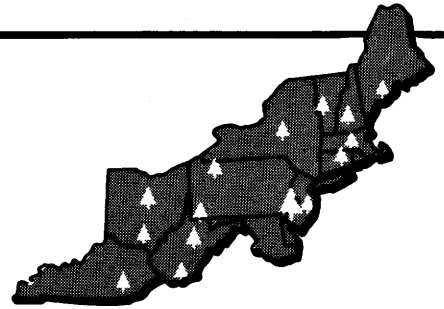


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CHANGE IN SOMATIC GROWTH RATES OF *MICROTUS PENNSYLVANICUS* AS A RESULT OF CROSS-FOSTERING WITH *PEROMYSCUS LEUCOPUS*

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Abstract.—A litter of five meadow voles (*Microtus pennsylvanicus*) was cross-fostered on a white-footed mouse (*Peromyscus leucopus*). All *Microtus* pups survived through weaning. Daily weight gain was 0.30 gm before weaning and 0.96 gm after weaning. When weaned, the *Microtus* pups were approximately 1/3 normal size for that stage of development. The timing of post-natal physiological events was not affected by cross-fostering.

KEYWORDS: *Microtus*, *Peromyscus*, cross-fostering, somatic growth, physiological growth.

This note documents the effects of cross-fostering five *Microtus pennsylvanicus* pups on a *Peromyscus leucopus* adult.

Cross-fostering is a technique commonly used to explore the imprinting effect of early experience on later behavior (Lagerspetz and Wuorinen 1965; Denenberg et al. 1966; Southwick 1968; Hudgens et al. 1968), but the technique has not been used to explore the physiological effects of such cross-fostering. Merchant and Sharman (1966), however, suggested that growth rates may be altered in a species cross-fostered on another.

With the exception of that study and another by Quadagno and Banks (1970), successful cross-fostering has been reported only among highly inbred strains of rats and mice. Blus and

Johnson (1969) reported a *Blarina brevicauda* adult suckling a *Mus musculus*; however, the mouse died within 1 week.

The Study

The haying of a small field in Branford, Connecticut, on 7 July 1972 exposed a nest containing five newborn meadow voles, *Microtus pennsylvanicus*. The biological dam was not seen and did not return to the nest during the next 2 hours. When found, the *Microtus* pups were resting. Two hours later they were noticeably restless.

Meanwhile, moments before the *Microtus* nest was found, a white-footed mouse (*Peromyscus leucopus*) had completed parturition in

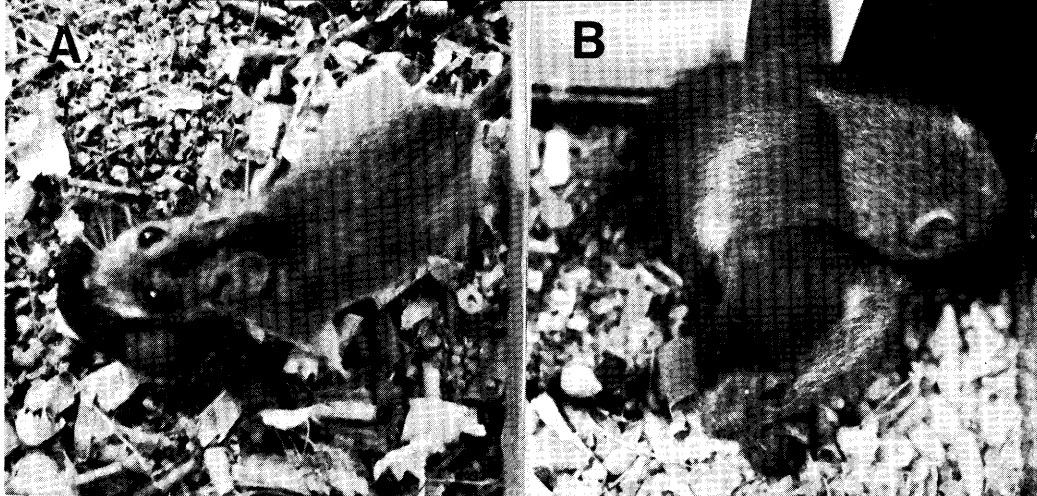


Figure 1.—A, (left), foster dam carrying young *Microtus* pup to nest. This photograph was taken about 4 days after the nest had been found. The *Microtus* pups were removed from the nest for photographing and were then returned to the nest by the *P. leucopus* dam. B, (right), two of the *Microtus* pups after weaning.

our field laboratory. This *P. leucopus*, born in captivity on 22 February 1972 to wild field-collected parents, presented an opportunity to cross-foster the *Microtus* pups with a different wild species. The *P. leucopus* litter of two was transferred to a second lactating female of the same species.

