

## Preferred temperatures of *Tarentola mauritanica* in spring

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**Abstract.** Variation of the preferred temperatures ( $T_p$ ) by the Moorish gecko (*Tarentola mauritanica*) in spring was analysed in a population from NE Iberia. Ten adult specimens were exposed to a thermal gradient and  $T_p$  was measured at seven time intervals between 16 and 24 h.  $T_p$  values were low ( $23.44 \pm 0.61$  °C, 20.7-26.9 °C, mean  $\pm$  SE, range) but geckoes gradually increased  $T_p$ s between late afternoon and early evening. Surprisingly, mean, maximum and minimum  $T_p$ s inversely correlated with the body size (SVL), but the results of the analyses remained after size correction. Compared to a previous study carried out in summer,  $T_p$ s found here were much lower but diel variation persisted. Such patterns are more similar to other nocturnal or crepuscular geckonids rather than to the well-studied diurnal lacertids living in the same sites. Specifically,  $T_p$  seems to be more plastic and the relationships with body size are opposite. Possible adaptive explanations and guidelines for further work are suggested.

**Keywords.** Preferred temperatures, thermal ecology, *Tarentola mauritanica*, Gekkonidae.

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### INTRODUCTION

In the framework of the lizard studies on thermal ecology, preferred body temperature in the absence of thermoregulatory constraints ( $T_p$ ) constitutes an important trait because it correlates with several physiological optima (Huey and Bennet, 1987; Bauwens et al., 1995; Anguilletta et al., 2002). Nevertheless,  $T_p$  may change at both evolutionary and individual scales. On one hand,  $T_p$  may shift evolutionarily to approach the dominant environmental temperatures but the rate of such adaptive response varies between phylogenetic lineages (Hertz et al., 1983; Bennet and John-Alder, 1986; Christian and Weavers, 1996; Labra, 1998; Castilla et al., 1999). On the other hand, individual lizards are also able to adapt their  $T_p$  in response to temporal variation within their life such as daily and seasonal changes, reproductive condition and feeding status (i.e., Van Damme et al., 1986; Castilla et al., 1999; Brown and Griffin, 2003; Carretero et al., 2005, 2006).

Whereas most of the literature on this topic focuses on diurnal lizards, less attention has been paid to nocturnal species. Nevertheless, several studies carried out on crepuscular or nocturnal geckonids indicate that  $T_p$  within the species level is less rigid than in diurnal lizards (Brown, 1996; Rock et al., 2000). Moreover, individual geckos may also change their  $T_p$  throughout the day, seasonally or due to pregnancy (Refinetti and Susalka, 1997; Zari, 1999; Rock et al., 2000, 2002; Anguilletta et al., 2002; Hare et al., 2002) although patterns are not common for all the species (Anguilletta and Werner, 1998).

Geckoes inhabiting temperate regions are of special interest because they must face stronger thermal constraints than those living in tropical habitats (Hitchcock and McBrayer, 2006). Whereas the lizard fauna of the northern side of the Mediterranean Basin is dominated by lacertids, only four geckonid species, all restricted to the warmer areas, are known to the region (Arnold and Ovenden, 2002). The Moorish gecko, *Tarentola mauritanica* is the most common one in the Western Mediterranean (Martínez-Rica, 1997). Although it is found on both sides of Gibraltar Strait, recent phylogeographic evidence (Harris et al., 2004a, b) suggests that the species has colonised Europe only recently after the Glaciations. The Moorish gecko is a medium-sized species (45–85 mm, SVL), mainly occupying natural and artificial vertical surfaces, displaying both diurnal and nocturnal activity and undergoing a winter diapause in the most continental localities (Salvador, 2002; Guarino and Picariello, 2006). Previously, the diel variation of  $T_p$  in this species was analysed in summer (when geckoes were already involved in reproduction) in a continental population from Central Spain (Gil et al., 1994).

