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SOCIAL BEHAVIOR OF THE PINE VOLE (*Pitymys pinetorum*): I. ACTIVITY PATTERNS OF MATED PINE VOLES IN SEMI-NATURAL ENVIRONMENTS

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Introduction

The root damage resulting from pine vole (Pitymys pinetorum) infestation of apple orchards remains a major vertebrate pest problem. Currently, research effort is being directed at habitat management and at toxic bait development and application as two potentially cost-effective methods for control of these rodents. Recently, investigations have begun into the detailed relationships between the pine vole's physiology and it's habitat in an effort to understand and perhaps disrupt the seemingly ideal balance achieved by the animal in apple orchard situations. In addition to these approaches, which have possible immediate application, one area of pine vole biology that is poorly understood but which holds a great deal of promise for incorporation into an integrated control program is the study of social organization of pine vole familial and non-familial social units. With the relatively recent application of Sociobiological Theory and Information Theory to the analysis of animal behavior, an understanding of the social biology of the pine vole is a necessity for the development of an integrated pest control program. Such a program, one that incorporates information not only about orchard management and toxic bait placement but also about the number of voles per family and the behavioral interactions occurring within pine vole social units could then take a socio-management approach in addressing the problem. For example, knowing i) the activity patterns of males and females, ii) the degree to which pine voles recongize kin and iii) the cohesiveness of social breeding units would undoubtedly aid in optimizing the timing of management procedures and toxic bait placements both in terms of when to manage (e.g. time of year) and where to place baits (e.g. dispersed vs. concentrated stations). Figure 1 illustrates several types of behavioral studies which might be included in the formulation of such a pest control program.

This paper presents data on pine vole social behavior derived from the activity patterns of opposite-sex pairs allowed to occupy semi-natural enclosures. Of particular interest are several questions about the time spent in various activities. For example, is there a sex or photoperiod difference in the amount of time that pine voles remain at the nest? Concomitantly, can either sex or photoperiod variables be implicated in the amount of time that pine voles engage in investigatory behavior, digging, nest building and eating? Lastly, do males and females spend a large/small amount of time in proximity to each other during the light and dark periods of the day? That is, when provided the opportunity to nest, eat, travel, etc. independently, do pine voles remain tightly bonded or loosely associated? The answers to these questions can provide insight into the behavior of orchard-dwelling animals.

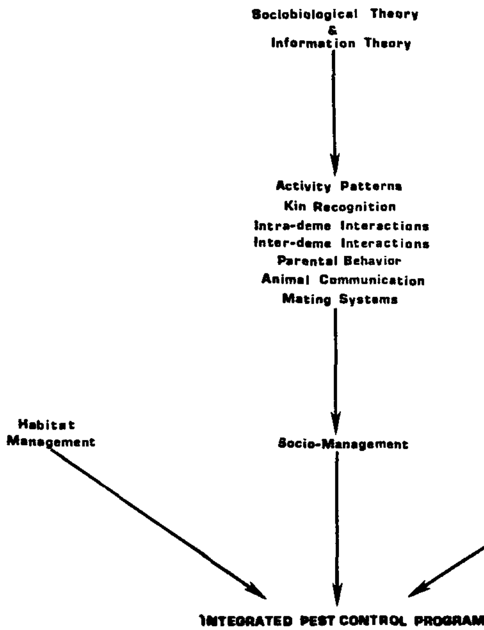

Figure 1. Flow diagram depicting the formation of an integrated pest control program from information obtained through the use of three different management strategies.

The objectives of this study are:

1) to understand social behavior of male/female pairs
2) to investigate effects of photoperiod on social behavior
3) to learn the activity patterns of males and females in semi-natural enclosures.

Methods

Adult opposite-sex pairs, established 14-15d pre-test were placed in semi-natural plexiglass enclosures (Figure 2) and allowed 24h for habituation. Both the nesting area and the tunnels were partially filled with dirt and covered with red acetate in an attempt to keep them as dark as possible at all times. Soil depth in the non-tunnel portion was approximately 8 cm. Orchard grass (*Dactylis glomerata*) was provided for nest material. Apple and sprouted wheat were provided *ad libitum* and served as food and water. Animals were kept on a 12:12 light cycle at a temperature of 15-18°C.

