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Potential Use of Barn Owls to Control  
Vole Populations in Orchards

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INTRODUCTION

The development of control methods for pine and meadow voles in orchard habitats has met with limited success. Though numerous physical, mechanical, and chemical methods have been recommended for limiting vole populations, few have effectively reduced and maintained vole populations at minimal densities for extended periods of time. Though the use of chemicals has been the most effective control method developed it has not resulted in the extinction of pest populations. The initial application of rodenticides frequently causes a significant reduction in pest species, but due to their high intrinsic rate of increase, vole densities quickly rise. Because of high costs many orchard owners can not apply rodenticides frequently enough to continually suppress vole populations. What is needed for effective rodent control therefore, is a means of maintaining low vole populations after an initial rodenticide application. A potential means of achieving such control is through the use of natural predators.

To qualify as an effective mode of biological control for voles in orchards a predator must 1) forage in orchard habitats 2) use voles as a primary food source and 3) exhibit moderate or weak territoriality to permit several individuals to forage in one area. A predator which qualifies for each of these requirements is the barn owl (Tyto alba).

Barn owls are highly specialized rodent predators which feed primarily on microtines, including pine (Microtus pinetorum) and meadow (M. pennsylvanicus) voles (Boyd and Shriner, 1951; Phillips, 1951; Parmalee, 1954; Marti, 1969; Rickart, 1972). These owls are primarily nocturnal and forage in open areas, including orchards (Merson and Byers, 1981), rather than forested areas. Barn owls will use nest boxes as supplementary nesting sites and exhibit weak territoriality and overlapping hunting ranges (Lenton, 1980). Because of these characteristics barn owls are a good candidate for use as biological control agents.

The impact a predator, such as a barn owl, has on an ecosystem is largely dependent on which and how many prey individuals it captures to fulfill its food requirements. Though barn owls are known to feed on microtines, it is not clear whether microtines are the preferred prey of barn owls and are thus selected over other available prey species. The objectives of this study were to determine what prey types are most vulnerable to barn owl predation and what prey characteristics are of primary importance in determining prey vulnerability to barn owls. The results of this study will provide basic information on barn owl food selection to determine their potential as a means of biological control in orchards.

#### MATERIALS AND METHODS

Two barn owls caught in July, 1979 in Blacksburg, Va. were used as predators and Peromyscus leucopus novboracensis, Microtus pennsylvanicus pennsylvanicus and M. pinetorum were used as prey. All prey animals were maintained in laboratory colonies on a 16L:8D light cycle with Microtus pennsylvanicus fed rabbit pellets, M. pinetorum fed Wayne lab bloc supplemented with apple and sunflower seed, and P. leucopus fed Wayne lab bloc ad lib. Water was available at all times. The owls were maintained in a semi-natural outdoor enclosure (6 by 12 by 4m) and fed randomly selected live prey ad lib. except during prey selection experiments.

Selection tests. Selection tests were performed using pairwise comparisons of the three prey species. The comparisons made were M. pinetorum adults tested with M. pennsylvanicus adults and juveniles, and P. leucopus adults tested with M. pinetorum adults and M. pennsylvanicus adults and juveniles. In all tests predator-naive prey individuals were used.

Selection tests were conducted in an indoor room (3 by 6 by 4m) from October, 1979 to May, 1980. Perches were located at opposite ends of the room with one 2.5 m above the ground and the other 1.5 m high. The floor was covered with sawdust, crushed oak leaves, and a few tree branches but no specific prey refuges were available. A plexiglass door covered with a double layer of cheese cloth permitted direct observation of predator behavior.

The indoor enclosure photoperiod corresponded to the current natural photoperiod. Selection tests were begun 30 min after dark with the enclosure lit by a fluorescent light covered with red filters and a dim light controlled by a variable power supply. This permitted direct observation of predator behavior while maintaining as low a level of illumination (0.63 lumens/sq. m) as possible to simulate natural foraging conditions.

For each trial, four prey individuals, two of each prey type being tested, were released into the enclosure in the presence of one owl. Prey individuals were identified by sex or toe clipping with body length, tail length, and body weight recorded prior to each trial. Each owl was given 45 min. in which to capture a maximum of three of the four prey individuals. A 20 channel Esterline Angus event recorder was used to monitor predator pursuit time (from when the owl left the perch to when it caught a prey item), handling time (from capture until eating commenced), and eating time. Ten trials were made per owl resulting in total of 20 trials per prey type comparison.

