REPRODUCTIVE ACTIVITY AND EMBRYO GROWTH OF THE SPECTACLED SALAMANDER *SALAMANDRINA TERDIGITATA* (LACEPÉDE, 1788) IN SOUTHERN LATIUM (CENTRAL ITALY)

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ABSTRACT

This paper summarises observations carried out in nature on populations of *Salamandrina terdigitata* in Southern Latium, where the species is widely distributed, if localized, in the hilly and mountainous areas. The laying period studied was notably wide: laying females were observed in nature at the end of October and larvae at the first stage of growth in the first days of November. This species, in the Mediterranean habitat and in the locations where the danger of late spring-summer drought is greater, uses different reproductive strategies: it begins egg-laying early in the autumn (starting from the first days of October) and winter months, which is the time in the study area of maximum rainfall (generally highest in November).

Furthermore, observations in nature and in the laboratory confirmed the relationship between water temperature and the duration of embryo growth.

INTRODUCTION

The data on the reproductive activity of *Salamandrina terdigitata* (Lacépède, 1788) has until now been generic, in spite of the high biogeographic interest of the species (endemism of the Italian fauna); few available data come from observation in captivity. For the Southern Latium anti-Apennines, observations relative to a few populations of *Salamandrina terdigitata* are reported in works of general character on the Italian herpetofauna (Bruno, 1973) and in some other contributions (Carruccio, 1990; Naviglio, 1971; Zerunian & Sciscione, 1984; Bonifazi & Carpaneto, 1990; Corsetti & Capula, 1992; Corsetti, 1994a, 1994b). The research on this group of mountains (an area of about 2,200 square kilometres) has identified the location of a high number of populations with different surrounding habitat characteristics.

As in most amphibians, reproduction is cyclic and seasonal, and in the species living in temperate areas it is generally annual. The potentially long reproductive activity of some species that can extend their breeding cycle up to January or the end of December has been noticed in the Mediterranean surroundings (Guarino, Caputa & Angelini, 1992; Corsetti, 1994b) but under no circumstances are there autumnal layings.

This paper describes the reproductive activity in nature of the populations of *Salamandrina terdigitata* in Southern Latium and it underlines the duration of the laying period. Further data has emerged on the length of embryo growth in relation to the water temperature.

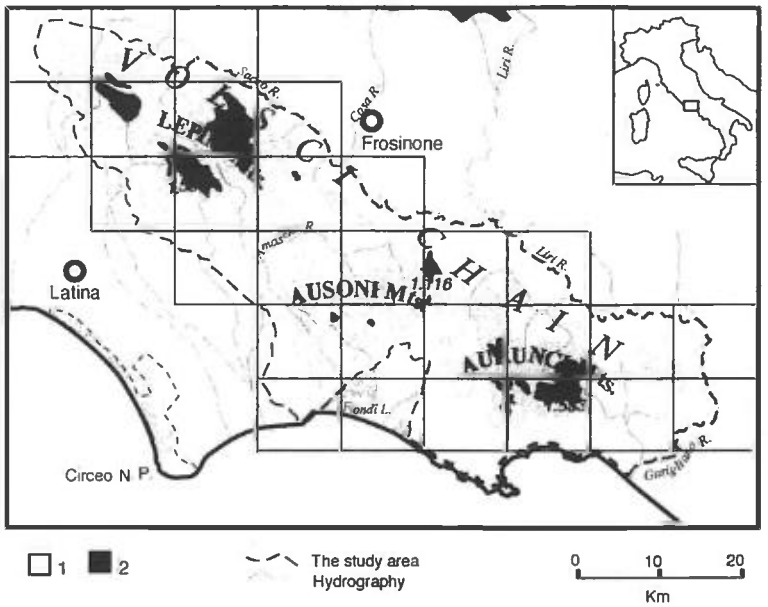

Fig. 1. Map of the Volsci Chain with grid reference, based on 1:25.000 I.G.M. (Military Geographic Institute) cartographic system. 1: areas included between 500 m and 1,000 m above sea level. 2: areas over 1,000 m.