Each enclosure was divided into eleven key areas to facilitate the recording of an animal's location. After the habituation period, pairs were observed at separate times over both the light and dark cycles during a six day period for a total of 33h. A 4 min sampling period

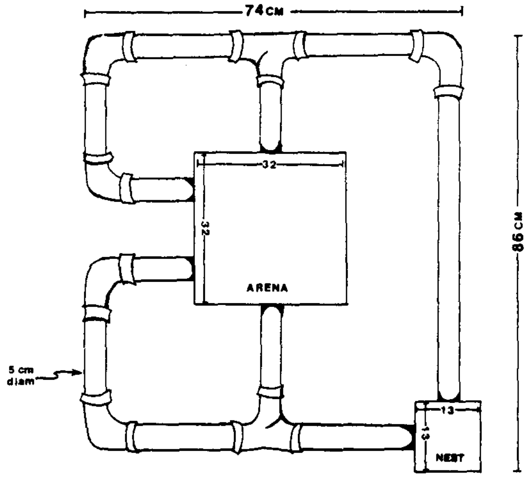

Figure 2. Diagram of the semi-natural plexiglass enclosure used in the study.

each hour was taken on all pairs, during which time sixteen scan samples of 15s each were performed. The scan samples consisted of observing the enclosure every 15s for 5-7s. The location and activity of each animal was recorded.

Results

Figure 3 shows the sum of all investigatory, digging, nesting and eating behaviors observed per hour (=frequency). This represents the hourly combined activity for each animal. The average frequency of occurrence of combined activity for males (n=8) and females (n=8) is plotted against the time of day for a 24h period. While both males and females appear more active during the dark period than during the light period, they seem to be in-phase only during the dark period. That is, the peak in light activity for males occurs early in the morning, immediately after lights are turned on. For females, this peak is shifted approximately 6h and occurs at about noon. During the dark period, peak activity for both sexes occurs between 8 pm and 11 pm. Both sexes exhibit a dramatic decrease in activity at 9 pm with a sharp increase following.

When the combined activity for each pair is graphed separately, several observations can be made. For the most part, each animal displays a characteristic pulsing of activity and non-activity rather evenly spaced throughout a 24h period. In addition, most animals show an increase in activity just after lights are turned off and a few animals show a similar activity burst just before lights come on again. These individual observations are somewhat obscured in the average graph (Figure 3). Of primary importance though, is the fact that each animal (or pair of animals) has it's own activity pulsing pattern and

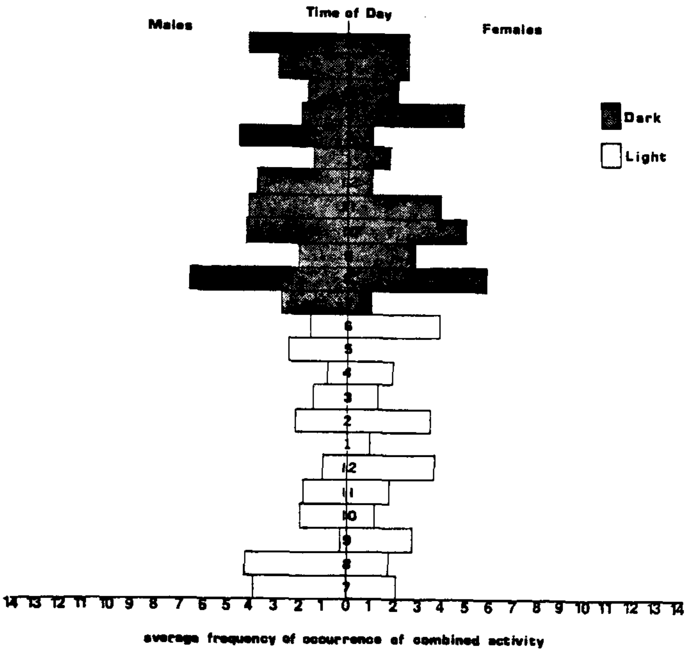

Figure 3. Average combined activity of 8 pairs of pine voles in semi-natural enclosures.

consequently, may be 1 or 2 h out of phase with other pairs. As a result, graphing the average activity patterns not only obscures this periodic pulsing but may even result in an average activity pattern that in some respects, differs dramatically from individual activity patterns.

Table 1 lists the behaviors that were monitored throughout the study, the average percent of a 24 hour day that was spent in each behavior and the total amount of activity engaged in by males and females. For all behaviors there appears to be no significant difference between male and female activity either in the light period, the dark period or the combined light/dark periods. Time period had more of an effect than did sex on pine vole activity. With all activities combined, males were significantly more active during the dark than they were during the light ($X^2 = 10.64$, 1 d.f. $p \leq .05$). Nest building, in which males engaged for a significantly longer time during the dark than during the light ($X^2 = 5.39$, 1 d.f. $p \leq .05$) probably accounts for the significant difference seen when all activities are combined. Females, on the other hand, did not show a significant difference in combined activities between dark and light periods, but, as was the case with males, they spent more time building the nest in the dark than the light ($X^2 = 12.35$, 1 d.f. $p \leq .05$).

