Selected body temperature of nine species of Mexican horned lizards (Phrynosoma)

Temperature corporal seleccionada de nueve especies mexicanas de lagartijas cornudas (Phrynosoma)

Rafael A. Lara-Reséndiz, a,b,* Diego M. Arenas-Moreno, a,c Elizabeth Beltrán-Sánchez, d Weendii Gramajo, d Javier Verdugo-Molina, e Wade C. Sherbrooke, f and Fausto R. Méndez-De la Cruz

Abstract

Temperature plays an important role in the behavior, ecology, physiology, and evolution of reptiles. Herein, we present selected body temperatures on 9 species of Phrynosoma under laboratory conditions, and note congeneric differences related to altitude and reproductive mode. The results are discussed with those of other phrynosomatid lizards.

Keywords: Thermal gradient; Phrynosomatids; Laboratory conditions; Preferred temperature; Reproductive mode; Altitude

Resumen

La temperatura juega un rol importante en el comportamiento, ecología, fisiología y evolución de reptiles. Aquí, se presentan las temperaturas corporales seleccionadas de nueve especies de Phrynosoma bajo condiciones de laboratorio, tomando en cuenta la relación con la altitud y el modo reproductor. Se discuten los resultados con las temperaturas corporales de otros phrynosomatidos.

Palabras clave: Gradiente térmico; Phrynosomatids; Condiciones de laboratorio; Temperatura preferida; Modo reproductor; Altitud

* Corresponding author.
E-mail address: rafas.lara@gmail.com (R.A. Lara-Reséndiz).
In ectotherms most physiological mechanisms are affected by temperature, therefore they carefully regulate body temperature \( (T_b) \) within a relatively narrow range by using behavioral adjustments (Cowles & Bogert, 1944). \( T_b \) data collected in the field form the basis of most thermal biology reports in the literature (Avery, 1982). In contrast, selected body temperatures \( (T_{sel}) \) in laboratory conditions are rarely reported. \( T_{sel} \), also known as preferred body temperature, represents the range of body temperatures at which an ectothermic animal seeks to maintain itself by behavioral means in order to carry on their normal activities (Brattstrom, 1965a). This temperature is commonly measured in laboratory conditions that provide an array of thermal environments free of physical and biotic constraints (e.g., predation, costs of thermoregulation; Clusella-Trullas, Terblanche, van Wyk, & Spotila, 2007). \( T_{sel} \) had been recorded for a wide range of diurnal lizard families, mostly in Scincidae, Agamidae, Lacertidae, Liolaemidae, and Phrynosomatidae (Clusella-Trullas & Chown, 2014), nonetheless, within this last family the \( T_{sel} \) of horned lizards (genus Phrynosoma) is actually quite rare in the literature (Lara-Reséndiz, Jezkova, Rosen, & Méndez-de la Cruz, 2014).

Horned lizards are one of the most distinctive lizards in North America. Most horned lizards have diets consisting primarily of native ants, dorsoventrally compressed bodies, cranial horns and body fringes, camouflage coloration and sedentary habits, a constellation of unusual and interrelated traits including “relaxed” thermoregulation (Pianka & Parker, 1975). According to the latest taxonomic revision, this genus comprises 17 species distributed from Canada to Guatemala (Nieto-Montes de Oca, Arenas-Moreno, Beltrán-Sánchez, & Leaché, 2014). Among lizards, this genus has one of the largest altitudinal distributions (~200 to 3,440 m elev.) and 2 groups have evolved viviparity, apparently a characteristic associated with montane habitats (Hodges, 2004). There have been several reports on \( T_b \) in the field and critical temperatures in Phrynosoma (Cowles & Bogert, 1944; Heath, 1962; Lemos-Espinal, Smith, & Ballinger, 1997; Pianka & Parker, 1975; Woolrich-Piña, Smith, & Lemos-Espinal, 2012, and others) and various other reports detailing aspects of its thermal ecology (Brattstrom, 1965b; Christian, 1998; Guyer & Linder, 1985; Powell & Russell, 1985; Prieto & Whitford, 1971, and others). Nevertheless \( T_{sel} \) of horned lizards has attracted relatively little study even though it is essential to understanding behavior, natural history, ecophysiology (Huey, 1982; Sherbrooke, 1997; Sherbrooke & Frost, 1989), and responses to the effects of global warming (Sinervo et al., 2010). Therefore, our principal objective was to determine the selected body temperatures of Phrynosoma in a laboratory thermal gradient and to discuss the results with those of other phrynosomatid lizards.

