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APODEMUS MYSTACINUS (ALSTON et DANFORD 1877) SUFFERS PHYSIOLOGIC TENSION IN ITS NORTHERN DISTRIBUTION AREA

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ABSTRACT. As a typical mesic and middle-sized rodent the broad-toothed mouse (Apodemus mystacinus) has eco-physiologic characteristics, which imply a non-perfect thermoregulation, being vulnerable to thermal stress at temperatures above and below a narrow optimal temperature range. In this work we test the hypothesis that its northern populations live in physiologic stress conditions. Our results reveal that its thermo-neutral zone (TNZ) is a conservative characteristic and it has elevated levels of the resting metabolic rate (RMR) during spring and we conclude that those two features may explain the absence of more northern distribution of the species.

KEY WORDS. *Apodemus mystacinus*, thermo-neutral zone, resting metabolic rate

INTRODUCTION

The broad-toothed mouse (Apodemus mystacinus) is widespread in the Middle East, Turkey and the Balkans (Niethammer and Krapp, 1978) and South-Western Bulgaria covers a part of the most northern distribution area of the species. Rocky shrubs patches on the slopes of the mountains adjacent to the River Struma valley represent the habitats of the species there (Попов, 1993; Марков, 1974). As the microclimatic conditions there are generally different (colder and more humid) (Dimitrov, 2004) when compared to those in the optimal distribution area (Haim et al., 1993), we assume that the broad-toothed mouse has developed physiologic adaptations to coupe with the colder environment. There are three main possible ways in rodents to adapt to such environment: to shift its thermo-neutral zone (TNZ), to decrease the body conductivity (C), and to adapt the metabolic rates (MR) (Kleiber, 1961), or to involve a combination of these adaptations. We obtain the TNZ and the resting metabolic rate (RMR) as a main component of the energy budget equation and compare these results with experiments conducted in the optimal distribution area of the species.

MATERIAL AND METHODS

The thermo-neutral zone (TNZ) is measured by the time spent at a particular temperature range. We used a thermo-preferendum system which provides a temperature gradient from 0 to 50ºC (Fig.1) and tested the animals for 90min after 30min of acclimation. The temperature range of the system where the animals have spent 80% of the length of the experiment establishes a good approximation of the TNZ (Башенина, 1977; Kleiber, 1961). 10 animals were used.

The resting metabolic rate (RMR) is measured as oxygen consumption per body weight per time (O2.g-1.h-1). It was measured in a closed respirometer system (Dimitrov et al., 2005) in a 30h experiment. The tested animals are supplied with food and water ad libitum, have an activity wheel and a hiding place. For the measurements are taken into account the periods of time when the mice is awake, non-active and in a post-absorptive condition (IUPS 2001). 20 animals were used for RMR determination. To avoid the photoperiod as an important factor in physiologic adaptations, we used animals adapted to spring light conditions (appr. 12L:12D). We used three groups of animals: 1. Adapted to early spring conditions from the Kouzucha height (Petritch area, South-Western Bulgaria, referred in the figures as PeS); 2. Adapted to spring conditions from the Kouzucha height (referred in the figures as PS); 3. Adapted to late spring conditions from the Zemen mountain (appr. 160km northwards from the Kouzucha height, South-Western Bulgaria, referred in the figures as ZlS).

RESULTS AND DISCUSSION

The obtained thermo-neutral zone of *A.mystacinus* from South-Western Bulgaria covers a range from 24 to 31ºC (Fig 2). Previous studies have shown that the TNZ of the species in the optimal distribution area (Israel, where it is a common species), lies between 24 and 30 ºC (Yahav et al., 1983). As the zone in South-Western Bulgaria is almost identical to the one determined in the Middle-East populations, our results prove that unlike many other rodents the TNZ is a conservative feature in the physiological capabilities of the species over a wide geographic area. Therefore we can exclude this way of adaptation of the species to colder environment.

These results restrict the capabilities of the species to cope with the climatic conditions through involving the body conductivity (C) and the metabolic rates (MR). C is assessed by direct measurements of the skin and tissues properties and requires killing of animals, and MR measures adaptations on a finer scale (Peters, 1983). This has guided us to concentrate on a basic physiologic feature in the adaptation to a colder environment – the resting metabolic rate, which is an important component in the energetic budget equation (Kleiber, 1961).

The animals from Kouzucha (April) (PeS) and Zemen (June) (ZlS) have considerably elevated levels of RMR when compared to those from Kouzucha (May) (PS) (Fig. 3) The RMR values in *Apodemus* are normally distributed (Corp, 1997) and we compared the values using ANOVA, which shows that the RMR levels are significantly different ($F_{2,17}$=8,98, P<0,05).

