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Activity Body Temperature and Diel Variation of Metabolic Rate in the Nocturnal Gecko, *Hemidactylus turcicus* (Reptilia: Gekkonidae)

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ABSTRACT. The mean activity body temperature of the nocturnal gecko, *Hemidactylus turcicus*, was 28°C during summer. The mass-specific metabolic rate equations at 28°C were calculated. The rate of oxygen consumption (ml g^{-1} h^{-1}) decreased with increasing body mass. The mass exponent 'b' values for resting metabolism were 0.60 at night and 0.62 during day. Resting metabolic rate at night was significantly higher than that during day. Diel cycles in O_2 consumption were correlated with daily activity of this nocturnal gecko.

Introduction

An understanding of the factors that influence the metabolic rate is necessary for modeling energy flow through individuals[1,2]. Body mass affects strongly the metabolic rate of lizards[3-7]. Daily variations in the metabolic rates of lizards are documented in several studies[8-11].

Many workers have studied the behaviour and activity patterns involved in thermoregulation in the field[12-14]. Lizards generally have selected body temperatures which display the range within which the body temperature of each is regulated. This is an important factor in ecological isolation and is species specific[15].

Hemidactylus turcicus occurs in the periphery of Arabia: western Saudi Arabia, North Yemen, South Yemen, Oman, eastern United Arab Emirates, also the coast of Iran and Pakistan and western coast of the Red Sea from Egypt to Somalia[16]. Temperature effects on resting metabolism of juvenile *H. turcicus* were examined by Zari[17]. However, there are no other published studies on the effects of body mass and time of day on metabolic rate of this species. Therefore, the objective of the present study is to investigate the time of activity and activity body temperatures of *H. turcicus* during summer, and to examine the effects of body mass and time of day on the metabolic rate at the mean activity body temperature in this nocturnal gecko from Jeddah Saudi Arabia.

Materials and Methods

Animals

Specimens of *H. turcicus* were captured by hand in or near buildings in Jeddah, Saudi Arabia during the summers of 1993 and 1994. Geckos were kept in glass aquaria (60 × 40 × 40 cm) with netwire sliding tops. A 60 watt heat lamp was hung over one end of each aquarium and was turned on automatically for 10 h to provide a temperature gradient. The ambient temperature in the room was around 28°C. Food (small insects and spiders) and water were constantly available to the animals. Geckos were fasted for at least 3 days before measuring their oxygen consumption.

Time of activity and activity body temperatures

H. turcicus of various body sizes were spotted by random walks through the study area at different times of day. The study area is located near King Abdulaziz University in Jeddah. Observations on time of activity for each gecko sighted were recorded. Some geckos sighted were caught by hand. The body temperatures of active geckos were measured at capture by the insertion of a quick reading Schultheis thermometer into the cloaca. Air temperature was taken at the place used by each gecko immediately after capture.

Metabolic rate measurements

The metabolic rate of geckos was measured as the rate of oxygen consumption (ml g^{-1} h^{-1}), using constant pressure manometric respirometers having both animal and control chambers as described by Zari[2,6,17]. At noon, the geckos were weighed, placed in the animal chambers, which were immersed in a constant temperature water bath at the test temperature. Oxygen consumption rates were measured on *H. turcicus* of various body sizes at the mean activity body temperature (28°C). Measurements of resting metabolic rate (RMR) were made on quiescent and post-absorptive lizards. Consequently, geckos were deprived of food for 3-5 days prior to respirometry. All RMR determinations were carried out between 20:00 and 03:00 hours at night and 09:00 to 16:00 hours during day.

Regression analyses of log-transformed oxygen consumption rate (ml g^{-1} h^{-1}) and body mass (g) data were carried out by the method of least squares. Comparisons of regression lines were made using the analysis of covariance (ANCOVA). Statistical comparisons between the mean activity body temperature and mean air temperature were made using analysis of variance (ANOVA). Differences were considered to be statistically significant when $P < 0.05$.

