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Effect of Group Size on Body Weight
in Different Thermal Environments for
Microtus pinetorum

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Seasonal variation in growth rates has been well documented in some small rodents (Kubik, 1965; Brown, 1973; Iverson and Turner, 1974; Peterborg, 1978; Pistole and Cranford, 1983). During winter juveniles tend to show little or no growth; however, Kubik (1965) found that Cleithronomys glareolus born in late fall went through a two-phase growth pattern. Growing rapidly until winter and then resuming rapid growth the following spring. Additionally, Brown (1973) has reported the same two-phase growth in Microtus pennsylvanicus. Iverson and Turner (1974) demonstrated that Microtus pennsylvanicus adults showed a loss of weight during winter, and Pistole and Cranford (1983) have shown that M. pennsylvanicus subadults continued growth under natural winter conditions but at a significantly slower rate than occurs under summer conditions. Additionally, adults lost weight until winter solstice and then gained weight with increasing photoperiod. This data implies a complex relationship between growth, photoperiod, and ambient temperature.

Ambient temperature has also been strongly related to huddling and nest building behavior. Nest building and huddling have been shown to prolong survivorship and enhance tolerance of low temperature exposure in four species of Peromyscus (Sealander, 1952). In Mus musculus huddling reduced food consumption and this effect was greatest when they were exposed to 0-5°C ambient temperatures (Prychodko, 1958). Huddling also lowered O₂ consumption and conserved body heat in several species of voles under laboratory conditions using a modified Morrison respirometer and Kalabaukhov-Shvortzov apparatus (Pearson, 1960; Weigert, 1961; Gebczynski, 1964; Gorecki, 1969; Fedyk, 1971). Gebczynski (1969) showed that in Cleithronomys glareolus larger groups have the highest efficiency of social regulation and it was directly related to ambient temperature.

Huddling should, therefore, indirectly effect growth. As ambient temperature decreases a social species should increase huddling which would lower their individual metabolic costs due to the reduction of exposed surface areas. Reduction in metabolic cost should enable a group of animals to maintain growth or show reduced weight loss when compared to an individual animal.

Since pine voles, Microtus pinetorum, are social, they are a model for studying the effects of huddling on growth, body weight

maintenance, and metabolism under different ambient temperatures. Groups of animals can be housed and maintained under identical conditions to single animals. This permits the direct comparison of the effect of low ambient temperature on grouped and single animals. This study tested grouped and singly housed animals under warm (19°C) and cold (2°C) ambient temperatures for juveniles (25-39 days) and adults (120+ days), monitoring weight change and food consumption to determine the effect huddling behavior had on growth and body weight maintenance.

MATERIALS AND METHODS

Voles (*Microtus pinetorum*), selected from an outbred laboratory colony maintained at V.P.I. & S.U., were separated at weaning by sex and housed in plastic cages (18 by 29 by 12 cm.) containing wood shavings for nesting material with lab blox (Wayne) and water were provided ad libitum. Animals were housed in a controlled environmental chamber (Kysor model CER-12) at 19 + 1°C, or 2 + 1°C on a long photoperiod (LD 16:8). Body weights were determined every three days using an American Scientific digital scale (model B-1240-1), to the nearest 0.1g.

Experiment one had 30 juvenile voles between 25 and 35 days of age with both sexes randomly divided into two unisexual caging groups: singles or trios. Temperature was maintained at 19°C for 10 days (day 1-10), then reduced to 2°C for 13 days (day 10-24), and restored to 19°C for 13 days (day 25-38).

Experiment two used 51 adults with sexes divided into two unisexual caging groups: singles (13 male and 11 female) and trios (5 male and 4 female). Temperature was maintained at 19°C for 10 days (day 1-10), then reduced to 2°C for 13 days (day 11-24), and restored to 19°C for 15 days (day 24-39).

Experiment two was partially replicated to determine food consumption per gram body weight. Wire bottoms (16 by 27 by 1 cm.) were placed in the cages to permit feces and spilled food to be recovered. Nest material provided was a compressed cotton ball approximately five centimeters in diameter. Animals were weighed, placed in clean cages, and maintained at 19°C for 5 days (day 1-5), then transferred to clean cages and maintained at 2°C for 6 days (day 6-12), and subsequently transferred to clean cages and maintained at 19°C for 8 days (day 12-20). To determine the amount of food eaten, pre-weighed oven dried amounts of food were added to the cages daily. Following each experimental period all food, spilled food, and feces were removed and dried to determine consumption.

RESULTS

Body weight dynamics of juveniles in experiment one over the 36 experimental days exhibited continuous growth. Sexes did not differ significantly ($t = -0.54, -0.945, -1.662$; $p > 0.5, 0.5, 0.1$) with respect to body weight in either housing type, by period. Therefore, data for both sexes was pooled for analysis of weight change within each housing type. Mean body weights of singly and multiply housed voles were compared using a two-sample t-test during the initial warm, cold, and final warm periods. During each of the periods mean body weight of singly housed voles ($\bar{x} = 20.64 + 4.08, 22.16 + 3.52, 25.10 + 2.93$) did not significantly differ ($t = 1.017, 0.98, 0.443$; $p > 0.3, 0.3, 0.5$) from mean weights of multiply housed voles ($\bar{x} = 22.14 + 3.62, 23.51 + 3.58, 25.85 + 5.15$). Between periods singly and multiply housed voles showed significant increases ($t =$ singles; 3.36, 5.73; multiples; 6.05, 3.76; $p < 0.01, 0.001, 0.001, 0.01$) in body weight through the experiment.

