A C T A T H E R I O L O G I C A

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Metabolic Rate of the Lesser Mole Rat*

[With 3 Tables & 2 Figs.]

In 8 specimens of the Lesser mole rat deriving from the region of Petrochan (Bulgaria) the basal metabolism rate (*BMR*), resting metabolism rate (*RMR*), and average daily metabolism rate (*ADMR*) were studied. *BMR* determined in the ambient temperature of 30°C was equal to 0.63 ccm O_2 per g × hr, or 46.4 kcal/kg$^{0.75}$ × 24 hr. Its dependence on the body weight (*W*) is described by the equation: $M = 1.41 W^{-0.16}$. *RMR* studied in the range of 0—35°C rised from 0.85 to 2.68 ccm O_2 per g × hr, and hence showed an increase of 0.05 ccm O_2/g × hr × °C. *ADMR* determined in 20°C in daily measurements was equal to 1.37 ccm O_2 per g × hr. The relationship between *ADMR* and body weight is illustrated by the equation: $M = 3.91 W^{-0.21}$. Daily energy budget calculated for this rodent amounted to 0.220 kcal per g × day in winter and to around 0.170 kcal per g × day in the remaining seasons. With the maximum population density, approximately 9 specimens/ha, the dissipation energy by this population will approach on the average 327 kcal/ha × day.

I. INTRODUCTION

One of the most interesting group of rodents consists of fossorial rodents. The Lesser mole rat (*Spalax leucodon* Nordmann, 1840), is a typical example of this group.

The physiology of these animals, closely associated with their subterranean life in a relatively warm environment, is rather poorly understood (McNab, 1966; Nevo, 1961; Kowalski & Skoczeń, 1963). Only the resting metabolic rate (*RMR*) was studied by Savić (1965 MS) [1]) on a relatively large material. The data concerning the basal metabolism rate (*BMR*) are meagre and obtained with very few animals (McNab, *l.c.*).

Thus it seemed advisable to investigate both the basal metabolism as well as the resting and average daily metabolism rate of these interesting animals.

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[1]) Savić J. R., 1965: Ekologija viste *Spalax leucodon* Nordmann, 1840 (*Rodentia*) u Jugoslaviji. Ph. D. thesis. 100 pp. Belgrad. The authors are greatly indebted to Dr. J. R. Savić for rendering his manuscript available.

II. MATERIAL AND METHODS

The range of Lesser mole rat in Europe includes the area of Yugoslavia, Hungary, Roumania and Ukraine. In some regions in Bulgaria the Lesser mole rat is reckoned among quite common rodents (Petrov, 1954; Straka, 1964; Markov, 1964).

The Lesser mole rats used in the investigations derived from the region of Petrochan (Stara Planina, 43°6′ N, 23°8′ E, 1414 m above sea level) in the north-western part of Bulgaria. The experiments were carried out on 8 specimens (4 ♀♀, 4 ♂♂) in a few days after their capture and transport to Poland. In the laboratory they were kept in cages (40 × 32 × 25 cm) or in terraria filled partially with soil, at the ambient temperature of 20°C and with 12 hours light rhythm. The animals were fed with oats, wheat, carrots, beets, potatoes, as well as with lucerne roots and apples. They were also supplied with drinking water.

All the measurements were carried out in October and November 1968. The determinations of resting metabolism rate were made in 1 liter chambers connected with a modified Kalabukhov — Skvortzov respirometer (Górecki, 1968). *RMR* was estimated from oxygen consumption in 5 ambient temperatures: 0, 10, 20, 30 and 35°C. The measurement lasted for 60—90 min. After every run the animal was weighed and its rectal temperature was recorded. Six to eight animals were used to measure of *RMR* in every ambient temperature. On the whole 37 measurements of resting metabolism rate were completed.

The Morrison respirometer was employed at 20°C to determine the average daily metabolism rate (*ADMR*) (Morrison & Grodziński, 1968) and basal metabolism rate (*BMR*). In case of *ADMR*, however, there were used large chambers, approximately 17 l in volume (43 × 27 × 21 cm). The animal was supplied there with the nest house and food. Before and after every 24 hr measurement the weight of the animal and its rectal temperature were determined.

