

Reproductive Status and the Assimilation of Introduced Females into a Wild Population of House Mice

David M. COPPOLA¹

Coppola D. M. 1986: Reproductive status and the assimilation of introduced females into a wild population of house mice. *Acta theriol.*, 31, 17: 221—237 [With 3 Figs.]

The fate of female mouse immigrants after release onto a highway cloverleaf with a resident house mouse population, was followed by mark and recapture methods. Few differences were found between pregnant or nonpregnant, multiparous or nulliparous females in trapability, persistence, movement, dispersion or physical condition after immigration. The potential value of the paradigm used in this study for future studies of dispersal is considered.

[North Carolina State University, Raleigh, North Carolina 27695, USA]

INTRODUCTION

A number of studies have tried to examine the impact of immigrants on rodent populations by introducing foreign animals to existing populations. Calhoun (1958) working with Norway rats, reported that many introduced animals became incorporated into the resident populations. Forty-five percent of introduced cotton rats became residents of a grass-field population (Golley, 1962) in one study and 60 percent in another (Ramsey & Briese, 1971). Introduced animals have been shown to deter the homing ability of resident deer mice (Terman, 1962) and to halt population increases in the Norway rat (Davis & Christian, 1956).

In contrast to the studies discussed thus far, the use of simulated immigration in this experiment centered on the fate of immigrants rather than the resident population. The aim of this experiment was to compare the fate of female house mice with different reproductive characteristics, after "immigration" to a preexisting population. Very little information is available on the reproductive condition of dispersing house mice (Myers, 1974; Lidicker, 1976; Newsome, 1969) or on the mortality rate and other fitness characteristics of dispersing versus non-dispersing rodents (Gaines & McClenaghan, 1980). The influence of re-

¹ Present address: The Worcester Foundation for Experimental Biology, 222 Maple Avenue, Shrewsbury, Massachusetts 01545, USA.

productive state on dispersal success is unknown. Immigrants are by definition dispersers and their assimilation into a strange population is probably one of the most difficult aspects of dispersal. Therefore, a study of how reproductive characteristics affect immigration in females could provide valuable insights into the dispersal process in house mice. This is especially true since females have been reported to be the predominant dispersers in at least one study (Myers, 1974). However, male-dominated dispersal has been reported in other studies (Lidicker, 1976; Rowe, Taylor & Chudley, 1963). An analysis of dispersal is a prerequisite to understanding the natural history of any species since it so profoundly affects the genetic structure and demographic characteristics of a population (Gaines & McClenaghan, 1980).

1. MATERIAL AND METHODS

1.1. Study Site

The study was conducted near Raleigh, North Carolina U.S.A., on a single highway-clover exchange or "highway island" (Massey & Vandenberg, 1980) of Interstate 40. This island consisted of old-field habitat in approximately its second to third year of succession. The island was well drained and dominated by broom sedge *Andropogon* spp. (See Coppola, 1985 for a detailed account of the island habitat). A boundary strip of 20 m, which was mown periodically by the highway department, separated the unmown center of the island (approximately 0.6 hectare) from the surrounding highway.

Five food stations consisting of 1.3 m×1.3 m×2.5 cm plywood boards were evenly distributed over the island. The boards were elevated from the ground by 2.5 cm×2.5 cm stripping affixed to opposite edges of the board. An excess of cracked corn was maintained under each board throughout the study. The food stations provided cover and superabundant food for rodents while their proximity to the ground prevented birds and larger mammals from exploiting them.

1.2. Population

The animals studied were an artificially founded population of house mice (*Mus musculus*). The founders of the population were laboratory born, second generation wild mice. The parent stock consisted of feral and commensal mice which had been captured at three different locations around Raleigh, North Carolina.

Prior to introducing eight male and ten female house mice to the island, the resident rodents were removed by live-trapping and relocating at least five miles away. The trapping and removal of residents was carried out nightly until no captures were recorded for three consecutive nights.

In March the founders were introduced to the island. Their subsequent movements on the island and population growth were followed by a monthly regimen of mark-recapture. The Sherman live traps used in the monthly mark-recapture regimen were placed at the intersections of the rows and columns of an irregularly

shaped grid consisting of 61 axes set at 10 m intervals. Two traps were also placed at each of the five food stations.

