

## NOTES ON THE BIOLOGY OF THE HIGH ALTITUDE LIZARD *LACERTA BEDRIAGAE*

AURORA M. CASTILLA<sup>1,3</sup>, DIRK BAUWENS<sup>1,4</sup>, RAOUL VAN DAMME<sup>1,2</sup> AND RUDOLF F. VERHEYEN<sup>2</sup>

<sup>1</sup> University of Antwerp (U.I.A.) Field Biological Station Verbindingsweg B-2180 Kalmthout, Belgium

<sup>2</sup> University of Antwerp (U.I.A.) Department of Biology Universiteitsplein 1 B-2610 Wilrijk, Belgium

<sup>3</sup> Present Address: Museo Nacional de Ciencias Naturales c/ J. Gutierrez Abascal 2 E-28006 Madrid, Spain

<sup>4</sup> Present Address: Departamento de Biología Animal Universidad de Salamanca E-37071 Salamanca, Spain

(Accepted 23 11 88)

### ABSTRACT

We report preliminary data on the natural history and biometry gathered during a short-term study in a Corsian population of the lizard *Lacerta bedriagae*. Lizards were encountered at heights of 1650-1950m. Main characteristics of its habitat are the presence of large rocks, boulders and rock pavements. Three size (age) classes were distinguished. Adult males average larger in body size and have larger heads and limbs than females. Females mature at a body size of 66-68mm. Earth-worms, arthropods and plant leaves were recorded as food items.

### INTRODUCTION

The lizard *Lacerta bedriagae* is an endemic species of the mediterranean islands Corsica and Sardinia. In Corsica, its distribution is largely restricted to heights above 1000m, although it has been reported from sea-level in the extreme southwest of Corsica and on small islets between Corsica and Sardinia (Schneider, 1984, Fretey, 1987). The natural history of this species appears little studied: much of the information reviewed by Schneider (1984) is anecdotal or based on observations made in captive conditions.

In an attempt to partially fill that gap, we recently made a short-term field study of a high-altitude population of this species in Corsica. Our aim here is to present limited information on habitats, size distribution, sex-ratio, ontogenetic and sexual variation of morphometric traits, reproductive characteristics and food items. Although remaining fragmentary and preliminary, these data are the first to become available for a natural population of this lizard. Data on activity rhythms and body temperatures are presented elsewhere (Bauwens *et al.*, in press).

### MATERIAL AND METHODS

Field work was carried out on 25 May and from 31 May to 3 June 1988 near Haut-Asco (42° 25' N, 8° 55' E; département Haute-Corse, Corsica, France). The study area was situated on the steep east-facing slope of the Mont Mufrella, on either side of the hike-path GR 20. We searched for lizards from Haut-Asco (1450m) up to the mountain-pass 'Bocca Alla Culaja' (1950m) that gives access to the top of the Mont Mufrella.

Active lizards were captured with a noose. Each lizard was marked individually by toe-clipping, sexed and weighed (to nearest 0.1g on a portable electronic Sartorius balance). We also measured (to nearest 0.1mm) snout-vent length (SVL), tail length (original

and regenerated portions separately), length of pileus (tip of snout to posterior end of parietal scales), width of pileus (at widest point on parietal scales), width and height of head (at widest and highest points, by closing the calipers until resistance was felt) and length of the stretched left fore (arm-pit to base of fourth toe) and hind-limb (first femoral pore to base of fourth toe). Reproductive condition of females was assessed by noting the presence of mating scars; the presence of oviductal eggs was detected by palpation of the abdomen. We collected and analysed the contents of some faecal pellets that the lizards excreted during manipulation.

Relative size of morphometric traits (length and width of pileus, width and height of head, length of fore and hind-limb, weight) versus SVL was investigated through application of the allometric equation ( $Y = a \text{ SVL}^b$  or  $\log Y = \log a + b \log \text{SVL}$ ). The parameters, and their standard errors, of this equation were estimated through least-square regression analysis of *log-log* transformed data. To determine whether a given body dimension deviates from geometric similarity during ontogeny, we compared the estimate of the corresponding regression slope (*b*) with the expected value (=1 for length measurements, =3 for weight). If *b* equals the expected value, growth is isometric and geometric similarity is maintained. When *b* > expected value growth is positive allometric; whereas a *b* < expected value indicates negative allometry. Differences between sexes in the parameters of the allometric equation were assessed by analysis of covariance (ANCOVA).

