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Metabolic Rates of Peromyscus maniculatus in Winter, Spring and Summer

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Stebbins L. L., Orich R. & Nagy J., 1980: Metabolic rates of *Peromyscus maniculatus* in winter, spring and summer. Acta theriol., 25, 9: 99—104 [With 1 Table & 1 Fig.].

Metabolic levels of 4 male *Peromyscus maniculatus*, caged from November through July in the semi-natural environment, were measured in a single respirometer also kept outside and exposed to natural meteorological conditions. For tests, conducted in January, April, and July, mice were placed in the respirometer and allowed to adjust for 2 days. The O_2 consumption was measured at 7 minute intervals for the succeeding 3 days. Average daily metabolic rates, expressed as ml. O_2/gm./hr., were 26% higher in January than in April and 27% higher in April than in July. Resting metabolic rate, expressed similarly, was 31% higher in January than in April and 19% higher in April than July.

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INTRODUCTION

The deer mouse, *Peromyscus maniculatus*, when caged in winter under nearly-natural meteorological conditions, employed several of the standard mechanisms to conserve energy (Stebbins, 1978). This observation raises the question of whether this species, under the test conditions described, uses the energy thus saved to increase thermogenesis. Purpose of the present study is to answer that question by measuring metabolic levels of deer mice acclimatized to and maintained under semi-natural environmental conditions similar to that reported in Stebbins (1978). Though this species can become torpid, no torpor was seen during these studies.

METHODS

Oxygen consumption of four adult male deer mice born in captivity from stock captured the previous summer in mountains 90 miles west of Lethbridge, Alberta, was studied. Animals used were held together in a wire mesh cage of dimensions 90 centimeters by 45 centimeters by 45 centimeters placed on the

forest floor in a popular grove one mile south of Lethbridge between November 20, 1969, and July 31, 1970. They were given a nest box of dimensions 14 centimeters by 8 centimeters by 8 centimeters, terylene fiber for nesting material, Purina Lab Chow *ad libitum* and water or snow. In winter, snow filled the cages. Except for bimonthly feeding, monthly cleaning, and removal for metabolic studies, the test animals were left undisturbed.

For metabolic studies, conducted January 12 to 15, April 23 to 25, and July 14 to 16, animals were removed from their holding cage, weighed and placed together in a plexiglass chamber of dimensions 25 centimeters by 20 centimeters by 20 centimeters. The chamber was placed in the poplar grove shielded by cardboard from direct sunlight adjacent to a trailer in the grove which housed the analytical equipment. The deer mice were given a nest box with .5 centimeter holes in the sides to allow for air flow. Purina Lab Chow, nesting material, and water or snow were provided and animals were allowed to adjust to their new surroundings for 48 hours prior to testing. A thermistor was placed in the chamber and temperature was recorded on a telethermometer in the trailer. A previous report (Stebbins, 1978) has indicated that four deer mice maintained in a similar nest box exposed to similar temperature ranges maintain nest temperatures similar to those existing naturally in winter (Hayward, 1965).

For recording oxygen consumption an open system employing a Beckman oxygen analyser was set up as described by Hayward (1965). Oxygen consumption was calculated by the method of Depocas & Hart (1957) using the following formula:

$$VO_2 = \frac{V_E\ (\%IO_2 - \%EO_2)}{100}$$

VO_2 =oxygen consumption in cubic centimeters of oxygen per minute

V_E =flow rate of inlet gas in cubic centimeters per minute (measured continously with a stop watch and Wet Test Flow Meter)

$\%IO_2$ =percentage of oxygen in inlet gas (measured every three hours)

$\%EO_2$=percentage of oxygen in outlet gas (measured at $7^1/_2$ minute intervals)

Each reading was converted to a value representing oxygen consumed per gram of mouse per hour. These values were then grouped by hour and values for any given hour for all three days of the experiment were combined, averaged, and graphed on a 24-hour basis. Student's test was used to test for significance between average values.

Energy expenditure in kilocalories was calculated assuming a respiratory quotient of 0.80 and a caloric equivalent of 1 liter of oxygen used equalled an energy expenditure of 4.8 kilocalories (Scholander *et al.*, 1950; Grodziński & Górecki, 1967). Using this procedure, oxygen consumption values were converted to kilocalories expended/averaged size animal/day. All values for any given hour for each day of the experiment were averaged, and graphed on a 24-hour basis.

Further, both oxygen consumption and energy expenditure values were used to compute an average daily metabolic rate (*ADMR*) and an average resting metabolic rate (*RMR*). This was done by averaging respectively all values for every hour of the experiment and all values for hours in which metabolism was generally at or near the lowest levels of the day. It should be noted here that the higher levels of metabolism were nocturnal in each season, giving a circadian periodicity similar to the daily rhythm of activity in this species (Stebbins, 1971).

RESULTS

Mean weight of test animals and temperature ranges and means in the metabolic chamber are given in Table 1.

Oxygen consumption expressed as kilocalories/animal/day and as millititers of oxygen/gram/hour is given in Figure 1. In January, the metabolic rate, expressed as kilocalories/animal/day, was significantly higher at the 1% level than corresponding values for July for every hour of the day except hour 0400 and 0500. Values for January were also

Table 1

Metabolic rates of four deermice housed in one nest box in a metabolic chamber exposed to natural meteorological conditions in the seminatural environment.

