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ECOLOGICAL RESPONSES IN A POPULATION OF SMOOTH NEWTS (*TRITURUS VULGARIS MERIDIONALIS*) IN AN UNPREDICTABLE ENVIRONMENT

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ABSTRACT

The annual cycle of a population of Smooth newts (*Triturus vulgaris meridionalis*) was studied at a temporary pond in Central Italy. Timing of migration differs from that described in northern countries. Immigration and reproduction take place as soon as weather conditions are favourable (December), males arriving earlier than females. Emigration lasts a short period (April-May) and ends before pond desiccation (June). Summer drought is therefore not a limiting factor for adult activity as it is for larval survival. The aquatic period is short compared to that of northern populations and during the summer terrestrial phase probably little activity occurs. Males exceed females in the breeding population. In particularly dry conditions not all the female population reaches the pond. The average growth rate during the aquatic phase is approximately 1mm. An hypothesis on the influence of environmental conditions on adult body size is suggested.

INTRODUCTION

Many studies have been carried out in the past few years on the ecology of *Triturus vulgaris* L. mainly in North and Central Europe. This research was on population dynamics (Bell, 1977, Blab and Blab, 1981, Griffiths, 1984, Verrell and Halliday, 1985), on several aspects of reproduction (Bell and Lawton, 1975, Halliday, 1977, Verrell *et al.*, 1986), on the niche (Dolmen, 1983, Dolmen and Koksvik, 1983, Griffiths, 1987), on the age determination and growth rates (Hagström, 1977, 1980, Verrell and Francillon, 1986, Verrell, 1987). The ecology of the Italian subspecies *Triturus vulgaris meridionalis* (Boulenger) has not yet been studied. The present distribution of newts in Italy might have been influenced by historical factors however climatic conditions, such as temperature and rainfall, probably also have a strong effect (Giacoma, 1988).

The pond which we investigated lies on the President's Estate of Castelporziano, a few kilometers south of Rome. The Estate is one of the last areas on the Tyrrhenian Coast still covered by floodplain forest. It is also close to the southern limit of the distribution area of *Triturus vulgaris meridionalis*. At Castelporziano the climate is particularly dry, the long summer drought causes ponds to dry up completely, this is the most dramatic event in the newts' annual cycle but it is also affected by other variable factors such as temperature, rainfall and the succession of the aquatic invertebrate community. Average pond water level varies from year to year since water comes exclusively from rainfall.

At Castelporziano *Triturus vulgaris meridionalis* spends less time in water than northern populations and it has little terrestrial activity in the summer, thus research on growth was undertaken during its aquatic phase in a temporary pond.

METHODS

The President's Estate of Castelporziano, strictly closed to the public, extends from the sea coast towards Rome for about 18km. The climate in this area is very dry especially during the long summer period when also the temperature is high (Fig. 1 and Fig. 2).

The pond which we chose for our study site, has a surface area of about 400m^2 and a maximum depth of 80cm. It is a temporary pond which lies at sea level in typical Mediterranean maquis. The aquatic vegetation consists of filamentous algae (*Spyrogira* and *Cladophora*) and herbaceous plants such as *Ranunculus* and *Mentha*. The pond is a breeding site for *Triturus vulgaris meridionalis*, *Triturus carnifex*, *Rana dalmatina*, *Rana esculenta 'complex'* and *Hyla arborea*.

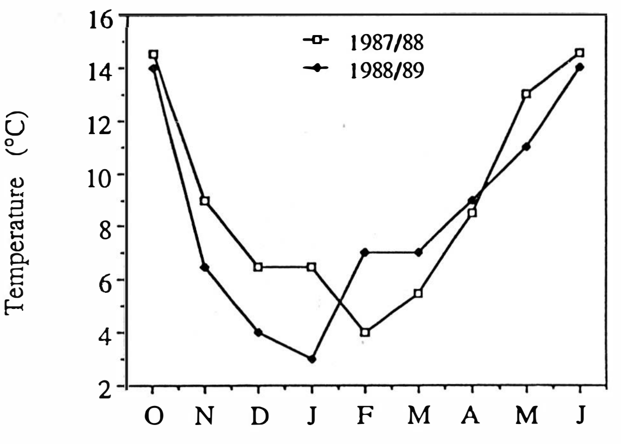

Fig. 1 Mean of the minimum air temperature recorded each month, during the two years of observations.

