



Sexual Size Dimorphism, Ovipositioning, and Hatching in *Leiocephalus macropus asbolomus* (Squamata: Leiocephalidae) in Alexander Von Humboldt National Park in Eastern Cuba

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Abstract.—The endemic Antillean family Leiocephalidae includes 28 currently recognized extant species in the genus *Leiocephalus*. These are distributed across Hispaniola, Cuba, and various islands and cays in the Bahamas. Sexual size dimorphism (SSD) is a fundamental and widespread biological phenomenon generally attributed to sexual differences in relationships between body size, survival, fecundity, and mating success. Six species with 40 subspecies are known from Cuba. Few data are available regarding SSD and reproduction. Herein we report new life-history data and the sexual size dimorphism index (SSDI) in *Leiocephalus macropus asbolomus*. Fieldwork was performed during mid-August 2009 in La Melba (Alexander von Humboldt National Park), Holguín Province, Cuba. All males were larger in size than females and the SSDI (1.44) is the highest reported for any species of *Leiocephalus*. Egg measurements averaged 18.2 x 12.7 mm; mean clutch size was 3. Eggs took 61–72 days to hatch; mean incubation time was 66.5 days, and mean hatchling SVL was 30.1 mm.

Key words: Leiocephalidae, sexual size dimorphism, oviposition, hatchling, eastern Cuba

Lizards in the genus *Leiocephalus* are widely distributed across Hispaniola, Cuba, and various islands and cays in the Bahamas (Gifford and Powell 2007, Powell and Henderson 2009). They are commonly known as “curly-tailed lizards” based on the habit in most species of raising and coiling their tails. Twenty-eight extant species of *Leiocephalus* are currently recognized (Henderson and Powell, 2009).

In many animal groups, sexual differences in morphological characters (sexual dimorphism) are common, with males typically larger than females (e.g., Schoener et al. 1982, Shine 1986, Fairbairn 1997, Anderson 1994). Sexual size dimorphism (SSD) is a fundamental and widespread biological phenomenon in which individuals of one sex are characteristically larger than those of the opposite sex for a given population or species (Cox and Calsbeek 2009). This widespread phenomenon is generally attributed to sexual differences in relationships between body size, survival, fecundity, and mating success, and contributes to differences in

behavior, demography, life history, physiology, ecology, and the evolution of males and females within a population (e.g., Cox et al. 2003, Cox and Calsbeek 2009).

Previous research has shown that most species of *Leiocephalus* demonstrate male-biased sexual dimorphism in body size (e.g., Rodríguez Schettino 1999, Gifford and Powell 2007, Henderson and Powell 2009 and literature therein). Reproductive behavior (e.g., mating, ovipositioning, incubation periods, hatching) has not been described in most species of *Leiocephalus* (op. cit., Petzold 1962, Petzold et al. 1970, Smith and Iverson 1993, Martínez Reyes 1994, Martínez Reyes in Rodríguez Schettino 1999, Owens and Knapp 2004). Only one previous study (Gifford and Powell 2007) examined egg volume.

Six diurnally active Cuban species are divided into a total of 40 subspecies, all robust, and of varying sizes, with limbs adapted for running and long slender digits for digging (Rodríguez Schettino 1999). The Cuban Side-blotched Curly-



Fig. 1. Cuban Side-blotched Curly-tailed Lizard (*Leiocephalus macropus asbolomus*): A. Gravid female about 1.5 m above the ground. B & C. Female and male, respectively, on a rock near the oviposition area at La Melba, Alexander von Humboldt National Park in eastern Cuba. Photographs by Yasel U. Alfonso.

tailed Lizard (*Leiocephalus macropus* Cope, 1862) has 11 currently recognized endemic subspecies distributed across the Cuban Archipelago in disjunct areas that include the extreme eastern coast and adjacent lower and interior montane slopes, northern Holguín Province, northern Camagüey coast, interior Ciego de Ávila Province, northern Matanzas coast and interior, Sierra de Escambray, Península de Guanahacabibes, Sierra del Rosario, Cayo Damas of the southeastern coast, and Isla de la Juventud (Powell and Henderson 2009). In this study, we report previously unknown data about life-history variables (e.g., clutch size, egg size, and neonates) and determine the sexual size dimorphism index (SSDI) for *L. m. asbolomus* (Fig. 1) in Alexander Von Humboldt National Park in eastern Cuba.

