

# Thermoregulatory and metabolic responses to photoperiod manipulations in a mesic population of the common spiny mouse, *Acomys cahirinus*

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## Introduction

In the Levant the common spiny mouse, *Acomys cahirinus* (*Acomys dimidiatus*) is widely distributed in rocky habitats of dry and warm desert as well as in mesic areas (HARRISON and BATES, 1991). Several biological aspects have been studied in this species. Among others, a comparative ecophysiological study was carried out, where individuals from arid and mesic environments were compared (WEISSEBERG and SHKOLNIK, 1994). This study revealed differences in thermoregulation, metabolism as well as in kidney morphology and functions between populations, occurring in different environments. Individuals from the arid environment could cope better with dry and warm conditions.

Many rodent species use the changes in photoperiod as an environmental signal for seasonal acclimatization of thermoregulatory and metabolic systems (LYNCH, 1970; HAIM and FOURIE, 1980; HELDMAIER *et al.*, 1981; HAIM, 1982). The daily rhythms of body temperature ( $T_b$ ) in rodents is well documented (ASCHOFF, 1982; HELDMAIER *et al.*, 1989). Seasonal acclimatization of  $T_b$  daily rhythms were revealed in common spiny mice from a mesic population (HAIM and RUBAL, 1994). Such changes in the temporal organization of  $T_b$  are assumed to be associated with control of energy balance (HAIM *et al.*, 1995). So it makes sense to assume that a change in the  $T_b$  daily rhythm could reflect a change in energy intake, which is also photoperiod responsive (HAIM and LEVI, 1990). Therefore, the aim of the present research was to study the thermoregulatory and metabolic responses of a mesic population of common spiny mice to photoperiod manipulation, in order to assess the use of photoperiodic cues by this species for seasonal acclimatization of its thermoregulatory system.

## Material and methods

Eight adult males with a body mass of ( $56.9 \pm 2.6$  g) were taken from our breeding colony at Oranim, Kiryat Tivon. The ancestors of these mice were captured on Mount Carmel, Israel. Mice were acclimatized for two weeks at least, to an ambient temperature of  $26 \pm 1$  °C, first under a short day (SD) photoperiod (lights were on between 08:00-16:00h) and then, after measurement of different variables, to a long day (LD) photoperiod (lights were on between 06:00-22:00h). Food trials started only after two weeks of acclimatization and body mass was measured at the beginning of each trial. During the light period, neon lights (800 lx) and dim red lights (40 lx) were on, while during the dark period only the dim light was on. Each mouse was kept separately in a cage and sawdust was used for bedding. During the period of acclimatization, mice were maintained on rodent chow *ad libitum* with fresh carrots and cucumbers served as a water source.

## *Daily rhythms of body temperature*

These were recorded at the end of the acclimatization period. Measurements continued for 48h at intervals of 4h. Body (rectal) temperature was measured by using a copper-constantan thermocouple connected to a Wescor (Logan, UT, USA) TH65 digital TC thermometer. The thermocouple was inserted 3 cm into the rectum of the tested mouse for a period less than 30 sec. During the measurement the tested mouse was kept inside a cotton bag (HAIM *et al.*, 1994).

## *Food, water and energy consumption*

Food consumption was measured as apparent Digested Dry Matter Intake, DDMI (the difference in mass, between Apparent Dry Matter Intake ADMI and the dry faeces outlet). Tested mice were kept separately in cages with filter paper as bedding, on a diet of dried (Memmert 60°C) rat pellets (20% protein, Koffolk Ltd., Israel) and fresh cucumbers (containing 96% water) throughout the measurements. Fifty grams (Sartorius, 1900 MPS) of dried rat pellets were provided once a week, while fresh weighed cucumbers were added every two days. Measurements went on for two weeks at each photoperiod regime and at the end of this period food leftovers, faeces and cucumber leftovers were dried at 60°C and separated from each others (HAIM, 1987). Water intake could be calculated from cucumber consumption assuming that cucumbers contain 96% water.

Energy consumption was measured as Gross Digestible Energy Intake GDEI, the difference between the measured caloric contents of the food consumed and of the faeces. The energy contents of samples of dried rat pellets, cucumber and faeces were determined by a computerized bomb calorimeter (PARR 1261, Parr instruments Co.). Digestibility was calculated as the ratio DDMI /ADMI (in percent), (HAIM *et al.*, 1994).

## *Statistics analysis*

All results are given as means  $\pm$  S.D. Students *t* test was used for determination of significant ( $p \leq 0.05$ ) differences between means.

