Laboratory Evaluation of Competition Between Three Species of Rodents

by

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ABSTRACT

Laboratory Evaluation of Competition
Between Three Species of Rodents

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Data on interspecific behavioral interactions between the cotton rat (Sigmodon hispidus), pygmy mouse (Baiomys taylori) and the fulvous harvest mouse (Reithrodontomys fulvescens) was collected from 1 September 1980 through 1 April 1981 at the Department of Wildlife and Fisheries Sciences, Texas A & M University.

Behavioral interactions were observed in 36 interspecific pairings to determine dominance and subordinance of each species. Pairings included all possible species and sex combinations. Nine behavioral categories were observed and classified as aggressive or submissive behaviors.

The cotton rat was significantly ($p<0.005$) more aggressive when paired with the pygmy mouse or the fulvous harvest mouse. The pygmy mouse was significantly ($p<0.005$) more aggressive when paired with the fulvous harvest mouse.

The length of time an individual was held in captivity had no effect on the frequency of aggressive or submissive behaviors, and the frequency of aggressive or submissive

behaviors did not vary significantly ($p>0.1$) among pairings involving the same two individuals.

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INTRODUCTION

Competition for limited resources may be an important factor in regulating sympatric animal populations (Terman, 1974; Howe, 1978; Miller, 1969). The competitive exclusion principle states that no two species can simultaneously occupy the same niche. However, potential competitors may coexist by partitioning the habitat in a manner that reduces competition. One mechanism by which this partitioning may take place involves behavioral interactions that may contribute toward spatial segregation of species within a community (Terman, 1974).

Knowledge concerning the relative dominance or subordinance of sympatric species may be of significance in determining the relative importance of behavioral interactions as a mechanism for spatial segregation. Behavioral interactions between small mammals often have been studied under laboratory conditions. Murie (1971) examined behavioral interactions in relation to habitat segregation of two sympatric species of *Microtus*. Terman (1974) studied *Sigmodon* and *Microtus* interactions in response to availability of cover. Peterson and Helland (1978) observed agonistic behaviors between two species of *Sigmodon*, and

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The style and format of this thesis follow the *Journal of Mammalogy*.

suggested that interspecific behavioral interactions may be related to population regulation of *S. hispidus* by *S. fulviventer*.

The cotton rat (*Sigmodon hispidus*), pygmy mouse (*Baiomys taylori*), and fulvous harvest mouse (*Reithrodontomys fulvescens*) occur sympatrically in many areas of Texas (Davis, 1974). Cameron (1977) has conducted experimental species removal studies with the cotton rat and fulvous harvest mouse in coastal prairie habitat in Texas. Cameron suggests that demographic variation for both cotton rats and fulvous harvest mice is due largely to differences in preferred habitat between experimental plots, and associated changes in movement, survival, and expectation of further life. Evidence indicates that competition may exist between *Sigmodon* and *Baiomys* populations. For example, Raun and Wilks (1964) reported that pygmy mice decreased in density from 15.2 per acre in 1959 to 0.2 per acre in 1960, while cotton rats increased from 1.7 to 12.4 per acre during the same period. Also during this period, a major shift in habitat utilization by pygmy mice occured following the invasion of cotton rats. Martin (1956) reported that high population levels of *Sigmodon* caused a decrease in the population of the praire vole (*Microtus orchrogaster*) in Kansas. Martin also reported occasions when cotton rats ate voles caught in the same live trap.

This paper examines the possibility that behavioral interactions between Sigmodon, Baiomys, and Reithrodontomys may have the potential to influence habitat partitioning by these species in areas where they occur sympatrically. More specifically, I have observed behavioral interactions between these species under laboratory conditions, quantified behavioral interactions as observed in one-on-one encounters, and determined which of the three species are dominant or subordinant in relation to each other based on these encounters.

METHODS

Six cotton rats, 6 pygmy mice, and 6 fulvous harvest mice, 3 males and 3 females of each species were live trapped in Post Oak Savanna habitat surrounding College Station, Brazos Co; Texas. Animals were caged individually and were visually isolated from each other. The diet of all species was scratch grain, oats and water. All animals were adults and were held in captivity for a minimum of two weeks prior to experimentation.

Experiments consisted of one-on-one encounters conducted in a 51 x 27 x 30 cm terrarium. The glass walls were covered with black paper, except for a 7 x 26 cm viewing hole and a red light suspended above the enclosure provided the only illumination. The floor was covered with wood shavings which were changed periodically. A removable partition separated two halves of the terrarium and the top was covered with plywood. Experiments were conducted between 19:00 and 24:00.

To begin an experiment, the two animals were weighed and placed on opposite sides of the partition for a five minute acclimation period. After removal of the partition, behavior of the two individuals was recorded for 30 minutes.