Materials and Methods

Observations in the field were made on 17–18 August 2009 at La Melba, Alexander von Humboldt National Park, Holguín

Province, Cuba (Fig. 2). For each individual, we measured snout-vent length (SVL), head width (HW) at the widest point of the head, head length (HL) from the anterior edge of the auricular opening, and weight (W). We found two nests (Fig. 3) buried in substrate near plant roots in lowland rainforest on a metamorphic complex (forest vegetation, see Fong et al. 2005). In both instances the females had removed the substrate with their hindlegs. We assumed that this is an ovipositioning behavior characteristic of these lizards as we had previously observed similar behavior in other species (*L. carinatus*, *L. raviceps*, unpubl. data).

We found three unhatched eggs in each nest. We measured all six eggs (maximum length and width) and collected them with some of the substrate for incubation in a plastic box (20 x 10 x 10 cm). Eggs were transported to CATEDES LAB, where they were incubated under laboratory conditions (temperature range: 25–28 °C) using an RZ Incandescent Day White Light Spot (75 watt) to simulate the natural day-

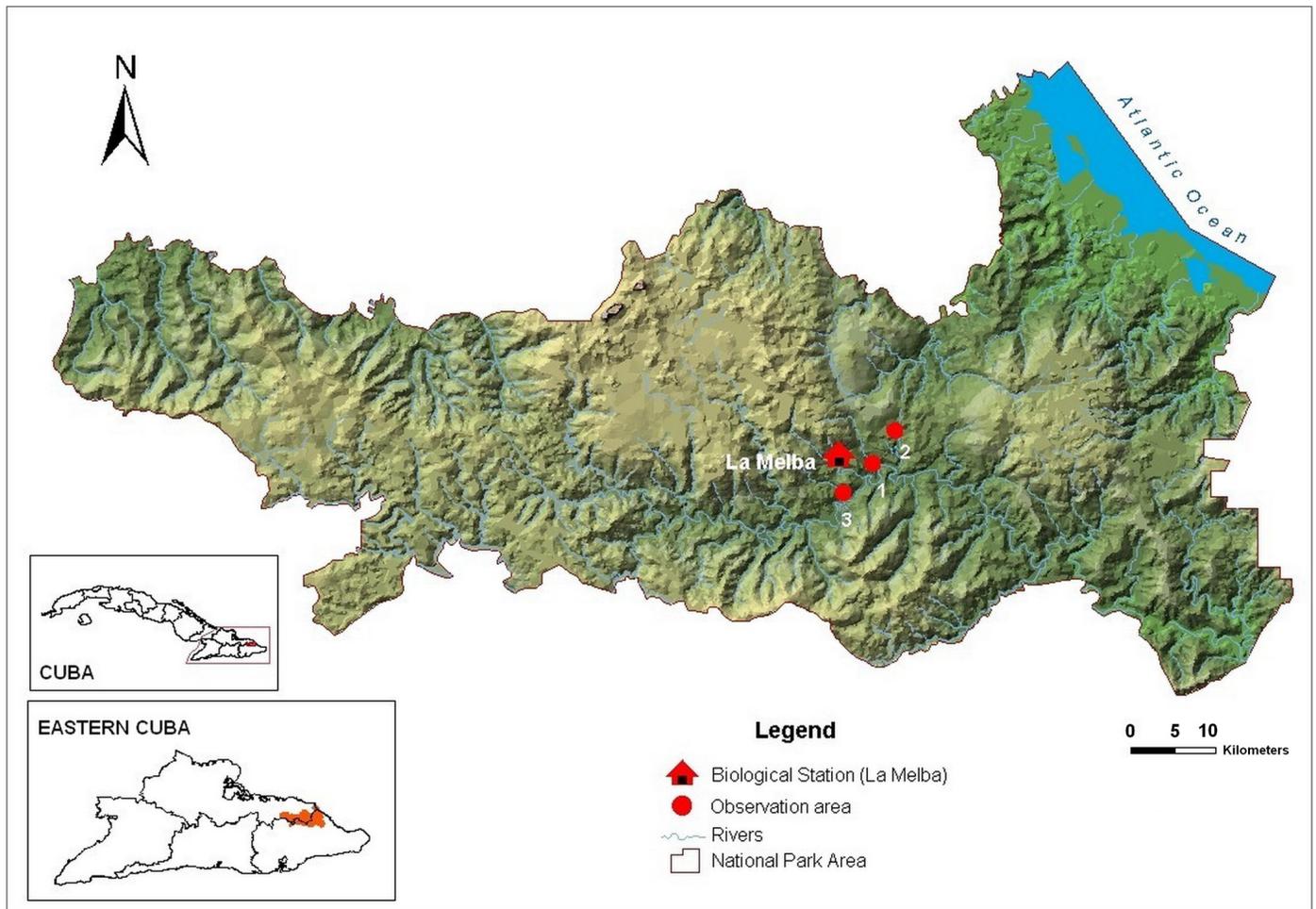


Fig. 2. Map showing the location of study sites at La Melba in Alexander von Humboldt National Park (1: 191 m asl, 20.445556 and -74.805833; 2: 341 m asl, 20.461389 and -74.796667; 3: 274 m asl, 20.441667 and -74.816667). Map by Gabriel Fajardo.

time photo-environment. After hatching, we measured the SVL of all hatchlings. All measurements were taken with a Vernier caliper (mm) and weights with a Pesola dynamometric balance (100 ± 0.05 g). Results are expressed as means \pm one standard deviation. We compared morphometric variables using Spearman rank correlations and Student's *t*-tests with \log_{10} -transformed data. For all tests, $\alpha = 0.05$.

Results