Until this occasion, all our attempts to cross-foster young came as a result of dam mortality and involved only intraspecies transfers. Our success at intraspecies cross-fostering (all attempts) has been about 50 percent. "Success" is defined as the number of young that survive through weaning and continue to show a steady increase in body weight.

In this interspecific experiment, a clean 10-gallon aquarium (floor space 180 square inches) was prepared by covering the floor to a depth of 2 inches with kitty litter, which was then covered with 2 inches of cedar shavings. A single 100-milliliter water bottle with a glass sipper tube was suspended in one corner, and the aquarium was covered with a 1/8-inch mesh hardware cloth lid.

The *Microtus* nest had been taken carefully from the field, and the young were removed before the nest was placed in the cage. The *Microtus* pups were transferred with forceps into a small cotton nest where they were held temporarily until the adult *P. leucopus* foster dam had been placed in the cage.

As soon as the white-footed mouse dam was placed in the cage, she examined the *Microtus* nest by thoroughly sniffing and exploring in and

around it. In the hope that the foster dam would rear the *Microtus* pups, I placed them singly on the floor of the cage at about 2-minute intervals. Without hesitation, the foster dam picked up each pup in her mouth (fig. 1) and carried it to the nest, remaining with it and examining it until another was placed on the floor of the cage. Shortly after the fifth and final *Microtus* pup was carried to the nest, the foster dam made herself available so that the young could nurse.

Weights were not taken before the pups were placed in the aquarium. However, judging from my previous experience in weighing several litters of that size, I estimated that they weighed about 2.5 to 3 grams each.

Results

The only difficulty encountered in cross-fostering this *Microtus* litter was the initial attachment of the young to the teats. The foster dam assumed a dorsum-up position, and the young burrowed beneath her to attach themselves to the teats. Because the foster dam had just given birth, her teats were not enlarged from suckling, and it appeared that the *Microtus* pups did not at first associate them with the larger teats of their biological dam.

Three hours later, the pups were all nursing, but would easily fall off the teats when the female mouse was disturbed. My first thought was that the tendency of the young to cling to the teats might vary between these species. However, by the following morning, the young

voles had obviously improved their grip because they were able to remain attached when the foster dam changed her position within the nest. I noticed that the foster dam had consumed a normal amount of water and solid mouse chow during the night, indicating that she had left the voles at least once and had returned to them.

Seven days after the nest had been found, the weights of the *Microtus* pups were individually recorded on a top-loading analytical balance. The initial weights ranged from 4.83 to 5.96 grams. Weights taken on five other occasions are shown in table 1, along with standard deviations that demonstrate the small range of variation between individuals.

The physiological development of each individual in the litter was checked daily. On 17 July (sixth day in captivity), the first pup opened its eyes. On the following day, all the pups had their eyes open and were wandering from the nest, sometimes stopping to nibble on solid food (mouse chow). On 21 July, the pups demonstrated their independence of the foster dam and could be classified as weaned (King et al. 1963; Layne 1968). This observation agrees with the 11- to 12-day weaning time reported by Hamilton (1937); however, the mean weight I recorded at weaning was 6.35 grams, which is considerably less than the 14-gram weight recorded by Hamilton.

The pups remained with the foster dam for an additional 3 days. During this period, she permitted them to nurse occasionally, which provided a valuable nutritional supplement to their diet, as evidenced by their rapid rate of weight gain (fig. 2). The voles gained an average of 1.5 grams per 24 hours.

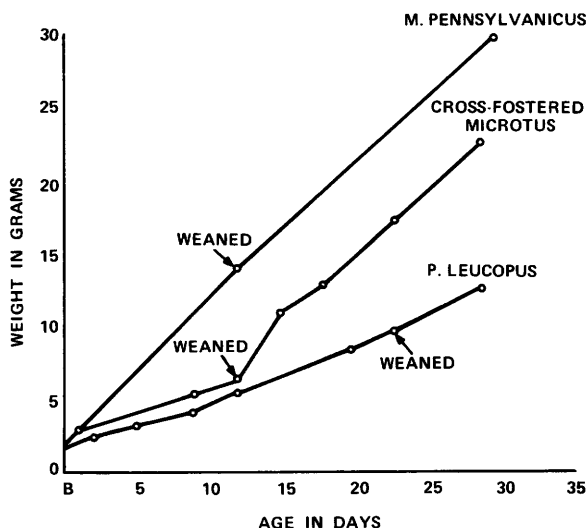
Table 1.—Mean weight of cross-fostered *M. pennsylvanicus* litter during period of observation.

