Sexual dimorphism in *Liolaemus occipitalis* (Iguania, Tropiduridae)[1]

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ABSTRACT. The sexual dimorphism in size, morphology and color of the lizard *Liolaemus occipitalis* Boulenger, 1885 was studied. Thirty-two adult males and twenty-eight adult females were sampled from a population in the Jardim do Éden beach, near Tramandaí, Rio Grande do Sul, Brazil. Size related sexual dimorphism occurred in all compared body dimensions. The largest female was 59.6 mm in snout-vent length, and the largest male was 69.3 mm. Males and females also presented differences in ventral and dorsal color pattern, and in the presence of pre-cloacal pores. The results suggest that, in *Liolaemus occipitalis,* sexual dimorphism in size is determined by sexual selection, competition between males and by the high energetic cost for females a few months after hatching.

KEYWORDS. Sauria, *Liolaemus*, sexual dimorphism, sexual selection.

INTRODUCTION

Sexual dimorphism can be observed in morphology, color pattern and behavior. Some authors discuss the evolution of size related sexual dimorphism in birds (Selander, 1972), primates (Crook, 1972), amphibians (Woolbright, 1983), insectivorous lizards (Stamps, 1983), omnivorous lizards (Rocha, 1996) and herbivorous lizards (Carothers, 1984).

According to Carothers (1984), sexual dimorphism is determined by three factors: female reproductive strategy (Tinkle *et al.*, 1970), sexual selection (Carothers, 1984) and competition for food resources (Schoener, 1967). Anderson & Vitt (1990) suggest that the causes of sexual dimorphism in size could be related to several factors: competition between males; differential mortality between sexes due to differences in longevity; larger amount of energy allocated by females for reproduction; males are more active because they need to search for females and thus present a larger predation risk. These authors also suggest that sexual dimorphism could be connected to the feeding strategy which is directly related to phylogenetic characteristics of the family.

Other studies dealing specifically with lizards have demonstrated that a size difference between sexes determines segregation in food resource utilization (Rand, 1967; Selander, 1972; Roughgarden, 1974; Schoener, 1977; Stamps, 1977b). Both body size and relative size of the head have been mentioned as factors that facilitate food partitioning (Schoener, 1967; 1977). Sexual selection also acts on competition between males, often resulting in larger body size and in larger sizes of morphological structures related to fight (Darwin, 1874). The males of territorial iguanids (Stamps, 1977b) are usually larger than females (Fitch, 1980), what suggests the existence of a relation between sexual selection and sexual dimorphism (Trivers, 1976; Stamps, 1983). Thus, when a larger body size is favored in male choice by females, selection tends to promote an increase in male size relative to female size (Vitt & Cooper, 1985).

The genus *Liolaemus* Wiegmann, 1883, is represented by two species in Rio Grande do Sul: *L. occipitalis* Boulenger, 1885, and *L. arambarensis* Verrastro, 2003 (Verrastro *et al.*, 2003). The distribution of *L. occipitalis* is restricted to the coastal sand dunes of Rio Grande do Sul and Santa Catarina (Müller & Steiniger, 1977). It is a carnivorous, basically insectivorous lizard, which reproduces between September and March (Verrastro & Krause, 1999). Verrastro & Krause (1994) observed that this species attains sexual maturity in the first reproductive season after they were born. Differences in growth rates, between juvenile males and females, and in adult size were also observed.

The objective is to describe sexual dimorphism in *Liolaemus occipitalis.*

MATERIAL AND METHODS

Specimens were captured in Jardim do Éden beach (30º05' S, 50º10' W), situated 10 km from Tramandaí, next to the RST 786 road linking Cidreira to Tramandaí, RS. The sampling area is about 1000 m from the ocean and 500 m east from lake Gentil. The region is typically characterized by moving sand dunes, and covered by sparse vegetation (Gramineae).