We collected 21 (9 ♂ and 12 ♀) *Leiocephalus macropus asbolomus*. Mean male SVL (89.7 ± 3.3 mm) was significantly greater than that of females (62.2 ± 9.2 mm; $t = 9.23$, $P < 0.001$), as were differences between sexes for HW (males: 15.8 ± 0.9 mm; females: 12.4 ± 1.1 mm; $t = 4.61$, $P < 0.05$), HL (males: 19.9 ± 1.1 mm; females: 16.8 ± 1.3 mm; $t = 5.04$, $P < 0.05$), and body mass (males: 22.2 ± 2.2 mm; females: 8.83 ± 0.7 mm; $t = 8.57$, $P < 0.001$) (Fig. 4A). The SSDI was 1.44 (Table 1). All morphometric variables were significantly ($P < 0.05$) and positively correlated: males, SVL/HW ($r_s = 0.933$), SVL/HL ($r_s = 0.967$), W/HL ($r_s = 0.667$), HW/HL ($r_s = 0.983$); females, SVL/W ($r_s = 0.825$), SVL/HW ($r_s =$

0.932), SVL/HL ($r_s = 0.951$), W/HW ($r_s = 0.939$), W/HL ($r_s = 0.741$), HL/HW ($r_s = 0.841$).

Mean egg measurements were $18.2 \pm 2.03 \times 12.7 \pm 1.57$ mm ($n = 6$) and mean clutch size was 3 ($n = 2$). The eggs took 61–72 days to hatch, minimum incubation time was 66.5 ± 5.85 days and hatchling SVL was 30.1 ± 1.79 mm.

Discussion

Consistent with previous studies on sexual size dimorphism in *Leiocephalus* (e.g., Henderson and Powell 2009 and references therein, Alfonso et al. 2012), *L. macropus asbolomus* demonstrated male-biased SSD. Few studies (Rodríguez Schettino 1999, Smith and Nickel 2002a, Alfonso et al. 2012) have examined SSD in Cuban species. Rodríguez Schettino (1999) analyzed only three morphometric variables (SVL, HL, and TL) in five Cuban *Leiocephalus* (omitting *L. onaneyi*) and found significant differences; however, she did not provide SSDIs. Measurements for recently rediscovered *L. onaneyi* Garrido 1973 (Diaz and Cadiz 2012) are insufficient for evaluating SSD and making comparisons with other species. Smith and Nickel (2002a) and Alfonso et al.

Table 1. Sexual size dimorphism index (SSDI) in species of *Leiocephalus* from Cuba, the Dominican Republic, and the Bahamian Archipelago. Species are listed in order of SSDI. Cuban localities include the U.S. Naval Base at Guantánamo Bay (¹), Yacabo Abajo at Guantánamo along the southern coast (²), and La Melba, Alexander von Humboldt National Park in eastern Cuba (³).