An array of 45 traps were placed on the closest property adjacent to the island. The purpose of these traps was to catch dispersers from the island. The array consisted of three rows of 15 traps at 15 m intervals with five meters between rows. The rows were parallel to the edge of the island and each row was staggered in relation to the other rows by 5 m to increase the likelihood of a disperser from the island encountering a trap. This method of assessing dispersal from the island was preferred over completely encircling the island with traps because studies of rodent dispersal across roads have shown that rodents prefer to cross roads where they will have the least open-ground to traverse (*e.g.* Oxley *et al.* 1974). This finding motivated the concentration of the traps along a 150 m arc of the closest suitable land bordering the island.

Traps were baited with a mixture of peanut butter and rolled oats and checked every morning for seven consecutive days every 28 days from March through August. Upon capture, the sex, reproductive condition, and incidents of wounding were recorded for each animal. The captured animals were also weighed to the nearest 0.1 g on a spring scale and individually marked by toe-clipping before release.

After the trap session in August, no more trapping was done until the first of October when the interlopers were released on the island. This was done to allow the resident population to be undisturbed for the month preceding the introduction.

1.3. Interlopers

In October, 52 foreign female mice were introduced onto the islands. These females were laboratory born third and fourth generation wild mice. The interlopers were presumed to be unrelated to the residents because the ancestors of these two groups had been captured at different and disparate locations. The age of the interlopers varied from 90 to 270 days and the group consisted of 31 nulliparous and 21 polyparous females. The interlopers were taken from a group of 60 females that were individually marked by toe-clipping, weighed and assigned at random to one of the treatment groups. The first group consisted of 25 females that were housed five per cage. The second group of 35 females were each paired with a second generation wild male of proven fertility. After 15 days all surviving females from both groups were removed from their respective housing condition, reweighed, and placed in cages to await transport to the island for release that evening.

Prior to the introduction of the interlopers to the island, an additional trap was added to each grid point to accommodate the larger population density created by the introduction. Twenty-eight females from the group that had lived with males and 24 females from the all-female groups were released onto the center of the highway island at dusk.

The female interlopers were followed by live-trapping for ten consecutive days following the introduction. The traps were then closed for one week. Traps were reopened on the 17th, 21st and 25th day after release. Captured interlopers were processed according to the procedures mentioned above.

1.4. Analysis

The analyses of all variables (except where noted) obtained from the trapping data were carried out with respect to the origin of the animals. Interlopers were compared to residents wherever possible. Within the interloper group the analysis was broken down according to treatment group (male exposure or no male exposure) and reproductive history which was only known qualitatively as nulliparous or polyparous.

An important aim of the study was to assess the effects of pregnancy on the assimilation of interlopers by the resident population. However, due to the lack of a non-intrusive pregnancy test and the stressfulness on wild mice of intrusive methods such as palpation, pregnancy was defined operationally as a greater than five percent increase in weight over the 15 days of cohabitation with the male. Obviously, with such a low criterion level some non-pregnant females were included in this group. This was less of a concern than excluding females that were pregnant, given the small sample size that was available. Each analysis was run with and without the females that did not meet the five percent criterion. However, the results will be reported for both groups only where they differed significantly.

Continuous variables were analyzed using Student's *t*-test, or analysis of variance when their distributions met the assumptions of these tests. Otherwise, Wilcoxon signed-rank tests or Kruskal-Wallis tests were used. Frequencies were analyzed using Chi-square.

2. RESULTS

2.1. Residents

The growth of the resident population from March through August can be seen in Fig. 1 along with a diagram of the highway island. The 22 residents captured during October had an average weight of 10.4 g (± 4.46). The male-female sex ratio was two to one ($p < 0.09$). If applicable, the residents were evaluated along with the interlopers for all the following characteristics.

2.2. Trappability

The ratio of interlopers captured versus those released in each treatment group over the 25 days of trapping in October can be seen in Fig. 2. Neither the slopes nor intercepts of the regression lines for the interlopers paired with males (M-treated) and for the interlopers that were grouped (G-treated) before release are significantly different. In Fig. 3 the cumulative percent captured of all those released is shown for each group. Though 54 percent of the M-treated females were captured at least once, compared to 46 percent of the G-treated females, this difference was not significant. The means for the number of captures

per individual were not significantly different for the two groups being 2.28 (± 1.07) for the M-treated and 2.0 (± 1.29) for the G-treated animals. Resident females were caught 2.1 (± 1.24) times on average. This did not differ significantly from either interloper group.

