hammocks southwest of the highway junction of US-1 and S-905 have been disturbed by logging and burning or destroyed by development.

Summarized data from transects (Table 1) indicated that northern Key Largo has approximately 475 ha of tropical hardwood forest occupied by woodrats. Average density of woodrat houses was 7.7 per ha (n = 60 transects), and approximately 3,670 woodrat houses were estimated to be present altogether. Using the conversion factor of one individual per 5.6 houses from Hersh's (1978) study, we calculated a total population of woodrats on Key Largo at 654 animals or 1.4 woodrats per ha of occupied habitat. Abundance of woodrats was directly related to the maturity of the forest in which they lived. One exception was the high-density population in the relatively young forest of tract L 1-12, which may have been a result of dispersal from the high-density population in mature forest across the road (see Fig. 1).

Considering forest size, woodrat nest density, and scarcity of encroaching developments, the most significant block of woodrat habitat consisted of tracts L 1-11, 12, 13, and 14 (Fig. 1, Table 1). These had a combined total area of 291 ha, an average of 10.0 woodrat nests per ha, and an estimated total of 2,668 nests and 476 animals (73% of the entire population). Tracts L 1-11 and 13 were outstanding in both forest maturity and woodrat density (averaging 2.2 animals per ha, n = 16).

Woodrat density on Lignum Vitae Key proved to be comparable to that on the intermediate sites on Key Largo (Table 1), even though the forest is mature. We estimated that the 90-ha preserve supported a population of 85 woodrats, at 0.9 per ha. This woodrat population was reported to be growing rapidly (Jennie Parks, pers. comm.).

Rainey (1956) noted that woodrats are highly vulnerable to predation because of their moderate size and terrestrial mode of life. Therefore he considered the two most important features of woodrat habitat to be nests, which provide refuges for rest and feeding, and cover, which provides escape routes throughout the home range. The high survival value of a woodrat house is maintained by continuous repair. Rainey (1956) described the frequency with which unoccupied houses were claimed by dispersing woodrats. In a continuously populated area, the houses were used by many generations of animals, and the houses became very large. In the hot, humid climate of Key Largo, unoccupied woodrat houses would decay in a few years. Consequently the presence of houses there indicates a fairly stable population of *N. f. smalli*, and those in a good state of repair have been occupied recently. Our data confirmed and quantified the observation of Brown (1978*a*) that densities of *N. f. smalli* are greatest in the most mature forest.

The difference in relative abundance of *P. g. allapaticola* in the two seral stages sampled was not attributable to trapping technique, season, or phase of the moon. We judge that the difference reflects a response to different levels of maturity of the plant community. The magnitude of this difference suggests that Key Largo cotton mice are more restricted to mature forests than are Key Largo woodrats.

The hardwood forest on Key Largo and Lignum Vitae Key is in the life zone designated Dry Tropical Forest (Holdridge, 1967). The taxonomic and ecologic similarity of the Upper Keys forests to those elsewhere in the Caribbean has been documented by Robertson (1955), among others. These forests are inhabited by an unusually large number of species accorded legal protection because they are endangered or threatened, and the ecosystem is a unique element of the natural diversity of the United States. Endangered status of the Key Largo woodrat and cotton mouse is appropriate in view of the rapid rate of destruction of these forests, the continuing decline of rodent populations, and the genetic distinctions of these subspecies.

As pointed out by the U.S. Department of the Interior (1973) and Brown (1978*a*), the most important conservation measure for woodrats would be purchase and protection of good woodrat habitat. Based on observations of saplings of many mature forest canopy species invading clearings and growing in young forest, we conclude that cleared or burned areas can recover naturally as suitable woodrat habitat, as long as seed sources are nearby. Therefore acquisition of young forest not now occupied by woodrats, such as the 147 ha of tracts L 2-4 and 5, or even of clearings adjacent to forest, could eventually improve the situation for these animals. Likewise, areas with low or intermediate tree maturity and woodrat density are expected to improve with age.

The introduced population has flourished on Lignum Vitae Key. A population increase from 19 in 1970 to 85 in 1979 suggests an average annual growth rate of 18%. The record shows that introduction of Key Largo woodrats into suitable but unoccupied habitat can be an effective management tool.

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STUD MALE MAINTENANCE OF PREGNANCY IN *MICROTUS MONTANUS*

The pre-implantation block to pregnancy in *Mus* resulting from interactions of a pregnant female with a strange male (the Bruce effect) has been widely investigated (Bruce, 1959, 1960). In addition to the laboratory mouse, strange male pregnancy block has been demonstrated in the deermouse, *Peromyscus maniculatus* (Eleftheriou et al., 1962; Bronson and Eleftheriou, 1963), the field vole, *Microtus agrestis* (Clulow and Clarke, 1964) and the meadow vole, *M. pennsylvanicus* (Clulow and Langford, 1971). It is exceedingly difficult to interpret the Bruce effect in evolutionary terms. Indeed, it has been suggested that the Bruce effect is a laboratory manifestation of pheromones that evolved primarily to induce estrus and/or promote sexual maturation (Bronson, 1971). While much attention has been devoted to the bizarre effects of the strange male on pregnancy, the effect of the stud or familiar male has received little attention. In deermice, removal of the stud male following insemination has no effect on the percent of successful pregnancies (Bronson and Eleftheriou, 1963). Bruce (1960) observed that the female could "recognize" the stud male after being separated from him for 24 h and, further, the presence of the stud male largely eliminated the pregnancy blocking response to strange males (Parkes and Bruce, 1961). Richmond and Stehn (1976) report that early removal of the stud male in *M. ochrogaster* significantly reduces the rate of conception. In this paper, we report on a study designed to examine the role of the stud male in maintenance of pregnancy in *Microtus montanus*.