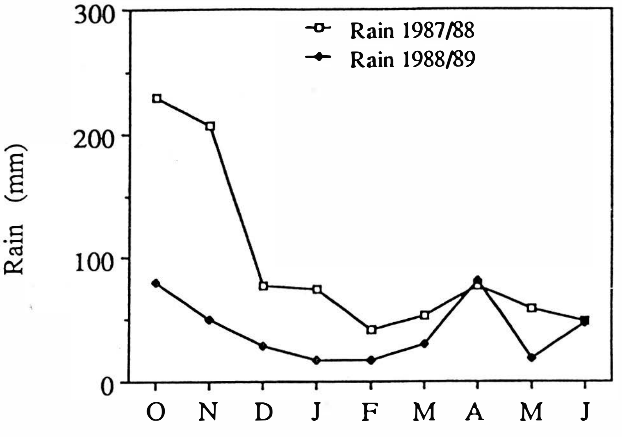

Fig. 2 Mean rainfall recorded each month, during the two years of observations.

Data reported in this paper refer to the period from November 1988 to June 1989 (data recorded the previous year have been used for comparison). We attempted to install a drift fence with pitfall traps but these were continuously damaged by the numerous wild boars which live on the Estate. Newts were caught weekly by dipnetting. Due to the turbid water the pond could only be investigated randomly. Dipnetting was performed for a total of one hour and a half by at least two people simultaneously all over the pond.

An 0.3:1000 solution of phenoxyethanol was used to anesthetize the newts. The sex of each animal caught and its secondary sexual characters were recorded, together with its snout-vent length (to the nearest 1mm). Individuals were then marked by clipping toes to show date of capture; each combination of toes clipped was unique for a weekly sampling. Furthermore the belly-pattern of every newt was recorded (photographically) for individual recognition. Any characteristics such as tail indentation and limb deformities were also recorded to aid in identification. Toe-clipped recaptured newts were measured again in order to verify whether the animals had grown. The experimenter who took the measurements was unaware of the previous size measured.

The weekly size of the population (Ni) was estimated using Chapman's modification of the Petersen Index. The absolute size of the population was obtained calculating $N = \Sigma Ni/s\text{-}1$ (where s = samplings), and variance (V) was calculated as $V(N) = \Sigma Vi/(s\text{-}1)^2$, (where Vi = variance obtained each week), (Seber, 1973). The mean time spent in water by each individual was calculated considering the mean recapture intervals between first and last captures (Griffiths, 1984). Animals recaptured after one week only were excluded from the mean.

RESULTS

THE TIMING OF MIGRATION

Weekly sample data show the seasonal migration patterns (Fig. 3). The first capture in 1988 was on 13th December. The number of animals caught increased until March 1989. The estimated size of the population (± standard deviation) which had visited the pond at that point was 229 ±33. In 1987-88 newts had first been caught on 3rd November and the increase was observed until March.

Emigration started in the same period in both years (beginning of April) but it proceeded faster in the first year. In 1988 the last newts were caught in water on 2nd May whereas in 1989 animals were still present on 1st June.

SEX RATIO AND POND RESIDENCY

In 1988-89 the overall male : female ratio was 1.72:1 (93 males and 54 females). Males migrated to the pond a few days earlier than females, and their number always exceeded that of females (Fig. 4a). The sex ratio in February was 1.70:1 and in May it was 1.25:1. In March the size of the population was estimated as 141±21 and 78±17 for males and females respectively. In 1987-88 males initially exceeded females, during the breeding period (December-March) the ratio approached 1:1 or was slightly female-biased, and males emigrated faster (Fig. 4b).

The average time spent in the water in 1988-89 is shown in Table 1. In 1987-88 the recapture interval was never longer than 84 days in either males or females.

BODY SIZE AND GROWTH RATE

The mean snout-vent lengths (SVL ± s.d.) were 34.7 ± 2.4mm (n = 93) and 35.3 ± 2.7mm (n = 54) in males and females respectively. Table 2 shows the