Date	Age	Mean weight	S.D.
	Days	Gm.	
11 July	2 ^a	3.00 ^b	—
18 July	9	5.35	0.45
21 July	12	6.36	.49
24 July	15	10.87	.74
27 July	18	12.77	1.40
1 August	23	17.73	2.33
7 August	29	22.69	3.34

^a Assumed age when found.

^b Visual estimate.

Figure 2.—Growth rate of the cross-fostered *Microtus* litter compared to the growth rate of a litter of *P. leucopus* and a growth rate for *M. pennsylvanicus* as indicated by Hamilton (1937).



The average rate of growth through weaning was 0.30 gram per 24 hours or about one-third of that recorded by Hamilton (1937) for the species. However, this is nearly identical to the 0.31-gram-per-24-hour growth rate demonstrated by the *P. leucopus* litter at 12 days of age (fig. 2).

Discussion

I can only speculate as to whether quantity or quality of the foster dam's milk was responsible for the low mean weight at weaning. It seems reasonable to assume, because of the size differential between the adult females of the two species, that quantity was the primary cause for the low daily weight gain. Hamilton (1937) reported an average weight of about 39 grams for a sample of 58 sexually mature *M. pennsylvanicus* females captured in July, which is 1.77 times heavier than the average adult *P. leucopus* female caught near our field station in July 1972. Because all the *Microtus* pups survived, the foster dam obviously provided milk in excess of their minimal requirements for subsistence, but simply did not have the capability of producing the necessary volume for the *Microtus* pups to reach normal weights at these ages. Furthermore, there is no apparent numerical difference in the mean litter size between these species.

Aside from the altered growth rate, three points are noteworthy:

First, the *P. leucopus* dam accepted all the *Microtus* pups, and each survived through weaning. Quadagno and Banks (1970) were the only researchers to report success percentages of cross-fostering among small mammal species. They reported that *Mus* dams accepted foster *Baiomys* pups 36.2 percent of the time, whereas *Baiomys* dams accepted *Mus* pups only 24.6 percent of the time; survival through weaning was 83 percent and 96 percent, respectively.

Second, within certain species (in this case, *M. pennsylvanicus*) the regulatory controls over physiological growth and somatic growth (size and weight) seem to function independently. Merchant and Sharman's (1966) work demonstrating the separateness of the two kinds of growth in marsupials is easily understandable because of the small body size and yet high degree of physiological competence of newborn marsupials and early pouch young. Moreover, in that instance a young of a smaller species was fostered on the female of a larger species, and this situation would not be expected to present a less-than-adequate environment for the young's survival.

My results, on the other hand, document the reverse case in placental animals: that is, the young of a large species were fostered on a female of a smaller species. One might expect that this would result in the death of the young due to an inadequate supply of milk, and indeed the weight gain before weaning was reduced to about one-third of normal growth. However, the post-natal physiological events of the cross-fostered *Microtus* pups agreed with the schedule indicated for that species by Hamilton (1937).

Clearly, the genetic programs for physiological progress and somatic growth can be separated and followed independently in these placental mammals. There are in the literature other examples of this decoupling that are not concerned with fostering and so support my contention from a different point of view (Weir and Rowlands 1973).

Third, it is also interesting to note the apparent difference in quantity between the amount of dam milk required for subsistence and that normally provided by *Microtus* mothers. It would at first seem reasonable to expect that natural selection would have brought

this range in milk quantities closer together. However, there would also be a clear adaptive value to a situation in which young are able to withstand long and even continuous periods of deprivation of resources, such as when the dam is absent or is unable to provide (for nutritional or other reasons) the usual quantity of milk.

Somatic growth, on the other hand, can generally be recouped at a later time. Indeed, once weaned, the *Microtus* pups in this experiment equalled the recorded daily weight gain for the species, including the 3-day period when solid food was supplemented with *P. leucopus* milk. The average weight gain was 0.96 gram per 24 hours. The alteration in their somatic growth was therefore only a temporary interruption.

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