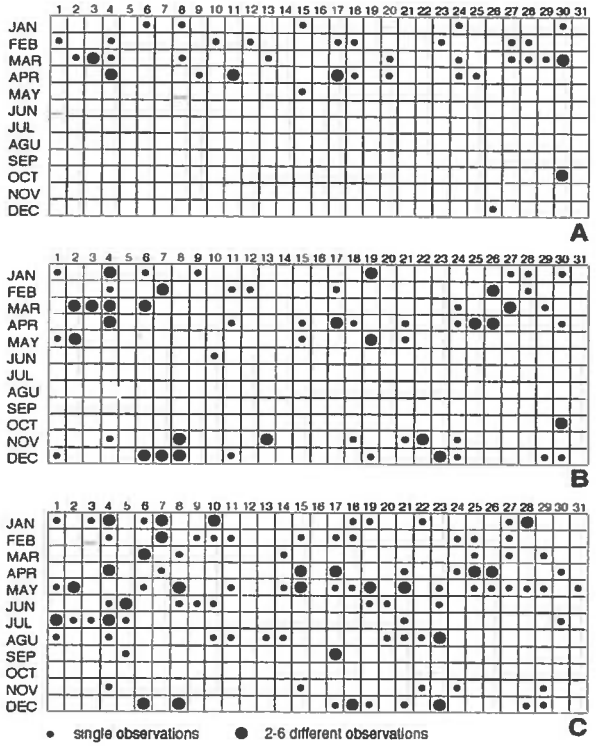

Fig. 2. Calendar of the presence of adult specimens (A) in water, eggs (B) and larvae (C) of *Salamandrina terdigitata*, collected in the years 1991-1996, in Southern Latium.

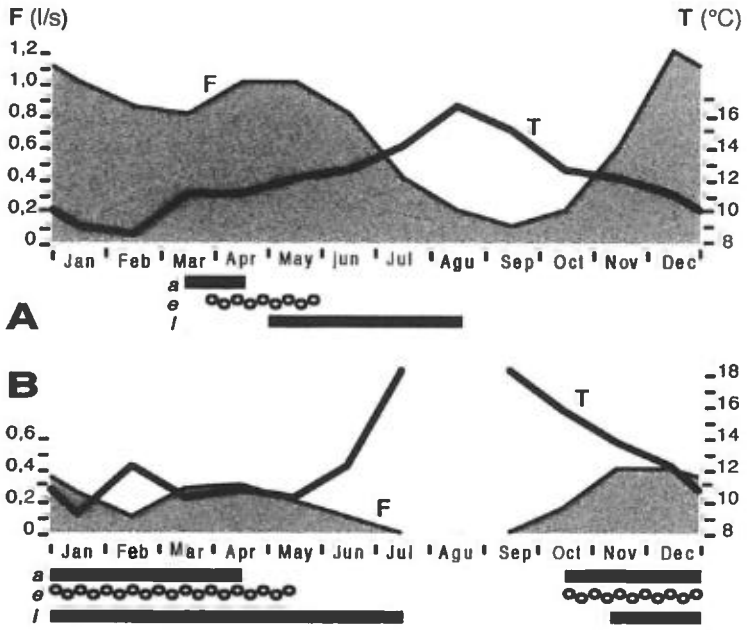

Fig. 3. Reproductive cycle of *Salamandrina terdigitata* in two locations, in relation to the flow (F) and temperatures of the water (T). a: presence of laying females; e: presence of eggs; l: presence of larvae.

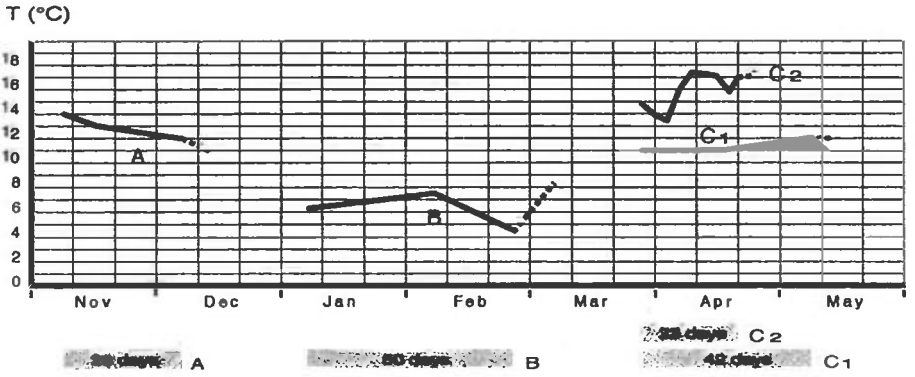

Fig. 4. The length of the embryo growth observed in 3 different locations of the studied area (A-B-C1) and in lab (C2) in relation to the water temperatures.

