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## USE OF THE «PATTERN MAPPING» TECHNIQUE TO STUDY THE BIOLOGY OF *SALAMANDRINA TERDIGITATA* (AMPHIBIA CAUDATA SALAMANDRIDAE)

**Abstract** - *Salamandrina terdigitata* (Lacépède, 1788), a caudate amphibian endemic to peninsular Italy, is characterized by a black, white and red ventral pattern; this pattern varies from specimen to specimen and it is practically impossible to find two identical individuals in the same population. The ventral patterns of about 700 specimens of *Salamandrina* were photographed and the photographs were used to recognize individual specimens in two populations from the environs of Florence (Tuscany; central Italy). The «pattern mapping» technique employed by us is briefly described. By this technique it was possible to obtain much biological and eco-ethological information about *Salamandrina* in the above-mentioned area.

**Key words** - *Salamandrina terdigitata*, marking techniques, individual identification.

**Riassunto** - *Uso della «pattern mapping technique» nello studio della biologia di Salamandrina terdigitata (Amphibia Caudata Salamandridae).* *Salamandrina terdigitata* (Lacépède, 1788), un Anfibia Urodela endemico dell'Italia appenninica, presenta un disegno ventrale formato dalla varia disposizione dei colori nero, bianco e rosso. Tale disegno è differente da esemplare a esemplare e rimane assolutamente costante nel corso della vita dell'animale. Utilizzando, in circa 700 esemplari, il metodo del marcamento fotografico del disegno ventrale, di cui viene fornita una breve descrizione tecnica, abbiamo potuto raccogliere numerosi dati sulla biologia e l'eco-etologia di due popolazioni di *Salamandrina* dei dintorni di Firenze.

**Parole chiave** - *Salamandrina terdigitata*, tecniche di marcamento, identificazione individuale.

*Salamandrina terdigitata* (Lacépède, 1788) is a caudate amphibian endemic to peninsular Italy, from central Liguria to southern Calabria. The species is characterized by a bright black, white and red ventral pattern; the distribution and extent of the three colours varies from specimen to specimen and it is practically impossible to find two identical animals in the same population. The belly pattern appears during the first year and remains quite constant throughout the animal's life, as was shown by the recapture of specimens after some years (see also Vanni, 1980).

Therefore the «pattern mapping» technique is a reliable tool for individual recognition of *Salamandrina* specimens. Moreover, it is not traumatic for the animals, unlike to marking by codified toe clipping (see also Castellano & Giacoma, 1993 and Golay & Durrer, 1994); the toe clipping method, furthermore,

can be rather unreliable due to the high regenerative capacity of some salamander species (see Ferner, 1979; Glandt, 1980; Andreone, 1986; Gutleb, 1991). The fluorescent marking technique proposed by Taylor & Deegan (1982) and Nishikawa & Service (1988), on the other hand, is limited in time as the marking usually disappears within a year (Nishikawa & Service, 1988).

Obviously, the pattern mapping technique can be employed only in amphibian species in which colour patterns remain perfectly constant in time and vary among individuals (see also Donnelly *et al.*, 1994). This marking technique, for instance, has been successfully used in *Salamandra salamandra* (Linnaeus, 1758) (Feldmann, 1967; Joly, 1968), *Triturus cristatus* (Laurenti, 1768) (Hagström, 1973; Glandt, 1980), *Triturus vulgaris* (Linnaeus, 1758) (Hagström, 1973), *Notophthalmus viridescens* (Rafinesque, 1820) (Healy, 1974; Gill, 1978), *Triturus carnifex* (Laurenti, 1768) (Andreone, 1986), *Andrias japonicus* (Temminck, 1837) (Tochimoto, 1989), *Triturus alpestris* (Laurenti, 1768) (Gutleb, 1991), *Ambystoma maculatum* (Shaw, 1802) (Loafman, 1991), and *Bombina variegata* (Linnaeus, 1758) (Abbühl & Durrer, 1993; Milesi *et al.*, 1994 e 1996; Di Cerbo, 1996), *Ambystoma opacum* (Doody, 1995).

We employed the pattern mapping technique to study the life history of *Salamandrina terdigitata* in two populations in the vicinity of Florence (Tuscany; central Italy): Monte Morello, about 8 km N of Florence at 450-470 m a.s.l., and La Rocchetta Farm, about 12 km NE of Florence at 470 m a.s.l.

Initially, the animals were taken to the laboratory to be weighed, measured and photographed; the specimens were released within a few days exactly where they had been collected. Later in the study the specimens were photographed on the spot and set free immediately, so that their behaviour would be altered as little as possible.

At first, photographic equipment similar to that reported by Hagström (1973) was used: a 6X6 cm format camera, an annular flash and colour slide film. The glass-box of Hagström's equipment was replaced with a sheet of grey or beige cardboard, on which each specimen was laid belly up and photographed while the tip of its tail was held with a pair of light forceps. Photocopying of the ventral patterns, as was done by Glandt (1980) with *T. cristatus*, did not work well in *Salamandrina* due to the lack of resolution among the three colours in the belly pattern.

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The 6X6 cm format provides large and very good images but is rather cumbersome and expensive; thus, we began to employ a more handy 24X36 mm reflex camera, with a 50 mm lens, a 12 mm extension tube, an annular flash and colour slide film. In the field the specimens were photographed with the latter equipment; they were turned quickly onto the back, a position in which they remain motionless for some seconds, time enough for 2 or 3 photographs.

Usually we collected the animals twice a year, in spring and in autumn; in the warmest and coldest periods, in fact, *Salamandrina* push deeply into the soil and become difficult to find in satisfactory numbers. The ventral patterns of all the specimens caught in each collecting campaign were photographed; the photographs were subsequently compared with those carried out in the previous samplings. By this technique about 700 individuals were marked from 1972 to 1990. All the marked and recaptured specimens were identified without the slightest doubt.

On land, the time elapsed between capture and recapture was from 8 to 36 months; one specimen from La Rocchetta Farm was recaptured twice, 8 and 32 months after the first capture. Recaptures in the same year varied from 9,7 to 21,7 per cent of the marked animals.

The specimens caught in the water were only females; many of them were recaptured in the same stream pond where they were originally caught while laying their eggs, from 12 to 36 months before. The recaptures of females in water the following year were about 10 per cent of the marked individuals; in a case, at a distance of three years, they were still 7.7 per cent.

The site fidelity of specimens captured on land (possibly males) was also remarkable, with most animals recaptured at a distance of less than 3 m from the marking spot (range 0-52 m); two individuals were found 8 months later exactly under the same stone. Information about the annual increase of length and weight was also obtained.

With this marking technique it was also possible estimate the density of the two *Salamandrina* populations. At Monte Morello the density was about one specimen per 1.6 m<sup>2</sup> and at La Rocchetta Farm about one specimen per 5.9 m<sup>2</sup>. The different density of the two *Salamandrina* populations seems to be due chiefly to a different kind of soil, on limestone rich in interstices at Monte Morello, and on sandstone more compact in texture at La Rocchetta Farm (for other data on the biology of this species at the above-mentioned sites see Vanni, 1980).

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