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INVASION OF A "TRAPPED-OUT" SOUTHERN NEVADA HABITAT BY *PEROGNATHUS LONGIMEMBRIS*

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Abstracts A 6.3 ha grid was established at the United States Atomic Energy Commission's Nevada Test Site and the small mammals trapped-out during the summers of 1964 and 1965 to study invasion by *Perognathus longimembris* Coues. Age analyses were made to determine the relationship between age and invasion. The mean age of invading animals was lowest in mid- and late summer, but varied widely with reproductive success. There was no statistically significant difference in mean age between male and female invaders. Ratios of male to female invaders varied directly with that of the natural population. Invasion rates varied widely and were mainly influenced by population density outside the grid.

Introduction

Small mammal invasion studies of "trapped-out" habitats are not numerous; but rates of invasion, home site origin, relationship of invasion behavior to population density, juvenile or adult classification of invaders, and sex ratios of invaders have been examined for several species by Andrzejewski (1963), Andrzejewski and Wroclowek (1962), Blair (1940), Calhoun and Webb (1953), Stickel (1946) and Webb (1965). These studies were made in non-arid environments and did not include any of the heteromyid rodents.

In this study a "trapped-out" habitat was created and *Perognathus longimembris* Coues movement into the grid (invasion) examined. Special attention was given to age composition of invading *P. longimembris*. The possibility that male and female invaders come from different age groups was examined along with sex ratios and rates of invasion. These analyses provide the basis for determining how the population characteristics of *P. longimembris* affect its invasion behavior.

Materials and Methods

The study was conducted at the United States Atomic Energy Commission's Nevada Test Site, 70 miles northwest of Las Vegas, Nevada. The study area was in relatively undisturbed Grayia-Lycium community (Allred, Beck and Jorgensen, 1963) in the northeast portion of Yucca Flat.

A 6.3 ha grid was established with 12 parallel transects placed at 22.9 m intervals. Each transect contained 12 trapping stations 22.9 m apart. Two Young-type live traps were placed at each of the 144 trapping stations.

Small mammals were trapped and removed daily from June 7 through Aug. 25, 1964, and from June 9 through Sept. 7, 1965. Small mammals were removed and traps baited with small amounts of

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rolle doats prior to 9:00 a.m. each day. Animals were killed and taken to the laboratory where age and sex were determined.

During Aug. 1965, three 460 m transects, 100 m apart, were established three miles southwest of the grid to sample the untrapped population for mean age. Fifty equally spaced Museum Special traps were placed on each transect and operated for seven nights between Aug. 15 and Sept. 7. All *P. longimembris* were taken to the laboratory for age and sex determinations.

The tooth wear technique developed for *Perognathus* by Howard Kaaz (University of California, Los Angeles, California, unpublished data) was used for age determination. A key for this technique and accompanying illustrations are included in Flake (1966).

Results

The number of *P. longimembris* trapped daily leveled off by the sixth day after trapping began in 1964 and those trapped after that were considered to be invaders. Numbers of *P. longimembris* trapped per day for the first 10 days of trapping in 1964 were respectively: 39, 15, 32, 15, 22, 16, 4, 7, 4 and 2. In support of the above observation it was found that after the fifth day of trapping, almost all captures were within 68.7 m of the borders. Similar results were obtained during the first six trapping days of 1965.

Mean ages of *P. longimembris* for the trapping-out periods and subsequent invasion periods are presented in Table I. Table II gives the mean age by sex and period of capture. Hereafter, the June 7-11, June 13-30, July 1-31 and Aug. 1-25, 1964, periods; and the June 9-13, June 15-30, July 1-31 and Aug. 15 - Sept. 7, 1965, periods are referred to as the 1st, 2nd, 3rd and 4th periods for the respective years. June 7-11, 1964, and June 9-13, 1965, are actually trapping-out periods while all other trapping intervals represent, by definition, invasion periods.

An analysis of variance of the age data, using the fixed effects model (model I), disclosed statistically significant differences (P - .05) in the main effect means for the years x periods interaction. The years x sex, periods x sex, and years x periods x sex interactions were not significant. Mean age comparisons within the years x periods interaction were accomplished with Cramer's modification of Duncan's multiple range test (Cramer, 1956). Use of the expression "significant difference" throughout the papers refers to a statistically significant difference at the 5 percent level.

