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REGULATION OF REPRODUCTION IN AN OUTBRED COLONY OF PINE VOLES

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Pine voles (Microtus pinetorum) cause economic losses to orchardists in the eastern United States by gnawing on the roots of fruit trees. Although they are small in body size, their impact on orchards can be quite substantial: in 1979 half of the annual mortality of apple trees in Henderson County, North Carolina, was attributed to vole damage (Sutton et al 1981).

Rodenticide application integrated with cultural management is currently regarded as a good combination for controlling vole populations in orchards. However, this solution to the vole problem is incomplete because poisons may unintentionally harm non-target organisms (Hegdal, Gatz & Fite 1981, Merson & Byers 1981) and there is evidence of genetic plasticity in pine vole populations since some have developed resistance to the rodenticide endrin (Webb & Horsfall 1967). Clearly, we need to continue working towards a safe and effective program for controlling pine voles. One approach is to examine the biological factors that regulate vole reproduction.

One striking characteristic of M. pinetorum is its low reproductive potential compared to other microtine rodents (Schadler & Butterstein 1979). Females have only 4 teats, the typical litter size is 2, and the earliest conception by a female is reported as being 77 days of age Schadler & Butterstein 1979). In establishing a breeding colony of pine voles at North Carolina State University, I have collected evidence that puberty can occur much earlier than this.

Founding pine voles were trapped in western North Carolina. Voles were maintained in the laboratory as heterosexual pairs of unrelated animals in plastic cages with wire lids and peatmoss substrate. Wayne rodent chow and water were available to them ad libitum; grass clippings (Agrostis spp.), Purina guinea pig chow, sunflower seeds, and a slice of apple were provided 3 times a week. Photoperiod was 14L:10D and room temperature varied between 4° and 23° C.

Voles were weaned between 30-40 days of age and each weanling was caged with an unrelated conspecific of the opposite sex for at least 60 days. The cagemates were of various ages and sexual experience. Age at first conception was obtained by subtracting 24 days (pine vole gestation period -- Schadler & Butterstein 1979) from the age at delivery of first litter. Because I checked for births only 3 times a week, the ages reported below may be 2 or 3 days off the true values. Of 28 weanling females, 13 produced litters and 15 did not. The mean age at first conception for the 13 successful females was 62 days with a range of 32 to 115 days. Of 27 weanling males, 12 produced litters and 15 did not.

For the 12 successful males, mean age at first conception was 69 days with a range of 44 to 99 days.

These breeding records reveal the variability inherent in the sexual maturation processes of the pine vole. Knowledge of factors that affect sexual maturation is important because it can lead to predictions regarding population dynamics. In a growing population, for example, the introduction of a factor that causes earlier puberty leads to more rapid population growth than would occur without that factor.

It is a fundamental observation in ecology that no population continues to grow without limit (Lidicker 1978). How population regulation is achieved remains a controversial topic but several mechanisms have been proposed (Gaines & McClenaghan 1980, Krebs 1978). In the house mouse, Mus musculus, urinary pheromones (chemical signals) affect female puberty and are proposed to influence population dynamics (Drickamer 1981). Colby and Vandenbergh (1974) reported that urine taken from adult male mice and applied to the nose of a young female mouse could accelerate sexual maturation. Drickamer (1977) reported that urine collected from females grouped in high-density cages had the opposite effect on young females -- it could delay sexual maturation. Experiments using urine collected from feral populations of Mus indicate that these pheromones operate under natural conditions and that the delay pheromone can function in a density-dependent manner (Massey & Vandenbergh 1980; 1981).

Pheromones that affect reproduction have been implicated in many microtine rodents, including M. ochrogaster (Carter et al 1980), and M. pennsylvanicus (Baddaloo & Clulow 1981). Schadler (1981) reported that male pheromones could induce post-implantation abortion in M. pinetorum. I plan the following experiment to determine if puberty-regulating pheromones are operating in the reproduction of pine voles. One hundred females will be taken from their parental cages at 30 days of age and housed in individual cages. Five treatment groups will be established: 1) urine from intact males 2) urine from castrated males 3) urine from solitarily-housed females 4) urine from group-housed females and 5) water as a control. Treatment consists of daily applications of a treatment substance on the noses of young females for 5 days. On the sixth day the females will be killed, their uteri and ovaries dissected out and weighed, and the ovaries will be histologically prepared to observe if follicular maturation or ovulation have occurred. Environmental conditions will be similar to those described above.

A second experiment is planned to determine if dietary factors affect pine vole reproductive potential. Green plants can stimulate reproduction in M. montanus (Negus & Berger 1971). Cranford (1982) reported that pine vole pairs bred slightly earlier when fed oat-sprout supplements compared to those not receiving oat sprouts; also, the sprout-supplemented group produced more litters over a 6 month experimental period. In my experiment I will pair young females with proven males and use grass clippings (Agrostis spp.) instead of oat sprouts. Following weaning at 30 days of age and pairing with a proven male, I will assign the pairs to one of two treatment groups: 1) those receiving grass supplements and 2) those not receiving grass. Both groups will have ad libitum access to water and rodent chow; a slice of apple will be provided 3 times a week. I will follow reproductive per-

formance for 150 days and compare the following data from the two groups: age at first conception, litter sizes and sex ratios, and litter survival to removal at 30 days of age. Non-productive females will be killed at the end of the experiment and their ovaries histologically prepared to see if follicular maturation or ovulation have occurred.

In conclusion, we may have been underestimating the reproductive potential of the pine vole. Female puberty may occur as early as 32 days of age and male puberty as early as 44 days of age. I have outlined experiments to investigate the role that pheromones play in female puberty and to test if the availability of green grass affects reproductive potential. These experiments will add to our understanding of how reproduction, and thus population size, can be regulated.

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