

## TEMPORAL AND SPATIAL DISTRIBUTION OF THE GOLDEN-STRIPED SALAMANDER (*CHIOGLOSSA LUSITANICA*) ALONG TWO MOUNTAIN BROOKS IN NORTHERN PORTUGAL

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A standardized search over a nine-month period revealed that *Chioglossa lusitanica* population density is highest close to a source of moving water. In spring and autumn over 90% of an adult population was found within 13 m of the water source. Most adults were observed even closer to the brook in summer, at sites characterized by availability of shelter, by the presence of small waterfalls in the stream, or both. A similar but more extreme pattern was observed for juveniles. With the drying up of hiding sites in early summer, part of the adult population migrates to deep hiding places, to return to the brook in autumn.

### INTRODUCTION

The golden-striped salamander, *Chioglossa lusitanica*, is one of the lesser-known species of the Palearctic herpetofauna. It is the single extant representative of the genus *Chioglossa* and endemic to the Iberian peninsula, with a distribution restricted to northern Portugal and north-western Spain. Two parameters, rainfall and altitude, appear to determine its range. *Chioglossa lusitanica* is largely restricted to areas of low and medium altitude (under 1000 m) and of high rainfall (annual precipitation over 1000 mm; Arntzen, 1981). Within its range the usual habitat is that of well-vegetated margins of swift mountain brooks. The species may be abundant locally but ecological factors relating to abundance remain to be identified. In the present study I describe the temporal and spatial distribution of juvenile and adult *C. lusitanica* from two sites in northern Portugal where the species is abundant (Goux, 1957; Arntzen, 1981).

### MATERIAL AND METHODS

Research was carried out along the Ribeira da Silveirinha and Ribeiro do Salto, both situated in a schistose mountain ridge near Porto, Portugal. Two lengths of stream bank, 185 m and 210 m respectively, were searched for salamanders, on average twice a month from March to November, except for June, 1977. Three periods were distinguished, 'spring' (March, April and May), 'summer' (July, August and September), and 'autumn' (October and November).

At Silveirinha a stone 'dam' covering the brook was searched, through a passage with the stream running through. The dam can best be described as an enormous dry stone wall (maximum height 7.5 m; width 20 m) spanning the Silveirinha over a length of 22 m (see Fig. 1 in Arntzen, 1994b). The dam is a man-made

structure but the reason for its construction is unclear. Up to 10 m from the dam the catches appeared to be dominated by foraging salamanders actually residing in the dam and they were counted as such. A 30 m wide strip was torch-searched on both sides of the Silveirinha stream; each search took four nights. Search width was up to 20 m on each side along the Salto brook, where a complete search took two nights. Salamander position was recorded by coordinates accurate to one metre, one coordinate parallel to the brook and one perpendicular to the brook. For analysis, observations were pooled into 'stations' of 5 m length.

All salamanders were marked by toe-clipping. This allowed monitoring of the movements of individuals by recapture and formed the basis for population size estimates (Arntzen, 1981). Specimens with body length exceeding 38 mm were considered adults and could generally be sexed.

### RESULTS

During spring and early summer, numerous *C. lusitanica* were observed along the Silveirinha and Salto brooks; during the dry summer months the number observed dropped dramatically. With the start of autumnal rains, large numbers were again observed. The activity pattern of *C. lusitanica* along the two brooks is shown as a function of seasonal and meteorological conditions in Fig. 1.

Over 90% of the adults at Silveirinha were found within 13 m of the brook. Adults are distributed closer to the brook in summer than in spring and autumn (Fig. 2). During spring, some adults were observed outside the strip of lush vegetation close to the brook, but with the drying up of the thin, unshaded soils in early summer such observations ceased. For juveniles, over 90% were observed within 7 m of the brook. In