Behavioral tests. To determine differences in the behavior of prey types, observations were made on prey before, during, and after an aerial silhouette flight in the indoor enclosure. Since responsiveness to aerial models by Peromyscus, Microtus, and other rodents is independent of model configuration (Fentress, 1968; Muller Schwarze and Muller Schwarze, 1971; Bildstein and Althoff, 1979) behavioral tests utilized a stylized silhouette model (137.5 cm wingspan, 38.8 cm length) which moved at 0.5 m/s along a monofilament line suspended between the perches. For each flight the silhouette 'flew' by force of gravity from the higher perch to the lower perch (3 m) and was then hand-pulled back to the higher perch.

A single naive individual was released into the room and its behavior monitored for 5 min prior to and 5 min subsequent to the silhouette's flight. The behaviors monitored were activity, freezing (no head or body movements), 'grooming' (grooming, chewing, sniffing, rearing), and use of corners. Twenty trials were conducted for each of the five prey type comparisons.

Analysis. Predator selection was determined using the selection index of Manly (1972) and Manly et al. (1972). Selection values range from 0 when all prey captured are of type A to +1.0 when all prey captured are of type B. A value of 0.5 occurs when there is no difference in the selection between prey types. To compare the number of each type presented with the number eaten a  $\chi^2$  test suggested by Manly et al. (1972:729) was used.

Other statistical analyses used standard parametric and nonparametric tests (Siegel, 1956; Walsh, 1965; Dixon and Massey, 1969; Hcllander and Wolfe, 1975).

## RESULTS

Selection tests showed that M. pennsylvanicus adults and juveniles were significantly more vulnerable to barn owl predation than were P. leucopus (Table 1). Microtus pinetorum tended to follow the same pattern as they were captured twice as often as P. leucopus, but the difference was not significant. There was little difference in the vulnerability of juvenile M. pennsylvanicus and adult M. pinetorum.

Table 1. Selection indices (SI) for prey selection tests. Asterisks denote significant selection between prey types ( $X^2$ ,  $p < 0.005$ ). Juv. = Juveniles. Ad. = Adults.

|   | Prey type A                   | SI value | Prey type B             | SI value |
|---|-------------------------------|----------|-------------------------|----------|
| * | <u>M. pennsylvanicus</u> Ad.  | 1.00     | <u>P. leucopus</u> Ad.  | 0.0      |
| * | <u>M. pennsylvanicus</u> Ad.  | 0.84     | <u>M. pinetorum</u> Ad. | 0.16     |
| * | <u>M. pennsylvanicus</u> Juv. | 0.75     | <u>P. leucopus</u> Ad.  | 0.25     |
|   | <u>M. pinetorum</u> Ad.       | 0.66     | <u>P. leucopus</u> Ad.  | 0.34     |
|   | <u>M. pennsylvanicus</u> Juv. | 0.61     | <u>M. pinetorum</u> Ad. | 0.39     |

With respect to sex, there were no differences in the vulnerability of male and female P. leucopus or M. pinetorum. Within M. pennsylvanicus, juvenile females were captured significantly more often than males, while the opposite occurred among the adults (Table 2).

Within each prey type comparison, the prey type with the greater mean body length was captured more frequently than that with the shorter mean body length (Table 3). This resulted in a significant correlation between differences in the selection index of the two prey types compared and differences in the weights of the two prey types (Spearman's Rank Correlation,  $r_s = 1.00$ ,  $p < 0.01$ ). A similar, but less consistent pattern occurred with respect to the weights of prey types, however no significant correlation between differences in prey weights and differences in their selection indices occurred ( $r_s = 0.64$ ,  $p > 0.2$ ).

Table 2. Predator selection between sexes. Sample sizes are the number of trials where both a o and a o were present and only one animal was caught. Asterisks denote significant differences in the capture frequency of males and females ( $\chi^2$ ,  $p < 0.005$ ). Juv. = Juvenile. Ad. = Adult.

| <u>Prey type</u>              | <u>Sample Size</u> | <u>Capture frequency</u> |               |
|-------------------------------|--------------------|--------------------------|---------------|
|                               |                    | <u>male</u>              | <u>female</u> |
| <u>P. leucopus</u> Ad.        | 9                  | 44%                      | 56%           |
| <u>M. pinetorum</u> Ad.       | 21                 | 48                       | 52            |
| <u>M. pennsylvanicus</u> Juv. | 11                 | 9                        | * 91          |
| <u>M. pennsylvanicus</u> Ad.  | 20                 | 80                       | * 20          |

Behaviorally, Microtus species differed from P. leucopus both before and after overhead silhouette flights. Significantly more M. pennsylvanicus (80%) and M. pinetorum (85%) spent time frozen than did Peromyscus (60%) prior to silhouette flights. All three prey species showed a similar response to the silhouette as it passed overhead, with 65-75% of the individuals of each species fleeing and the others exhibiting freezing behavior. After the silhouette flight significantly more P. leucopus were active (55%) and significantly fewer exhibited freezing behavior (80%) than individuals of either Microtus species (X number active = 33%, X number frozen = 99%).

