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Sexual Dimorphism of *Gallotia atlantica atlantica* and *Gallotia atlantica mahoratae* (Lacertidae) from the Eastern Canary Islands

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ABSTRACT.—I examined sexual dimorphism in the lacertids *Gallotia atlantica atlantica* and *Gallotia atlantica mahoratae* from Lanzarote and Fuerteventura Islands, respectively. Mean body size was smaller in *G. a. mahoratae* than in *G. a. atlantica*. Sexual size dimorphism was greater in *G. a. atlantica* than in *G. a. mahoratae*, but relative size of several morphological traits was not different between the two populations. In both subspecies, head and body traits scaled to SVL, with head size of males having a positive allometry, indicating a disproportionate increase of this trait with the increase in body size. Relative size in hind-limb length was greater in males than in females in *G. a. atlantica* but not in *G. a. mahoratae*.

Analyses of morphological and behavioral traits of conspecifics from different geographical locations often reveal within and between population variation. Lizards in the genus *Gallotia* are endemic to the Canary Islands (Arnold, 1989) and seven living species have been described. Comparative analyses of this supposedly monophyletic genus may provide valuable information about local variability and help us understand possible adaptations as well as evolutionary relationships. Given the variety of habitats occurring on a single island, opportunities exist for different selective factors to act on different populations (e.g., Losos et al., 1997, for Caribbean Anolis). Although some species of *Gallotia* have been studied (Thorpe and Brown, 1991; Bischoff, 1998), few detailed analyses have been carried out comparing morphological or behavioral traits from two or more species or populations (Bischoff, 1985; Thorpe and Brown, 1989; Molina-Borja et al., 1997).

Gallotia atlantica is the smallest lizard of the Canary Islands and two subspecies have been described: *Gallotia atlantica atlantica* from Lanzarote and *Gallotia atlantica mahoratae* from Fuerteventura (for a detailed description of the species, see Bischoff, 1998). Both subspecies are omnivorous and as they may live in several different habitat types, there is a potential for morphological variation to be influenced by local ecological factors. Therefore, I selected two different habitats with different lizard densities, one on each island, to analyze morphological variation in each population.

My first objective was to analyze sexual dimorphism in two populations of *G. atlantica* living in very different habitats. I predicted that the degree of sexual body size dimorphism would be different, being larger in the Lanzarote population, which has a higher lizard density. My second objective was to determine the scaling relationships of different traits to SVL in each sex and population and to examine these relationships between the sexes and populations.

MATERIAL AND METHODS

I selected two different habitats for collecting specimens, one in an abandoned agricultural field near Punta Mujeres (*G. a. atlantica*, northeast Lanzarote) and the other in the lava field of Malpaís de la Arena (*G. a.*

mahoratae, north of Fuerteventura). In the first habitat, vegetation was mainly the herbaceous *Launaea arborescens* (Compositae) and *Kleinia neriifolia* (Asteraceae), whereas the second habitat had a few dispersed *L. arborescens* and *Lycium* sp., as well as plentiful lichen *Ramalina bourgeana* growing on lava stones.

Lizards were captured between April and September 1998 and 1999 using 5-liter can traps baited with small pieces of tomato and banana. About the same number of individuals were captured in both habitats with the same number of traps and sampling days (see sample sizes in Table 1). Traps were closer together for *G. a. atlantica* than for *G. a. mahoratae*; thus trap density was higher for *G. a. atlantica* than *G. a. mahoratae*.

Lizards with a body size (SVL) greater than the minimum size at sexual maturity were considered adults and were included in the analyses of sexual dimorphism; that is, the smallest male having easily evetable hemipenes (*G. a. atlantica* = 59.5 mm; *G. a. mahoratae* = 52.6 mm) and the smallest female having enlarged ovarian follicles (*G. a. atlantica* = 57.0 mm; *G. a. mahoratae* = 49.2 mm).

For each individual, I measured snout-vent length (SVL), body mass (BM), pileus width (PW, distance between rear lateral edge of both parietal scales), head depth (HD, height between rear edge of parietal scale and lower border of the jaw), fore- and hind-limb lengths (FLL, HLL, distances between groin and distal end of longest digit from each limb), and the number of right lateral blue or green spots (NLS). Gravid females were detected by palpation of the abdomen. After the measurements, all animals were released at their capture site.

Traits were measured for all individuals in the field with a caliper (to the nearest 0.01 mm), or spring balance (to the nearest 1 g). Measurement errors, calculated as the inverse of repeatability values (Zar, 1984), varied for the different traits: 0.05 (SVL and BW), 0.18 (pileus width), 0.30 (FLL) and 0.13 (HLL). Traits were not considered for statistical analysis (for example FLL) when their measurement error was greater than the difference for that trait between sexes or between populations.

Data were analysed using SPSS version 9.0. When data did not meet the assumptions of parametric tests, nonparametric tests were used. Sexual size dimorphism

Table 1. Mean value (\pm SE) and range for the biometric traits of the two subspecies analysed. m = male; f = female (range in parentheses).