Results

Figure 1 shows the percentage of active *H. turcicus* observed (N = 140) at hourly intervals during summer. These nocturnal geckos are mainly active after sunset and they retreat to shelter before sunrise. Some emerge from shelter before sunset (Fig. 1). They feed on a variety of small invertebrates. They are usually found in or near build-

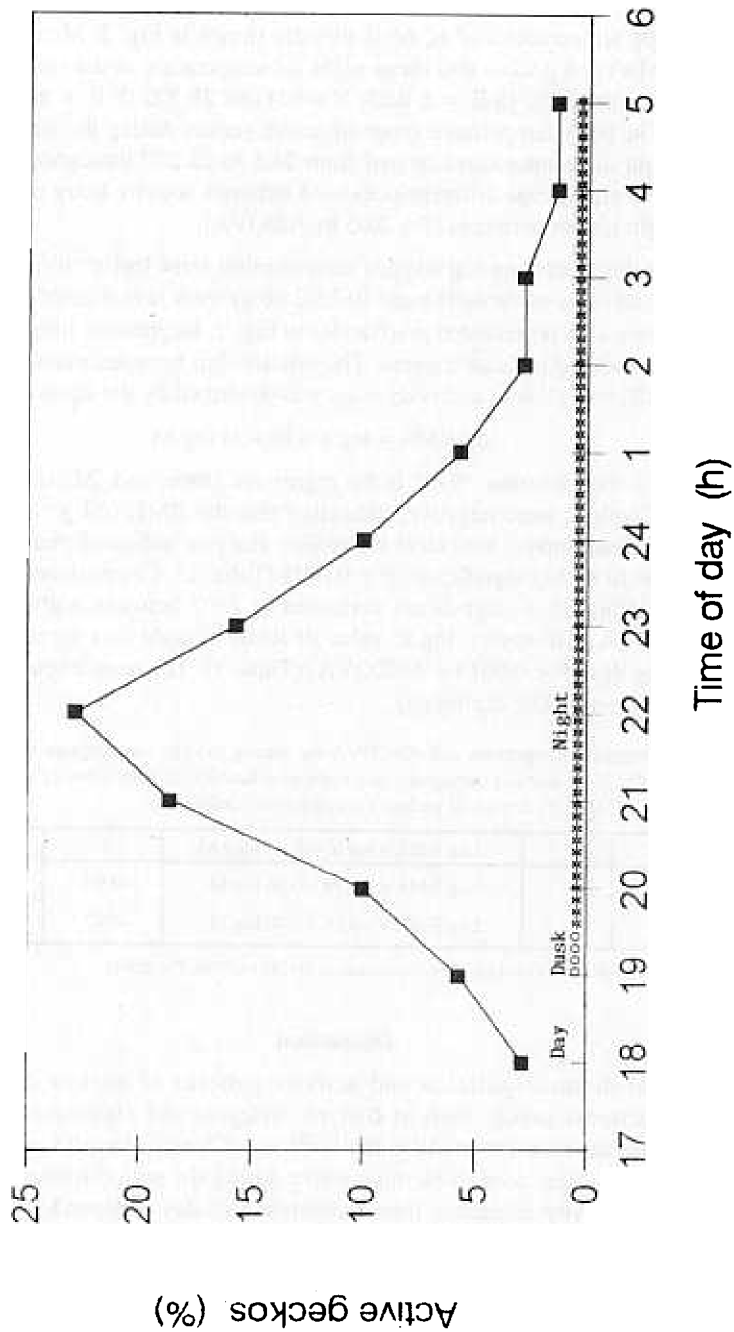


FIG. 1. Percentage of active *H. turcicus* (N = 140) that were observed during summer at different times of day (h).

ings where at night they catch mainly insects. They climb well on walls and ceilings. They are also seen on roadways and grass at night. The gecko *Ptyodactylus hasselquistii* was also seen at night with *H. turcicus.*

Activity body temperatures of *H. turcicus* were shown in Fig. 2. Mean activity body temperature (MAT) of geckos and mean night air temperature at the time of collection during summer were 28°C (S.E. = ± 0.25, N = 62) and 28.3°C (S.E. = ± 0.27, N = 62), respectively. The body temperature range of active geckos during the summer was 8°C (24-32°C). Night air temperatures ranged from 24.5 to 32.2°C throughout the observation periods. No significant differences existed between activity body temperatures of geckos and night air temperatures (P > 0.05 by ANOVA).