The microclimatic conditions in Kouzucha habitat (May) correspond to spring conditions in Israel, while those in Kouzucha (April) and Zemen (June) are considerably colder and more humid (Dimitrov 2004; Haim et al., 1993). This represents a clear pattern of elevation of RMR in colder environment. Previously we have shown this pattern in Kouzuha only (Dimitrov et al., 2005) and here we show that this adaptation applies to a broader range of the northern distribution area, which enables us to conclude that increasing RMR is a typical way of adaptation in the species.

Other Apodemus species adapt to colder environment through decrease of body conductivity and keeping the RMR levels at the levels, which characterize them in optimal temperature environment (e.g. Corp, 1997). As *A.mystacinus* in South-Western Bulgaria reacts by elevating RMR one can speculate that it either does not decrease its C, or it has reached some critical point of a potential decrease of C, which is not enough for coupling with the colder environment. In both cases anyway the significant elevation of RMR in colder environment shows clearly that the species suffers physiologic tension in its northern distribution area during long periods of time every year. As we revealed it does not adapt by its TNZ, C is either not influenced or is not enough decreased, and the only remaining way of adaptation remains the change of MR. These data show that the species has limited tools for long lasting existence in pessimal conditions and this can explain the relatively smaller distribution area in comparison to the other Palearctic Apodemus species.

CONCLUSION

A.mystacinus is conservative in its TNZ characteristics and adapts to colder environment be increasing its RMR. It exists in its northern distribution area in physiologic tension during long periods of time. Further experiments are needed to analyze how sex, age and acclimation conditions influence RMR. Our results give a strong suggestion to investigate other MR values as well.

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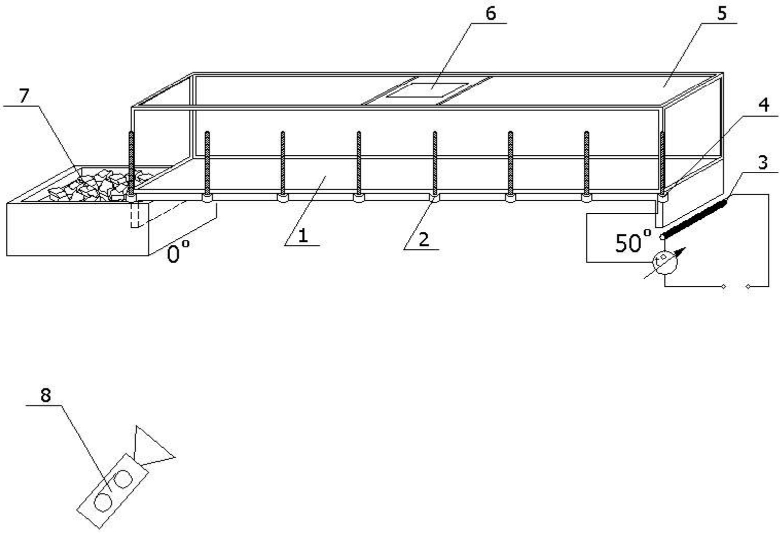

Fig. 1 *Termo-preferendum system.. 1-copper plate; 2-thermometers; 3-heater; 4-control device; 5 glass body; 6-entrance; 7 – ice; 8-VCR.*