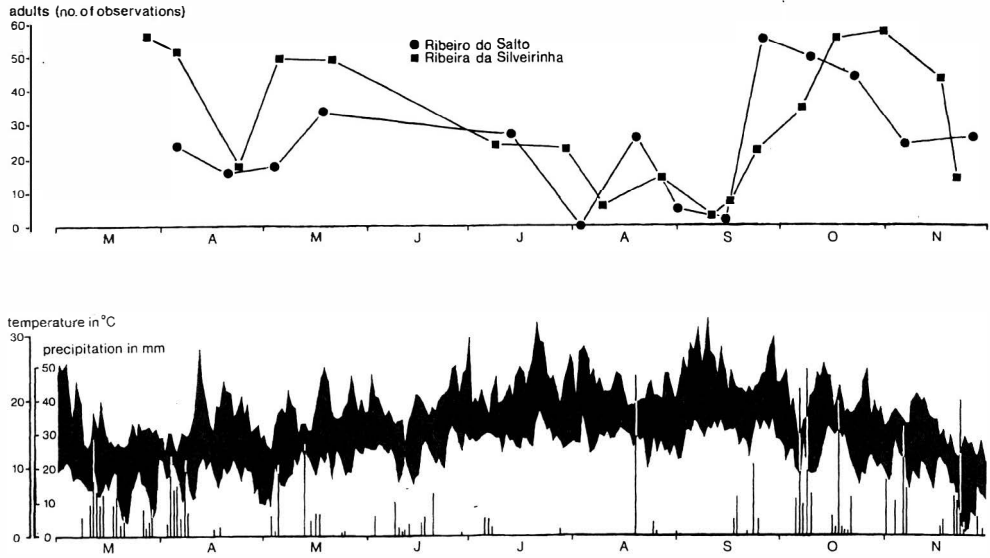


FIG. 1. Adult *Chioglossa lusitanica* observed in standard searches of set trajectories along Ribeira da Silveirinha and Ribeiro do Salto, in northern Portugal (top - details see text). Meteorological conditions (max. and min. temperature and rainfall) observed at Serra do Pilar, Vila Nova de Gaia (bottom). Adapted from Arntzen (1981) and reproduced with permission from E. J. Brill, Leiden.

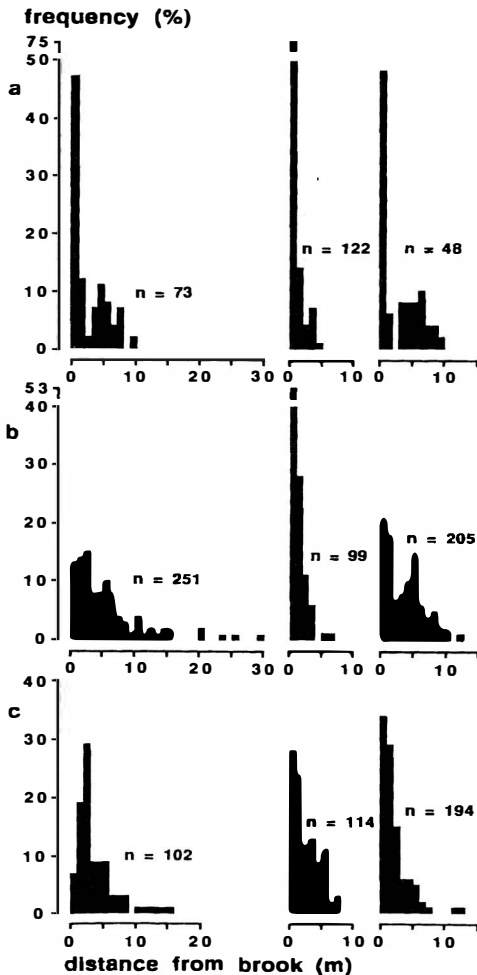


FIG. 2. Distribution of *Chioglossa lusitanica* along the axis perpendicular to the water source over the seasons (from left to right: spring, summer and autumn); (a) Ribeira da Silveirinha, juveniles; (b) Ribeira da Silveirinha, adults, and (c) Ribeiro do Salto, adults.

summer, 90% were found within 3 m of the stream and three out of four were found at or within 1 m of the brook, mostly within the splash zone. Along the Salto brook, too few juveniles were observed ( $n = 9$ ) to allow analysis. For adults at Salto the pattern observed was similar to that at Silveirinha, with 90% of observations made within a 10 m, 6 m, and 5 m zone in spring, summer and autumn, respectively (Fig. 2). No significant difference in spatial distribution was found for males versus females at any locality in any season regarding distance to the bank ( $G$ -tests of independence,  $P > 0.05$  in all cases,  $df \leq 10$ ; classes representing 1 m wide strips parallel to the bank were pooled when necessary to obtain expected frequencies  $\geq 5.0$ ).