	January 12—15	April 23—25	July 14—16
mean wt. of animals	21.9 gr.	23.2 gr.	30.2 gr.
mean temperature *	−17.7°C	+8 to +22°C	+20.6°C
temperature range	−6 to −22°C	14.45 + .81	+14 to +32°C
ADMR (kcal./mouse/day)	14.62 ± .54**	14.45 ± .81	10.88 ± .50
ADMR (ml. O_2/gm./hr.)	5.76 ± .22	4.26 ± .30	3.12 ± .14
RMR (kcal./mouse/day)	11.94 ± .32	8.68 ± .36	9.24 ± .26
RMR (ml. O_2/gm./hr.)	4.67 ± .12	3.21 ± .10	2.66 ± .08
Hours involved *RMR*	0900—1800	0700—2100	0700—2100

* Temperature inside metabolic chamber outside next box,
** Mean ± one standard error of the mean.

significantly higher at the 1% level than corresponding values for April, except during hours 0200 through hour 0500. During hours 0200 through 0500 values for April were significantly higher at the 1% level than corresponding values for January. Quite high levels of activity occurred during these particular hours in April while very little activity occurred in January (unpublished data, available from the Department of Biological Sciences, University of Lethbridge).

Expressed as milliliters of oxygen/gram/hour, every value for January is significantly higher than the corresponding values for the other two months except that during the higher point of activity, hours 0200 through 0500, in April. All values for April are significantly higher at the 1% level than the corresponding values for July, with the exception of hour 1600.

Average daily metabolic rates and resting metabolic rates are given in Table 1. Resting metabolic rate expressed as kilocalories/animal/day was significantly higher at the 1% level in January than in April and July; expressed as milliliters of oxygen/gram/hour, differences between all values were significant at the 1% level. Average daily metabolic

rate, expressed as kilocalories/animal/day, was significantly higher at the 1% level in January than in April and July; expressed as milliliters of oxygen/gram/hour, differences between all values were significant at the 1% level.

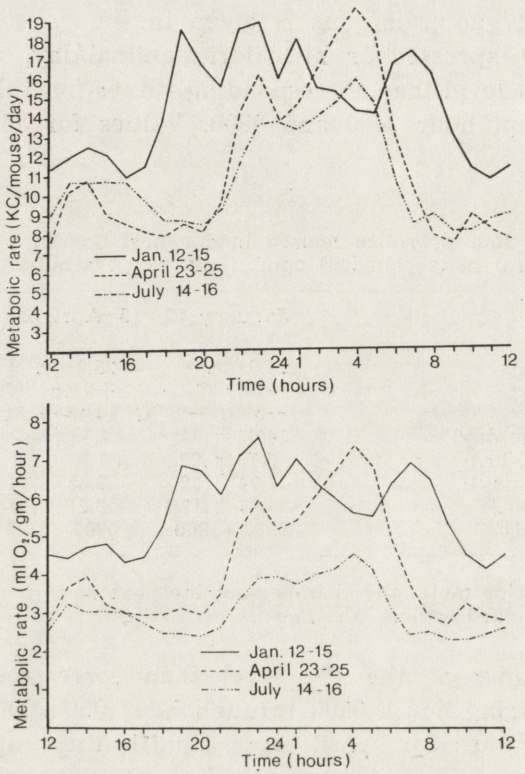

Fig. 1. Mean metabolic rates of four adult male *P. maniculatus*. Measurement was taken every seven minutes for three days and averged on an hourly basis. During the tests, animals were housed in a single nest box in a small plexiglass chamber exposed to natural meteorological conditions.

DISCUSSION

Higher metabolic rates recorded in winter presumably reflect increased thermoregulatory demands. But increased metabolism, being just one of many adaptive changes comprising acclimatization to winter in small mammals, must be viewed in a wider context. Acclimatization to winter also involves, among non-hibernating species, a variety of behavioral, anatomical, and physiological changes which act to save energy. Among these adaptive changes are reduced rates of growth (Kalela, 1957; Sealander, 1966, Stebbins, 1976), actual reductions in body weight (Mezhzherin & Melnikova, 1966), smaller body size in

winter (Schwartz *et al.*, 1964; Fuller, 1969), increased insulation from pelage (Hart *et al.*, *1956;* Sealander, 1972; Hinds, 1973), decreased activity (Stebbins, 1971, 1972), nest building changes (Glaser & Lustick, 1957; Pearson, 1960; Thorne, 1958; Wolfe, 1970), huddling (Howard, 1951; Pearson, 1947; Sealander, 1952), use of snow cover for thermal protection (Coulianos & Johnels, 1962), food hoarding (Eisenberg, 1968), and decreases in body lipid content and in size of several viscreal organs (Lynch, 1973). One adaptive strategy of these many processes may be the channeling of more energy into thermogenesis. Results reported here suggest *P. maniculatus* does just this.

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METABOLIZM *PEROMYSCUS MANICULATUS* W RÓŻNYCH SEZONACH

Streszczenie

Poziom metabolizmu 4 samców *Peromyscus maniculatus* trzymanych w klatce od listopada do lipca włącznie, w półnaturalnych warunkach, mierzono w respirometrach trzymanych na zewnątrz (Ryc. 1). Do doświadczeń, prowadzonych w styczniu, kwietniu i lipcu zwierzęta umieszczano w respirometrze na 2 dni w celu adaptacji. Zużycie O_2 było mierzone co 7 minut przez 3 doby. Średni metabolizm dobowy wyrażony w ml O_2/g/godz., był o 26% wyższy w styczniu niż w kwietniu i o 27% wyższy w kwietniu niż w lipcu. Metabolizm spoczynkowy był o 31% wyższy w styczniu niż w kwietniu i 14% wyższy w kwietniu niż w lipcu (Tabela 1).