### RESULTS AND DISCUSSION

#### ALTITUDINAL DISTRIBUTION AND HABITATS

Within our study area, we did not encounter *L. bedriagae* at altitudes <1650m. We exclude the local presence of this species at heights between 1450 and 1500m as we extensively searched there for lizards during a parallel study of *Podarcis tiliguerta* (Van

Damme *et al.*, in press). The incidence of *L. bedriagae* from a height of 1650m, coincided with a rather abrupt change in vegetation composition and habitat structure. An open *Pinus nigra* forest dominates at the lower altitudes. Trees are absent above 1650m, the scanty vegetation there is composed of dwarf-shrubs (dominant species: *Juniperus nana* *Genista labelli* *Berberis actnensis*) and grasses that grow patchily between large boulders, screes and extensive zones of rocky outcrops. In this zone, we found *L. bedriagae* up to an elevation of 1950m. As our searches were restricted to that height, we cannot dismiss its presence at higher altitudes. Although quantitative data are lacking, no obvious altitudinal variation in sighting frequency of this lizard was evident within the elevational range 1650-1950m.

Almost all lizards were seen on large and exposed boulders, rocks and bare rock pavement, although they stayed often near some vegetation cover. During the midday hours some individuals foraged under cover of dwarf-shrubs.

Throughout its local altitudinal range, we found *L. bedriagae* to be sympatric with *P. tiliguerta*. However, frequency of sightings of the latter species was distinctly highest at heights between 1450 and 1600m, where this lizard was ubiquitous and very conspicuous, and dropped sharply above 1650m altitude. In the area where both lizards occurred, *P. tiliguerta* tended to occupy microhabitats with a

relative high cover of dwarf-shrubs was often observed on piles of small rocks and stones, but was virtually absent from large boulders and rocky outcrops.

BODY SIZE DISTRIBUTION, SEX-RATIO AND TAIL-BREAK FREQUENCY

Snout-vent length of 73 captured lizards ranged from 35.6mm to 84.8mm for males and 79.8mm for females (Fig 1).

The smallest individuals, with SVL of 35.6 and 36.3mm, could not be sexed. They had brown back colours and blueish tails, characteristic for the youngest age-class in some *Lacerta* and *Podarcis* (Arnold *et al.*, 1978). As newborns of *L. bedriagae* have a SVL of ca. 30mm at hatching (Schneider, 1984), we suggest that these individuals were born at the end of the preceding activity season. Lizards with SVL of 50-63mm could easily be distinguished in the field from their larger conspecifics by their back coloration, which was brown or grey-brown, whereas the larger had green, olive-green or brownish green back colours. This size class probably represents lizards that were in their third activity season. Lizards with SVL  $\geq 66$ mm were considered as adults, although some females with SVL of 66-68mm did not evidence signs of sexual activity (see further). We suggest that adults were in their fourth activity year or older, although (some of) the smaller individuals of this size class might have