We conducted fieldwork during 4 years (2010-2013) in 9 localities from Mexico. A) Zumpango de Neri, Guerrero (P. asio and P. taurus; 17°36′11.73″ N, 99°31′19.74″ W, 1,130-1,400 m elev.) in a deciduous tropical forest; B) Ensenada, Baja California (P. blainvillii; 31°55′14.94″ N, 116°36′32.6″ W, 235 m elev.) in a chaparral community; C) volcán La Malinche, Tlaxcala (P. orbiculare; 19°14′38.49″ N, 97°59′26.48″ W, 3,140 m elev.) in a montane woodland and grassland; D) Chilapa de Álvarez, Guerrero (P. sherbrookei; 17°33′10.85″ N, 99°16′15.01″ W, 2,020 m elev.) in an oak forest with patches of grassland and scrub; E) Zapotitlán de las Salinas, Puebla (P. taurus; 18°19′39.68″ N, 97°27′16.17″ W, 1,400 m elev.) in a desert scrub with cacti and xerophytic plants; F) Hermosillo, Sonora (P. solare; 28°57′49.82″ N, 111°4′1.2″ W, 160 m elev.) in a desert scrub habitat, some with large, columnar cacti and small trees; G) Altamirano, Janos, Chihuahua (P. hernandesi; 30°20′58.24″ N, 108°29′26.3″ W, 1,830 m elev.) in an oak forest with patches of grassland and scrub; H) Samalayuca, Ciudad Juárez, Chihuahua (P. modestum; 31°28′33.1″ N, 106°28′33.6″ W, 1,260 m elev.) in sand dunes and semi stabilized dunes; I) Janos, Chihuahua (P. cornutum; 30°49′31.6″ N, 108°28′26.6″ W, 1,435 m elev.) in grasslands and scrublands.

All animals were captured by hand. Snout-vent length (SVL) was measured to the nearest 0.1 mm, and sex was determined

<table>
<thead>
<tr>
<th>Species</th>
<th>n (♀:♂)</th>
<th>Adult body size (SVL, mm)</th>
<th>( T_{sel} ) (°C)</th>
<th>( T_{sel} ) 25%</th>
<th>( T_{sel} ) 75%</th>
<th>Elevation (m asl)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. asio**</td>
<td>67 (33:34)</td>
<td>≥90</td>
<td>35.9±0.13</td>
<td>34.3</td>
<td>38.0</td>
<td>1,260</td>
<td>Hodges, 2002; present study</td>
</tr>
<tr>
<td>P. blainvillii**</td>
<td>5 (3:2)</td>
<td>≥62</td>
<td>37.6±0.39</td>
<td>35.0</td>
<td>39.2</td>
<td>235</td>
<td>Goldberg, 1983; present study</td>
</tr>
<tr>
<td>P. brachomanni</td>
<td>78 (56:22)</td>
<td>≥49</td>
<td>35.9±ND</td>
<td>33.9</td>
<td>37.4</td>
<td>2,470</td>
<td>Zamudio and Parra-Olea, 2000; Hernández-Ríos, not published data</td>
</tr>
<tr>
<td>P. cornutum**</td>
<td>10</td>
<td>ND</td>
<td>38.5±ND</td>
<td>37.5</td>
<td>39.0</td>
<td>1,435</td>
<td>Lemos-Espinal and Smith, 2009; present study</td>
</tr>
<tr>
<td>P. cornutum**</td>
<td>97 (61:36)</td>
<td>≥69</td>
<td>34.2±0.1</td>
<td>32.5</td>
<td>36.0</td>
<td>1,260</td>
<td>Pianka and Parker, 1975; Lara-Reséndiz et al., 2014</td>
</tr>
<tr>
<td>P. goodiei**</td>
<td>40 (16:24)</td>
<td>≥66</td>
<td>34.2±0.18</td>
<td>32.5</td>
<td>37.3</td>
<td>375</td>
<td>Zamudio and Parra-Olea, 2000; Hernández-Ríos, not published data</td>
</tr>
<tr>
<td>P. hernandesi* (Chihuahua)</td>
<td>7 (6:1)</td>
<td>≥50</td>
<td>33.0±0.18</td>
<td>30.9</td>
<td>35.5</td>
<td>1,830</td>
<td>James, 2002; present study</td>
</tr>
<tr>
<td>P. hernandesi* (o douglassii)</td>
<td>10</td>
<td>ND</td>
<td>35.0±ND</td>
<td>33.0</td>
<td>36.0</td>
<td>2,620</td>
<td>Prieto and Whitford, 1971</td>
</tr>
<tr>
<td>P. modestum**</td>
<td>8 (6:2)</td>
<td>≥37</td>
<td>33.6±0.51</td>
<td>31.1</td>
<td>36.5</td>
<td>1,260</td>
<td>Goldberg, 2012; present study</td>
</tr>
<tr>
<td>P. orbiculare* (Tlaxcala)</td>
<td>10 (5:5)</td>
<td>≥67</td>
<td>31.4±0.22</td>
<td>30.8</td>
<td>33.7</td>
<td>3,140</td>
<td>Hodges, 2002; present study</td>
</tr>
<tr>
<td>P. orbiculare* (State of México)</td>
<td>57</td>
<td>≥67</td>
<td>33.1±0.19</td>
<td>30.5</td>
<td>33.3</td>
<td>2,600</td>
<td>Hodges, 2002; Arias-Balderas, 2011</td>
</tr>
<tr>
<td>P. platyrhinos**</td>
<td>1</td>
<td>ND</td>
<td>36.0±ND</td>
<td>ND</td>
<td>ND</td>
<td>1,440</td>
<td>Pianka and Parker, 1975; Lara-Reséndiz et al., 2014</td>
</tr>
<tr>
<td>P. sherbrookei*</td>
<td>45 (26:19)</td>
<td>≥54</td>
<td>33.4±0.14</td>
<td>31.1</td>
<td>36.2</td>
<td>2,020</td>
<td>Nieto-Montes de et al., 2014; present study</td>
</tr>
<tr>
<td>P. solare**</td>
<td>26 (15:11)</td>
<td>≥69</td>
<td>37.5±0.12</td>
<td>36.8</td>
<td>38.5</td>
<td>160</td>
<td>Howard, 1974; present study</td>
</tr>
<tr>
<td>P. taurus* (Puebla)</td>
<td>11 (8:3)</td>
<td>≥55.5</td>
<td>35.9±0.24</td>
<td>34.9</td>
<td>37.5</td>
<td>1,400</td>
<td>Zamudio and Parra-Olea, 2000; present study</td>
</tr>
<tr>
<td>P. taurus* (Guerrero)</td>
<td>23 (12:11)</td>
<td>≥55.5</td>
<td>34.3±0.23</td>
<td>32.4</td>
<td>36.6</td>
<td>1,130</td>
<td>Zamudio and Parra-Olea, 2000; present study</td>
</tr>
</tbody>
</table>
for all individuals. Our data are based only on adult Phrynosoma (Table 1). In the laboratory, the lizards were maintained at 20 °C in plastic containers. Laboratory experiments were conducted one day after capture using a thermal gradient located in a 20 °C controlled-temperature room. The thermal gradient consisted of a wood box 150 cm × 100 cm × 70 cm high divided into 10 lengthwise tracks separated by insulation barriers to prevent behavioral influence of adjacent lizards. The substrate was 2-3 cm of sandy soil. At one end, and at the center of the box, 3 lamps of 100 W hanging at 30 cm to generate a thermal gradient from 20 to 50 °C throughout the tracks. The $T_{\text{sel}}$ of individuals in the thermal gradient was taken manually each hour, using the digital thermometer Fluke model 51-II, according to the activity period observed in the field and previous records for each species. The 25% and 75% quartiles of each species’ $T_{\text{sel}}$ range ($T_{\text{sel25}}$ and $T_{\text{sel75}}$) were calculated to obtain the lower and upper limits. After laboratory experiments, all lizards were released at the site of capture.