The relationships between log oxygen consumption rates (ml $g^{-1}h^{-1}$) and log body mass (g) of *H. turcicus* of variable mass (0.15-2.86 g) were investigated at 28°C (Table 1). The data were also represented graphically in Fig. 1. Regression lines were fitted to the data by the method of least squares. The relationship between mass-specific metabolic rate (RMR) (ml g^{-1} h^{-1}) and body mass was described by the equation :

$$\log \text{RMR} = \log a + (b - 1) \log M$$

where 'log a' is the elevation, 'b−1' is the regression slope, and 'M' is the body mass (g). The 'b−1' values were negative, indicating that the RMR (ml g^{-1} h^{-1}) decreased with increasing body mass. Statistical regression analysis indicated that the regression slopes 'b−1' were highly significant (P < 0.001) (Table 1). Comparisons of 'b−1' values for RMR indicated no significant variations at 28°C between night and day (P > 0.05 by ANCOVA). However, 'log a' value of RMR at night was significantly higher than that during day (P < 0.001 by ANCOVA) (Table 1). The mass exponent 'b' values were 0.60 at night and 0.62 during day.

TABLE Regression equations and ANCOVA for resting oxygen consumption rates (ml g^{-1} h^{-1}) of *H. turcicus* during day and night as a function of body mass (g) measured at 28°C (Fig. 1). n = no. of geckos; r = correlation coefficient.

State	n	Log RMR = log a + (b − 1) log M	r	P
Day	23	Log RMR = −0.79 − 0.38 log M	−0.92	< 0.001
Night	23	Log RMR = −0.66 − 0.40 log M	−0.97	< 0.001

ANCOVA: slopes, F(1, 42) = 0.18, P > 0.05; elevations, F(1, 43) = 70.58, P < 0.001

Discussion

Behavioural thermoregulation and activity patterns in geckos differ between species[18]. Nocturnal geckos such as *Gehyra variegata* and *Heteronotia binoei* from relatively temperate climates in Australia[19,20] and *Chondrodactylus angulifer* in the Kalahari Desert[21] often tend to be most active during the period immediately following sunset. The activity of geckos from temperate climates is dependent on both light and temperature regimes[19,20]. However, activity patterns in the tropical gecko *Hemidactylus frenatus* are wholly independent of temperature[22]. During summer, *H. turcicus* are mainly active after sunset and they retreat to shelter before sunrise (Fig. 1).