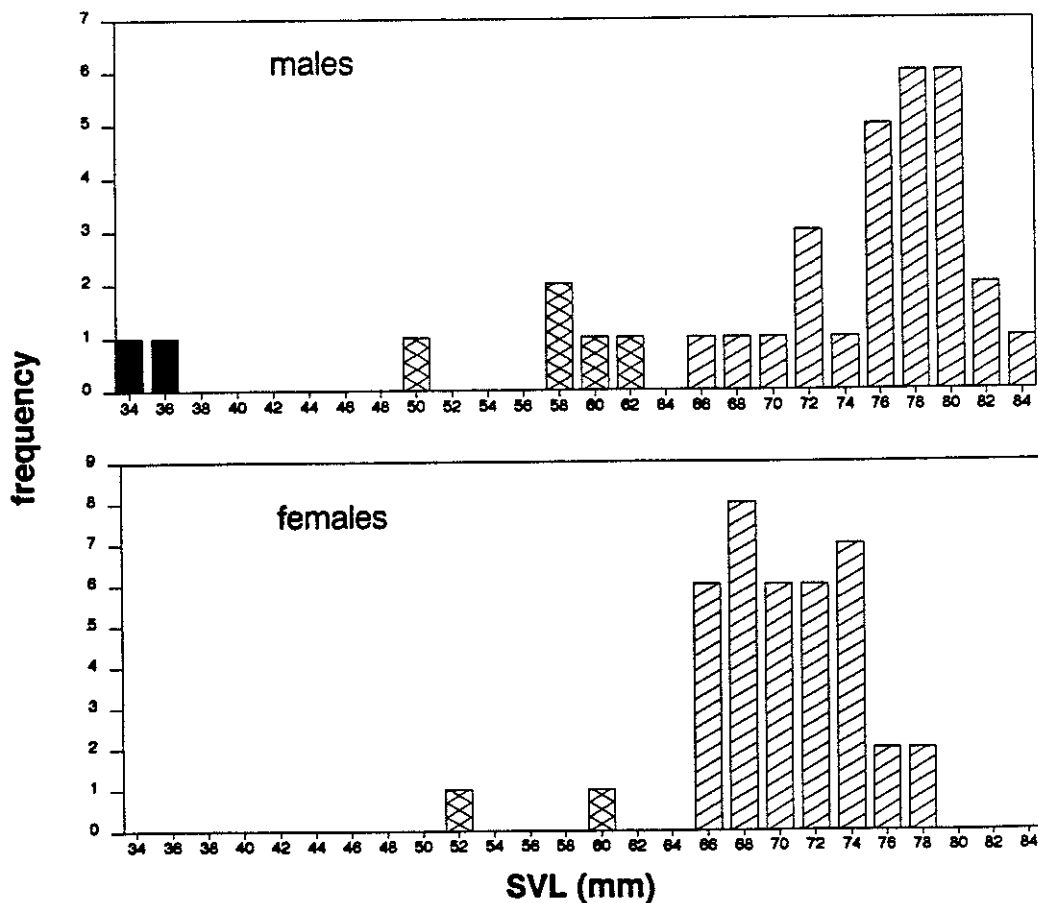


Fig. 1 Distribution of body size in male and female *Lacerta bedriagae*. Black : unsexed individuals; cross-hatched : lizards with brownish back colours; hatched : adults

been in their third activity season. Mean SVL of adult males was significantly larger than that of the adult females (males :  $\bar{x} = 77.6$ ,  $SD = 4.2$ ,  $n = 27$ ; females :  $\bar{x} = 71.9$ ,  $SD = 3.6$ ,  $n = 37$ ;  $t = 5.982$ ,  $P < 0.001$ ).

Sex ratio (males/females) within the adult size class was 0.73 (27/37), which does not differ significantly from unity ( $\chi^2 = 1.563$ ,  $P > 0.20$ ).

The percentage of lizards with regenerated tails was high and increased with body size (SVL < 50mm: 0% ( $n = 2$ ), 50-65mm: 43% ( $n = 7$ ),  $\geq 66$ mm: 81% ( $n = 64$ );  $\chi^2 = 11.3$ , 2 df,  $P < 0.01$ ). Incidence of natural tail breaks was not different in adult males (89%,  $n = 27$ ) and females (76%,  $n = 37$ ;  $\chi^2 = 2.7$ ,  $P > 0.05$ ).

RELATIVE SIZE OF MORPHOMETRIC TRAITS

The smallest, unsexable lizards ( $n = 2$ , see Fig 1) were not included in subsequent analyses. Our data, which consist of a cross-sectional sample, hence only represent part of the range of body sizes that can be encountered in this lizard. Parameter estimates for the allometric equations are presented in Table 1.

All four dimensions of head size exhibited sexual dimorphism. In males, positive allometry occurred for length of the pileus and head height, indicating that relative size of these traits increases with SVL. In females, length and width of the pileus showed negative allometry and hence decrease in relative size during ontogeny. As a result of these relations, sexual differences in length and width of the pileus and in head height are most pronounced in the larger lizards (Fig 2). Relative growth of head width was isometric in both sexes. The sexual difference in regression intercepts indicates that head width is largest in males over the entire body range span (Table 1, Fig 2). In summary, males have larger and more robust heads than females and, except for head height, differences in head dimensions tend to increase with body size. Comparable sexual differences in relative head size, have previously been described in representatives of different lizard families (e.g. Iguanidae: Schoener *et al.*, 1982; Scincidae: Vitt and Cooper, 1985, 1986; Lacertidae: Wermuth, 1955, Castilla and Bauwens, in prep.)

	males		females		ANCOVA	
	log a	b + SE	log a	b + SE	b	a
length pileus	-2.120	1.180±0.040***	-0.576	0.793±0.049***	***	
width pileus	-2.233	1.009±0.083	-1.000	0.701±0.090**	*	
height head	-5.072	1.634±0.094***	-2.800	1.072±0.178	***	
width head	-2.320	1.132±0.080	-1.532	0.916±0.085	ns	***
length forelimb	-0.956	0.878±0.060*	0.137	0.596±0.109***	*	
length hindlimb	-0.830	0.932±0.049	-0.295	0.782±0.080**	ns	***
weight	-11.462	3.178±0.128	-11.902	3.274±0.203	ns	ns

