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Age and Huddling as Determinants of Metabolic Rate in Grasshopper Mice (Onychomys leucogaster)

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Age and Huddling as Determinants of Metabolic Rate In Grasshopper Mice *(Onychomys leucogaster)*

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ABSTRACT

The metabolic rates of grasshopper mice *(Onychomys leucogaster)* were determined every third day from birth to adulthood. Metabolic rates were quantitated by measuring oxygen consumption in an open circuit system. There was a rapid fall in oxygen consumption from the third day after birth until the ninth day. Mice which were housed separately assumed a constant metabolic rate at an earlier age than mice which were kept with litter-mates. The greatest increases in metabolism occurred when immature mice were separated from litter-mates for oxygen consumption determinations. It is concluded that huddling plays an important role in reducing the metabolic rate of young grasshopper mice.

INTRODUCTION

It is well known that metabolism varies inversely with the size of a homeothermic animal. This is particularly evident when comparing the young and adult animals of a single species; for example, studies involving rats (Benedict and MacLeod, 1929) have demonstrated that oxygen consumption is greater at two months of age than at four months. Likewise, Davis and Hastings (1934), working with rats, observed a 34% decrease in oxygen consumption from the second to the fourth month of age. In a related study McCashland (1951) found a 57% decrease in the oxygen consumption of rats from the thirteenth to the twenty-ninth day of age. These reports all suggest great metabolic changes during the period of rapid growth in rats.

There is some controversy in the literature concerning the effect of huddling on the oxygen consumption of young mammals. Hill and Hill (1913) showed that, when two-month old rats were placed together in a calorimeter, their heat production dropped below that of rats studied singly. Taylor (1960) found only slight decreases in oxygen consumption as a result of huddling in 48 hr old mice. Finally, Fitzgerald (1953) measured a decrease in the oxygen consumption of young mice as the ambient temperature was lowered. From this observation he predicted that huddling would tend to increase the ambient temperature and, thus, the oxygen consumption of young mice.

The objectives of our study were twofold. First, to follow the changes in oxygen consumption and general metabolic pattern of the grasshopper mouse (*Onychomys leucogaster*) from three days of age to the adult. Secondly, to observe the effects of huddling on the oxygen consumption of young grasshopper mice.

MATERIALS AND METHODS

The Northern grasshopper mice (*Onychomys leucogaster*) used in this study were first generation offspring of adults captured in June 1976 in Quay County, New Mexico. The mice were housed in polypropylene cages and were provided with Aspen bedding. Food (Purina Labchow 5008) and water were provided *ad libetum*.

Experimental animals were arranged in two groups. Group 1 consisted of two female litter-mates which were weaned before metabolic determinations were started on the eighteenth day after birth. Metabolic determinations were performed every third day until the animals were 102 days old. The animals were grouped for the first two determinations only, thereafter they were housed spearately, and all subsequent determinations were performed on single individuals. Group 2 consisted of five litter-mates (four female, one male). Metabolic determinations for Group 2 started on the third day after birth and continued every third day for 97 days. The first seven determinations were performed on the five mice grouped together, and subsequent measurements were done on individual mice. The litter-mates in Group 2 were housed as a group and were kept with their mother throughout the experimental period.

Metabolic determinations were performed by measuring oxygen consumption in an open circuit system. During the measurements the mice were confined in a cylindrical Plexiglas chamber (22.9 cm long, 8.9 cm diameter). In order to minimize the possibility of disturbing the mice during a measurement, the chamber was covered with a sheet of black plastic, and cotton was provided for nesting material.

A low-pressure pump was used to push air through a tube containing water absorbent (Drierite) and into one end of the chamber. The air passed through the chamber, exiting at the opposite end, and flowed through a rotometer for measuring and adjusting flow rate. Flowing at 100 ml/min, the air was passed through a second tube of Drierite and entered a Beckman Model E2 oxygen analyzer.