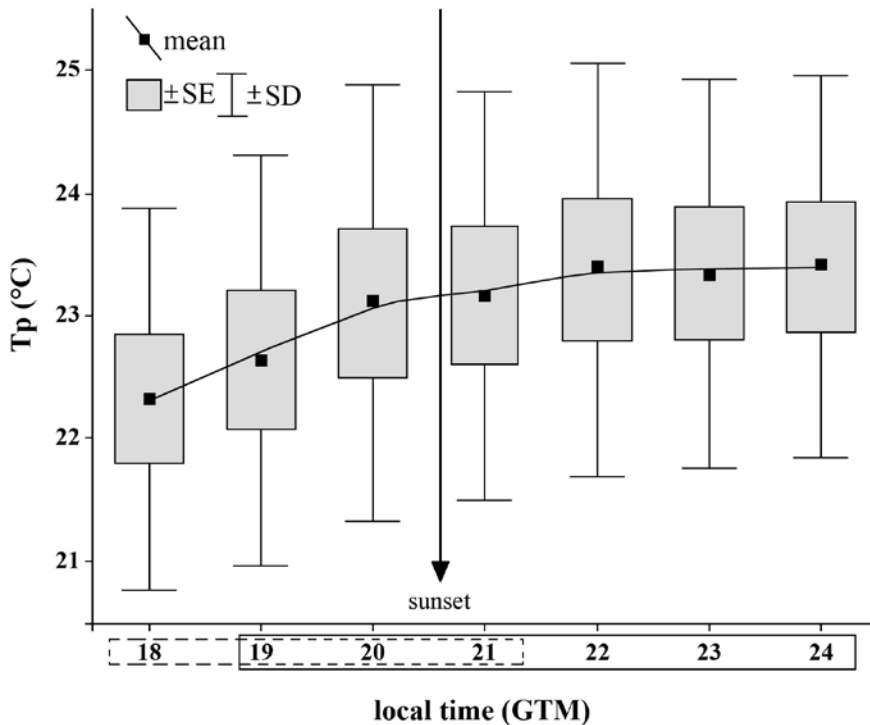
The aim of this study was to analyse the intraspecific variation of  $T_p$  in a population of this species living in milder conditions with full activity but not involved in reproduction.

## MATERIAL AND METHODS

A total of ten adult *T. mauritanica* were collected in a thermomediterranean site from NE Iberia (Bellaterra, Cerdanyola del Vallès, UTM 31T DF2395, 150 m altitude) in late April 2000. Animals were not sexed because reliable sexing tools (Atzori et al., 2007) were not currently available. However, in this period of the year, Moorish geckoes were not still involved in reproductive activities and females should not be pregnant (pers. obs.; Picariello et al., 1989).

Geckoes were kept in individual 0.5×0.4×0.3 m housing terraria during less than one week with food (*Drosophila* flies and *Acheta domestica* crickets) and water provided *ad libitum* and then released back at the site of capture after the experiments. Specimens were measured (snout-vent length, SVL) to the nearest 0.05 mm with a digital calliper. Subsequently, they were individually exposed to a thermal gradient (~15–45 °C, 0.5×0.5×1.5 m length experimental terrarium) produced by a 100 W reflector bulb fixed 15 cm above the substrate and maintaining natural photoperiod.  $T_p$  was measured with k-termocouple digital thermometer (Digitron® 3208K, accuracy 0.01 °C) by inserting a probe in the cloaca. Body temperatures were recorded during a single day at seven consecutive intervals (Fig. 1, Table 1) between 16 and 24 hours (local time, GMT) when the activity of the species in this season peaks in the field (Martínez-Rica, 1974). In order to minimise thermal shifts due to stress or contact with the researcher's hand, no more than 10 seconds mediated between the capture of the gecko in the terrarium and the temperature measurement.

Values of  $T_p$  were not transformed since distributions did not deviate from normality (Komogorov-Smirnov tests,  $P > 0.05$  in all cases), were homoscedastic (univariate Levene tests and multivariate Box M,  $P > 0.05$ ) and variances and means were uncorrelated. Since measurements



**Fig. 1.** Temporal variation of the preferred temperatures ( $T_p$ ) of *T. mauritanica*. The arrow points the sunset. Distinctive time measures according to Scheffé post-hoc comparisons ( $P < 0.05$ ) following a significant rmANOVA (Table 2) are indicated in the ordinates.

were repeated for the same individual for each interval, an Analysis of Variance for Repeated Measures (rmANOVA) was performed with time as the only independent factor. Sphericity assumption was tested prior to the analyses and subsequent corrections were performed in case that assumption was violated (Statsoft, 2006).