Behaviors were classified into nine categories.

1. Approach- one species moves torward and comes within close proximity of the other species.

2. Flee- a species runs away upon approach from the other species.

3. Chase- a species may chase an approaching or fleeing species.

4. Contact- a species makes brief contact with another species.

5. Continued contact- one species fighting with or on top of another species.

6. Groom- a species grooms itself.

7. Box with forefeet- a species raises up on hind legs and moves forefeet.

8. No response- a species does not respond to the behavior of another species, or both species do not move.

9. Mortality- a species is killed by another species.

For analysis, these categories were aggregated into (1) aggressive or (2) submissive behaviors. Aggressive behaviors were approach, chase and continued contact. Submissive behaviors were flee and mortality. Other categories occured rarely and were not included in the analysis.

The main experimental design consisted of 36 experiments each pairing two individuals of different species. The interspecific pairings consisted of male-male, male-female, and female-female combinations. Each individual was paired with an individual of each sex and species (excluding intraspecific pairings), resulting in 12 encounter types, with each encounter type replicated three times, and each replication involving a different pair of individuals (Fig. 1).

Data from the 36 experiments were aggretated in two different ways for analysis. First, all data involving a given pair of species were aggregated. This resulted in three data sets consisting of all data from (1) cotton rat-pygmy mouse, (2) cotton rat-harvest mouse, and (3) pygmy mouse-harvest mouse experiments, respectively (12 experiments per data set). For each of the three species combinations, a 2 x 2 Chi-square contingency table was used to test the null hypothesis of no significant difference in the frequency of aggressive and submissive behaviors between species combinations.

Second, within each of these three initial data sets, data were further aggregated into four subsets, with each subset containing all data from a given sex combination; (1) male-male, (2) male-female, (3) female-male, and (4) female-female (three experiments per subset). For each of the 12 species-sex combinations, a 2 x 2 Chi-square contingency table was used to test the null hypothesis of no significant difference in frequency of aggressive and submissive behaviors between species-sex combinations.

In addition to the 36 experiments indicated in Figure 1, nine more experiments were conducted to examine the variability inherent in the experimental procedure. This was