Species	Location	SSDI	Reference
<i>L. carinatus</i> Gray	Bahamas	1.02–1.18	Schoener et al. (1982)
<i>L. semilineatus</i> Dunn	Dominican Republic	1.03	Nelson et al. (2001)
<i>L. semilineatus</i> Dunn	Dominican Republic	1.07	Gifford and Powell (2007)
<i>L. macropus macropus</i> Cope ¹	Cuba	1.11	Smith and Nickel (2002a)
<i>L. semilineatus</i> Dunn	Dominican Republic	1.11	Nelson et al. (2001)
<i>L. loxogrammus</i> Cope	Bahamas	1.12	Schoener et al. (1982)
<i>L. lunatus</i> Cochran	Dominican Republic	1.15	Gifford and Powell (2007)
<i>L. barahonensis</i> Schmidt	Dominican Republic	1.19	Micco et al. (1997)
<i>L. psammotromus</i> Barbour	Caicos Islands	1.20	Smith (1992)
<i>L. barahonensis</i> Schmidt	Dominican Republic	1.20	Gifford and Powell (2007)
<i>L. schreibersii</i> Gravenhorst	Dominican Republic	1.22	Schreiber et al. (1993), Nelson et al. (2001)
<i>L. schreibersii</i> Gravenhorst	Dominican Republic	1.26	Gifford and Powell (2007)
<i>L. raviceps</i> Cope	Cuba	1.30	Smith and Nickel (2002a)
<i>L. inaguae</i> Cochran	Bahamas	1.30	Schoener et al. (1982)
<i>L. stictigaster</i> Schwartz	Cuba	1.33	Smith and Nickel (2002a)
<i>L. personatus</i> Cope	Dominican Republic	1.33	Gifford and Powell (2007)
<i>L. macropus macropus</i> Cope ²	Cuba	1.43	Alfonso et al. (2012, In press)
<i>L. macropus asbolomus</i> Cope ³	Cuba	1.44	This study

(2012) did provide SSDIs (Table 1) for *L. macropus*, *L. raviceps*, and *L. stictigaster*. Those studies evaluated two different populations of *L. macropus macropus* on the southern coast of Guantánamo Province, demonstrating some variability in body size and SSD among populations of the same species. The SSDI (1.44) reported in this study for *L. macropus asbolomus* is larger than any previously reported for any species of *Leiocephalus* (Smith and Nickel 2002a, Gifford and Powell 2007, Alfonso et al. 2012).

Several possible hypotheses have attempted to explain the male-biased sexual dimorphism (body size and head size) found in *Leiocephalus* (see Smith and Nickel 2002a, Gifford and Powell 2007; Fig. 4B). Sexual selection might result in larger males that usually win aggressive encounters with smaller males (Anderson and Vitt 1990, Hews 1990, Cooper and Vitt 1993). Differences in body or head size might have evolved in response to varying niche dimensions (habitat type, perch height, or diet), thus decreasing intraspecific competition between individuals. For example, larger males, capable of ingesting larger prey items, might exploit different prey than females (Schoener 1967, Shine 1989, Herrel et al. 1996). Additionally, differen-

tial growth rates between sexes due to ecological, physiological, or behavioral factors (Gifford and Powell 2007 and references therein) or greater biting capacity of larger males with larger heads (Herrel et al. 1996) might provide an advantage in same-sex combat or increase chances of successful fertilization during copulation.

Our observations of ovipositioning were in mid-August. Other gravid females (*L. macropus immaculatus*) have been observed in February, March, and May, but not September (Martínez Reyes in Rodríguez Schettino 1999). The reproductive period in other Cuban species ranges from February through August (Rodríguez Schettino 1999), with some species reproducing continuously throughout the year, albeit more frequently in some months.

Egg measurements have not been reported for any subspecies of *L. macropus*. Martínez Reyes in Rodríguez Schettino (1999) provided measurements of oviductal eggs in *L. macropus immaculatus* (12.0–20.3 mm, mean = 12.5 mm). Egg dimensions for other Cuban species of *Leiocephalus* are 16.3–19.0 x 9.4–14.4 mm in *L. cubensis* (Rodríguez Schettino 1999; Martínez Reyes 1994), 18.0 x 8.0 mm in *L.*