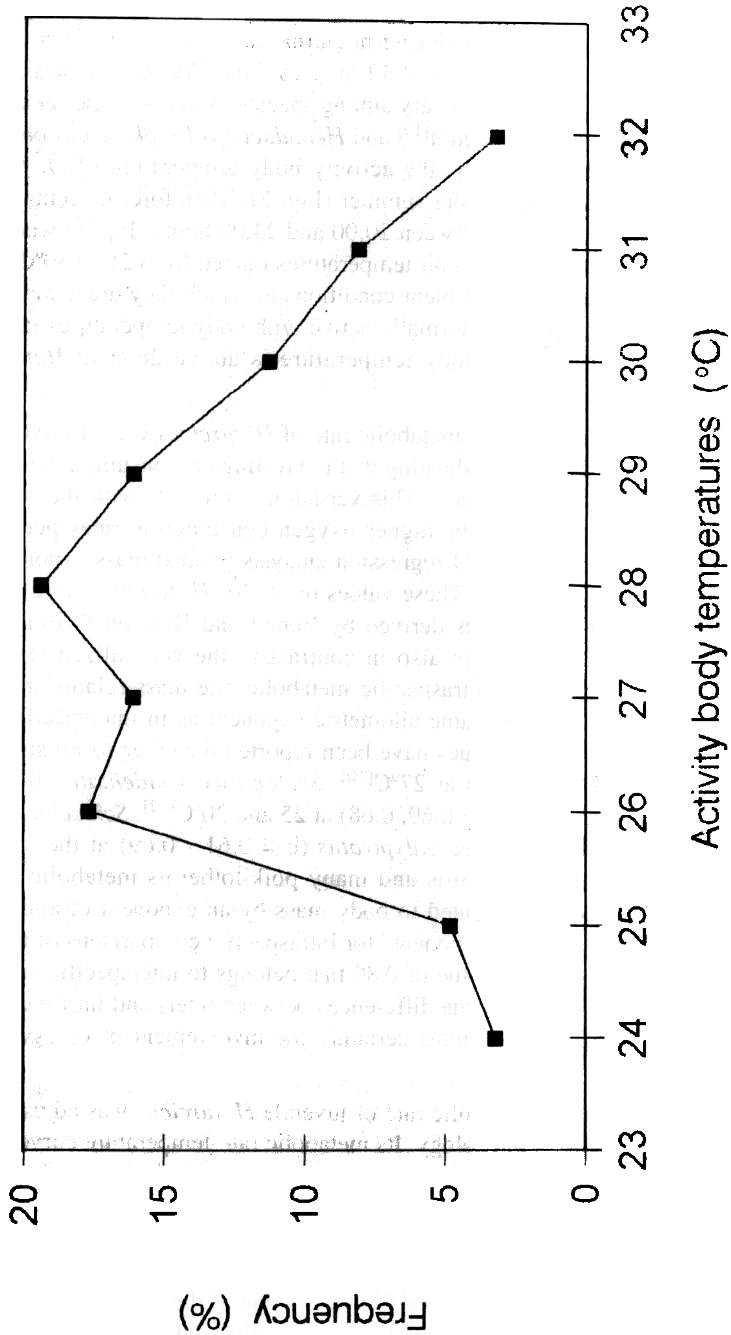
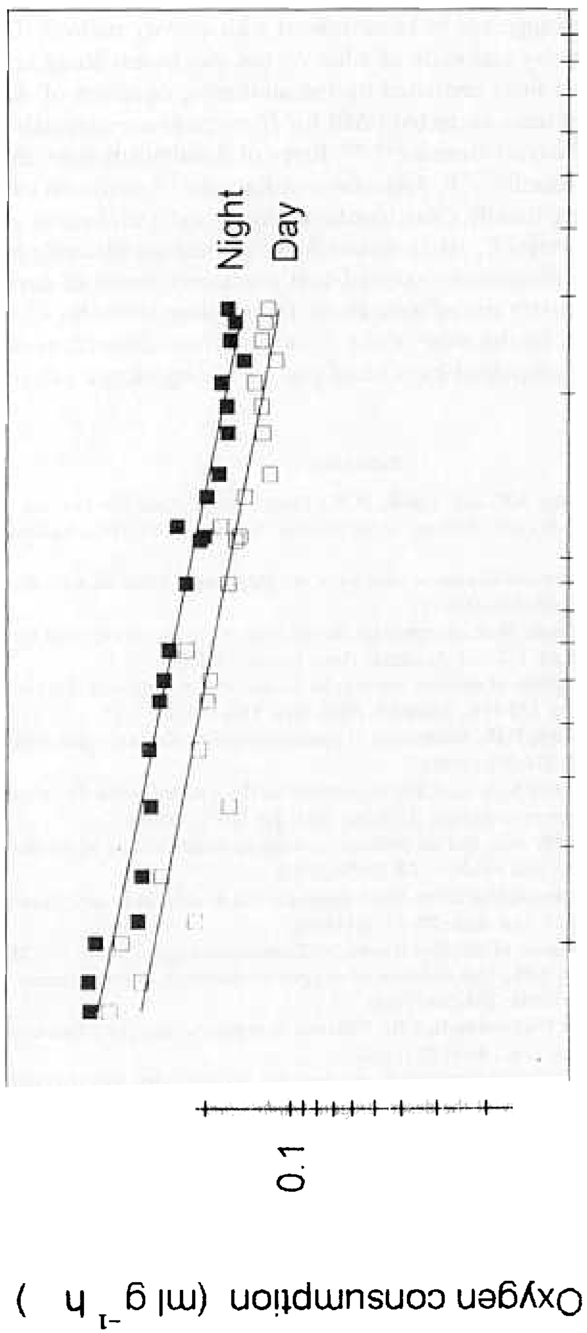


FIG. 2. Frequency distribution of activity body temperatures of *H. turcicus* during summer. Each point represents the frequency within 1°C temperature interval.

Activity body temperatures of *H. turcicus* are close to air temperatures at the time of collection during summer. Similarly, body temperatures of many species of geckos follow air temperatures rather closely during nocturnal activity, *e.g. Coleonyx variegatus*[23], *Hoplodactylus maculatus*[24] and 12 species from Western Australia[25]. The temperatures at which activity ceases vary among species. Activity ceases at air temperatures below 18°C in *Gehyra variegata*[19] and *Hemidactylus brookii* feeds only sporadically below 26°C[26]. In this study, the activity body temperature of *H. turcicus* is between 24 and 32°C at night during summer (Fig. 2). Therefore, it seems that these geckos were most active at night between 20:00 and 24:00 hours (Fig. 1) when activity body temperatures (Fig. 2) and night air temperatures ranged from 26 to 30°C to reduce the impact of daily variations in ambient conditions to which they are actually experienced. Most nocturnal geckos are normally active with body temperatures in the range 20-28°C[18]. The mean activity body temperature is above 26°C in *Hemidactylus brookii*[26].