M-treated females who were also nulliparous were more likely to be caught at least once than M-treated polyparous females [$\chi^2(1)=3.46$,

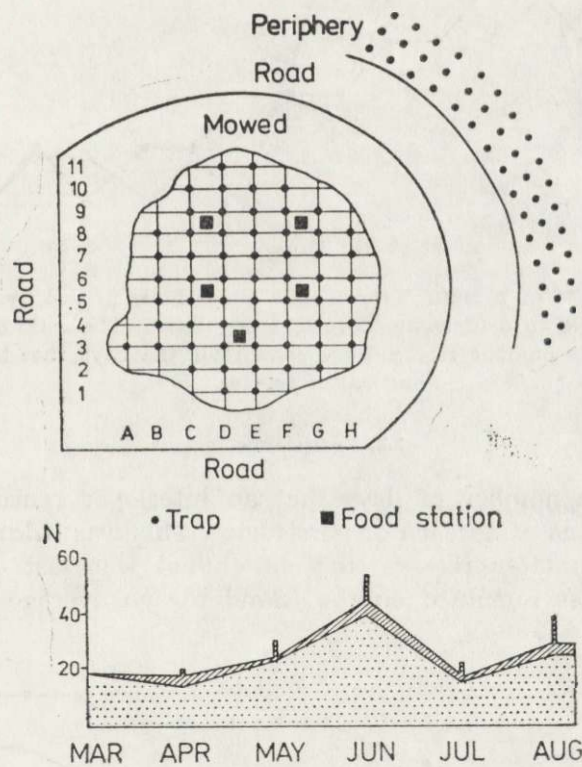


Fig. 1. A diagram of the highway cloverleaf showing the placement of traps and food stations in relation to the surrounding roads (top). The size of the resident population of house mice after its founding in March until trapping was suspended in August (bottom). The stippled area represents the minimum number alive. The hatched area represents computer generated population estimates and their 95% confidence intervals using model M_0 of the program capture (Otis *et al.*, 1978).

$p < 0.6$], however, the three-way test of independence for treatment, reproductive history and recapture was not significant [$\chi^2(4)=4.83$, NS]. None of the results discussed thus far were altered by excluding, from the analysis, M-treated females that did not make the weight gain criterion.

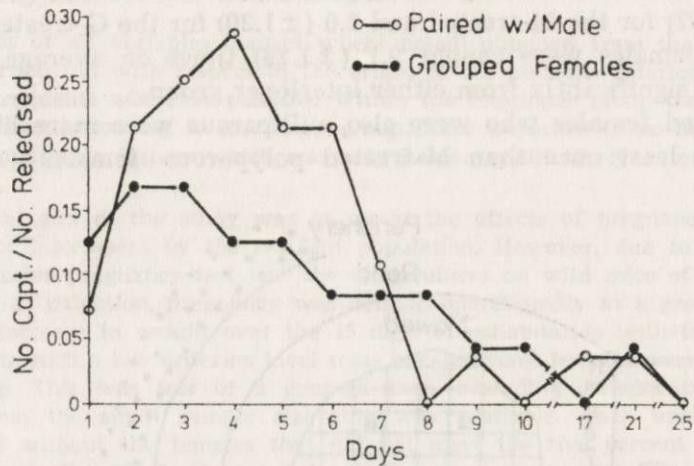


Fig. 2. The incidence of recapture for female house mice in two treatment groups that were introduced to a highway cloverleaf population. The ratio of the number captured versus the number released are shown for the days that the traps were open after release.

2.3. Persistence

The minimum number of days that an interloper remained on the island was used as a measure of persistence. This was calculated as the number of days after release that an animal was last caught. The M-treated females remained on the island for an average of 7.1 days

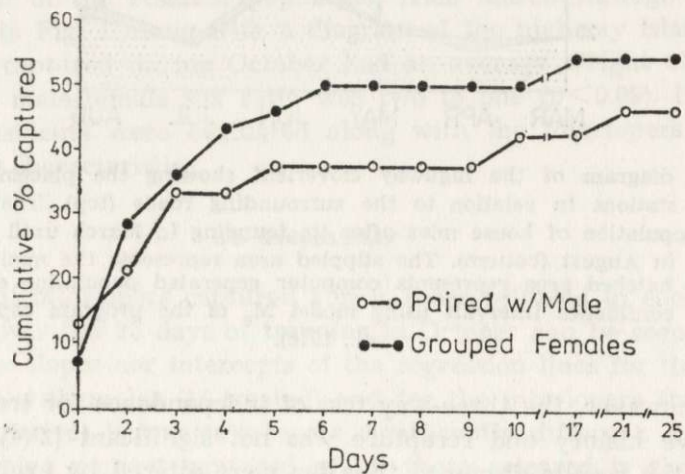


Fig. 3. The cumulative percentage captured versus the total released for two treatment groups of female mice introduced to a highway cloverleaf population. The percentages are shown for each day that the traps were opened after release.