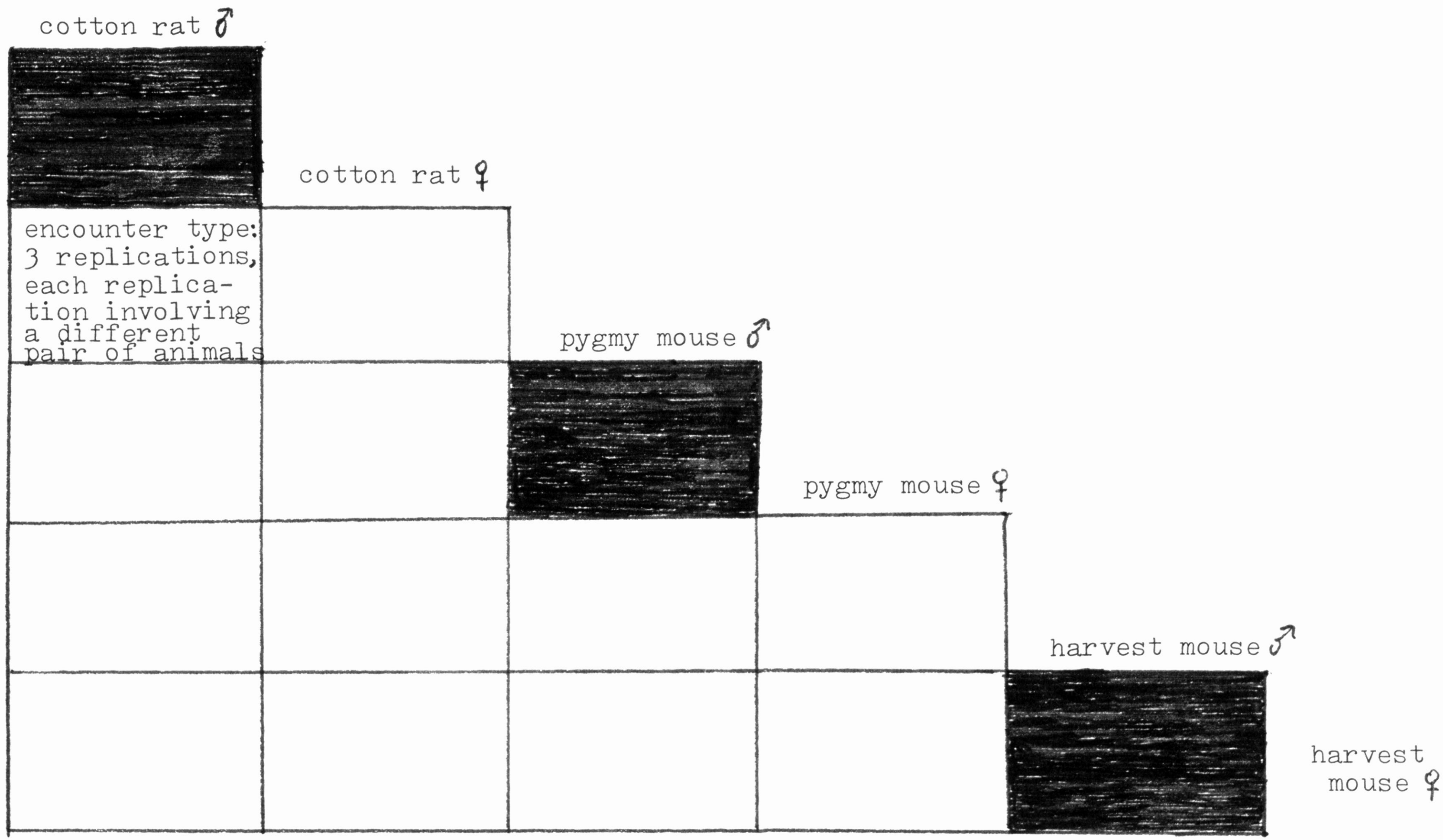

Figure 1. Experimental design depicting 12 encounter types, each type replicated three times, and each replication involving a different pair of individuals. Black squares represent intraspecific pairings and were not observed in this study

done by replicating three of the initial 36 experiments, three times each. For each of the three replicated experiments, two 2 x 2 Chi-square contingency tables were used to test (1) the null hypothesis of no significant difference in frequency of aggressive and submissive behaviors between replications for the first individual, and (2) the same null hypothesis for the second individual.

To determine if the length of time an animal was held in captivity affected frequency of aggressive or submissive behaviors, four regression analyses were conducted on each of the three initial species combination data sets. Each regression related the frequency of aggressive (or submissive) behaviors of one of the species to the number of days that it had been held in captivity. The equation for regression analyses was:

$$Y = \beta_0 + \beta_1 X + E \qquad (1)$$

where Y= frequency of aggressive (or submissive) behavior

X= number of days held in captivity

RESULTS

The cotton rat was significantly ($p<0.005$) more aggressive and less submissive when paired with the pygmy mouse or with the fulvous harvest mouse. The pygmy mouse was significantly ($p<0.005$) more aggressive and less submissive when paired with the fulvous harvest mouse (Table 1).

It is interesting to note that pygmy mice approached cotton rats 28 times in 12 experiments, whereas fulvous harvest mice approached cotton rats only 11 times in 12 experiments. Moreover, three pygmy mice were killed when paired with cotton rats. Thus the fulvous harvest mouse exhibited greater avoidance of encounters when in close proximity to a cotton rat. The fulvous harvest mouse also exhibited avoidance of encounters when paired with the pygmy mouse (18 approaches in 12 experiments).

When paired with the pygmy mouse, the cotton rat was significantly ($p<0.005$) more aggressive and less submissive in all sex combinations (Table 2). The cotton rat was also significantly ($p<0.005$) more aggressive and less submissive in all sex combinations when paired with the fulvous harvest mouse (Table 3). The pygmy mouse was significantly ($p<0.005$ or $p<0.050$) more aggressive and less submissive than the fulvous harvest mouse in all sex combinations except the female-female combination (Table 4).

Table 1. Mean frequencies of aggressive and submissive behaviors (±1SD) resulting from the various species combinations

	Number of experiments	Mean frequencies of behavior		p
		Aggressive	Submissive	
Cotton rat		6.9 ± 2.7	0.92 ± 1.2	
vs	12			<0.005
Pygmy mouse		2.6 ± 2.4	6.9 ± 1.5	
Cotton rat		8.5 ± 4.9	0.33 ± 6.5	
vs	12			<0.005
Harvest mouse		1.0 ± 1.3	7.5 ± 5.6	
Pygmy mouse		7.3 ± 4.1	4.8 ± 3.0	
vs	12			<0.005
Harvest mouse		2.2 ± 1.6	6.1 ± 4.8	

Table 2. Mean frequencies of aggressive and submissive behaviors (±1SD) resulting from the various sex combinations of the cotton rat and pygmy mouse

	Number of experiments	Mean frequencies of behavior		p
		Aggressive	Submissive	
Cotton rat ♂		6.7 ± 2.5	1.3 ± 0.58	
vs	3			<0.005
Pygmy mouse ♂		3.0 ± 2.0	7.0 ± 1.0	
Cotton rat ♂		6.7 ± 2.9	1.3 ± 1.5	
vs	3			<0.005
Pygmy mouse ♀		4.0 ± 3.6	6.0 ± 2.0	
Cotton rat ♀		8.3 ± 4.1	1.0 ± 1.7	
vs	3			<0.005
Pygmy mouse ♂		2.7 ± 2.1	8.3 ± 0.58	
Cotton rat ♀		5.7 ± 2.1	0.0	
vs	3			<0.005
Pygmy mouse ♀		0.67 ± 1.2	6.3 ± 1.5	