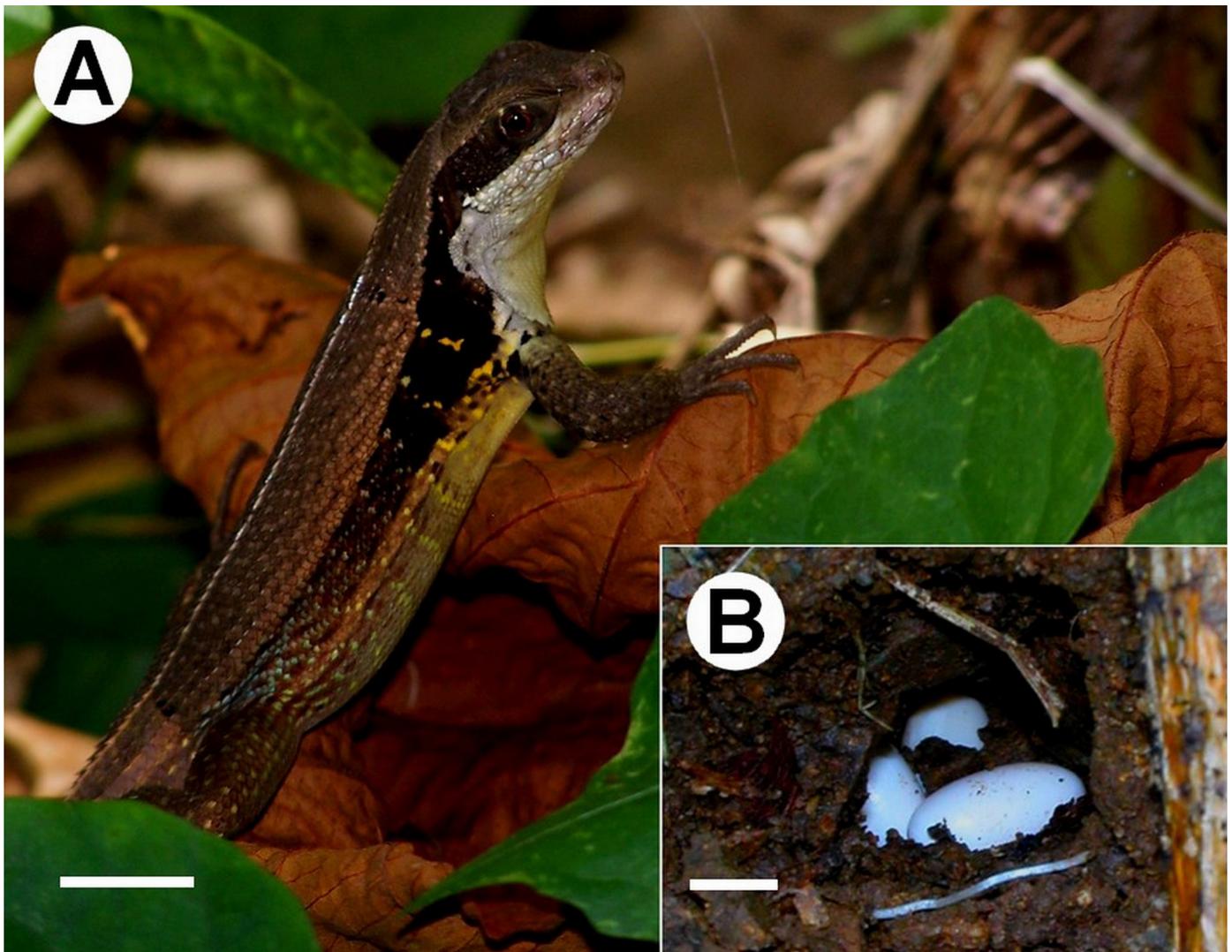


Fig. 3. Adult female *Leiocephalus macropus asbolomus* near an oviposition site at La Melba in Alexander von Humboldt National Park, eastern Cuba. Inset: Three eggs deposited in an excavated cavity. Scale bars = 1 cm. Photographs by Yasel U. Alfonso.

raviceps (Rodríguez Schettino et al. 1999), (15.0–17.0 x 7.0–8.3 mm in *L. stictigaster* (Martínez Reyes et al. 1990), and 14–26 x 9–19 mm in *L. carinatus* (Rodríguez Schettino 1999, Petzold 1962, Petzold et al. 1970, Owens and Knapp 2004). Data for species of *Leiocephalus* from elsewhere in the West Indies include means of 15.05 mm for *L. barahonensis*, 13.45 mm for *L. lunatus*, 15.49 mm for *L. personatus*, 16.29 mm for *L. schreibersii*, and 12.89 mm for *L. semilineatus* in the Dominican Republic (Gifford and Powell 2007), and 19–24 x 10–11 mm for *L. inaguae* (Noble and Klingel 1932) and 19.9 x 9.2 mm for *L. psammmodromus* (Smith and Iverson 1993) in the Bahamian Archipelago.