(± 5.31) while the G-treated females remained on the island an average of 4.6 days (± 3.47). However, this measure of persistence was not significantly different for the two treatment groups.

The number of days between the first and last capture was used as an index of persistence of the residents. Since this measure required a mouse to be captured twice, it is not directly comparable to the persistence measure for the interlopers which only required one recapture. Nevertheless, the residents persisted on the island for less time than the M-treated interlopers but not the G-treated females. The reproductive history of the interlopers did not account for a significant amount of variation in persistence.

2.4. Movement

Several indices were used to compare the movements of residents and interlopers. Total distance travelled was calculated for interlopers as the distance from the origin to the first point of capture plus the distance between all subsequent points of capture. There was no significant difference in this index of movement, among interlopers from different treatment groups or with different reproductive histories. A similar index was calculated for residents by adding the distance between successive capture locations. The index of the total distance moved by residents was not significantly different from that of the interlopers despite the fact that these indices are not directly comparable. Within the M-treated group, weight gain during the 14 days of cohabitation with a male, and presumably stage of pregnancy, was not significantly correlated with the index of total distance travelled ($r = -0.08$, $p > 0.77$). A significant negative correlation would be expected if pregnancy limited a female's movements substantially.

The distance from the release point to the location of first capture was used as another index of movement. Presumably, interlopers that were moving quickly and in a straight line from the point of release would encounter fewer traps than interlopers that were wandering aimlessly about the point of release. M-treated females had significantly shorter distances to first capture than G-treated females (Wilcoxon signed-rank test $W = 1.79$, $p < 0.03$). Previous reproductive history of the interlopers did not account for a significant amount of the variance in this parameter.

Home range was calculated for residents and interlopers by the inclusive boundary strip method (Stickel, 1954). There was a significant difference among residents and interlopers with respect to home range ($F_{2,38} = 8.36$, $p < 0.001$). A post-hoc test (Tukey's studentized range) revealed a significantly ($p < 0.05$) smaller home range size, on average,

for residents compared to interlopers. In fact, residents' home ranges were 67 percent smaller, on average, than interlopers. There were no significant differences among interlopers in different treatment groups or among interlopers with different reproductive histories regarding home range. In the M-treated interlopers, there was no significant ($r=-0.06$, $p<0.84$) correlation between weight gain after cohabitation with the male and home range size.

Home range indices such as the inclusive boundary strip method are known to increase with the number of times an individual is captured. To ameliorate this confounding factor, all analyses were also done using home range divided by the number of captures as the random variable. However, none of the conclusions from the analysis of the raw scores were altered by using the corrected variable.

2.5. Dispersal

The array of 45 traps that had been placed across the highway from the island (Fig. 1) failed to capture any of the interlopers introduced to the island. Moreover, no marked animals that were residents of the island were caught across the highway during the 25 days of intensive trapping.

The localization of interlopers and residents on the island was assessed using a dispersion index (Southwood, 1978, p. 39):

$$I_D = S^2(n-1)/X$$

where n equals the number of samples and X and S^2 are the mean and variance of the samples. The highway islands' unmown area was randomly divided into twenty 200 m² quadrants and ten 400 m² quadrants. The center of activity was considered to be the center of mass of all the locations where an individual was captured. This point was determined for all residents and interlopers that were captured at least once. The number of these centers in a sample was used to calculate the dispersion index. The dispersion index of M-treated and G-treated females did not differ significantly from random, nor did the dispersion indices of nulliparous and polyparous females. However, residents were found to have a contagious distribution using both 200 m² quadrants ($I_D=30.8$, $p<0.05$) and 400 m² quadrants ($I_D=22$, $p<0.01$).

The distance of the centers of activity from the nearest edge of the unmown area of the island was calculated. Since the habitat deteriorated near the edge of the highway island, the distance of the activity centers from the edge provides an index of the habitat in which mice lived. No significant differences were found for this measure among any of the groups of interest.

The X and Y coordinates of the centers of activity were used to test localization differences in G-treated and M-treated females. The two bivariate samples were not significantly different using the Mardia-Watson-Wheeler test (Jones, 1968). Moreover, there was no significant difference in the location of the activity centers when residents and interlopers were compared using this test.

