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Thermal ecology of *Microlophus occipitalis* (Sauria: Tropiduridae) in the Plain Dry Forest of Tumbes, Peru

Ecología térmica de *Microlophus occipitalis* (Sauria: Tropiduridae) en el Bosque Seco de Llanura de Tumbes, Perú

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Resumen

Se estudió la ecología termal de *Microlophus occipitalis* Peters 1871 en el Bosque Seco de Llanura de Tumbes (noroeste del Perú). La temperatura corporal promedio fue de 36,1 ± 1,8 ºC, similar a las temperaturas exhibidas por *Microlophus peruvianus* en el norte del Perú. No se identificaron diferencias entre la temperatura corporal y el grado de termorregulación de hembras y machos, posiblemente asociado a su estructura social y uso de microhábitat. La temperatura del aire y del sustrato afectaron la temperatura corporal de *Microlophus occipitalis*, aunque la temperatura del aire afecta en mayor grado la variación de la temperatura corporal. Se sugiere realizar estudios más detallados en esta especie, especialmente bajo escenarios de cambio climático en el noroeste del Perú.

Palabras clave: lagartijas, ecología termal, Parque Nacional Cerros de Amotape, Tumbes.

Abstract

The thermal ecology of *Microlophus occipitalis* Peters 1871 in the plain dry forests of Tumbes (northewestern Peru) was studied. Mean body temperature was 36.1 ± 1.8 ºC, similar to body temperatures exposed by *Microlophus peruvianus* in northern Peru. There were no differences between body temperature and degree of thermoregulation of males and females, due to a possible association to their social structure and microhabitat use. Air and substrate temperature affects the body temperature of *Microlophus occipitalis*, where air temperature accounts for a significant proportion of body temperature variation. We suggest more detailed studies on this lizard species, especially under climate change scenarios in northwestern Peru.

Key words: lizard, thermal ecology, Cerros de Amotape National Park, Tumbes

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Introduction

It is well known that environmental temperature affects diverse physiological processes of reptiles such as growth, reproduction, and locomotion which in turn affect whole functions of the individual and therefore its fitness (Huey & Slatkin 1976, Castilla et al. 1999). Lizards tend to select a range of temperatures where all functions can be maximized (Cowles & Bogert 1944) and maintain their field body temperature close to their optimal temperatures through physiological or behavioral mechanisms (Castilla et al. 1999 and references therein). There are few studies on the relationships between body and environmental temperatures in Peruvian lizards (Huey 1974, Pérez 2005, Catenazzi et al. 2005, Jordán 2010).

Species of the genus *Microlophus* occupy the west side of the Andean mountains (Frost et al. 2001). This genus is distributed from south of Ecuador, including the Galapagos Islands, to northern Chile (Dixon & Wright 1975, Frost et al. 2001, Victoriano et al. 2003), and can be found in diverse ecosystems such as coastal desert and beaches, lomas formations and dry forests (Dixon & Wright 1975, Pérez 2005, Catenazzi et al. 2005, Pérez & Balta 2007). *Microlophus occipitalis* Peters 1871 is a small lizard of 45-80 mm snout-vent length, and inhabits the dry forest of southern Ecuador and northern Peru (Dixon & Wright 1975, Watkins 1996) using diverse microhabitats such as rocky outcrops, bushes, and algarrobo trees (*Prosopis pallida*) (Dixon & Wright 1975).

Information on the ecology of *M. occipitalis* is not available to date; however, some aspects on its sexual dimorphism have been reported by Watkins (1996, 1998).

We present data on body and environmental temperatures of active *M. occipitalis* in a dry forest in northwestern Peru. Specifically, we address the following questions: i) what is the mean and range field body temperatures attained by *M. occipitalis*? ii) are there any differences in body temperatures between sexes?, and iii) is body temperature related to air temperature, substrate temperature or, both?

Material and methods

Field work was conducted during February 2005 at the former Zona Reservada de Tumbes (currently included in the Parque Nacional Cerros de Amotape –PNCA- since 2006), located in the northwestern extreme of Peru, near the Ecuadorian border. Our study site was located at Quebrada La Angostura (S 03º45´14.4", W 080º23´17.9", 70 m of altitude). This area is characterized by an isotermic climate, with a mean average annual temperature of 26 ºC, and a highly marked seasonality with a dry (May to October) and wet season (November to April). The average annual rainfall is 1450 mm with interannual variations due to the influence of El Niño Southern Oscillation (Ponte 1998, INRENA 2001).

Accordingly to Aguirre et al. (2006), the study area could be considered a "matorral deciduo" with low dense and xerophitic-spiny vegetation. This is well represented by *Prosopis pallida*, *Prosopis juliflora*, *Acacia macracantha*, *Capparis scabrida*, *C. crotonoides*, *C. avicenniifolia*, *Caesalpinia glabrata*, *Ipomoea carnea*, *Cordia lutea*, *Armatocereus cartwrightianus* among others (Linares-Palomino 2006).

In the study area, *Microlophus occipitalis* is simpatric with *Phyllodactylus reisii*, *Iguana iguana*, *Stenocercus puyango, Callopistes flavipunctatus, Ameiva edracantha, and Dicrodon guttualtum* (Tello 1998).

Lizards were captured with a self-made noose and data on sex were recorded by inspection of pattern of coloration. Snout-vent length (SVL) were recorded with a caliper (to the nearest 0.02 mm) and body temperature (T_b) with a cloacal thermometer Miller-Weber ® (to the nearest 0.2 Cº) within 30 seconds of capture. Individuals were handled in the thorax to avoid transference of heat from a researcher. Only adult individuals of *Microlophus occipitalis* were collected, with a minimum SVL of 45 mm. We also recorded the thermometer air temperature (T_a) 1 cm above ground and substrate temperature (T_s) where the individual was first observed. When the substrate was soil, the bulb was introduced 1 cm. deep and when it was a trunk or another perches, the bulb was pressed against it to record a more accurate reading. After temperatures were measured, the individuals were released at the point of capture.