The results in Table 1 show the $T_{\text{sel}}$ average ± standard error (mean±SE) and sample size (n) of each species studied and previous published data. The means of $T_{\text{sel}}$ of the Phrynosoma species reported here are within the range of $T_{\text{sel}}$ observed in other species of Phrynosoma (Table 1). Furthermore, Sinervo et al. (2010) reported an average of $T_{\text{b}}$ of 35.2±0.20 °C for the family Phrynosomatidae considering 210 populations and a $T_{\text{b}}$ range of 26.8-41.5 °C, which is similar to other diurnal lizards (Andrews, 1998). Similarly, Clusella-Trullas and Chown (2014) reported an average of $T_{\text{sel}}$ of 35.1±2.2 °C considering 20 species of phynosomatids. Moreover, Phrynosoma cornutum had the highest $T_{\text{sel}}$ (38.5 °C) and P. orbiculare had the lowest (31.4 °C) (Fig. 1).

Figure 1. Mean selected body temperature ($T_{\text{sel}}$) of horned lizards (Phrynosoma) as a function of elevation (A) and reproductive mode (B).

Future phylogenetic comparative analysis of thermal preferences of horned lizards should refine issues related to elevation, reproductive mode and other life history traits. In addition, the direction and magnitude of labile shifts in $T_{\text{sel}}$ should be incorporated into mechanistic models (Lara-Reséndiz et al., 2014; Sinervo et al., 2010), to improve predictions of the impact of global climate change on populations of Phrynosoma.
In conclusion, the results presented above suggest that *Phrynosoma* maintain similar $T_{air}$ to other phrynosomatids and relatively higher $T_{b}$ at low elevations than at high elevations. However, this conclusion should be considered preliminary, pending broader data and incorporating biophysical models and phylogenetic analysis on their thermal biology.

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References