The food stations were the most abundant and temporally stable resource on the island and due to their small size they could be easily defended. The likelihood of capture at or adjacent (one of the four traps surrounding the food station) to a food station was used as a measure of a mouse's tendency to be near a food station. Eighty percent of the M-treated interlopers that were captured were found at or adjacent to a food station at least once. Only 33 percent of the G-treated females were ever found in proximity to the food stations. However, this difference was not significant ($X^2=3.425$, $0.05 < p < 0.1$). No other significant differences emerged for this parameter among any of the groups of interest.

Another indication of proximity to the food stations was the distance between a mouse's center of activity and the nearest food station. There were no significant differences among any of the groups of interest for this parameter. If the mean distance from the nearest food station was calculated from all the locations at which an animal was captured, these values could also be used as an index of proximity to the food stations. Female residents and interlopers did not show significant differences for this measure, however, male residents tended to be trapped significantly closer to food stations than either of these groups (Kruskal-Wallis $H=14.2$, $p < 0.05$; Dunn's critical 2.53, $p < 0.06$). Reproductive history of the interlopers did not account for a significant amount of the variation in this parameter.

Light readings taken at each grid point provided an index of primary cover (see Coppola, 1985 for detailed methods). Since primary cover is known to be important to house mice, the relationship between where a mouse is caught and the primary cover at that location would indicate the quality of the habitat in its home range. A mean index of primary cover was calculated from the primary cover indices of all locations where an individual was captured. No significant differences emerged from the analysis of group differences for this measure.

The last factor that might account for the localities where a mouse was captured was trap odor. Animal odors are known to alter the effectiveness of live traps in capturing conspecific and heterospecific animals (Stoddart, 1982). Since the live traps in this study were not cleaned after captures, residual odors may have influenced subsequent

captures. Two traps were placed at each location and their relative positions were switched daily, so that the influence of trap odor on captures could be tested. When given a choice between a clean trap or a house mouse-soiled trap mice preferred to enter the soiled trap ($X^2(1)=4.48$, $p<0.05$). Due to the small sample sizes, no more specific results were obtained concerning the effect of odor on trap response. Only 25 percent of the M-treated females entered a trap previously soiled by a male mouse when a clean trap was available at the same location while 67 percent of G-treated females did so. However, this difference was not significant.

2.6. Physical Condition

Body weight and wounding were two measures made on the interlopers that could have been indicative of changes in physical condition. Visible wounds were observed on some of the interlopers but the incidence of wounding was very small. No significant differences were found for the frequency or severity of wounding in any group of interest.

M-treated interlopers gained an average of 20 (± 18.0) percent in weight after 14 days of cohabitation with a male, while G-treated females lost an average of three percent (± 5.1). Clearly, many of the M-treated females had become pregnant during cohabitation with the male. Conception rates for wild mice in the colony were consistent above 70%.

Weight change at the time of release compared to the lowest weight at capture was used to assess the health of the interlopers after release. M-treated interlopers lost an average of 15.7 (± 10.8) percent of their body weight while G-treated females lost 15.5 (± 12.3) percent on average. While both groups suffered severe declines in weight after release onto the island, the groups did not lose weight differentially. Reproductive history did not account for differences in weight loss on the islands.

3. DISCUSSION

3.1. Residents

The resident population fluctuated considerably from the time of its founding in March until August. The population reached a peak in June and a decline from June to July which may have been due to the extremely hot and dry month of June in 1983. The fact that most of the 22 residents caught in July were young is evidence of the pop-

ulation's vitality at the time the interlopers were released. The lack of replication renders any conclusions about the effect of the introduction on the resident population impotent.

3.2. Trappability

Neither treatment nor reproductive history had a significant influence on trappability in the interlopers. Such an effect would be expected if one of the groups was denied entry into the food stations by intra-specific aggression since the traps would be a refuge in which to obtain food. Moreover, animals that are forced to wander are more likely to encounter traps. Since the interloper groups did not differ significantly for this measure, it is unlikely that gross differences in assimilation into the resident population existed. Surprisingly, residents did not differ from the interlopers in trappability. Interlopers were expected to be more trappable than residents since they were unfamiliar with the habitat and they would be wandering from territory to territory trying to find a vacancy. Both of these factors were expected to make the interlopers more trappable. One possible explanation for the similar trappability in residents and interlopers is provided by a consideration of the residents themselves. It appears that the residents caught were not a random sample of the island population. The average weight of the captured residents was expected to be lighter than that of the laboratory-reared interlopers. However, the mean weight of the residents is so low that it can only be indicative of the preponderance of juveniles in the sample. Moreover, the male-skewed sex ratio is further evidence that the captured residents were not a random sample of the resident population but were dispersing young. Given this view, the sex ratio is also evidence for male-dominated dispersal, in this population.