Along the length of the Silveirinha, observations show a non-random pattern, for adults ( $P < 0.001$ ) as well as for juveniles ( $P < 0.001$ ;  $G$ -tests of independence,  $df = 36$ ). Clusters of adult salamanders are found at stations 9, 17, 18 and 28 (Fig. 3). (Clusters are defined arbitrarily as occurring at stations that show a partial  $G$ -value  $\geq 20.0$ ). Similarly, clusters of juveniles are found at stations 9, 18, 19, 28, and 37. Observations in summer are too few to allow separate statistical analysis, but visual inspection of the data suggests the clustering pattern in summer to be especially pronounced, because few salamanders were observed outside recognized cluster localities.

At Silveirinha, 68 adult salamanders initially observed at stations 1-37 along the brook were later encountered inside the dam. The date midway between capture and recapture is taken as the best estimate for the time of actual migration. A cumulative representation of the observations allows the construction of a migration curve (Fig. 4). A curve representing the return migration could also be constructed on the basis of

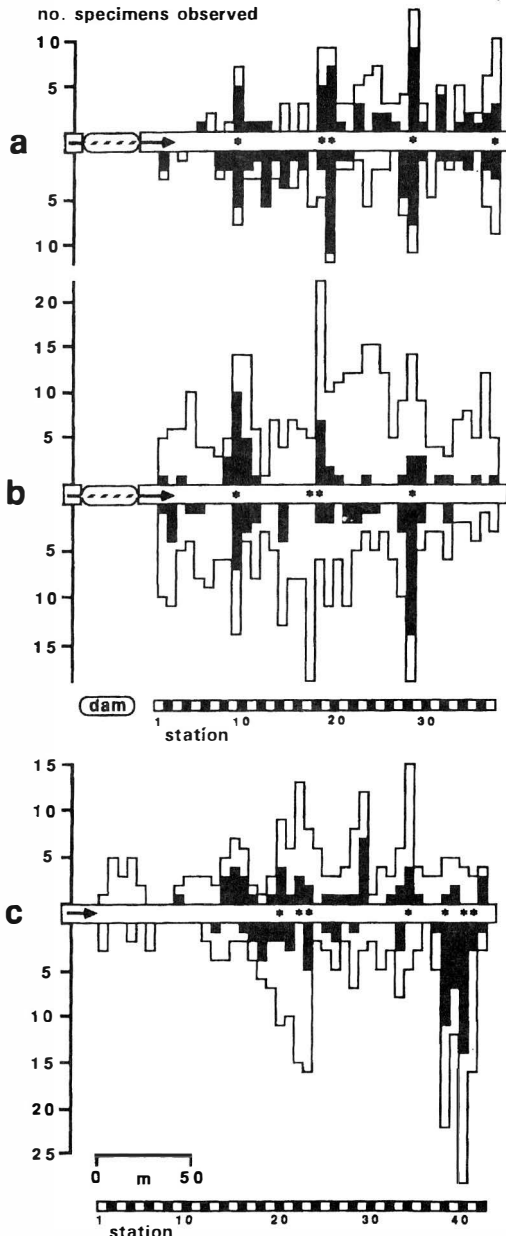


FIG. 3. Distribution of *Chioglossa lusitanica* along the water source in summer (solid bars) and in spring and autumn (open bars) at (a) Ribeira da Silveirinha, juveniles, (b) Ribeira da Silveirinha, adults, and (c) Ribeiro do Salto, adults. The arrow indicates the direction of flow. Asterisks indicate stations with observations clustered (for details see text).

38 specimens first observed in the dam and recaptured at stations 1-37. Immigration took place mostly during late spring and early summer, while return migration was most pronounced in September and October. Comparison of both curves indicates that the highest number of salamanders residing in the dam were present from late August to early September. No juveniles migrated between the brook and the dam, and few juveniles ( $n = 44$ ) were observed in the dam or close to it.