Table 1. The percent of a 24 hour day spent in various behaviors by paired male and female pine voles in semi-natural enclosures.

	Male			Female		
Location	Dark	Light		Dark	Light	
Nest	73.07	87.07	*	80.15	81.46	ns
Arena	19.49	2.86	*	11.82	11.20	ns
Tunnel	7.44	10.07	ns	8.02	7.34	ns
Total	100.00	100.00		100.00	100.00	
Activity						
Investigating	8.59	4.47	ns	5.62	4.69	ns
Eating	7.19	3.34	ns	4.43	3.77	ns
Digging	2.65	2.78	ns	3.85	5.86	ns
Nesting	3.18	0.26	*	5.05	0.04	*
Chewing	1.19	0.13	ns	0.31	0.22	ns
Caching	0.05	<0.01	*	0.47	0.61	ns
Copulating	0.05	0.56	ns	0.05	0.56	ns
Grooming	0.26	0.04	ns	0.26	0.08	ns
Following	<0.01	0.22	*	<0.01	<0.01	ns
Contact						
naso-genital	0.31	0.22	ns	<0.01	0.09	*
naso-lateral	0.05	0.04	ns	<0.01	<0.01	ns
naso-nasal	0.05	0.04	ns	<0.01	<0.01	ns
Aggressing	<0.01	<0.01	ns	<0.01	<0.01	ns
Urinating	<0.01	<0.01	ns	<0.01	<0.01	ns
Defecating	<0.01	<0.01	ns	<0.01	<0.01	ns
Total	23.61	12.14	*	20.11	15.98	ns
Inactivity						
Total	76.39	87.86		79.89	84.02	

*Chi Square test; $p \leq .05$

ns = not significant

There was no significant difference between the amount of time that males spent in the nest and the amount of time that females spent in the nest during the light period, dark period or combined light/dark periods. However, males did remain at the nest significantly longer during the light period than during the dark periods ($X^2 = 13.04$, 1 d.f. $p \leq .05$). Conversely, females showed no preference for the nest during light or dark periods.

Three of eight pairs engaged in copulatory behavior during the course of the sampling. In each of these cases, one to three bouts of copulatory activity were observed, most occurring in the light period. These copulations plus other apparently normal interactive behaviors (see Table 1) most likely attest to the accurate representation of a semi-natural environment for studying pine vole behavior. In addition to the copulatory behavior seen, litters were born to two other pairs. Back-dating from the date of birth revealed that one pair apparently mated prior to the end of sampling (no copulations were observed, however). The other pair apparently mated during the 14d pre-test pairing period. This female therefore was pregnant during the study. Interestingly, she spent more of the dark period (97%) at the nest than any other animal. Only one other female spent more time at the nest than this female during the light period. In addition, this pair spent more time (89%) than any other pair in proximity to one another during the dark period. On average, however, males and females were together signficantly longer during the light period than during the dark period ($X^2 = 4.07$, 1 d.f. $p \leq .05$).

All eight pairs engaged in caching behavior, however, much of this activity occurred when animals were not being observed. Nonetheless, males cached for a significantly greater length of time when the lights were off than when the lights were on ($X^2 = 5.72$, 1 d.f. $p \leq .05$). In all cases, animals cached sprouted wheat (and only occasionally small apple chunks) at the corners of the plexiglass tunnels.

Discussion and Conclusion

The purpose of this study was to investigate the activity patterns of mated pine voles. None of the four prevalent behaviors (investigating, digging, nesting and eating) was engaged in for a significantly different amount of time by males and females (Table 1). However, males engaged in nest building for a significantly longer amount of time in the dark period than in the light period. The same was true for females.

The most intriguing result does not concern what constituted the animal's activity, but rather, when the animal was active. On average males achieved two activity peaks during the 24h cycle; one just at dark (between 7:00 pm and 10:00 pm) and the other beginning one hour before the lights came on and continuing on into the early light period, dropping off as the light period continued. Females showed a similar peak, but achieved no early morning peak. Instead, they displayed an activity peak in the middle of the light period (about 6h after the male peak). One can speculate on the significance of phase-shifting activity patterns in wild populations of pine voles. Phase-shifting could serve to keep one animal at the nest while the other forages thus ensuring protection of the nest and any young that might be present there. In-phase activity during the night would not appear to be as adaptive as phase-shifted day activity. While mutual night foraging may serve as added protection against predators, females risk the loss of any nest young to nocturnal predators. A reduction in home range size by pregnant and lactating females may allow such females to forage effectively and still remain close to the nest.

Further research in this area and other areas of social interaction is necessary to gain a fuller understanding of the behavior of orchard-dwelling pine voles.

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