	<i>G. a. atlantica</i> m (N = 25)	f (N = 21)	<i>G. a. mahoratae</i> m (N = 26)	f (N = 24)
Body mass	19.4 \pm 1.2 (7.4–27.9)	6.7 \pm 0.37 (5.4–9.4)	6.1 \pm 0.29 (3.5–9.6)	3.6 \pm 0.12 (2.0–5.0)
Snout–vent length	88.0 \pm 1.4 (69–96)	67.0 \pm 0.74 (64–73)	62.7 \pm 0.94 (53–69)	56.8 \pm 0.58 (49–61.5)
Pleuro width	10.2 \pm 0.18 (7.98–11.9)	7.2 \pm 0.09 (6.6–7.71)	7.4 \pm 0.13 (6.08–8.54)	6.2 \pm 0.06 (5.6–6.85)
Head depth	11.8 \pm 0.29 (8.53–14.39)	7.5 \pm 0.08 (6.98–8.02)	7.8 \pm 0.18 (6.15–9.6)	6.0 \pm 0.07 (5.24–6.92)
Forelimb length	28.0 \pm 0.43 (24.1–32.35)	19.8 \pm 0.63 (12.68–22.27)	20.5 \pm 0.35 (16.87–23.31)	17.6 \pm 0.17 (16.13–19.73)
Hind-limb length	46.6 \pm 0.7 (38.8–52.6)	31.2 \pm 0.78 (24.34–35.38)	33.5 \pm 0.42 (29.08–36.78)	27.6 \pm 0.31 (23.81–30.72)
Number of lateral spots	8.86 \pm 0.29 (6–12)	9.0 \pm 0.47 (6–12)	7.85 \pm 0.2 (7–10)	8.38 \pm 0.14 (7–10)

was calculated following Lovich and Gibbons (1992; mean male SVL/mean female SVL – 1).

Multivariate analysis of variance (MANOVA) was used to detect possible differences between males and females within each population taking into account all traits. Regression analyses on \log_{10} -transformed data were performed to determine patterns of isometry or allometry between head and body traits and SVL. Reduced major axis (RMA) regression was used to correct the associated error to the measurements of the independent variable (McArdle, 1988; LaBarbera, 1989). Deviations from isometry (slope of 1) were tested using a *t*-statistic described in Clarke (1980) with degrees of freedom calculated from his equation 5.1. Comparisons between the slopes from male and female scaling relationships were also computed with a test described by the same author. Comparisons of the relative size of the traits (residuals on SVL) both between males and females within a population and between males or females of the two subspecies were done with a *t*-test. Significance level was set at 0.05 with the simultaneous Bonferroni correction applied.

RESULTS

For both populations all head and body traits increased with SVL in both sexes except HLL in female *G. a. atlantica* and number of lateral spots (NLS) in males and females of both populations (Table 2). The sexes did not differ significantly (after Bonferroni correction) for any of the trait to SVL slopes (*t*-test of Clark, 1980). Only HD in males of both populations exhibited statistically significant positive allometry (slope $>$ 1; Fig. 1; Table 2). Interestingly, variance in trait-SVL relationships was greater in females (as indicated by lower R^2) for all traits in both populations.

In both populations male body size (SVL) was significantly greater than female size ($t = 9.8$, $df = 32$, $P < 0.001$ for *G. a. atlantica* and $t = 5.3$, $df = 51$, $P < 0.001$ for *G. a. mahoratae*). Sexual body size dimorphism was higher in *G. a. atlantica* (0.323) than in *G. a. mahoratae* (0.113). Relative trait size did not differ between the sexes for all traits, except for HLL in *G. a. atlantica* where males had relatively larger HLL than females ($t = 3.08$, $P < 0.01$, Fig. 2).

Taking all traits together, males and females of each population differed significantly (MANOVA: $F_{1,39} = 61.0$, $P < 0.001$ for *G. a. atlantica* and $F_{1,47} = 35.03$, $P < 0.001$ for *G. a. mahoratae*) and also when considering each trait individually, except for the number of lateral spots (Table 1).

DISCUSSION

Sexual size dimorphism in body length (SVL) was present in both populations, but was greater in *G. a. atlantica* than in *G. a. mahoratae*. Further, *G. a. atlantica* were generally larger than *G. a. mahoratae*. Differences in post-maturation growth between the sexes has not been documented in *G. atlantica*, but if it follows the same pattern as other Canarian lizards (Castanet and Báez, 1991; Rodríguez-Domínguez et al., 1998), at least part of the sexual dimorphism in SVL documented for this species could be accounted for by this proximal factor.

Current ecological processes could also account for the described SSD. Although no precise quantitative data exist on lizard densities for the two populations

Table 2. Regression parameters (RMA method) of the scaling relationships between head and limb traits in males (m) and females (f) from both subspecies. “-”: regression not significant; $t = t$ -test of Clarke (1980) for testing deviation from isometry (slope significantly different from 1).