TABLE 1: Allometric equations with snout-vent length as independent variable. Shown are estimates for intercepts (log a) and slopes (b) of log-log regression equations. Results of comparisons of slopes with expected values (see methods) and of comparisons between the sexes of the regression equations through ANCOVA. (ns :  $P > 0.05$ , \* :  $P < 0.05$ , \*\*\* :  $P < 0.001$ )

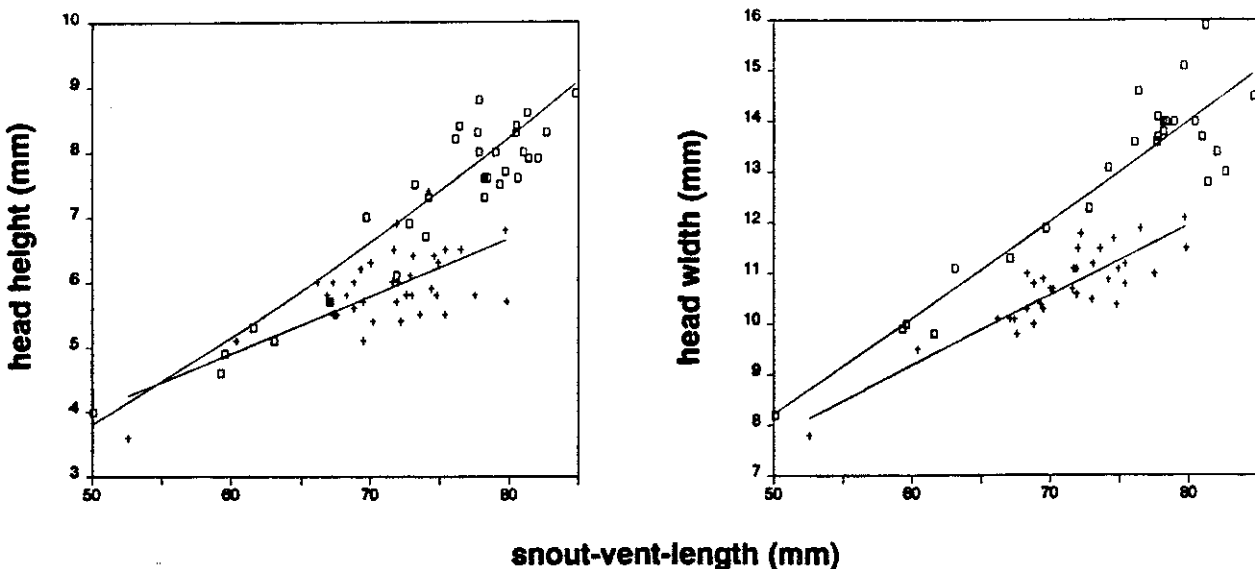


Fig 2 Relations of head height and head width to snout-vent-length in male (squares) and female (crosses) *Lacerta bedriagae*. See Table 1 for regression equations.

Negative allometry of limb sizes was seen in three of four cases (Table 1). Relative size of fore and hindlimbs was largest in males. Negative allometry of limb dimensions seems to be rather common in lizards (e.g. Kramer, 1951, Laerm, 1974, Pounds *et al.*, 1983, Garland, 1985).

In spite of sexual differences in head and limb sizes, no sexual difference in weight-size relations were evident.

#### REPRODUCTIVE CHARACTERISTICS AND BEHAVIOUR

None of the females with a SVL <66mm had mating scars and they were therefore considered to be non-reproductive. The smallest reproductive female had a SVL of 66mm, whereas four females with SVL of 66-68mm showed no signs of sexual activity. All females >68mm were reproductive. A SVL of 66-68mm can therefore be considered as the minimum size of reproductive females.

Most reproductive females beared numerous mating scars, to the extent that these scars almost completely coloured the ventral side of the pelvic region and the anal scale. These observations are considered as evidence for the occurrence of multiple matings in individual females. A direct relation between the number of mating scars and mating frequency has been observed in the closely related *L. vivipara* (Bauwens, unpubl. obs.).