3.3. Persistence

The M-treated interlopers appeared to persist on the island longer than the G-treated ones. However, due to the large variability in this measure the differences were not significant. The conclusion from the analysis of resident trappability makes interpretations of the persistence measure and many of the other measures difficult. If mostly young dispersers were being captured, then adult territory holders were virtually invisible with regard to live-trap sampling. Therefore, a difference between persistence measures in interlopers may mean a difference in mortality, immigration or assimilation into territories. Since the first two factors can rarely be separated their confounding was

expected but the addition of the last factor would make even significant differences between interloper groups hard to interpret.

3.4. Movement

Total distance travelled did not differ among the interloper groups or between interlopers and residents, suggesting that each group was equally free-ranging. Pregnancies among the M-treated interlopers did not seem to hinder their mobility. Further evidence of this is provided by the lack of correlation between weight gain after cohabitation with a male and total distance travelled.

The significantly shorter distance to first capture in M-treated interlopers compared to G-treated interlopers may be indicative of differences in their movement after release. Animals moving directionally toward the edge of the island would be expected to encounter fewer traps than animals searching for a vacancy on the island. If it was true that M-treated interlopers tended to move in a more circuitous path than G-treated interlopers, it was not borne out by any of the other measurements.

The large difference between home range sizes in interlopers and residents was the first indication that the interlopers were behaving differently than residents. Because the resident home ranges were so much smaller than the interlopers, it is difficult to dispell this difference as a statistical anomaly. The home ranges of interlopers were expected to be large due to these animals' unfamiliarity with the island and their need to seek out vacancies. Though this was the aprior expectation, it does not jibe with the other information on movement and persistence that supports the idea that the residents captured were also predominantly dispersers.

The correlation between home range size and weight gain after cohabitation with the male in M-treated interlopers provided no evidence that pregnancy hinders mobility. The evidence provided in this section allows us to address a hypotheses concerning the negative effect of pregnancy before dispersal in house mice. It has been suggested that pregnancy may limit the distance that an animal can disperse (Bronson, 1979). While this hypothesis was not tested directly, the evidence from the study of interloper movements fails to support this idea.

3.5. Dispersal

The absence of dispersers from the island in the trap record of the periphery (Fig. 1) was not surprising. In another study of house mouse populations residing on highway cloverleaves, Massey & Vandenberg

(1980) trapped and marked over 200 mice in over 10,000 trap-nights (available traps X nights open) devoted to capturing animals on the island and in adjacent habitat. Less than two percent of the marked animals were found to cross the highway between the island and adjacent habitat. Due to the large number of animals introduced to the island in this study, different results could have been possible as Massey and Vandenberg did not make such large introductions.

The failure to catch interlopers in the periphery traps is difficult to interpret. It could mean that the rapid decline of interloper captures through October is more indicative of mortality than immigration. However, it could be that the 1125 trap nights devoted to peripheral trapping was insufficient. If the latter is true, the failure of the peripheral traps to capture dispersers does not support the idea that rodents cross roads where the adjacent habitat is most commodious (Oxley *et al.* 1974), since the array of traps was placed in the closest suitable habitat.

The dispersion indices failed to demonstrate that any interloper group was dispersed over the island in a non-random fashion. It was expected that interlopers might be avoiding each other and/or residents, in which case their dispersion index would show that they were over-dispersed. The contagious distribution of the residents supports the notion that these animals were remaining within a natal territory.

It was not true that interlopers of either group were forced to remain at the edge of the island in suboptimal habitat. If this were so the centers of activity would have been significantly closer to the edge for one or more of the groups. Yet, there were no such differences among interloper groups or between interlopers and residents. In fact, the results of the bivariate test failed to show any localization differences among interloper groups or between interlopers and residents. These results fail to show any evidence of intra-specific aggression that might have manifested itself in compartmentalization of the island by interlopers and residents.