## Results

A difference in the  $T_b$  daily rhythm was noted between SD- and LD-acclimatized mice. While under SD-acclimatization  $T_b$  values were high between 19:00 and 03:00h ( $p < 0.05$ , compared with  $T_b$  at 11:00h). Under LD-acclimatization, high  $T_b$  values were recorded at 23:00 and 03:00h ( $p < 0.01$ ; compared with  $T_b$  at any other time). However, the values at 03:00h were significantly ( $p < 0.01$ ) higher than those obtained at 23:00h. Under LD-acclimatization a sharp decrease in  $T_b$  was noted at 07:00h, while in SD-acclimatized mice, the decrease was moderated (Fig 1).

Body mass decreased significantly ( $p < 0.05$ ) under SD-acclimatization, while under LD-acclimatization it did not change. Water consumption was significantly higher in LD-acclimatized mice ( $p < 0.05$ ), compared with SD-acclimatized mice. However, in all food and energy consumption variables, the values obtained for SD-acclimatized mice were significantly higher than those of LD-acclimatized ones ( $p < 0.05$ ; Table 1).

## Discussion

The common spiny mice population on Mount Carmel, Israel, is exposed to seasonal changes where the cold and wet season is short (four months) and the dry and warm season is long (eight months). The change in ambient temperature ( $D = 10-15$  °C) takes place in a very short period, a few days. Therefore, rodent species such as the broad-toothed wood-mice *Apodemus mystacinus* were found to use changes in photoperiod (which occur before the changes in ambient temperature) as a major cue for seasonal acclimatization of their thermoregulatory system (HAIM and YAHAV, 1982).

The results of our study show that common spiny mice inhabiting Mount Carmel, can use photoperiod cues for seasonal acclimatization of their thermoregulatory system. Body temperature is an outcome of the relation between heat production (metabolism) and heat

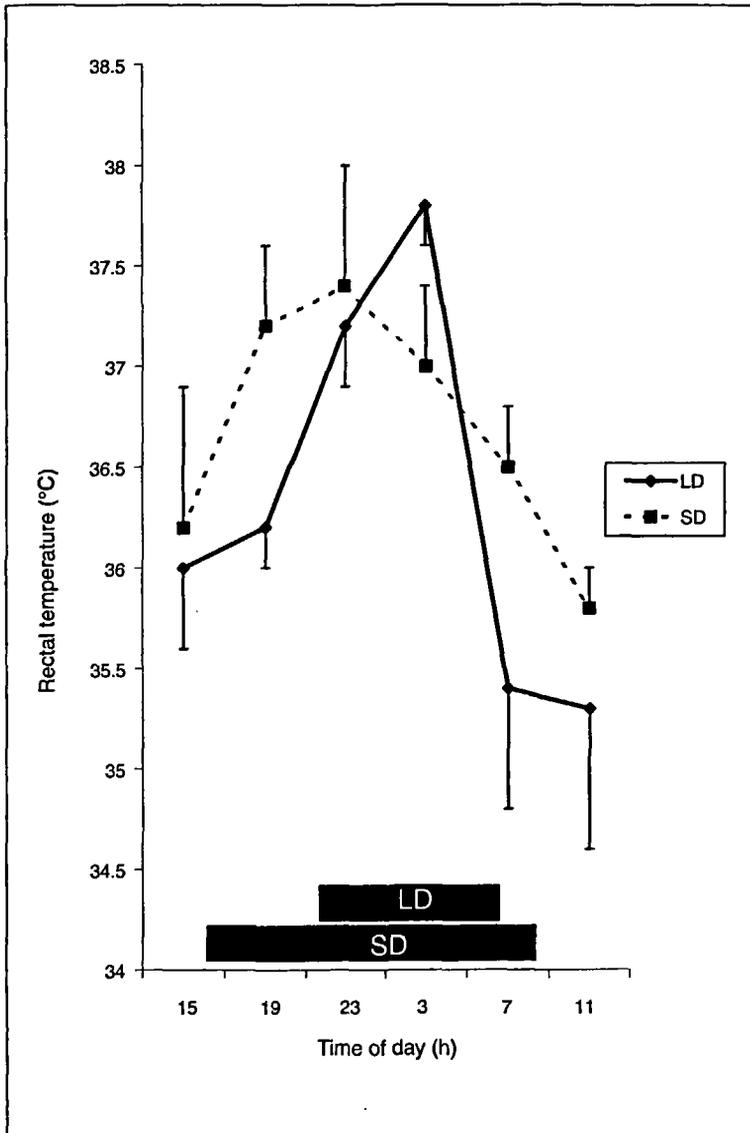


Figure 1

Body temperature ( $T_b$ , °C) of daily rhythms of common spiny mice *Acomys cahirinus* (*Acomys dimidiatus*) from Mount Carmel, Israel. Mice were acclimatized to two different photoperiod regimes at an ambient temperature of  $26 \pm 1$  °C. Mice acclimatized to short day (SD, 8L:16D), mice acclimatized to long day (LD, 16L:8D). Each point is a mean value + S.D., for  $n = 8$ .