Comparison of mean ages for 1964 and 1965 trapping periods (Table I) yielded the following results. In 1964 and 1965 there was no significant difference between means for the 1st and 2nd periods within either year. For both years there was a significant difference between the mean for the 1st period and the means for the 3rd and 4th periods. Similarly, there was a significant difference between the mean for the 2nd period and the means for the 3rd and 4th periods in both years. No significant difference was observed between the means for 3rd and 4th periods within years. There was no significant difference in 1st and 2nd period means between years, but there was a significant difference in means for the 3rd and 4th periods between years. In summary, the mean age of invaders decreased from early to late summer in both 1964 and 1965 though the decrease was much greater in 1965.

As noted previously, *P. longimembris* were trapped from an untrapped population three miles southwest of the grid between Aug. 15 and Sept. 7, 1965. The mean age ($n = 88$, $x = 4.6$ months, $s = 7.9$ months was not significantly different from that of period 4, 1965, grid invaders (Table I).

The ratios of males to females for the trapping periods are given in Table I. In 1964, there were 1.3 males per female captured during period 1 (trapping-out period). Since reproduction was negligible in 1964 (French, Maza and Aschwanden, 1967), the sample ratio for the 1st period may be used to estimate the sex ratio in the untrapped population outside the grid. Among total invaders for 1964, 1.5 males invaded per female. A chi-square test disclosed no significant difference in proportion of males to females between the period 1 estimate of the untrapped population and total invaders ($X^2{}_{(1\ df,\ .05)} = .08$. In 1965 among total invaders 0.8 males invader per female. When the proportion of males among total invaders was compared with that for *P. longimembris* trapped three miles southwest of the grid from Aug. 15 to Sept. 7 ($n = 88$, 42 males, 46 females), no significant difference was found $X^2{}_{(1\ df,\ .05)} = .01$).

Invasion rates varied from one period to the next as well as between 1964 and 1965 (Table 1). One may question the high invasion rate from Aug. 15 to Sept. 7, -965, since the grid was not trapped the two previous weeks. The daily trapping records (Flake, 1966) show that the largest numbers per day were observed during late August and early September rather than mid-August. If there had been extensive invasion and settlement during the two weeks when there was no trapping, the highest trapping incidence would be expected to occur early after trapping was resumed. These data suggest the increase in rate was mainly due to invasion and not belated capture.

Discussion and Conclusion

Reproductive activity and its relationship to the environment is an essential consideration in understanding age distribution and invasion. Hall (1946) reported that *P. longimembris* have one litter per year and noted pregnancies from early April through June. Duke (1957) stated that *Perognathus* in Utah may have two litters each year and that pregnancy is possible between early April and early June. Speth, Pritchett, and Jorgensen (1968) found that *Perognathus parvus* in southern Idaho may have two litters per year and suggested that the number of litters depends on food availability. At the Nevada Test Site, French, Maza and Aschwanden (1967) reported extremely low rainfall and poor plant growth in the winter and spring of 1962-63 and 1963-64. They found essentially no *P. longimembris*

Table 1. Summary of *Perognathus longimembris* trapped inside the study grid

Trapping Period	Trap Period	Number of Animals	Mean Age (Months) ± ISD	Ratio of Males to Females	Invasion Rates (Animals/day)
1964					
June 7 to 11*	1	128	22.1 ± 8.9	1.3	
June 13 to 30	2	64	20.8 ± 10.6	1.2	3.6
July 1 to 31	3	28	16.0 ± 11.4	3.0	.9
Aug. 1 to 25	4	27	14.7 ± 11.5	1.2	1.1
Total 1964					
Invaders	2, 3, 4	119	18.4 ± 11.3	1.5	1.6
1965					
June 9 to 13*	1	38	21.6 ± 10.2	0.7	
June 15 to 30	2	4	18.0 ± 8.9	1.0	.3
July 1 to 31	3	34	4.4 ± 6.4	1.4	1.1
Aug. 15 to Sept. 7	4	596	3.3 ± 3.3	0.8	24.8
Total 1965					
Invaders	2, 3, 4	634	3.5 ± 3.9	0.8	8.9

*Trapping-out period

Table 2. Mean ages in months (± std dev) by sex of *Perognathus longimembris* for 1964 and 1965 trapping-out periods.

