Field Body Temperatures and Thermoregulatory Behavior of the High Altitude Lizard, *Lacerta bedriagae*

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Many species of lizards are known to maintain relatively high and constant body temperatures (Avery, 1982; Huey, 1982). Their abilities do so depend largely on regulatory behaviors that alter heat exchange with the environment and on the thermal conditions within their habitats. Ectotherms living at high altitudes (and latitudes) offer unique opportunities to study thermoregulatory responses to the rather unfavorable and strongly variable thermal characteristics of these regions. High altitude lizards often exhibit lower and more variable activity body temperatures, and/or thermoregulate less precisely than conspecific or congeneric populations living at lower elevations (Brattsrom, 1965; Hertz and Nevo, 1981; Vial, 1984; Crowley, 1985).

We report here results of a short-term study on field body temperatures and aspects of thermoregulatory behavior of the lizard *Lacerta bedriagae*. This medium-sized lizard (adult male body size = 66–84 mm, mass = 7–14 g; adult female body size = 66–80 mm, mass = 7–11 g) is endemic to the Mediterranean islands Corsica and Sardinia, where its distribution is usually restricted to altitudes >1000 m (Schneider, 1984). We review information on the habits of this poorly known species. We hypothesized that this lizard, living in an environment characterized by low and variable ambient temperatures, would be active over a relatively wide range of body temperatures. Our main aim therefore was to examine changes in body temperature and thermoregulatory behavior in relation to diel variations in the thermal environment.

Field work was carried out from 31 May to 3 June 1988 near Haut-Asco (42°25′N, 8°55′E; Département Haute-Corse, Corinca, France), where *L. bedriagae* seems to be restricted to altitudes >1500 m (pers. obs.). The study area was between 1750 and 1800 m elevation, on the steep east-facing slope of Mont Muflera. The site was characterized by extensive areas with bare rock pavements, large boulders and scree, which alternate with grassy patches and shrubs (dominant species: *Juniperus communis*, *Genista labelli*, *Berberis actinensis*).

We made random walks through the area and, upon each spotting of a lizard, we noted time of day, age

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**Fig. 1.** Number of lizards observed per person hour at different times (Mean European Time) of day during periods of uninterrupted sunshine.

**Fig. 2.** Percentage of lizards observed during hourly intervals that were assigned to the behavioral categories of basking, resting, walking or feeding and unknown. Data for periods of uninterrupted sunshine only; sample sizes are above bars.
TABLE 1. Temperature means ± 1 SD and range (in parentheses) of body ($T_b$), air ($T_a$) and substrate ($T_s$) during sunny and cloudy weather. N = number of temperature measurements.

<table>
<thead>
<tr>
<th></th>
<th>$T_b$</th>
<th>$T_a$</th>
<th>$T_s$</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunny</td>
<td>32.79 ± 2.30</td>
<td>15.28 ± 2.89</td>
<td>26.07 ± 4.90</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>(23.3–36.3)</td>
<td>(10.2–21.7)</td>
<td>(13.7–36.2)</td>
<td></td>
</tr>
<tr>
<td>Cloudy</td>
<td>28.38 ± 1.80</td>
<td>13.71 ± 2.79</td>
<td>24.18 ± 2.31</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>(25.2–31.4)</td>
<td>(11.0–18.7)</td>
<td>(20.2–27.9)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>31.95 ± 2.81</td>
<td>14.98 ± 2.92</td>
<td>25.71 ± 4.58</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>(23.3–36.3)</td>
<td>(10.2–21.7)</td>
<td>(13.7–36.2)</td>
<td></td>
</tr>
</tbody>
</table>

We used t-tests (two-tailed) or one-way analyses of variance (ANOVA) to evaluate differences among group means, G- and χ²-tests for contingency tests of independence (Sokal and Rohlf, 1981), analyses of covariance (ANCOVA) to test for differences between regression equations, and Spearman rank correlations (r_s). The standard criterion of statistical significance was $\alpha = 0.05$.