Few differences occurred in the time spent by the owls pursuing, handling, and eating the various prey types. No significant differences occurred in pursuit and handling times for the four prey types. However, the largest and heaviest prey types, M. pennsylvanicus adults and M. pinetorum required significantly more time to eat than did M. pennsylvanicus juveniles and P. leucopus. There were no significant differences in the number of attempts required to capture individuals of each prey type.

Table 3. Comparison of captured prey types weight and body length differences. Significant differences in owl selection between prey types are denoted by (\*)  $\chi^2$ ,  $p < 0.005$ ). All weight and body length differences are significant (t-test,  $p < 0.01$ ) except those marked (\*\*).

| <u>Preferred prey type vs.<br/>less preferred prey type</u> | <u>Mean diff.<br/>in weights (g)</u> | <u>Mean diff. in<br/>body length (mm)</u> |
|---|--------------------------------------|---|
| * <u>M. pennsylvanicus</u> Ad.<br><u>P. leucopus</u> Ad.    | 32.80                                | 33.6                                      |
| * <u>M. pennsylvanicus</u> Ad.<br><u>P. pinetorum</u> Ad.   | 17.16                                | 18.8                                      |
| * <u>M. pennsylvanicus</u> Juv.<br><u>P. leucopus</u> Ad.   | 0.43**                               | 8.5                                       |
| <u>M. pinetorum</u> Ad.<br><u>P. leucopus</u> Ad.           | 10.33                                | 7.8                                       |
| <u>M. pennsylvanicus</u> Juv.<br><u>P. pinetorum</u> Ad.    | -7.50                                | -5.8**                                    |

#### DISCUSSION

Differential vulnerability of prey and the selection of specific prey types by barn owls has been demonstrated in this study. During the selection tests, all prey were equally vulnerable in terms of the experimental conditions (i.e. no refuges existed) and prey types differed only in terms of their behavioral and physical characteristics. Under these conditions, the two Microtus species were more vulnerable to barn owl predation than were P. leucopus. Similar results have been reported for barn owls (Fast and Ambrose, 1976) and kestrels (Barrett and Mackey, 1975) in semi-natural enclosures where M. pennsylvanicus were captured more frequently than Peromyscus.

The greater vulnerability of Microtus species was due partly to their greater body length when compared with P. leucopus. Large body size may be indicative of a potentially greater caloric yield and greater energy benefits for predators and thus Microtus were captured more frequently than the smaller species P. leucopus. The lack of a significant difference in the body sizes of juvenile M. pennsylvanicus and adult M. pinetorum resulted in no significant selection between these two prey types.

Behavior was also important in determining prey vulnerability. It was easier for the owls to capture prey individuals which were frozen rather than active. The greater tendency for both M. pennsylvanicus and M. pinetorum to freeze than for P. leucopus to freeze may have increased the vulnerability of these microtines.

Because Microtus were selected more frequently than were P. leucopus it appears that barn owls have potential use as a means of biological control for microtines in orchards. The use of carnivores such as mongooses, cats, and weasels to control rodents has not been very successful partly due to the diversity of their diets (i.e. birds, rabbits, frogs) (Wodzicki, 1973; Sullivan and Sullivan, 1980). Barn owls however, are rodent specialists and have been found to aid in rat control (Lenton, 1980).

If barn owls are efficient vole predators in the field even when other prey species are available, they could contribute to the control of microtines. It is unlikely that owls could eliminate vole populations but in conjunction with chemical methods vole populations could be reduced and maintained at minimum densities for an appreciable period of time. The hazard to owls would have to be minimized by using rodenticides which do not concentrate in secondary consumers or which result in the death of rodents while in unexposed areas such as burrows or nests. If such an integrated control program were successful economic benefits could be realized through reduced expenditures on the purchase and application of rodenticides.

Though this study shows that microtines are highly vulnerable to barn owl predation in a laboratory situation, additional testing is needed to determine if the same foraging pattern occurs in orchards. Density estimates of all potential prey species within orchards need to be determined and compared with types and numbers of prey actually eaten by barn owls or other avian predators foraging in orchards. If the results of field tests show that barn owls follow the same foraging pattern in the field as they have in the laboratory (i.e. select animals according to their size and possibly behavior) then one can predict in what areas owls will be most effective at reducing microtine populations rather than those of co-occurring species.

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