We observed a copulation on 25.5.1988 at 10.30h (MET). The behavioural sequence described hereafter took place on a large exposed rock, in full sun. An adult male was seen running over a distance of ca 3m towards an adult female. The male obtained a mouthhold on the posterior part of the female's tail and maintained the grip while the female moved forward ca 2m. When the latter halted, the male displaced his grip toward the female's trunk and obtained a hold just anterior to the pelvis. After exhibiting some jerky movements, the female layed down. The male then arched his body, curling its tail underneath the female's and moving his cloacal region toward that of the female. Both lizards maintained this position during ca 6 min. The observed copulatory posture is similar to that of other species of *Lacerta* and *Podarcis* (Verbeek, 1972). The absence of any preliminary courtship displays is noteworthy.

Oviductal eggs were detected in three females with SVL of 74.2, 74.6 and 79.7mm.

#### FOOD

Limited data on diet composition, were obtained through direct observations of foraging lizards and the analysis of faecal pellets. These evidenced the consumption of Oligochaeta, Aranea, Coleoptera, Hymenoptera and Lepidoptera. We frequently observed lizards feeding on ants, which were also the most numeric prey type encountered in the faecal pellets. Remnants of vegetables, mainly grass-leaves, were present in 6 out of 12 faecal pellets, and were the exclusive contents of two of them. More detailed data are however needed to establish the degree of herbivory in *L. bedriagae*.

#### ACKNOWLEDGEMENTS

We greatly appreciated the help and companionship of Iduna Smans in the field. Dr. D. Bay provided hospitality at the biological station 'Stareso' (Calvi). This study was supported by travel grants of the Belgian Ministry of National Education (to RVD) and the Spanish 'Consejo Superior de Investigaciones Cientificas' (Departamento de Relaciones Internacionales) (to AMC), and by the Belgian 'Fonds voor Kollektief Fundamenteel Onderzoek' (project n° 2.0076.87). Preparation of the manuscript was aided by logistic support of IBERIA, National Spanish Airlines.

#### REFERENCES

- Arnold, E. N., Burton, J. A. and Oviden, D. W. (1978). *A field guide to the reptiles and amphibians of Britain and Europe*. Collins, London.
- Bauwens, D., Castilla, A. M., Van Damme, R. and Verheyen, R. F. (in press). Field body temperatures and thermoregulatory behavior of the high altitude lizard *Lacerta bedriagae*. *J. Herpetol.*
- Fretey, J. (1987). *Les reptiles de France métropolitaine et des îles satellites*. Hatier, Paris.
- Garland, I. (1985). Ontogenetic and individual variation in size, shape and speed in the Australian agamid lizard *Amphibolurus nuchalis*. *J. Zool. (Lond.)*, **207**, 425-439.
- Kramer, G. (1951). Body proportions of mainland and island lizards. *Evolution*, **5**, 193-206.
- Laerm, J. (1974). A functional analysis of morphological variation and differential niche utilization in basilisk lizards. *Ecology*, **55**, 404-411.
- Pounds, J. A., Jackson, J. F. and Shively, S. H. (1983). Allometric growth of the hind limbs of some terrestrial iguanid lizards. *Am. Midl. Nat.*, **110**, 201-206.
- Schneider, B. (1984). *Lacerta bedriagae* Camerano, 1885 — Tyrrhenische Gebirgseidechse. In *Handbuch der Reptilien und Amphibien Europas, Band 2/1*. 211-224. Böhmé W. (Ed.) AULA-Verlag, Wiesbaden.
- Schoener, T. W., Slade, J. B. and Stinson, C. H. (1982). Diet and sexual dimorphism in the very catholic lizard genus *Leiocephalus* of the Bahamas. *Oecologia (Berl.)*, **53**, 160-169.
- Van Damme, R., Bauwens, D., Castilla, A. M. and Verheyen, R. F. (in press). Altitudinal variation of the thermal biology and running performance in the lizard *Podarcis tiliguerta*. *Oecologia (Berl.)*
- Verbeek, B. (1972). Ethologische Untersuchungen an einigen europäischen Eidechsen. *Bonn Zool. Beitr.*, **23**, 122-151.
- Vitt, L. J. and Cooper, W. E. Jr. (1985). The evolution of sexual dimorphism in the skink *Eumeces laticeps*: an example of sexual selection. *Can. J. Zool.*, **63**, 995-1002.
- Vitt, L. J. and Cooper, W. E. Jr. (1986). Skink reproduction and sexual dimorphism: *Eumeces fasciatus* in the south-eastern United States, with notes on *Eumeces inexpectatus*. *J. Herpetol.*, **20**, 65-76.
- Wermuth, H. (1955). Biometrische Studien an *Lacerta vivipara* Jacquin. *Abhand. Berichte Naturk. Vorges. 9*, 221-235.