III. RESULTS

Basal metabolism rate (*BMR*) of Lesser mole rats measured in the respirometer in 30°C amounted for animals of average body weight (178 g) to 0.626 ccm O_2 per g × hr, or after computation for heat production to 46.4 kcal/kg$^{0.75}$ × 24 hr (Table 1). The conversion of oxygen consumption to calories was based on the respiratory quotient $RQ = 0.82$, which corresponds to 4.8 kcal per 1 l of oxygen.

The relationship between basal metabolism (*M*) and body weight (*W*) is described by the following regression equation:

$$M = 1.41\ W^{-0.16}$$

Basal metabolism was also calculated from the formula of Kleiber (1961): $M = 3.42\ W^{-0.25}$ for animals of the same body weight. The obtained value was markedly higher and equal to 0.964 ccm O_2 per g × hr (Fig. 1, Table 1).

If the equation employed in the present study is transformed assuming the value of exponent equal to —0.25 (Kleiber, *l.c.*), then the following relationship is obtained: $M = 2.21\ W^{-0.25}$. It is clear that the difference between the value of this function, and that of Kleiber (1961) exceeds 50%.

Resting metabolism rate decreased by 0.052 ccm/g × hr × °C within the

Table 1.

Comparison of basal, resting and average daily metabolism rate in Lesser mole rat.

Metabolism	°C	N	Body weight in g ± S.E.	Oxygen consumption ccm/g × h ± S.E.	$kcal/kg^{0.75} \times 24h$	Per cent
Experimental *BMR*	30	6	177.9 ± 16.6	0.63 ± 0.02	46.4	100
Predicted *) *BMR*	—	6	177.9 ± 16.6	0.96 ± 0.03	71.8	155
RMR	20	8	194.0 ± 15.8	1.10 ± 0.08	83.8	181
ADMR	20	8	200.2 ± 16.3	1.37 ± 0.21	104.6	225

Calculated from equation: $M = 3.42\ W^{-0.25}$ (Kleiber, 1961).

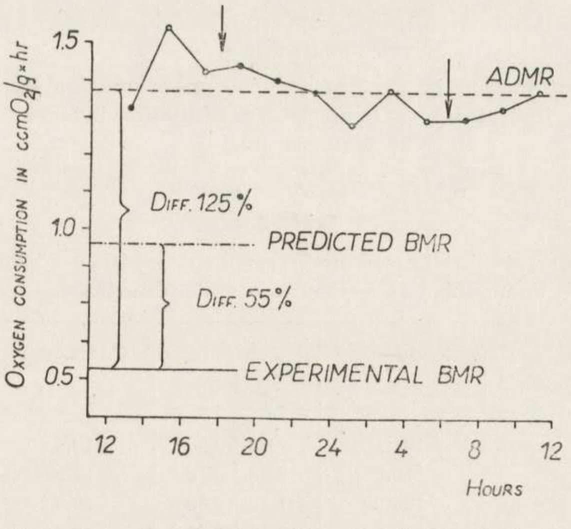

Fig. 1. Daily rhythm of oxygen consumption, basal metabolism rate and average daily metabolism rate in Lesser mole rat. Arrows indicate length of day.

whole range of ambient temperatures. This decrease was more significant and amounted to 0.079 ccm O_2/g × hr × °C between 0 and 20°C, whereas between 20 and 35°C the corresponding figure was equal to 0.017 ccm O_2 per g × hr × °C (Fig. 2, Table 2). Body temperature of the animals was almost constant in the whole studied range of ambient temperatures and equal to 37.7°C on the average (Table 2). Insulation index computed from the formula of H a r t and H é r o u x (1955):

$$Ii = \frac{\text{Body temperature} - \text{Ambient temperature}}{\text{Oxygen consumption}}$$

was fairly uniform in the whole range of ambient temperatures and varied between 7 and 14 (Fig. 2).