Manual collection of female and male specimens was done in 1996. A total of 28 adult males and 31 adult females was selected for obtaining biometric data. Specimen selection was based in Verrastro & Krause (1994; 1999), which describe the minimum size of an adult male as 50.0 mm and of adult female as 45.5 mm, and the size relations and morphological characteristics of individuals hatched in the same reproductive season. According to the later authors, the growth rates after sexual maturity decrease considerably, reaching values close to zero when individuals are larger than the mean adult size. Adult individuals larger than the mean adult size were selected in order to avoid the influence of age in the sample. Biometric variables used in the analysis were snout-vent length (SVL), head width (HW), head

length (HL), tale base length (TBL) and lower jaw length (LJL). Means were calculated after three measurements for each variable. Statistical comparisons were made using the Mann-Whitney test. Additionally, the presence of cloacal pores was also analyzed and the dorsal and ventral color pattern was compared between males and females, in a total of 128 individuals: 73 adults (42 males and 31 females) and 55 young (28 males and 27 females). The color pattern was registered in the field, before fixation of the individuals.

All analyzed specimens are catalogued in the collection of the Laboratório de Herpetologia, Universidade Federal do Rio Grande do Sul (UFRS).

RESULTS

The data obtained indicated a marked sexual dimorphism in *Liolaemus occipitalis*, both in size and morphology.

Adult males tend to be larger than females with significant differences being found in the five biometric measurements tested (tab. I).

The largest snout-vent length observed in females was 59.6 mm, and 69.3 mm in males. The mean value for adult females was 53.5 mm, and for adult males, 60.4 mm. Maximum size and mean size of males were 16.3% and 12.9% larger than females, respectively. In addition to the biometric differences, morphological contrasts between males and females were also found. In females (fig. 1), the margin of the cloaca forms a sharp angle (V-shaped) and pre-cloacal pores are absent. In males, the margin of the cloaca is less angular (U-shaped) and presents 4 to 8 orange cloacal pores (fig. 1).

Table I. Biometric data (mm) for adult females and males of *Liolaemus occipitalis* (SVL, snout-vent length; HL, head length; HW, head width; TBL, tale base length; LJL, lower jaw length; SD, standard deviation; n, number of specimens; *, indicates significantly different proportions ($p < 0.0001$), Mann-Whitney test).

| Variable | Females (n = 32) | | | Males (n = 28) | | | |
	Min	mean± SD	Max	Min	mean± SD	Max	test
SVL	46.3	53.18±3.499	59.6	50.3	60.41±5.246	69.3	*
HL	10.0	11.51±0.689	12.9	11.5	13.23±0.984	14.8	*
HW	7.3	8.92±0.623	10.2	9.3	10.63±0.854	12.2	*
TBL	5.7	6.26±0.418	7.2	6.5	8.10±0.788	9.5	*
LJL	9.7	10.85±0.590	11.8	10.5	12.48±0.965	14.5	*

Males and females also differed in color pattern. Adult males present a black stripe in the dorso-lateral region of the body and black spots in the gular region (tab. II). Females usually present a pale dorsal color. The gular region of both adult and young females can be either completely covered, filled, or spotted by an intense

Table II. Color pattern and pre-cloacal pores in *Liolaemus occipitalis* (P, present; A, absent; O, occasionally).

sex/age	black strip	black spots	yellow spots	pores
adult male	P	P	A	P
adult female (2nd year)	P/O	P/O	A	A
adult female (1st year)	A	A	P/O	A
young male	A	A	A	P
young female	A	A	P	A

Fig. 1. Morphological sexual dimorphism in *Liolaemus occipitalis*: form of the cloaca and the pre-cloacal pores in the male (right specimen, UFRS 2865, SVL=61,2 mm); female (left, UFRS 2853, SVL=54,9 mm).

yellowish color, which is more evident soon after hatching or during the breeding season (fig. 2). During the second year of life, some females may also present the black spots or the black strip in the dorso-lateral region.

Agonistic encounters between males were observed in the field. As a result of these encounters, males presented injuries in the head and neck, which were most evident in the breeding season. Building of lurking

Fig. 2. Morphological and ventral color sexual dimorphism in *Liolaemus occipitalis*: female (left specimen, UFRS 2853, SVL=54,9 mm), gular region, yellow; male (right, UFRS 2865, SVL=61,2 mm), gular region with black spots and cloacal pores.

holes was also observed during the reproductive season (September to March), when mainly adult males occupied holes. There was no record of two males occupying the same hole, except for one case where the second male was a dead young individual showing evident injuries.