The number of lizards observed per person hour remained approximately constant during the course of sunny days (Fig. 1). The hourly number of observations was directly proportional to the amount of time spent searching ($x explain the relationship between $T_b$ and $T_a$. We observed the first individuals soon after our arrival at the study area at about 0700 h. Lizards retreated between 1600 and 1630 h (MET), when the sun gradually disappeared behind the mountain ridge. Our data suggest a sex-linked difference in diel activity ($G = 19.553$, 9 df, $P = 0.02$); adult males have a bimodal activity pattern and are relatively inactive at midday; activity in adult females peaks during midday and afternoon (Fig. 1).

All lizards were seen on rocky or stony substrates, and the majority (96% of $N = 108$) of those observed during sunny weather were in full sun when first sighted. The percentage of lizards that were basking varied with time of day (Fig. 2; $G = 24.478$, 9 df, $P < 0.005$). Between 1000 h and 1500 h basking incidence was lowest, but remained considerable (31% of $N = 61$). During this interval we observed all resting lizards and most of those that were walking or feeding (Fig. 2).

When weather conditions changed from sunny to cloudy during the midday or afternoon hours, lizards initially exposed themselves on stony substrates in a basking-like posture. Within one hour, most of them retreated to shelter.

We found no differences in mean body temperatures between immatures, adult males and adult females (ANOVA, $P > 0.60$). Therefore, our further analyses are based upon combined samples. Body temperatures recorded during sunny weather were higher than those observed under cloudy conditions (Table 1). $t = 7.429$, $P < 0.001$. Especially during sunny weather, differences between $T_b$ and $T_a$ were large ($d = 12.5$, $s = 3.1$, range = 10.3–24.6, $N = 73$), and variation in $T_b$ was remarkably low (CV = 7%; interquartile range = 3.1).

Relations between body, air and substrate temperatures are shown in Fig. 3. Slopes of the regression equations of $T_b$ on $T_a$ are low, though significantly larger than zero, during both sunny ($b = 0.258$, $s = 0.089$, $P < 0.01$) and cloudy weather ($b = 0.336$, $s = 0.143$, $P < 0.05$), and are not mutually different (ANCOVA, $P > 0.70$). The intercept is highest for the regression line for sunny weather samples (ANCOVA, $P < 0.001$). We obtained comparable results for the relations between $T_b$ and $T_s$ (sunny: $b = 0.205$,

![Fig. 3](image.png)

FIG. 3. Relations between body temperature and air and substrate temperature during sunny (squares) and cloudy weather (dots).
to experience higher and less variable air temperatures than *L. bedriagae*.

Several behavioral characteristics seem to enable this lizard to maintain high and constant Ts. (1) Most lizards were seen on boulders, rocks and rock pavements that were exposed to full sun. Such sites were amply available in their habitat, where the only shade was provided by dwarf-scrubs. (2) When the sun became obscured by clouds, lizards rapidly retreated to shelter, thereby reducing the variation in environmental conditions to which they were exposed. The constancy of Ts at various times of the day suggests that lizards restricted their activity to times when external conditions enabled them to maintain Ts within a narrow range. This needs to be confirmed by long-term observations and estimates of operative temperatures (Bakken and Gates, 1975; Beuchat, 1986; Peterson, 1987). (3) The percentage of lizards observed basking, which was highest at the onset and end of the diel activity period, remained considerable during the midday hours. These observations suggest that individual lizards basked frequently and/or for long periods of time. Comparable findings have been made for *Lolotes multiformis*, that basks about 70% of the time spent above ground (Pearson and Bradford, 1976). (4) While basking or resting, lizards maintain close contact with sun-warmed rocks or boulders, seemingly to facilitate conductive heat gain. However, Ts were lower during cloudy than during sunny weather; even after accounting for differences in air and substrate temperatures. Hence, Ts seem to drop rapidly in the absence of direct sunshine, suggesting that thigmothermic heat gain is of but secondary importance to these lizards.

It should be noted that our results apply only to the spring period. Seasonal changes in thermoregulatory behavior and activity temperatures have been documented in other lizards (e.g., Huey and Pianka, 1977; Christian et al., 1983; Van Damme et al., 1987). At present, we can only speculate whether seasonal changes in the thermal biology of *L. bedriagae* would alter our conclusions.

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**LITERATURE CITED**


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