	Short Day	Long Day	t	P <
ADMI g/100 g W <sub>b</sub> .day	5.3 ± 0.28	4.4 ± 0.33	4.28	0.01
DDMI g/100 g W <sub>b</sub> .day	4.6 ± 0.37	3.9 ± 0.34	4.77	0.01
GEI Cal./g.day	226.2 ± 20.2	194.5 ± 14.0	3.41	0.05
DEI Cal./g.day	195.0 ± 22.1	168.5 ± 13.5	2.80	0.05
Water Consumption GH <sub>2</sub> O/100 g W <sub>b</sub> .day	12.3 ± 0.9	13.6 ± 0.7	3.02	0.05
W <sub>b</sub> before g	56.9 ± 2.6	52.8 ± 4.4	4.425	0.05
W <sub>b</sub> after g	50.8 ± 1.8	52.0 ± 3.8	4.425	0.05

■ Table 1

Food, energy and water variables of common spiny mice *Acomys cahirinus* (*Acomys dimidiatus*) from Mount Carmel, Israel, acclimatized to two different photoperiod regimes (short day SD - 8L:16D, long day LD - 16L:8D) at an ambient temperature of 26 ± 1°C.

ADMI - Apparent Dry Matter Intake, DDMI - Digestible Dry Matter Intake, GEI - Gross energy intake, DEI - Digestible Energy Intake, W<sub>b</sub> - Body mass before and after acclimatization to each photoperiod regime. All variables are means ± S.D. for n = 8 mice. For establishing statistical differences, Student t-test was used. Values are significantly different at p < 0.05.

dissipation (conductance or insulation). Therefore, a further question that can be asked is: "what mechanism is affected by the photoperiodic changes"? For a species with a body mass of about 50 g the change will mainly depend on heat production mechanisms rather than on heat dissipation, as seasonal changes of insulation in small mammals are of minor significance (HART, 1956). Our food and energy consumption results (Table 1) support this idea.

The role of photoperiodicity in the control of T<sub>b</sub> rhythms was discussed by HELDMAIER *et al.* (1989) and the results they used were obtained mainly from mesic or cold adapted species. Acclimatization to SD in such species decreased the time in the 24h cycles in which T<sub>b</sub> was

kept at high values. Such a change in  $T_b$  temporal organization results in energy conservation. However, in desert adapted rodents as the fat jird *Meriones crassus* (HAIM and LEVI, 1990) and the golden spiny mouse *A. russatus* (HAIM *et al.*, 1994) a different pattern was observed, where SD acclimatization resulted in higher  $T_b$  values for a longer period each day. The results obtained in this study for the common spiny mouse, although of a mesic population, agree with those of the desert-adapted species rather than mesic adapted ones (Fig. 1).

Photoperiod and ambient temperature are two environmental parameters that are seasonally dependent, and the changes in ambient temperature follow those of photoperiod. The response of food and energy intake, in rodents from different habitats to long and short photoperiod acclimatization were summarized by HAIM and RUBAL (1993). They found a difference between desert and mesic species. While under short photoperiod acclimatization, an increase in food and energy intake was noted, such differences were not revealed in species of a mesic origin. An increase in food and energy intake under short photoperiod acclimatization, were also noted in the golden spiny mice from extreme arid habitats (HAIM *et al.*, 1994). The results of our study show that SD-acclimatized *A. cahirinus*, also increased food and energy intake as compared with LD-acclimatized ones (Table 1).

This increase in energy intake of SD-acclimatized mice, was accompanied by a decrease in body mass, while in LD-acclimatized mice body mass did not change. Such a decrease in body mass was not revealed in SD-acclimatized *A. russatus* (HAIM *et al.*, 1994). The results obtained for *A. cahirinus* show that LD-acclimatized mice, increased water consumption relatively to SD-acclimatized mice. This increase contrasts with the results obtained for *A. russatus* (HAIM *et al.*, 1994). *Acomys cahirinus*, depends on water evaporation through the skin for cooling (SHKOLNIK and BORUT, 1969), therefore, it may be assumed that the increase in water consumption of LD-acclimatized mice, could be an outcome of summer seasonal acclimatization of peripheral blood vessels.

The results of our study suggest that the metabolic and thermoregulatory seasonal changes in *A. cahirinus* from a mesic population are at least partly a response to the changes in photoperiod. Therefore, it may be concluded that seasonal acclimatization of these systems are

photoperiod- dependent and that the changes in day length can be used as a cue. Although this species inhabits mesic habitats in the Mediterranean ecosystem (HARRISON and BATES, 1991), it retains several physiological characteristics which are typical for African desert adapted species.

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