The importance of the food stations to the mouse populations was obvious. Routinely, the boards at the food stations were raised during the checking of traps. Adult mice were often seen under the boards and quickly escaped into what appeared to be extensive burrow systems. If the food stations were defended against intrusion and if pregnant and non-pregnant females were differentially accepted into these food station territories, then the distance of activity centers from the food stations should have differed in the two interloper groups. This was not the case, nor was it true that any interloper group was more likely than any other to be caught adjacent to a food station. It is difficult

to explain why female residents were not found significantly closer to the food stations than interlopers, unless they too were excluded by territory holders who were rarely if ever captured. It was expected that residents would be found closer to the food stations than interlopers since they were familiar with their abundant food supply. This was true of resident males but not females. The meaning of this difference is unknown.

The mean index of primary cover from all the locations where an animal was captured should have been indicative of the habitat quality where it lived. The absence of these differences is evidence that the two interloper groups were equally free to move throughout the habitat. Moreover, interlopers did not differ from residents in this regard.

The analysis of the influence of conspecific odors on trap preference could have provided the most direct test of avoidance of residents of either sex by certain subgroups of interlopers. Avoidance of strange males by pregnant female house mice might be expected due to the pregnancy blocking effect of strange males (Bruce, 1959). The avoidance or attraction of some sub-groups of interlopers and residents by other sub-groups could not be satisfactorily assessed due to the small sample sizes. The data only show that house mice preferred to enter traps soiled by other house mice. While this may be a novel finding for house mice, several studies have shown the influence of conspecific odors on trappability in other rodents (*e.g.* Boonstra & Krebs, 1976; Mazdzer *et al.*, 1976; Stoddart, 1982).

3.6. Physical Condition

M-treated interlopers were expected to lose more weight than G-treated females after release onto the island because most of them appeared to have become pregnant during their cohabitation with males. The rationale for this expectation lies in the female mouse's tendency to terminate her own pregnancy during bad times. Since pregnant females have more weight to lose, they were expected to lose more on a percent of body weight basis. Moreover, if they were avoiding strange males or were excluded from the food station territories more than G-treated females they would be expected to lose more weight. The statistically equivalent weight loss in the two groups fails to uphold these assumptions. There was a large amount of variability in weight loss that could not be explained by treatment or reproductive history. It is not true that all the pregnant females aborted their pregnancies. A few actually gained weight when on the island. Only one of the M-treated females was ever observed to be lactating but other lactating females may have simply disappeared from the trap record because they were attending their litters.

3.7. Conclusions

Feral house mice are known to be semi-nomadic (Caldwell, 1964). Frequent immigration and emigration resulting from resource fluctuations are a key feature of their natural history. The general goal of this study was to evaluate female immigration success and how it was influenced by reproductive characteristics. Taken together, the results of this study provide little evidence that reproductive history influences dispersal success in females. Age was also partially confounded with reproductive history; there were some old nulliparous females released but there were no young multiparous females among the interlopers. Though age was not known exactly for all interlopers and age was not considered explicitly, the results of this study do not demonstrate age-related immigration success.

Pregnancy did not account for differences among interlopers in the majority of measurements made. Pregnant animals persisted in the trap record longer than nonpregnant ones. This implies that their survivability was at least as great as nonpregnant females given that disappearance can be equated with mortality because emigration from the island is rare.

The results of this study strongly detract from the theory that pregnancy limits dispersal in house mice (Bronson, 1979). The mobility in pregnant and nonpregnant females was not different, yet both groups had home range sizes over twice the size of residents on average. The facts that a few pregnant females continued to gain weight after release and that at least one female was lactating demonstrate that some pregnant females succeeded in becoming residents of the island.

The inferences that can be drawn from this study are limited in a number of ways. First, results from the study of only one population can not support global conclusions about dispersal in any species, particularly, given the artificial origin and maintenance of these populations. Further studies of highway island population will be required to determine if they are typical of commensal mouse populations. Second, the variables considered in this study were, for the most part, indirect indices of parameters that could not be measured directly. Moreover, all the variables were obtained from trapping records. Since sampling in this kind of experiment is governed by the whim of the study animal rather than by a random process, assumptions often overshadow conclusions in importance. More direct measurements could be obtained using telemetry techniques. Other techniques need to be developed to study secretive species such as the house mouse. Finally, the use of laboratory-raised wild house mice must

be considered. If the results of this study are to be useful, the very large assumption that laboratory-raised wild mice that are introduced to a population behave as natural immigrants must be tested. If so, the use of this immigration paradigm, in conjunction with highway island populations, may provide important insights into the process of dispersal in house mice and other species.