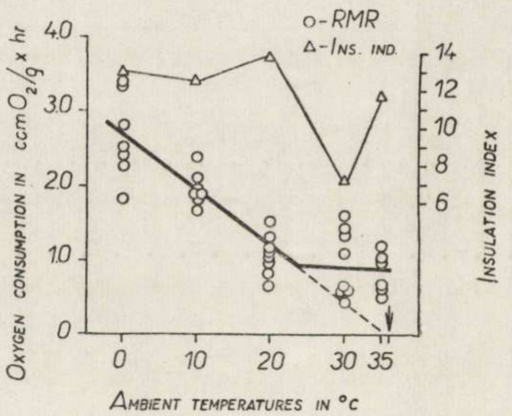

Fig. 2. Oxygen consumption in *Spalax leucodon*, as a function of ambient temperature. The arrows indicates body temperature. Insulation index in various ambient temperatures.

Table 2.

Resting metabolism rate in Lesser mole rat expressed by oxygen consumption under various environmental temperatures.

Ambient temp., °C	No. of animals	Body wt in g	ccm/g/h ± S.E.	Coeff. var. %	Body temp. in °C
0	7	191.1	2.68±0.20	19.6	35.4
10	8	210.7	2.10±0.13	17.2	35.6
20	8	194.0	1.10±0.80	20.9	36.0
30	8	199.6	1.00±0.02	8.0	35.9
35	6	208.1	0.85±0.04	10.6	35.7

Average daily metabolism rate reached the highest value when determined at 20°C. The Lesser mole rat of average weight around 200 g consumed 1.37 ccm O_2/g × hr, or after computing for heat production 0.158 ± 0.002 kcal/g × 24 hr (Table 1). The relationship between oxygen consumption (M) and body weight (W) of Lesser mole rats was also calculated for *ADMR* and it can be described by the following function:

$$M = 3.91\ W^{-0.21}$$

The ratio of metabolism during the period of activity, to the metabolism during the rest (usually the sleep of the animal), calculated for 2 hr intervals amounts to 2.26 ± 0.20. The minimum metabolism was equal to 1.05 ccm O_2/g × hr, the maximum to 2.37 ccm O_2/g × hr. The daily activity rhythm was multiphase with a marked peak around 4—6 p.m. (Fig. 1).

IV. DISCUSSION

1. Daily Energy Budget

By employing the *ADMR* values one can easily construct a model of daily energy budget (*DEB*) of Lesser mole rat (Grodziński & Górecki, 1967; Górecki, 1968). An attempt of calculation of such budget for the period of autumn, when the measurements of *ADMR* in Lesser mole rats were carried out, is presented below.

This species is active for approximately 56% of time out of 24 hours and shows a typical multi-phase pattern of activity (Savić & Mikes, 1967; Veselinka, 1968). With an assumption that the temperature

Table 3.

Daily energy budget (*DEB*) in Lesser mole rat during autumn day.

	kcal/g × 24 h
ADMR in the nest (20°C)	10.5 h × 1.37 ccm O_2/g × h = 0.069
Metabolic rate during period of out-of-the nest activity (15°C)	13.5 h × 1.60 ccm O_2/g × h = 0.104
Corrected *ADMR* value × average body weight	0.173 200.2 g
DEB in kcal/animal × day	34.63

of underground channels of the burrow approaches 15°C in the autumn (at 1414 m above sea level), the Lesser mole rat dissipates approximately 0.104 kcal/g during the period of activity (Table 3). During a rest the animal requires only 0.069 kcal/g. Hence on the whole the adult Lesser mole rat dissipates approximately 34.6 kcal during 24 hr (Table 3).

Seasonal differences of such physiological parameters as intensity of heat production and body insulation are strongly pronounced. Also the environmental conditions are quite variable during the year cycle with extreme differences in the winter and summer. In the period of summer the *DEB* value will be similar or only slightly lower than the presented above, because some reduction of energetic expenses for the cost of thermoregulation will be counterbalanced by the cost of reproduction (Samarskij, 1962). This last value includes the costs of pregnancy and lactation, which are quite large, and as an example in the bank and common voles amount on the average to 70% of energy requirements (Kaczmarski, 1966; Trojan & Wojciechowska, 1967; Migula, 1969).