DISCUSSION

Liolaemus occipitalis presented marked sexual dimorphism in size, with males significantly larger than females in all measured body dimensions. Some authors have observed that, in females, energy allocation to reproduction results in smaller body and smaller relative head size (COOPER & VITT, 1989; ROCHA, 1996). According to VERRASTRO & KRAUSE (1999), *L. occipitalis* reaches sexual maturity during the first year of life, in the first reproductive season after hatching. This situation implies

females allocate a lot of energy to reproduction for producing their first clutch. Females have their growth rates reduced before males, growing at lower rates in winter and spring (VERRASTRO & KRAUSE, 1994).

According to CAROTHERS (1984), sexual dimorphism can be the result of sexual selection as a mechanism for reducing competition for food between males and females. Numerous studies on insectivorous lizards have shown that size differences between sexes are related to segregation of food resources (RAND, 1967; SELANDER, 1972; SCHOENER, 1977; STAMPS, 1977a). Both body size and relative size of the head have been mentioned as factors that facilitate food resource partitioning (SCHOENER, 1967; 1977). ROCHA (1996) related sexual dimorphism in size of *Liolaemus lutzae* Mertens, 1938 to sexual selection, which is associated to its omnivorous diet in early life stages and to herbivorous diet in adult individuals, as well as to territorial behavior. The later author followed CAROTHERS (1984), which considers sexual selection as the most important factor influencing sexual dimorphism in size of herbivorous lizards. If diet differences between sexes occur in *L. occipitalis* (an insectivorous lizard), it is possible that competition for food between males and females could be one of the factors determining sexual dimorphism. According to the present knowledge about the diet of this species it can be suggested that differences in consumption of food items do no support competition as a main factor in the determination of sexual dimorphism. Home range data indicate this species presents territorial behavior, with larger males being more successful in determining territories and in choosing females. For males, larger sizes usually imply an increase in competitive ability. Therefore, in situations where a larger size is favored in the choice of males by females, selection tends to promote an increase in male size relative to females (VITT & COOPER, 1985). Sexual selection often causes males to present larger body and mandible sizes, which are characteristics linked to success in fighting (CARPENTER & FERGUNSON, 1977; CAROTHERS, 1984). This was observed in *L. occipitalis*, as males presented mandibles significantly larger than females. Males of territorial iguanid species are usually larger than females (STAMPS, 1977b; FITCH, 1980), what suggests a relation between sexual selection and dimorphism (TRIVERS, 1976; STAMPS, 1983). Therefore, the sexual selection due to competition between males, and the high energetic allocation of females a few months after hatching, could be selective forces with preponderant action on the determination of sexual dimorphism of body size in *L. occipitalis*.

Females and males also differed in the dorsal and ventral color pattern, with males presenting a darker dorsal color than females. Differences in the color pattern of females and males were observed in several *Liolaemus* species, with males generally being more colorful (ETHERIDGE, 2000). In *L. lutzae* Mertens, 1938, ROCHA (1996) observed orange colors in the ventral side of the thighs. Males of *L. multimaculatus* Boulenger, 1885, *L. rabinoi* Cei, 1974, and *L. salinicola* Laurent, 1986 present black blotches in the throat (ETHERIDGE, 2000). These color differences are quite probably associated to intra- and intersexual recognition.

Another difference between females and males is that only the later present cloacal pores. These pores were always more colorful and opened during the reproductive season. Similarly to *L. occipitalis*, females of other *Liolaemus* species also lack cloacal pores, e.g. *L. lutzae*, *L. multimaculatus*, *L. rabinoi*, *L. riojanus* Cei, 1979, *L. salinicola* Laurent, 1986 (Cei, 1974, 1979; Laurent, 1986; Rocha, 1996). In those species in which cloacal pores were observed in both sexes, females presented always a smaller number of pores than males (*L. scapularis* Laurent, 1982; *L. wiegmannii* Dumeril & Bibron, 1837) (Laurent, 1982; Ramirez-Pinilla, 1991). Cloacal pores are tegumentary glands that would be responsible for producing secretions to stimulate copulation (Pope, 1956 *apud* Rocha, 1996).

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