	Traits	Sex	R^2	Constant	Slope	t	df	P
<i>G. a. atlantica</i>	PW	m	0.804	-1.083	1.077	0.76	17	n.s.
		f	0.506	-1.282	1.172	0.74	10.7	n.s.
	HD	m	0.720	-1.929	1.543	3.75	17.4	<0.01
		f	0.564	-0.987	1.018	0.09	10.5	n.s.
	HLL	m	0.572	0.081	0.90	0.73	18.3	n.s.
		f	0.06	0.62	0.48	-	-	-
<i>G. a. mahoratae</i>	NLS	m	0.114	-0.028	0.502	-	-	-
		f	0.002	1.133	-0.102	-	-	-
	PW	m	0.834	-1.324	1.22	2.39	19	n.s.
		f	0.622	-1.105	1.081	0.62	20	n.s.
<i>G. a. atlantica</i>	HD	m	0.802	-1.859	1.532	4.92	19	<0.005
		f	0.557	-1.339	1.209	1.39	20.7	n.s.
	HLL	m	0.737	0.024	0.835	1.61	17.3	n.s.
		f	0.294	-0.484	1.097	0.36	11.5	n.s.
<i>G. a. mahoratae</i>	NLS	m	0.152	-0.203	0.609	-	-	-
		f	0.003	1.084	-0.092	-	-	-

studied, *G. a. atlantica* had more lizards per unit area than *G. a. mahoratae*. Stamps et al. (1997) found a significant positive association between SSD and density in a phylogenetic study of several *Anolis* species.

Sexual dimorphism in *G. atlantica* could result from different selection pressures acting on each sex. For example, a higher intramale sexual competition in

certain habitats could have led to increased selection for larger male size (Carothers, 1984; Stamps et al., 1997) or increased reproductive output with larger body size in females (see review in Fairbairn, 1997). No data are available to address the potential role of these selective pressures in these populations.

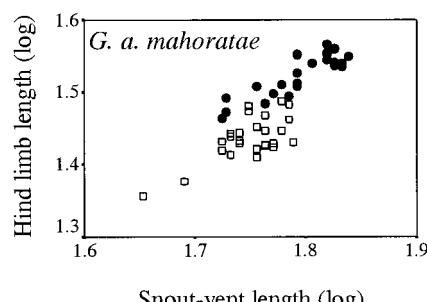
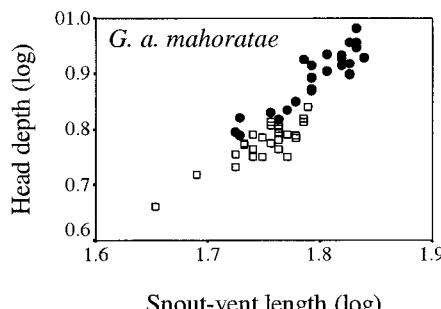
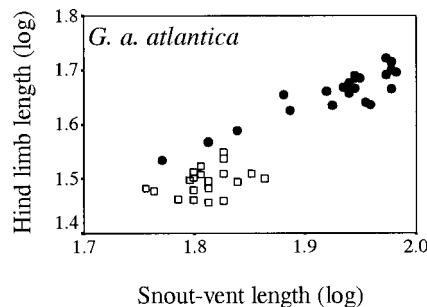
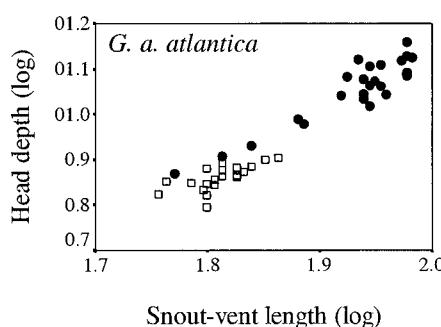


FIG. 1. Relationship of head depth to SVL in males (filled circles) and females (open squares) of *Gallotia atlantica atlantica* and *Gallotia atlantica mahoratae*.

FIG. 2. Scaling relationships of hind-limb lengths to SVL in *Gallotia atlantica atlantica* and *Gallotia atlantica mahoratae*.

Several processes may account for the present differences in sexual size dimorphism (as has been shown in the teiid *Ameiva plei*, Censky, 1996). It is clear that no adaptive significance can be deduced from a two-species study (Garland and Adolph, 1994) and that the differences found between the two populations studied may only suggest differences in genetic, ethological, ecological, and evolutionary factors affecting them. However, I suggest that the ensemble of processes may have been operating with higher intensity in *G. a. atlantica* than in *G. a. mahoratae*.

The relative size of hind-limb lengths did not differ between sexes in *G. a. mahoratae*, but males had larger relative HLL than females in *G. a. atlantica*. Larger or stronger hind limbs in males than in females have usually been interpreted as a trait contributing to higher running speeds or fighting abilities in this sex (e.g., Garland and Losos, 1994; Bauwens et al., 1995; Lappin and Swinney, 1999).

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