Martínez Reyes in Rodríguez Schettino (1999) noted that all females in their study of *L. macropus immaculatus* contained two oviductal eggs. Smith and Nickel (2002b) gave a mean clutch size of 1.75 ± 0.25 (range 1–2); however, Hedges (in prep., cited in Powell and Henderson 2009) reported a mean clutch size of two for this species. Our results suggest,

at least for *L. macropus asbolomus*, that the mean clutch size can vary in this species. Maximum clutch size for any species of *Leiocephalus* is nine oviductal eggs in *L. carinatus* (Martínez Reyes in Rodríguez Schettino 1999).

Our sample size was too small to analyze a relationship between female SVL and clutch size. Only two studies provided those types of data. Smith and Iverson (1992) showed no relationship between clutch size and female SVL in *L. psammmodromus*, and data for species in the Dominican Republic (Gifford and Powell 2007) were similar, except for *L. barahonensis*, which showed a weak correlation of clutch size with female body size.

The relatively limited variation in clutch and egg sizes among species might be suggestive of an optimal reproductive strategy for *Leiocephalus* (Gifford and Powell 2007). The optimal egg-size theory suggests that the minimum size of an egg is constrained by the minimum offspring size necessary for survival (Brockelman 1975). Gifford and Powell (2007) pro-

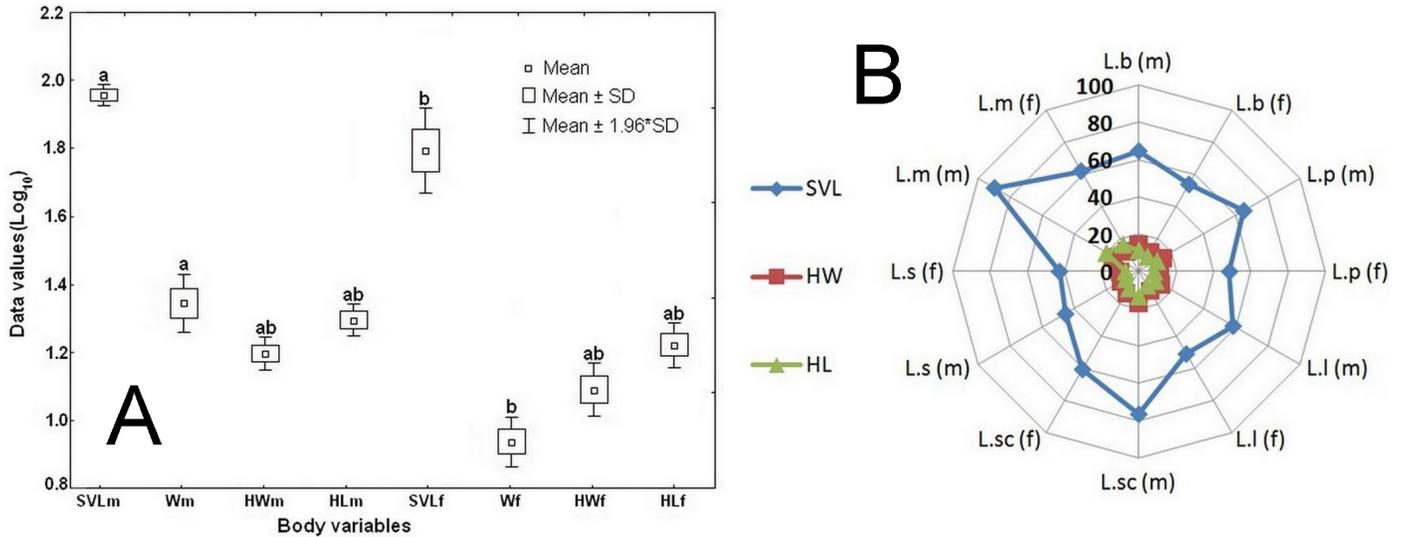


Fig. 4. A. Student's t-test (data log₁₀-transformed) and descriptive statistics for intraspecific analysis in *L. macropus asbolomus*. Significant differences between variables are indicated by ab ($P < 0.05$) and a or b ($P < 0.001$). B. Interspecific comparisons of three morphometric variables in *L. macropus asbolomus* and five species of *Leiocephalus* from the Dominican Republic (L.b = *L. barabonensis*, L.p = *L. personatus*, L.l = *L. lunatus*, L.sc = *L. schreibersii* and L.s = *L. semilineatus*); data from Gifford and Powell (2007).

posed that maximum egg size might be physically constrained (e.g., volume of the body cavity or energy availability), and Tinkle et al. (1970) suggested that the competition in tropical island systems might be intense because of high lizard densities, and proposed that reproductive characteristics could be under energetic constraints.

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