Along the Salto brook two main clusters of adults are observed at and around stations 22 and 38 (Fig. 3). Equally striking is the relative rarity of salamanders

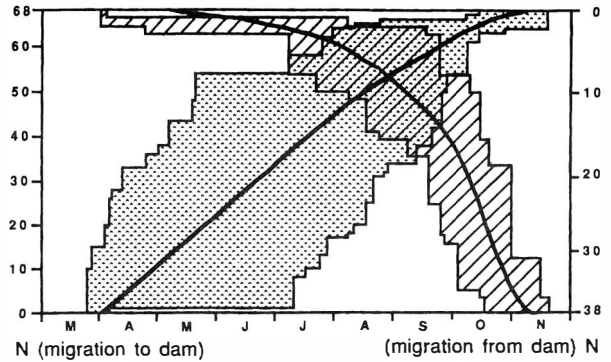


FIG. 4. Reconstruction of the migratory activity of adult *Chioglossa lusitanica* along Ribeira da Silveirinha. Observations are based on the capture - recapture of marked individuals. Sixty-eight observations were made on migration from stations 1-37 (cf. Fig. 3) to the dam (the shaded graph with dates of marking to the left and dates of recapture to the right, ordered cumulatively according to date, and migration curve in the middle). Thirty-eight observations were made on migration from the dam to stations 1-37 (the hatched graph with dates of capture to the left, dates of recapture to the right and migration curve in the middle). Migration curves are fitted by hand to the data points representing the mid-points of observations (data points not shown). The population in the dam is largest in late August and early September.

upstream, at stations 1 - 13. Only two specimens were observed there in summer.

## DISCUSSION

Data regarding spatial and temporal distribution of *C. lusitanica* indicate that during the dry summer months the salamanders concentrate at sites close to the brook. Adults and juveniles favour the same sites close to small cascades, such as those found at Silveirinha stations 9, 18 and 28. These sites may be preferred because they are moist and provide shelter due to the washing out of soil from plant root systems. In this microhabitat, the black and copper striped colouration of *C. lusitanica* is highly effective and cryptic.

The Salto brook runs across a tectonic rupture, and upstream (stations 1-13) the soil is thin on flat slate. Downstream from the fault (from station 14 onwards) the bottom is also schistose but the valley is steep, and soil and rock have gathered along its course. Along the Salto, two mines have been dug out at stations 21 and 38, where the rocky debris has been deposited close to the brook. Population density was lowest where few hiding sites were available (stations 1-13) and highest where there were many (around stations 22 and 38). Population density of *C. lusitanica* is therefore reflected by the amount of shelter available.

*Chioglossa lusitanica* is not evenly distributed in the areas investigated. Instead, it shows a patchy distribution with population density the highest at

moist and sheltered sites. This describes the preferred microhabitat of *C. lusitanica*.

Shallow hiding sites may be appropriate in spring and autumn but, due to aridity, conditions are harsher in summer. If deep shelter is unavailable, such as along the Silveirinha where the bottom consists of slate and the layer of soil is thin, migration to a suitable summer refuge (i.e. the dam) occurs. It was estimated that 60% of the adult population migrated to the dam, with the total number peaking at 1300 at the end of August / beginning of September (Arntzen, 1981). For observations on speed and directionality of moving *C. lusitanica* see Arntzen (1994b). Juveniles apparently do not migrate to the dam; instead most of them reside in very close proximity to the brook.

The distribution of *C. lusitanica* along the mountain brooks bears little resemblance to the ecological distribution of a species like *Salamandra salamandra*. *S. salamandra* deposits its larvae in mountain streams such as the Silveirinha, but from metamorphosis onwards the occurrence of the species is not strongly associated with streams (Arntzen, 1981; cf. Joly, 1968). Similarities are more readily found between *Chioglossa* and some Nearctic streamside salamanders of the family Plethodontidae (cf. Hairston, 1987). Wake & Özeti (1969) were the first to point out the apparent evolutionary convergence between these taxa (see also Arntzen, 1994a). The morphological convergence has a parallel in *Chioglossa* occupying plethodontid-type ecological niches. A Palearctic salamander with an ecology and morphology similar to *C. lusitanica* is the Caucasian salamander, *Mertensiella caucasica* (Tarkhnishvili & Serbinova, 1993). To what extent the parallels hold true has yet to be determined.

#### ACKNOWLEDGEMENTS

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