The number of Lesser mole rats in some regions in Bulgaria approaches from 1 to 4 specimens per ha (Straka, 1964). In the lucerne fields their numbers may reach even 9 specimens/ha (Markov, 1964). Assuming that the winter energy expenses are around 0.220 kcal/g × day, and the spring and summer budgets are similar to the autumn one (Table 3), then the dissipation of energy by such population in an average day of the year will exceed 327 kcal/ha. During the whole year this value will amount to almost 120 thousand kcal/ha.

2. Metabolism Rate in the Lesser Mole Rat

The absolute level of resting metabolism rate determined in the present study can be compared with the results obtained by Savić (1965, MS) for the Lesser mole rat in Yugoslavia. The *RMR* value reported by that author is slightly higher, but after a correction for the body weight is applied the difference does not exceed a few per cent. Almost identical is the temperature-metabolism curve obtained by McNab (1966), although it derived from an experiment with one specimen only.

An interresting phenomenon from the physiology of fossorial rodents depends on the fact that metabolism determined experimentally in conditions close to basal ones is lower than that calculated from Kleiber's (1961) equation for animals of the same body weight. In other groups of rodents this relationship is just reverse. McNab (1966) found that in the Lesser mole rat the *BMR* value was only 86% of the expected one. In the present study even lower value of basal metabolism was obtained amounting to barely 66% of the expected metabolism rate.

Temperature in the burrow of Lesser mole rat living in warm regions is rather high, and the relative humidity of the air is even higher (McNab, 1966). These may lead to some difficulties in the exchange of the produced heat. Thus the low level of basal metabolism in fossorial rodents represents probably one of the physiological adaptations reducing these difficulties.

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METABOLIZM I TERMOREGULACJA U ŚLEPCÓW

Streszczenie

U ośmiu ślepców, *Spalax leucodon* Nordmann, 1840 pochodzących z okolic Petrochanu (Bułgaria) zbadano metabolizm podstawowy (*BMR*), średni metabolizm dobowy (*ADMR*), oraz metabolizm spoczynkowy (*RMR*). *BMR* i *ADMR* badano w automatycznym resporometrze systemu Morrison'a, natomiast *RMR* w zmodyfikowanym respirometrze systemu Kalabukhova - Skvortzova.

BMR mierzony w temperaturze otoczenia 30°C wynosił 0,626 ± 0,02 cm^3 O_2/g godz. (u ślepców ze średnim ciężarem ciała 178 g), lub 46,4 kcal/$kg^{0,75}$ × 24 godziny (Ryc. 1, Tabela 1). Metabolizm podstawowy wykazywał następującą zależność od ciężaru ciała (*W*) zwierząt: $M = 1,41\ W^{-0,16}$.

Metabolizm spoczynkowy (*RMR*) badano w zakresie temperatur otoczenia od 0 do 35°C. Wzrastał on od 0,85 ± 0,04 cm^3 O_2/g × godzina do 2,68 × 0,20 cm^3 O_2/g × godzina, wykazywał więc wzrost o 0,052 cm^3 O_2/g × godzina × °C (Ryc. 2, Tabela 1, 2).

ADMR badany w temperaturze 20°C w całodobowych pomiarach wynosił 1.37 cm^3 O_2/g × godzina (ciężar ciała ślepców wynosił tu średnio 200 g) (Tabela 1, Ryc. 1). Zależność średniego metabolizmu dobowego od ciężaru ciała zwierząt przedstawia następujące równanie:

$$M = 3,91\ W^{-0,21}.$$

Dobowy budżet energetyczny wykalkulowany dla ślepców wynosił 0,220 kcal/g × doba w okresie zimy i około 0,173 kcal/g × doba w pozostałych sezonach roku (Tabela 3). Przy maksymalnym zagęszczeniu populacji — około 9 osobników/ha rozproszenie energii w „średnim dniu roku" wyniesie około 327 kcal/ha.