Growth rates in experiment one were calculated using weight change (grams) over time (days). Sexes did not significantly differ ($t = 0.79, 0.68, 0.66$; $p > 0.5$) with respect to growth rate in either housing type, by period. Therefore, data for both sexes was pooled for growth analysis within each housing type. Mean growth rates for both housing types were compared using a two-sample t-test during the three periods. During the initial warm period multiply housed voles grew significantly faster ($t = 2.28$; $p < 0.05$) than singly housed voles. However, during the other two periods there was no significant difference ($t = 0.24, 0.56$; $p > 0.5$) in the rate of growth between housing types. In addition, growth rates were compared between periods using a two-sample t-test. Singly housed voles' growth rates in the initial period were not significantly different ($t = 0.08$; $p > 0.5$) from those in the cold period. Cold period growth rates were significantly lower ($t = 2.23$; $p = 0.05$) than the final warm period rates. Multiply housed voles' growth rates in the initial period were significantly higher ($t = 3.94$; $p < 0.01$) than those in the cold period, however cold period growth rates (although high) were not significantly different ($t = 0.72$; $p > 0.4$) from the final warm period rates.

Body weight changes of adults in experiment two over the initial warm period did not differ but in the cold period they exhibited a weight loss while in the warm period they exhibit a steady weight recovery. Sexes did not differ significantly ($t = 0.48, 0.591, 1.206$; $p > 0.5, 0.5, 0.2$) with respect to body weight when singly housed or multiply housed ($t = 0.642, 0.784, 0.443$; $p > 0.5$). Data for both sexes was pooled and mean body weights for both housing types were compared using a two-sample t-test during all periods. During each of the periods the mean body weights did not differ significantly ($t = 1.89, 1.957, 0.71$; $p > 0.05, 0.05, 0.4$) between the two housing types. Body weights

were then compared between periods using a paired t-test. In both housing types mean body weights during the initial warm period were significantly higher ($t = 4.97, 2.51; p < 0.02$) than those during the cold period. Cold period weights were significantly lower ($t = 2.34, 2.41; p < 0.05$) than those during the final warm period.

Growth rates in experiment two were determined during the cold and final warm periods. Sexes did not differ significantly ($t = 0.85, 0.88, 0.43; p > 0.4, 0.4, 0.5$) with respect to growth in either period or in either housing type. During the cold period, multiply housed voles lost weight at a significantly slower ($t = 3.15; p < 0.01$) rate than singly housed voles. During the final warm period, there was no significant difference ($t = 0.21; p > 0.5$) in the rate of weight gain between the two housing types.

Food consumption in experiment two was calculated on a gram per gram body weight basis. Food consumption for both housing types was compared using a two-sample t-test during all periods. In all three periods, there was a significant difference ($t = 2.32, 2.73, 2.47; p > 0.02, 0.02, 0.02$) with respect to food consumption between the two housing types with grouped voles eating significantly less in the cold environment. Comparisons between periods showed that food consumption in the initial warm period was significantly lower ($t = 3.76; p < 0.01$) than in the cold period while the final period had an intermediate rate between the first two periods.

DISCUSSION

Body weight change and growth rates show significant differences between juvenile and adult response's to cold thermal environments. Juveniles show continuous growth while adults lost weight during the cold period. This growth pattern corresponds with the growth patterns Pistole and Cranford (1983) found for Microtus pennsylvanicus and Peterborg (1978) found for Microtus montanus. In M. pennsylvanicus and M. montanus (Pistole and Cranford, 1983 Peterborg, 1978) the use of photoperiod as a cue for these physiological changes has been reported. This experiment suggests that Microtus pinetorum uses ambient temperature as the cue for these physiological changes. This agrees with the ecology in so far as M. pinetorum is a burrower not a meadow dweller like the other two species, therefore temperature changes could be a more reliable cue than photoperiod.

In the food consumption experiment performed on adults there was a significant difference between the rate of consumption in the initial warm and the cold period. At low temperatures animals ate more to maintain body temperature yet this still

resulted in a reduction of body weight. This implies that they either are eating at a maximal rate or they are not and body weight loss is adaptive during cold periods. Food consumption was higher in singly housed voles than multiply housed voles with the difference approaching significance during and after the cold period. As food consumption was not maximal for grouped voles, body weight loss appears to be adaptive when groups are exposed to thermal stress.

Unfortunately singly and multiply housed voles did not consistently differ from each other in body weight changes or growth rates. In the first experiment the sample size was small and from the data it appears that some of the groups were not entirely social because one member maintained a considerably lower body weight than the other's. Gorecki (1969) observed a difference in nest utilization between pairs and quadruples in Cleithronomys glareolus which may explain this data but no observations were made in this study. Experiment two had a larger sample size and although some groups did not appear cohesive, the results for weight changes were much closer to being significantly different.

Multiply housed females had a much lower mortality than any of the other groups. In addition, multiply housed females differed from multiply housed males by a greater degree in body weight and growth rate changes than singly housed females differed from singly housed males. Together this data can be interpreted to indicate that females form better huddling groups than males. This may be understood by looking at the population dynamics. Fitzgerald and Madison (1981) have shown that free ranging pine voles exist in discrete non-overlapping family units with an average of 3 or 4 adults which agrees with our findings on optimal group size. In addition, they found that females spent more time in or near the nest than males. Hence, although a high degree of social tolerance exists in both sexes of the same family group, one could propose that females would have more contact with one another and so be more socially tolerant of other individuals than males.

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