Mice were placed in the chamber and allowed to acclimate for a 15 min period before measurements were taken. Oxygen uptake was measured for 5 min periods, and five consecutive measurements were made on each mouse or group and the results averaged. After the measurements, the mice were weighed to the nearest 0.5 g.

Recording started when the rate of oxygen uptake reached its lowest steady level. Occasionally a mouse would become active during a metabolic determination, and its oxygen uptake would be elevated and erratic. In such cases recording was delayed until the oxygen uptake stabilized at or near a resting level. From the resting oxygen uptake and the rate of air flow, the oxygen consumption was calculated in terms of ml of oxygen consumed/hr/g with all values being corrected to s.t.p.

RESULTS AND DISCUSSION

Figures 1 and 2 show the metabolic pattern of the two groups of grasshopper mice from early life to the adult. There was not a detectable difference between the oxygen consumption of the female mice and the single male in Group 2, which is in agreement with the results of Kibler and Brody (1942) in young rats.

From day three to approximately day 70, the oxygen consumption of the grasshopper mice remained essentially constant throughout both day and night. This is probably due to the fact that the young mice had not yet developed nocturnal activity patterns characteristic of the adults. After day 70 the oxygen consumption was considerably elevated during nighttime hours, thus it was necessary to confine metabolic determinations to the late morning and early afternoon hours (times when grasshopper mice are normally in a quiescent state).

An increase in oxygen consumption shortly after birth has been demonstrated in a variety of mammals. This increase has been shown to be two-to-threefold in lambs (Dawes and Mott, 1959), monkeys (Dawes et al., 1960), dogs (Gelineo, 1957) and mice (Fitzgerald, 1953). Similarly, in our study, the oxygen consumption of the grasshopper mice in Group 2 fell from a value of 2.51 ml/hr/g on day 3 to 1.28 ml/hr/g on day 9 (Figure 2). This decrease in metabolism coincided with the first appearance of a slight covering of fur on day six. By day eight the dorsal fur was velvety and dark, and white fur

covered the ventor. The fur provided an insulatory effect by maintaining an unstirred layer of air next to the skin, thus aiding the 9-day old mice in coping with the lower temperatures of the metabolic chamber without increasing their metabolism.

The metabolic rates of the animals in Group 1 reached an adult level at an earlier date than did those of Group 2 (Figures 1 and 2). This is explained by the fact that the animals in Group 1 attained their maximum adult weights by day 66 while the animals in Group 2 were not fully grown until day 80. These unequal growth rates are a reflection of dietary differences between the two groups. The mice in Group 1 were weaned early (day 18) and, thus, were forced to utilize the exogenous food supply provided them. The mice in Group 2, on the other hand, grew at a slower rate because they relied on the diminishing supply of maternal milk for a greater period of time before turning to the exogenous food supply.

The most pronounced increases in metabolism were evidenced when the mice were separated for the first time on day 24 for the oxygen consumption determinations (Figures 1 and 2). The increased metabolic rates observed after day 24 were most likely a response to a reduction in temperature when moving from the nest to the metabolic chamber. According to observations by Mourek (1959) and Taylor (1960) the average nest temperature for small rodents lies between 30 and 32°C. The mean temperature and standard deviation for the 68 oxygen consumption measurements in our study was 24.8 ± 1.6°C. The increased oxygen consumption in response to lowered ambient temperatures would be necessary to promote additional heat production to maintain a constant deep-body temperature. Thus, grasshopper mice, even at the very early age of 24 days, are quite capable of thermoregulation.

The increased metabolism which we observed in response to lowered temperatures agrees with the results of Lagerspetz (1966) and Stanier (1975) who found that during a fall in ambient temperature from 35 to 30°C, young white mice demonstrated increased motor activity and oxygen consumption. It also agrees with observations by Taylor (1960) who showed that rats, as young as 4 hours, respond to a reduction in ambient temperature by increasing oxygen consumption. Our results are, however, at variance with those of Fitzgerald (1953) who measured a fall in the oxygen consumption of young mice as the ambient temperature was lowered from 35 to 30°C.