## RESULTS

One of the individuals (no. 4, SVL: 73.1 mm) showed an abnormal behaviour, remaining motionless next to the bulb for three hours. Because of that, this experiment was interrupted at 21:00 and the specimen was excluded from all the analyses. The  $T_p$ s recorded for this individual were 25.0 °C (18:00), 25.90 °C (19:00), 28.0 °C (20:00) and 28.70 °C (21:00). For the remaining nine animals, which were normally active, the  $T_p$  values recorded are shown in Table 1, grouped by individual and time interval. The rmANOVA detected a significant increase in  $T_p$  throughout the monitoring time (Fig. 1, Table 2). In fact, the main difference was detected between the measures before sunset, which increased gradually, and those after sunset, which were relatively uniform (Fig. 2).

**Table 1.**

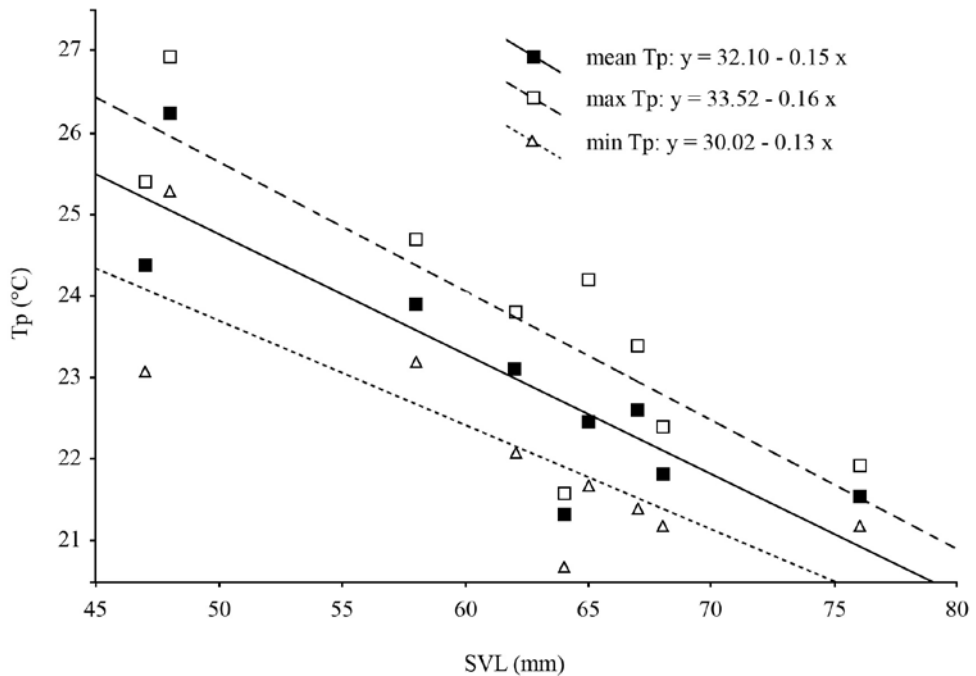
	Group	n	mean	SE	min.	max.
Time	18:00	9	22.32	0.52	20.7	25.3
	19:00	9	22.64	0.56	21.2	25.8
	20:00	9	23.11	0.59	21.3	26.2
	21:00	9	23.17	0.56	21.6	26.2
	22:00	9	23.38	0.56	21.6	26.9
	23:00	9	23.34	0.53	21.5	26.7
	24:00	9	23.40	0.52	21.5	26.6
Individual	1	7	21.56	0.11	21.2	21.9
	2	7	22.47	0.31	21.7	24.2
	3	7	24.39	0.34	23.1	25.4
	5	7	22.61	0.33	21.4	23.4
	6	7	23.11	0.22	22.1	23.8
	7	7	23.90	0.22	23.2	24.7
	8	7	26.24	0.21	25.3	26.9
	9	7	21.34	0.12	20.7	21.6
	10	7	21.84	0.17	21.2	22.4
	total*	9	23.05	0.52	21.3	26.2

\* calculated over the individual means of the seven time intervals

**Table 2.**

rmANOVA Tp	<i>F</i>	df	<i>P</i>
time (R)	5.96	6, 48	0.0001
Mauchley Sphericity test, $\chi^2$	43.52	20	0.002
Greenhouse-Geisser epsilon	0.04		
Hunyh-Feldt epsilon	0.05		
rmANOVA Tp (SVL residual)	<i>F</i>	df	<i>P</i>
time (R)	5.96	6, 48	0.0001

Surprisingly, Tp (mean, maximum and minimum of all measures of each individual) was also negatively correlated with body size (Fig. 2). Because of this, the rmANOVA was repeated using the residuals of the Tp against SVL, but results remained identical (Table 2).



