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Introduction

Previous field studies in Virginia reported a longer breeding season in pine voles in maintained apple orchards than in abandoned orchards and attributed the difference to nutrition (Cengel et al. 1978, Noffsinger 1976). The maintained orchard was theorized to have better quantity and quality of forage in fall due to mowing, fertilizing and the presence of apple drops. Hasbrouck et al. (1981) found adult male pine voles snap-trapped in November and December in an orchard where apples were present had significantly heavier reproductive organs and higher spermatozoa counts than those trapped in an area of the orchard where apples had been removed.

Noffsinger (1976) speculated an interaction between a declining or short photoperiod and level of energy intake determined length of the breeding season in pine voles in autumn. Noffsinger (1976) and Merson (1979) suggested studies be conducted to determine the effects of a declining photoperiod on reproduction. The objective of this study was to determine the influence of photoperiod and nutrition on food consumption, body condition and reproduction in the pine vole.

Methods and Materials

The experiment was conducted in a metal frame building with skylight panels in the ceiling allowing sunlight into the building One to two inches of soil were placed in the bottom of concrete troughs inside the building and each trough was partitioned into four equal sections 2.3m^2 in area.

Voles were live-trapped from an orchard in late July and immediately placed in the troughs. During the first week of September, 2 males and 5 females were placed at random into 12 of 16 sections of the troughs. Half of the groups were fed a diet of _ad libitum_ amounts of Purina Rabbit Chow (66% digestible energy, Servello 1981) which had been ground in a Wiley Mill. The remaining groups were given the same diet supplemented with apples. In mid-September fluorescent lights and black plastic were suspended from the rafters of the building so that half of the groups were kept on a constant 14L:10D photoperiod and the other half maintained on a natural declining photoperiod. Thus, the treatment groups were those on a 14L:10D light regime with a group fed apple and chow and a group fed only chow, and those on a natural declining photoperiod with a group given apple and chow and a group given only chow. In subsequent discussion, these groups will be denoted as LA (Long photoperiod-Chow diet), SA (Short photoperiod-Apple and chow diet), and SC (Short photoperiod-Chow diet).

The experiment was run for 12 weeks. The natural photoperiod was approximately 12L:12D at the beginning of the experiment and 9.5L:14.5D at the end. Food consumption was determined for apple and chow separately and converted to kcal digestible energy consumed per vole per week. Body weight was measured every two weeks. Dead voles were replaced during the first half of the experiment, but no voles were added during the last six weeks. Because of complications due to replacing voles, food consumption and body weights taken biweekly were analyzed statistically for only the last six weeks.

The voles were sacrificed in mid-December and frozen until necropsy. After thawing, reproductive organs and adrenal glands were removed from the animals, placed in fixative solutions for two weeks and weighed. Testes removed from males were frozen and sperm counts were done later. All remaining organs were then removed from the carcass, stripped of excess fat and the fat returned to the carcass. The carcass was homogenized and crude body fat determined by ether extraction.

Results and Discussion

Intake of digestible energy ranged from 90-135 kcal DE/vole/week. Voles on the chow diet consumed significantly ($P<0.001$) more digestible energy than those fed apple and chow. Apples comprised 50-65% of the digestible energy intake in groups with access to apples.

There was a significant ($P<0.03$) effect due to diet for change in body weight from week 6 to week 12. Voles on the chow diet lost weight, while those fed apple and chow maintained body weight.

Voles given apple and chow had significantly ($P<0.01$) more body fat than those fed chow. Female voles tended ($P<0.09$) to have higher mean final body weights and had significantly ($P<0.04$) more body fat than males. Females on the apple and chow diet had mean body fat levels around 40%.

Voles on the 14L:10D photoperiod had significantly heavier seminal vesicles ($P<0.004$), paired testes ($P<0.008$) and uteri ($P<0.04$), and tended to have more sperm/mg testes ($P<0.06$) and heavier paired ovaries ($P<0.07$) than those on the declining light regime. Males on the apple and chow diet had higher mean values for reproductive characteristics, but only paired testes weight was significantly ($P<0.05$) higher. Diet had no effect on the reproductive organ weight in females.

Field studies have found a peak in reproductive activity during summer and little or no activity during the short days of late fall and winter (Noffsinger 1976, Cengel et al. 1978). These studies also related higher reproductive activity in maintained orchards to higher quality and/or quantity of forage. In this study voles on the declining or short photoperiod had lower values for reproductive characteristics than those on the long photoperiod. Males on the apple and chow diet consistently had heavier reproductive organs and higher sperm counts than those on the chow diet.

At first glance the effects of diet in this experiment appear contradictory. Voles fed apple and chow consumed less digestible energy, but maintained body weight, had more body fat and, in males, had higher values for reproductive characteristics than those on the chow diet. The digestible dry matter (DDM) in the stomach of voles trapped in an orchard in an area with apples available was not different from the DDM of those in an area with apples removed (Servello 1981). However, reproductive organs and sperm counts were higher in voles trapped in the area with apples available (Hasbrouck et al. 1981). Thus, apples do not appear to increase digestible energy intake, but do affect the reproductive physiology of pine voles.

In an orchard environment, perhaps both photoperiod and nutrition have additive effects on reproductive activity and length of the breeding season. When some aspect of nutrition reaches a low or critical level in fall, reproduction ceases. In areas where food quality and/or quantity is not limiting, reproduction may continue to occur in fall and even into winter, but at reduced levels due to the inhibitory effects of a declining or short photoperiod. The availability of apples may be important in determining how quickly a declining photoperiod curtails the breeding season in pine voles.

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