DESCRIPTION OF THE STUDY AREA

The area examined is in the southern Latium "anti-Apennine", or Volsci Chain, that includes the Lepini Mts., Auson Mts. and Aurunci Mts. (Fig. 1) which form a homogeneous and well defined geographic and geologic entity located in the administrative provinces of Rome, Frosinone and Latina. This area, of about 2,000 sq. km., extends mainly in the direction NW-SE and includes heights from sea level to 1.536 m (Mt. Semprevisa, Lepini Mts.).

The Volsci Chain is made up of Mesozoic Limestone and is characterised by both hypogean and superficial carsism.

According to the bio-climatic map of Italy (Tomaselli, Balduzzi & Filipello, 1973), the study area belongs to the Thermo-mediterranean and Meso-mediterranean subregions. On the southern slopes of the basal plain, the vegetation is represented by the relics of the Mediterranean forest of Holm Oak (*Quercus ilex*), often reduced to low bushes, or degraded steppes of *Ampelodesmos mauritancus*. On the mountainous southern slopes, in the basal northern slopes and in internal areas, the vegetation is a mixed association of *Quercus pubescens, Quercus cerris, Ostrya carpinifolia.* Moreover, in a few relict areas the vegetation is represented by Beech woods (*Fagus sylvatica*) with the presence of Holly (*Ilex aquifolium*) and Yew (*Taxus baccata*).

METHODS

The study is based firstly on data collected by means of regular field observations from 1991 to 1996 spending little more than 300 hours in the field; some first-hand data were partially obtained by irregular observations from 1981 to 1990 in spring and summer months.

A careful cartographic inspection of the whole area in order to point out all potential sites for the species preceded the field survey. Each of the 28 I.G.M. (Istituto Geografico Militare = Military Geographic Institute) maps 1:25.000 scale were examined (Fig. 1) and 199 potential sites were scheduled. *Salamandrina terdigitata* was observed in 57 sites (28.6%), with 75 laying sites. The locations are distributed at heights between 150 m and 1,150 m above sea level.

When it was required, larvae were captured by means of a close mesh net and then released in the same place. During this research I adopted a methodology respectful of the herpetologic fauna without the harvest of specimens, according to the regional law (no. 18 dated April 5, 1988). Only in March 1993 were some eggs collected in a site situated on the Lepini mountains, and after hatching in captivity, the larvae were released in the same places.

From October 1992 two sample locations were monitored for the whole year, with one or more visits each month, to study the reproductive strategies adopted by this species.

RESULTS

According to Lanza (1983) *Salamandrina terdigitata* egg-laying occurs between March and April but it may start at the end of December as well, as observed by Naviglio (1971) near Tivoli (Roma); earlier observations by Chiarugi (1899, 1900) reported it in January in the environs of Florence. Only recently have the first observation of eggs and larvae in November been reported on the Lepini mountains (Corsetti 1994a).

The analysis of the annual averages of the rainfall in the mountainous area studied, indicates a peak in autumn, generally in November, and a minimum in July. In the locations in which the danger of drought at the end of spring-summer is greater, *Salamandrina terdigitata* has adopted a different breeding strategy: it begins laying earlier, in the autumn-winter months, when rains are more abundant, so that larvae have a greater probability of completing their metamorphosis. The *Salamandrina terdigitata*, besides winter and spring, lays in autumn, beginning in the days following the first abundant rains of the season. In 45.6% of the locations the laying period occurs chiefly between October and January but, rather often, in some sites eggs were observed up to the following spring. In the remainder of the locations (54.4%) the females enter the water exclusively between February and May.

The first laying in nature was observed on October 30, 1993 in two location of the Lepini mountains. On this occasion 3 females were observed in the water, in the first location, and 2 in the second location. In 1992, November 8, there were already several eggs ready to hatch present, and in 1996, November 4, in another location, in addition to several eggs, there were also some larvae at the first stage of growth (cf. Lanza 1983): their laying probably occurred in the first days of October, considering the long period of time necessary for the development of the embryos at low temperatures. In 1994 in the first locations at two of the Lepini Mountains, the laying took place in the second half of November, only after the first abundant rains of the season, occurring at the beginning of the month.

In Fig. 2 are shown all the observations of eggs, larvae and adult specimen of *Salamandrina terdigitata* observed in the study area between 1991 and 1996.