Table 3. Mean frequencies of aggressive and submissive behaviors (±1SD) resulting from the various sex combinations of the cotton rat and fulvous harvest mouse

	Number of experiments	Mean frequencies of behavior		p
		Aggressive	Submissive	
Cotton rat ♂		9.7 ± 2.1	0.0	
vs	3			<0.005
Harvest mouse ♂		1.0 ± 1.0	9.7 ± 2.1	
Cotton rat ♂		6.3 ± 3.2	0.0	
vs	3			<0.005
Harvest mouse ♀		1.3 ± 2.3	6.0 ± 3.6	
Cotton rat ♀		5.3 ± 3.1	1.0 ± 1.0	
vs	3			<0.005
Harvest mouse ♂		0.67 ± 1.0	5.3 ± 2.1	
Cotton rat ♀		12.7 ± 7.8	0.33 ± 0.58	
vs	3			<0.005
Harvest mouse ♀		1.0 ± 1.7	8.7 ± 4.1	

Table 4. Mean frequencies of aggressive and submissive behaviors (±1SD) resulting from the various sex combinations of the pygmy mouse and fulvous harvest mouse

	Number of experiments	Mean frequencies of behavior		p
		Aggressive	Submissive	
Pygmy mouse ♂		5.3 ± 0.58	3.3 ± 0.58	
vs	3			< 0.050
Harvest mouse ♂		4.0 ± 1.0	7.3 ± 1.5	
Pygmy mouse ♂		9.0 ± 2.6	5.0 ± 5.3	
vs	3			< 0.005
Harvest mouse ♀		1.3 ± 1.5	6.7 ± 2.1	
Pygmy mouse ♀		9.7 ± 7.4	4.3 ± 3.5	
vs	3			< 0.005
Harvest mouse ♂		1.7 ± 0.58	7.0 ± 9.6	
Pygmy mouse ♀		5.3 ± 2.1	6.3 ± 1.5	
vs	3			> 0.1
Harvest mouse ♀		1.7 ± 2.1	3.3 ± 3.5	

Frequency of aggressive and submissive behaviors of a given individual did not vary significantly ($p>0.1$) between replications when paired with the same opponent (Table 5).

Regression analyses indicated no significant ($p>0.05$) relationship between the frequency of aggressive or submissive behaviors and the number of days that an individual had been held in captivity, with two exceptions. One exception was the frequency of submissive behaviors of the cotton rat as a function of the frequency of submissive behaviors of the pygmy mouse and the time in captivity of the cotton rat. The other was the frequency of aggressive behaviors of the cotton rat as a function of the frequency of aggressive behaviors of a harvest mouse and the time in captivity of the cotton rat.

Table 5. Mean frequencies of aggressive and submissive behaviors (±1SD) resulting from replicated pairings with the same opponent (indicated parenthetically)

	Number of experiments	Mean frequencies of behavior		p
		Aggressive	Submissive	
Cotton rat♀ (pygmy mouse♂)		7.3 ± 4.2	2.7 ± 0.58	>0.1
vs	3			
Pygmy mouse♂ (cotton rat♀)		3.3 ± 1.5	9.7 ± 2.9	>0.1
Cotton rat♂ (harvest mouse♂)		7.7 ± 3.2	0.0	>0.1
vs	3			
Harvest mouse♂ (cotton rat♂)		1.7 ± 2.1	7.7 ± 3.2	>0.1
Pygmy mouse♀ (harvest mouse♂)		10.7 ± 4.7	6.0 ± 5.6	>0.1
vs	3			
Harvest mouse♂ (pygmy mouse♀)		3.0 ± 1.0	3.3 ± 2.5	>0.1

DISCUSSION

It has been suggested that the cotton rat, and the fulvous harvest mouse may compete for space in coastal prairie habitats in Texas (Cameron, 1977). It also has been suggested that the pygmy mouse may compete for space with these two species in post oak savanna habitats in Texas, where all three species occur (Clarence Turner, pers. comm.).

Cotton rats normally inhabit tall grass areas in which they form runways (Davis, 1974). Pygmy mice and fulvous harvest mice travel in runways of their own or in those of cotton rats (Davis, 1974). If individuals are subject to physical contact in the field, such as the use of runways, behavioral reactions may be one mechanism which contributes to spatial segregation between the species.

Behavioral interactions, as observed in the laboratory, may provide useful information torward interpretation of population structure of sympatric species, as observed in field research.

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