Hill (1976) found that young *Peromyscus leucopus* could maintain normal body temperatures in the nest, but when individuals were removed from the presence of litter-mates their body temperatures declined. In the grouped grasshopper mice of our study the effect of huddling would help to maintain the elevated temperatures characteristic of the nest, which in turn would bring down the oxygen consumption per animal, as compared to that of solitary litter-mates. According to Fitzgerald's hypothesis the huddling of grouped mice would have had the opposite effect, tending to raise the oxygen consumption.

The effect of huddling to lower metabolism which we observed is of importance for survival in a natural habitat. The huddling of young mice would help maintain an elevated nest temperature even when the mother is away. This would have an important energy conserving effect by reducing the amount of energy spent on heat production to maintain a constant deep-body temperature.

The mice in Group 1 did not demonstrate as pronounced an increase in oxygen consumption as a result of a separation as did those in Group 2. The mice in Group 1 were housed separately beginning on day 24. The mice in Group 2, however, were only separated for the actual oxygen consumption measurements and afterwards were returned to their mother and litter-mates. The greater increase in oxygen consumption witnessed in Group 2 is probably the result of the added trauma induced by removal from the nest for the metabolic determinations.

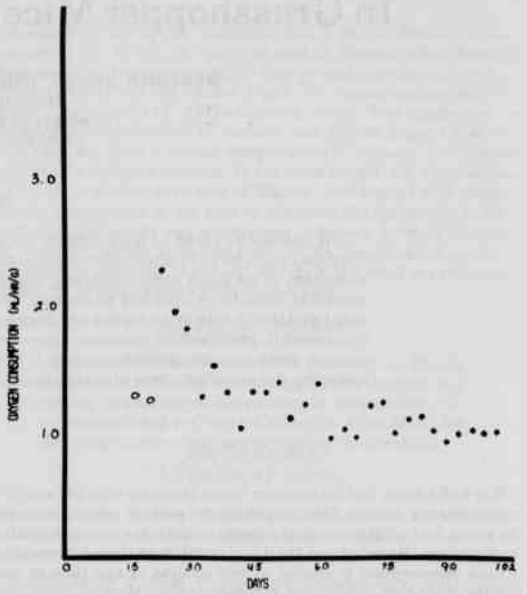

Figure 1. Oxygen consumption determinations for Group 1. Open circles represent the means of measurements made on grouped mice, closed circles represent the means of measurements on individual mice.

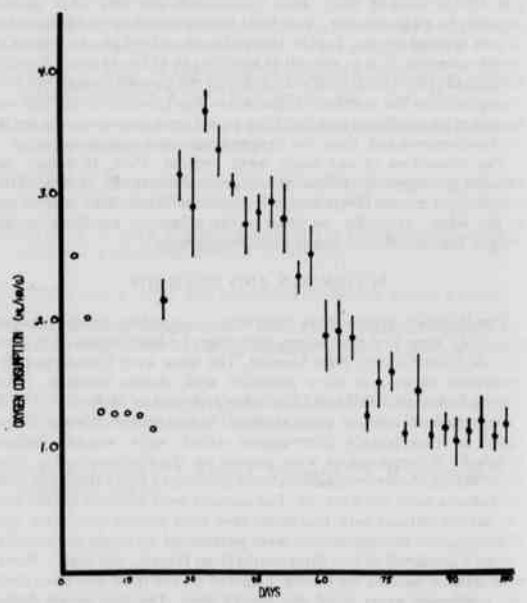

Figure 2. Oxygen consumption determinations for Group 2. Open circles represent the means of measurements made on grouped mice, closed circles represent the means of measurements on individual mice. Vertical lines denote standard deviations.

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