In Fig. 3 are synthesized all the observations made in two locations of the Lepini mountains considered as a sample and examined for a complete year, with one or more monthly visits, beginning from October 1992 (for a more effective exposure of the data I considered the solar year from January to December. The activity pattern of the two populations of *Salamandrina terdigitata* is considered in relation to the flow and to the temperature of the water. The first (Fig. 3A) is an old spring whose water comes from a source; the second (Fig. 3B) is a small source, usually subject to drainage in the summer months: in 1994 the drought exceeded 3 months.

All the females of location A went down into water in spring and finished their laying in little more than a month. Those of location B laid more than once, with a better concentration in two different periods: in November-December and March-April.

In literature, the available information on the duration of the embryonic development of *Salamandrina terdigitata* originates from observations made in the laboratory. Lanza (1983) states that "in the laboratory and in conditions which are similar to nature, the hatching occurs after twenty days"; also Vanni (1980) reports that the hatching, occurring in the laboratory with a water temperature of about 14°C, needs 20 days. Chiarugi & Banchi (1896) and Chiarugi (1899) observed that the water temperature influences the duration of the process of segmentation of the eggs of *Salamandrina terdigitata* and recently other authors have studied, in the laboratory and in nature, the duration of the embryonic development of some anurans, in relation to the water temperatures (Guyetant 1969; Guarino 1992).

During the autumn-winter of 1992-93 I made observations in 3 different locations of the studied area, on the duration of the embryonic development in relation to the water temperatures (Fig. 4). In the first station (A), on November 8, 1992, there were 64 eggs

under a big stone; on December 6, they still contained embryos, almost all of them ready to hatch, and only on December 12 (water temp.: 11°C) it was possible to ascertain the hatching of 62 eggs.

In the second location (B), on January 7, 1993 there were some tens of eggs among the mud, probably laid the day before; some of them were not completely submerged (water temp.: 6.3°C). On February 7 the eggs were still at the first stage of embryonic development. In the visit of February 26 (water temp.: 4.5°C) the same eggs had embryos ready to hatch; only on March 6 did I see the first larvae (water temp.: 8.5°C).

In the third location (C1) on March 27 I observed numerous eggs at the first stage of development, laid on a small submerged branch. The same eggs were present on April 17 and only on May 8 was it possible to see the hatch beginning.

In the aforesaid cases a very slow embryonic development has been observed due to the low temperatures of the water. Experiments in the laboratory have confirmed the relationship between the water temperature and the duration of embryonic development. In the third location some of the eggs laid (14) in the same day and maybe by the same female were withdrawn. They were put in a plexiglass tank (C2) filled with water from the spring (renewed every three days), and maintained at a temperature which was higher than that of the site of origin (13.5-16.5°C). Such eggs required 23-28 total days for their hatching, while in nature at 11-12°C, some of the eggs under observation still contained embryos after 42 days.

DISCUSSION

Continuous observations in the study area have allowed us to ascertain that the laying period is longer, in the course of the year, with respect to the pre-existing data in literature and in comparison with other species of urodeles (Cei, 1946; Galgano, 1944; Bell & Lawton 1975; Lanza, 1983; Verrell, Halliday & Griffiths, 1986; Guarino et al. 1992).

The data collected in the course of this research points out that the species can resort to different breeding strategies: in the Mediterranean surroundings and in locations in which the limiting factor is the availability of water, it begins to lay eggs in the autumn,when the rains are more abundant, avoiding in this way the summer droughts. In fact the locations in which laying occurs in winter and autumn are only those with modest values of waterflow and subject to drainage in the summer months.

The potentially long reproductive activity in *Salamandrina terdigitata* depends also on the availability of sperm from late-summer or autumn, to the next spring. In this species there is not a complete halt in the activity of the testis during the winter months, but there is a "hemistasis" (Brizzi, Calloni & Vanni, 1985). Spermiation occurs with a period of courtship interactions that goes on, depending on the climatic variations, from autumn to the next spring (Lanza, 1983).

Interesting knowledge emerged also from the observations in nature on the duration of the embryonic development in relation to the temperature of the water, aspects that will be the object of subsequent and deeper investigations.

Additionally the higher number of stations of *Salamandrina terdigitata* present in Southern Latium (57), compared to the rare presences observed in other mountainous groups or regions of the Italian Apennines, further confirms the high naturalistic value of the area, which deserves a more effective protection through the institution of natural parks (Parks of the Lepini, Ausoni, and Aurunci Mountains) awaited for a long time (Corsetti 1979).

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