Acknowledgements: I would like to gratefully acknowledge Dr. John B. Vandenberg's contributions to and guidance during this project. The study was supported by NSF grant BRS-8214558 A02 to him. The preparation of this manuscript was supported in part by NIH grant NS-14453 to Dr. Robert J. O'Connell.

REFERENCES

1. Boonstra R. & Krebs C. S., 1976: The effect of odour on trap response in *Microtus townsendii*. *J. Zool., Lond.*, 180: 467—476.
2. Bronson F. H., 1979: The reproductive ecology of the house mouse. *Quart. Rev. Biol.*, 54: 264—299.
3. Bruce H. M., 1959: An exteroceptive block to pregnancy in the mouse. *Nature*, 184: 105.
4. Caldwell L. D., 1964: An investigation of competition in natural populations of mice. *J. Mamm.*, 45: 12—30.
5. Calhoun J. B., 1958: Mortality and movement of brown rats (*Rattus norvegicus*) in artificially supersaturated populations. *J. Wildl. Manage.*, 12: 167—172.
6. Coppola D. M., 1985: The puberty delay pheromone and population regulation in the house mouse. Doctoral Thesis: North Carolina State University, Raleigh, N. C.
7. Davis D. E., & Christian J. J., 1956: Changes in Norway rat populations induced by introduction of rats. *J. Wildl. Manage.*, 20: 378—383.
8. Gaines M. S. & McClenaghan L. R., Jr., 1980: Dispersal in small mammals. *Ann. Rev. Ecol. Syst.*, 11: 163—196.
9. Golley F. B., 1962: *Mammals of Georgia*. Univ. of Georgia Press: Athens.
10. Jones T. A., 1968: Statistical analysis of orientation data. *J. Sed. Pet.*, 38: 61—67.
11. Lidicker W. Z., 1976: Social behavior and density regulation in house mice living in large enclosures. *J. Anim. Ecol.*, 45: 677—697.
12. Massey A. & Vandenberg J. G., 1980: Puberty delay by a urinary cue from female house mice in feral populations. *Science*, 209: 821—822.
13. Mazdzer E., Capone M. R. & Drickamer L. C., 1976: Conspecific odors and trappability of deer mice (*Peromyscus leucopus novboracensis*). *J. Mamm.*, 57: 607—609.
14. Myers J. H., 1974: Genetic and social structure of feral house mouse populations on Grizzly Island, California. *Ecology*, 55: 747—749.
15. Newsome A. E., 1969: A population study of house mice permanently inhabiting a reedbed in South Australia. *J. Anim. Ecol.*, 38: 361—377.
16. Otis D. L., Burnham G. C., White G. C. & Anderson D. R., 1978: *Statistical inferences from capture data on closed animal populations*. Wildlife Society, Inc.: Louisville.

17. Oxley D. J., Fenton M. B., & Carmody G. R., 1974: The effects of roads on populations of small mammals. *J. Wildl. Manage.*, 38: 546—551.
18. Ramsey P. R. & Breise L. A., 1971: Effects of immigrants on the spatial structure of a small mammal community. *Acta theriol.*, 16: 191—202.
19. Southwood T. R. E., 1978: *Ecological methods*. Chapman & Hall: London.
20. Stickel L. F., 1954: A comparison of certain methods of measuring ranges of small mammals. *J. Mamm.*, 35: 1—15.
21. Stoddart D. M., 1982: Does trap odour influence estimation of population size of the short-tailed vole, *Microtus agrestis*. *J. Anim. Ecol.*, 51: 375—386.
22. Terman C. R., 1962: Spatial and homing consequences of the introduction of aliens into a semi-natural populations of prairie deermice. *Ecology*, 43: 216—223.

Accepted, July 25, 1984

David M. COPPOLA

KONDYCJA ROZRODCZA A LOSY SAMIC MYSZY DOMOWEJ
INTRODUKOWANYCH W DZIKIEJ POPULACJI

Streszczenie

Sledzono losy samic myszy domowej introdukowanych do wczesniej zalozonej „wyspowej” populacji tego gatunku. Po introdukcji samice cięzarne i niecięzarne, wieloródki i nierodzące nieznacznie różniły się pod względem łowności, czasu pozostawania w populacji, intensywności przemieszczania się, dyspersji i kondycji fizycznej. Wykazano, że kondycja rozrodcza samic nie ma istotnego wpływu na stopień ich aklimatyzowania się w populacji, do której zostały introdukowane. Rozważana jest możliwość wykorzystania tego rodzaju eksperymentów jako wzorca do dalszych badań nad dyspersją.