**Fig. 2.** Significant relationships between preferred temperatures (mean, maximum and minimum  $T_p$ ) and body size (SVL) in *T. mauritanica*.

## DISCUSSION

The temperatures selected by *Tarentola mauritanica* in the thermogradient corresponded to those typical in other crepuscular geckos in the temperate region. Thus,  $T_p$  values were lower than those of the diurnal lacertid *Podarcis (hispanica) liolepis*, living syntopically in the same locality and time (Carretero et al., 2006) and other Mediterranean lacertids (Bauwens et al., 1995), but still higher than the activity temperatures found in nature (per. obs.). Moreover,  $T_p$ s were also much lower than those selected by the continental population in summer (31.56 °C on average, Gil et al., 1994). Because there is minimal genetic variation between both populations (Harris et al., 2004a, b) and no inter-population variation in  $T_p$ s has been recorded in other *Tarentola* species (Brown, 1996), phylogenetic shift is considered negligible in this case. The lab methodologies between this study and that by Gil et al. (1994) were very similar. Once comparativeness between both works is granted, differences in  $T_p$  found are to be attributed to changes in body condition and/or reproductive status. Coastal specimens analysed in spring here could be still in low nutritional condition and select for low temperatures (Brown and Griffin, 2003), whereas continental specimens analysed in summer should have higher fat reserves, but be involved in reproductive activities. Authors did not provide information on the reproductive status of the specimens or on female pregnancy. However, in other temperate geckonids, pregnant females are known to select for higher temperatures than non-preg-

nant females and males (Rock et al., 2000; Hitchcock and McBrayer, 2006). Nevertheless, seasonal acclimatisation also needs to be considered (Zari, 1999). Whatever the case, the differences between seasons (or reproductive classes) greatly exceed those found in Mediterranean lacertids (Carretero et al., 2006).

Huey et al. (1989) suggested that the thermal traits of geckonids are more associated to the temperatures of diurnal shelters than to those of the microhabitats of nocturnal activity. The increase of  $T_p$  during the final part of the day found here seems to correspond to the gradual selection of warmer microhabitats in the wild when getting dark (Martínez-Rica, 1974), in order to keep longer foraging activity after sunset (Anguilletta et al., 1999). A similar pattern (but a higher level) was also recorded for the continental population in summer (Gil et al., 1994).

On the other hand, to our knowledge, this is the first evidence of an inverse relationship between  $T_p$  and body size in geckonids. Because of the strict protocol followed here, such differences cannot be attributed to a methodological artefact. In fact, in a previous study on the lacertid *Podarcis (hispanica) liolepis*, similar in size and sympatric with *T. mauritanica*, the correlation between  $T_p$  and body size was positive (Carretero et al., 2006). Usually, small geckos tend to select for similar (Anguilletta et al., 1999) or lower (Hitchcock and McBrayer, 2006) temperatures than large ones. Different causes have been invoked to explain this pattern including poorer body condition, different foraging and growth rates and avoidance of aggression by large individuals (Hitchcock and McBrayer, 2006). The opposite pattern found here is tentatively interpreted as the result of the monopolisation by bigger animals of the warmer refuges, which would be of higher thermal quality in spring due to moderate diurnal temperatures and restricted crepuscular activity. Although the territoriality and interspecific aggressions in this species is not under question (Salvador, 2002), this hypothesis needs experimental testing with specimens of different sizes in different seasons.

In summary, results indicate that *T. mauritanica* displays high plasticity in preferred temperatures according to the diel and seasonal variation of its thermal environment and also probably modulated by interspecific interactions and reproductive requirements.

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