A strong effect of body mass on metabolic rate of *H. turcicus* was observed (Fig. 3). The 'b−1' values were negative, indicating that the resting O_2 consumption (ml g^{-1} h^{-1}) decreased with increasing body mass. This variation conforms with the well-known observation that small animals have higher oxygen consumption rates per unit mass than do larger ones[27-29]. Results of regression analysis yielded mass exponents 'b' of 0.60 at night and 0.62 during day. These values of 'b' for *H. turcicus* were lower than the interspecific generalized values derived by Benett and Dawson[3], Bennett[4] and Andrews and Pough[5]. They were also in contrast to the generalized statement of Zeuthen[30] and Kleiber[28] that intraspecific metabolic rate-mass relationships in animals would have essentially the same allometric exponent as in interspecific relationships. Similar intraspecific 'b' values have been reported for other lizard species, *e.g. Hemidactylus frenatus* (b = 0.69) at 27°C[10], *Sceloporus occidentalis* (b = 0.67) at 25°C[31], *Sceloporus graciosus* (b = 0.69, 0.68) at 25 and 30°C[32], *Scincella lateralis* (b = 0.63) at 30°C[33] and *Chamaeleo calyptratus* (b = 0.61 - 0.69) at the temperature range 20-35°C[7]. In mammals, birds and many poikilotherms metabolic rate under standard or basal conditions is related to body mass by an exponent of approximately 0.75[27-29]. However, most mass exponents for intraspecific comparisons of metabolism are significantly lower than the value of 0.80 that belongs to interspecific comparisons of adult lizards[5]. One reason for the differences between inter- and intraspecific metabolic rate-mass relationships is almost certainly the involvement of ontogenetic variables in the latter[34].

Zari[17] reported that the metabolic rate of juvenile *H. turcicus* was adjusted to their thermoregulatory behavior and ecology. Its metabolic rate-temperature curve was rotated to give reduced temperature sensitivity and elevated metabolism at low temperatures. The overall Q_{10} values were low for juvenile *Hemidactylus turcicus* (Q_{10} = 1.62). Similar results were also observed in juvenile *Ptyodactylus hasselquistii* from Jeddah, Saudi Arabia[17], subadult and adult *Ptyodactylus hasselquistii* and adult *Bunopus tuberculatus* from Riyadh, Saudi Arabia[35]. Knowledge of diel cycles in metabolic rate is critical for calculating daily energy budgets. Typically, highest metabolic rates occur



represents a single measurement. The regression lines

squares

during active periods and lowest during inactive periods[8,10]. Lowest O_2 consumption in *H. turcicus* occurred during day and highest at night (Fig. 1). Metabolic oscillations of this nocturnal gecko appeared to be correlated with activity periods. The observed values of RMR during day and night of adult *H. turcicus* in this study at 28°C are in close agreement with values predicted by the allometric equation of Andrews and Pough[5]. The values of mass-corrected RMR for *H. turcicus* are reasonably consistent with values for *Hemidactylus frenatus*[10,36]. Rates of metabolism were also measured for several free-living lizards[37-39]. Anderson and Karasov[37] measured energy metabolism in the free-living lizards *Cnemidophorus tigris* and *Callisaurus draconoides* using doubly labeled water. *C. tigris* (active foragers) had significantly higher field metabolic rate than *C. draconoides* (sit-and-wait predators). Rates of energy metabolism during the field activity period were about 1.5 × resting levels for *C. draconoides* and 3.3 × resting levels for the more active *C. tigris*. These differences demonstrated that the foraging mode employed by a lizard can have a significant effect on its total energy budget.

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درجة الحرارة النشطة والاختلاف اليومي في معدل أيض البرص الليلي ، هيميداكتلس تركيكس (زواحف : أبراص)

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المستخلص . متوسط درجة الحرارة النشطة للبرص الليلي ، هيميداكتلس تركيكس ، هو ٢٨°م . وقد حسبت معادلات معدل الأيض النوعية في ٢٨°م . انخفض معدل استهلاك الأكسجين (مل جم$^{-١}$ س$^{-١}$) مع زيادة كتلة الحيوان . قيم أس الكتلة «ب» هي ٠,٦٠ للأيض السكوني الليلي ، و ٠,٦٢ للأيض السكوني النهاري . معدل الأيض السكوني أثناء الليل أعلى منه أثناء النهار . تتناسب الدورات اليومية في استهلاك الأكسجين مع النشاط اليومي لهذا البرص الليلي .