1964

Sex	June 7-11 (Period 1)	June 13-30 (Period 2)	July 1-31 (Period 3)	Aug. 1-25 (Period 4)	June 13-Aug. 25 (Periods 2, 3, & 4)
Male	20.2	20.3	15.1	15.2	17.7
	±8.6	±10.4	±11.1	±10.6	±10.9
	(73)*	(35)	(21)	(15)	(71)
Female	24.8	21.9	20.7	14.1	19.8
	±9.4	±10.7	±12.0	±13.1	±11.8
	(55)	(29)	(7)	(12)	(48)

1965

Sex	June 9-13 (Period 1)	June 15-30 (Period 2)	July 1-31 (Period 3)	Aug. 15-Sept. 7 (Period 4)	June 15-Sept. 7 (Periods 2, 3, & 4)
Male	23.6	24.0	5.6	3.5	3.8
	±9.9	±2.8	±8.3	±4.1	±4.1
	(16)*	(2)	(20)	(265)	(287)
Female	20.1	21.0	2.8	3.0	3.1
	±10.4	±14.8	±1.2	±2.4	±2.7
	(22)	(2)	(14)	(331)	(347)

*Number of observations

reproduction in the summers of 1963 and 1964. When conditions improved for plant growth in the winter and spring of 1964-65, they noted rapid population growth the following summer. During this period they found several individual *P. longimembris* living from 2 to 5 years in the field. Jorgensen (Brigham Young University, Provo, Utah, personal communication) also noted that several *P. longimembris* survived at least 3 years in the field at the Nevada Test Site.

The relatively high mean age of animals trapped in 1964 and June of 1965 probably reflects extremely poor reproduction in the summers of 1963 and 1964. Thus, a mean age of 22 months (June of both years) is not unreasonable considering the extremely limited addition of young to the population during and prior to trapping. The difference in mean age of 3rd and 4th period invaders between years is likely a reflection of poor reproduction in 1964 versus increased reproduction in 1965. The decrease in mean age through both summers correlates well with appearance of young in the population and reproduction success.

There was no significant difference in the mean age of male and female *P. longimembris* invaders (Table II) and no significant interaction involving sex; therefore, the sexes were treated as a single group in age analysis.

As there was no significaant difference between age of animals in the untrapped population (3 miles southwest of the grid) and 4th period invaders for 1965, it could not be concluded that young animals have a greater tendency to invade than adults. The mean age of the untrapped population was extremely small $x = 4.6$ months, $s = 7.9$ months), probably because of high reproductive success. Hence, a preferential invasion by young *P. longimembris* probably would not have been detectable.

Stickle (1946) observed that adult *Peromyscus leucopus* invading a "trapped-out" grid consisted of 2 males per female while the natural population in the immediate area contained approximately equal numbers of males and females. In the present study of *P. longimembris*, males invading the study grid outnumbered females in 1964 and similar ratios were obtained within the grid's original population (trapping out period) which was used to estimate the ratio in the untrapped population. Contrary to the 1964 results, females invaded more frequently than males in 1965. In 1965, the sex ratio of *P. longimembris* from the untrapped population 3 miles southwest of the grid was compared with that in the study grid and ratios of males to females for both samples were almost identical. These results indicate the sex ratios of invading *P. longimembris* are approximately the same as those in the natural population.

The rates of invasion are likely influenced by several population characters. Stickle (1946) noted that *Peromyscus* with home ranges overlapping the borders of a newly established void were first to invade. Andrezejewski and Wroclowek (1962) concluded that the rates of invasion of *Apodemus* and *Clethrionomys* were determined by the density of the adjacent population, and further Andrzejewski (1963) stated that increased rates of invasion and settling during the mid-summer were due primarily to emergence of young and subsequent increase of density.

In this study, the highest invasion rate in 1964 occurred from June 13 to 30 and was possibly the result of the rapid removal of animals with home ranges overlapping or adjacent to the grid. Since reproduction during 1964 was extremely poor, the invasion rate remained low through the summer. In 1965 the low density in the surrounding population (resulting from the 1964 low reproduction) resulted in low invasion rates in June and July but the rate increased greatly in August and September as the numerous young increased the density of the surrounding population.

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