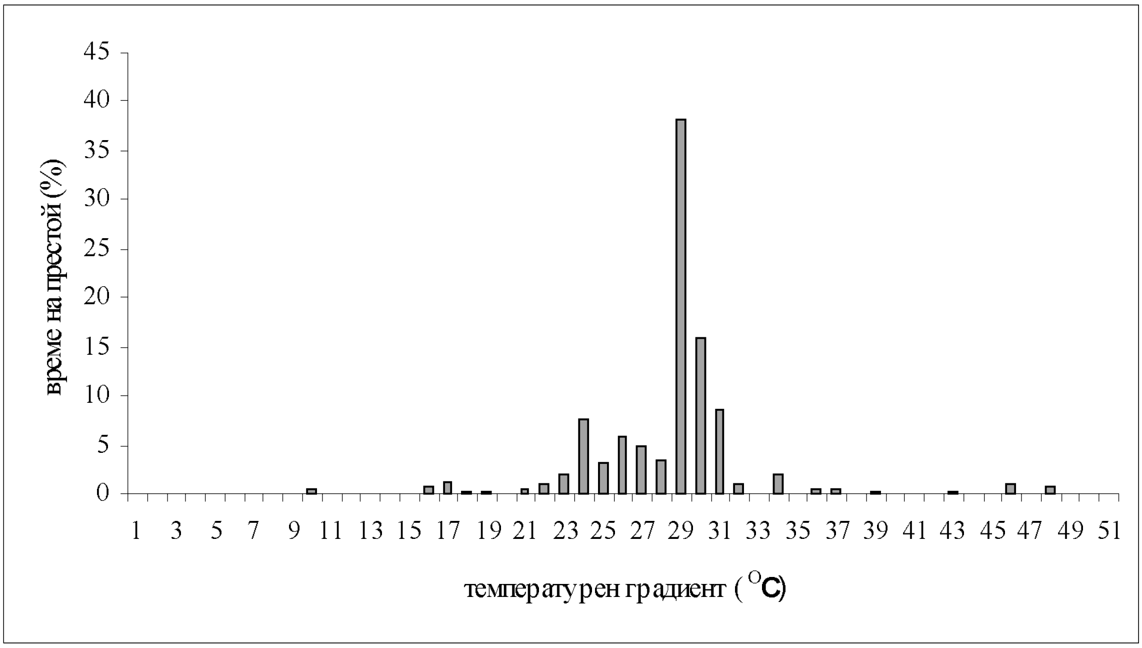

Fig.2 *Termo-neutral zone of A.mystacinus in South-Western Bulgaria.*

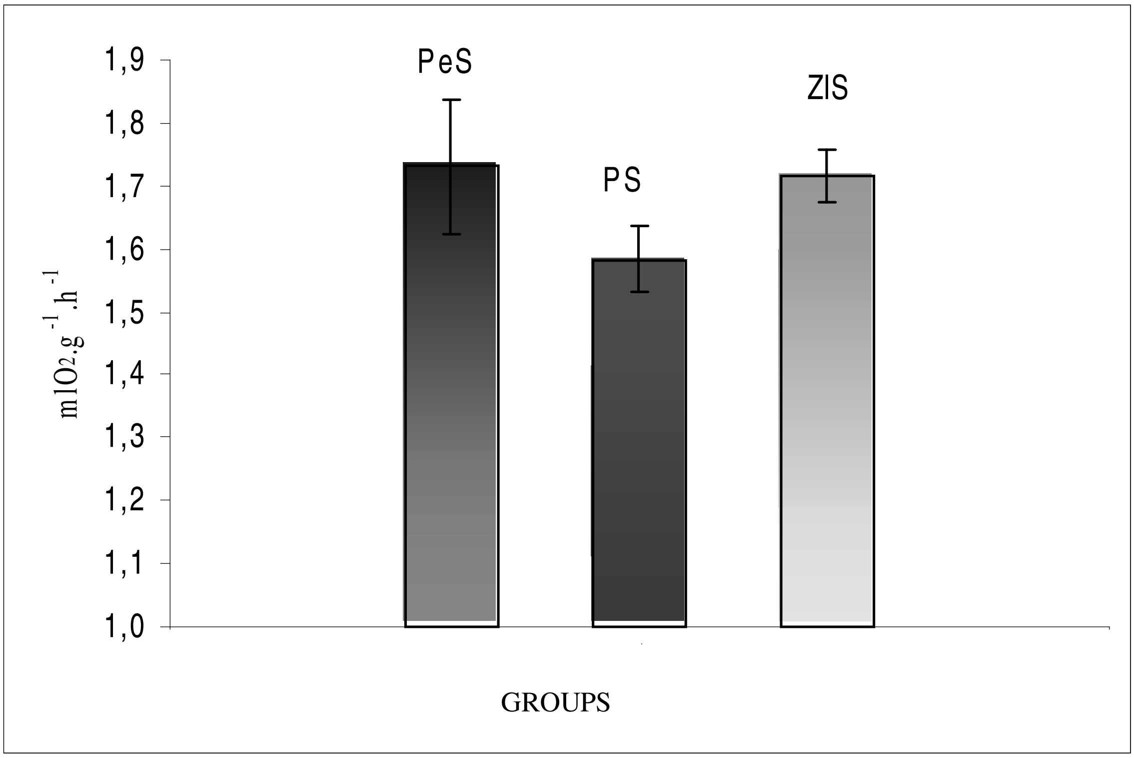

Fig. 4. *Resting metabolic rates. Kouzucha (P), Zemen (Z), eS – early spring, April, S – spring, May, lS – late spring, June*