Differences in SVL, T_b and environmental temperatures (T_a and T_s) between sexes were analyzed with an ANOVA test (Zar 1999). The degree of thermoregulatory behavior of males and females was evaluated by calculating the difference (in absolute values) between active body temperature and environmental temperatures (Vrcibradic & Rocha 1998), where ΔTs = [Tb–Ts] and ΔTa = [Tb–Ta]. This estimates the individual's investment to thermoregulate and maintain an appropriate body temperature and does not reflect environmental temperatures. Data were tested for normality and variances homogeneity with Kolmogorov-Smirnov and Barlet test (Zar 1999), respectively. We used simple and multiple linear regressions (Zar 1999) among T_b and environmental temperatures (T_a and T_s) to determine the relationship among them. All statistical analysis was performed with Statistica® software with a α-level of 0.05.

Results

In the dry forest of Tumbes, *Microlophus occipitalis* is active from early morning (08:00 h) through late afternoon (17:00 h) with peak activity around midday, facing high environmental temperatures throughout the day.

The mean T_b of *M. occipitalis* was 36.1 ± 1.8 ºC (n= 47) with a range between 32.2 – 39.8 ºC. The mean and range of T_a and T_s were 33.3 ± 2.1 ºC (29.9 – 39.2 ºC) and 35.1 ºC ± 2.4 (30.1 – 40.0 ºC), respectively.

Between males and female, the snout-vent length had significant difference ($F_{1,40}$ = 103.06, n = 42, p > 0.001) but not in body temperature ($F_{1,45}$ = 0.06, n = 47, p = 0.80). There was no difference among T_b of males and females and environmental temperatures (T_b-T_a: $F_{1,43}$ = 0.19, n = 45, p = 0.67, T_b-T_s: $F_{1,43}$ = 0.18, n = 45, p = 0.67). In a similar manner, there was no conclusive differences among Δ T_a and Δ T_s between males and females ($F_{1,43}$ = 0.25, n = 45, p = 0.62; T_s: $F_{1,43}$ = 0.18, n = 45, p = 0.68 respectively).

Regressions between T_b and T_a was significative (R^2 = 0.54, p < 0.01, n = 45) and between Tb and T_s too (R^2 = 0.32, p < 0.01, n = 45). Multiple regression analysis indicated a significant interaction between T_a and T_s, affecting T_b (R^2 = 0.54, p < 0.01, n = 45). When the effect of T_a ceases, T_s does not significantly affect T_b.

Discussion

Microlophus occipitalis (36.1 ± 1.8 ºC) exhibits similar body temperatures to *M. peruvianus*, both for winter body temperatures (36.3 ± 0.3 ºC) recorded in Illescas (Piura, northwestern Peru) and summer body temperatures (36.1 ± 1.8 ºC) recorded in Paracas (south Peru, Catenazzi et al. 2005). However, body temperature of *M. occipitalis* differs from that of *M. tigris* (32.2 ± 1.6 ºC, Pérez 2005), recorded at summer in Lomas de Lachay, central Peru. These three species are relatively abundant in the Peruvian coast, with overlapping distribution ranges (*M. peruvianus* and *M. occipitalis* in northern Peru and *M. tigris and M. peruvianus* in central Peru, Dixon & Wright 1975, Pérez 2005, Catenazzi et al. 2005). Information on thermal ecology of other *Microlophus* species in Peru is not available. Based on the data collected, the observed variations could be explained by differences in habitat or microhabitat use and/or geographic locations which impose climatic differences (for example, fog cover increase and wind temperatures decrease from north to south, Huey 1974, Catenazzi et al. 2005). Observed differences could also be related to ecological constraints and/or phylogenetic components; however, it remains unknown.

Additionally, *Microlophus occipitalis* displays behavioral adjustments by altering their position with respect to the sun or by shifting their microhabitat (J. Jordán, pers. obs.). During the morning, rocky substrate or open spaces are used with more frequency. Towards midday, bushes and trees which contain shadows are selected by the lizards, using higher perches. Late in the afternoon, they have been seen on rocks or fallen logs pressing their bodies to these surfaces to maintain their T_{bs} for longer periods. Moreover, they have been seen active during slight rainfalls meanwhile other species in the same area (e.g. *Stenocercus puyango* and *Ameiva edracantha*) cease their activities (J. Jordán, pers. obs.) suggesting a possible temporal segregation between them. The overall contribution of air temperature to body temperature of *Microlophus occipitalis* in PNCA occurs in combination with other factors, such as wind speed, microhabitat structure, and solar radiation, forming an environmental mosaic, where individuals could select an appropriate range of operative temperatures, as reported in other lizard species (Castilla et al. 1999, Adolph 1990).

Microlophus occipitalis male and female similarities in body temperatures could reflect similarity in microhabitat used by both sexes. Females were usually captured near or within male's territories, sharing similar microhabitat characteristics and environmental temperatures. A review of an extensive thermal ecology database of 56 desert lizard species revealed that differences in T_b between sexes are not common in desert lizard species, with only a few exceptions (Huey & Pianka 2007). The absence of significant differences of the degree of thermoregulatory behavior between male and female *M. occipitalis* (estimated by ΔT_s and ΔT_a) was partially explained by T_b and microhabitats temperatures, suggesting similar thermoregulatory behaviors for both sexes.

In addition to this first contribution, more descriptive and experimental data on thermal ecology and physiology are needed to gain insights in *Microlophus occipitalis* population dynamics, specially reated to regional climate change scenarios.

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