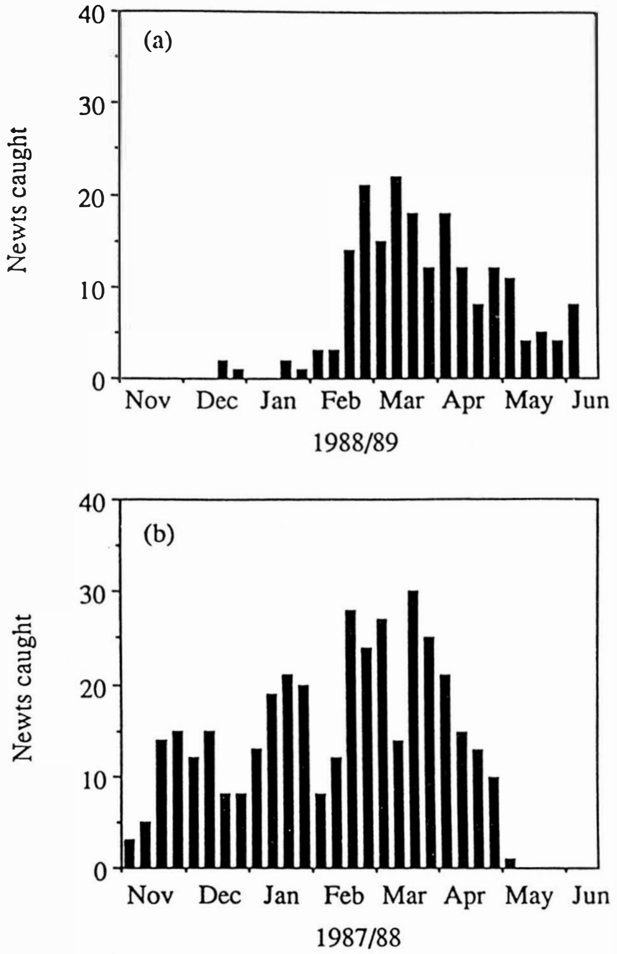

Fig. 3 Number of newts caught weekly in fixed time samplings, in 1988/89 (a) and 1987/88 (b).

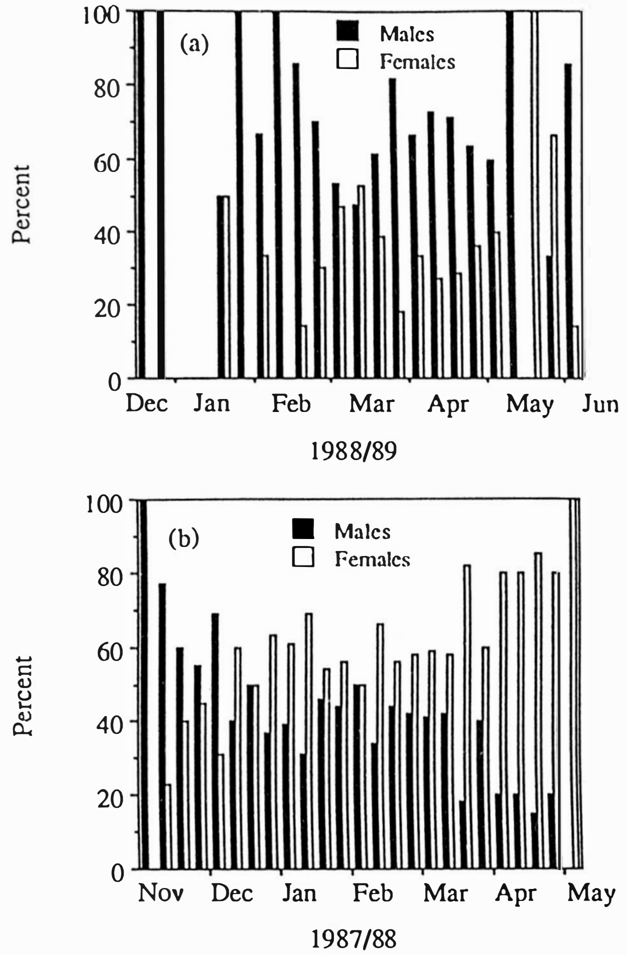

Fig. 4 Sex ratio expressed in percentage of males and females caught each week in 1988/89 (a) and 1987/88 (b).

mean snout-vent lengths measured each month. (Monthly samplings < 10 individuals have been omitted.)

	min.	*max.*	*mean ± s.d.*
Males	12	106	37 ± 26 (n = 14)
Females	14	42	25 ± 9 (n = 6)

TABLE 1: Recapture intervals, in days, of newts caught in 1988/89. (n = sample size, s.d. = standard deviation)

Of the 27 recaptured newts (20 males and 7 females) 8 males (40 per cent) and 3 females (43 per cent) had increased by 1mm in size, only one individual 31mm long was recaptured 3 weeks later measuring 34mm. Newts were never found decreased in size. No correlation was noted between recapture time interval or length at first capture and increase in size. Three males were recaptured twice after quite a long time. At their first recapture (after 21, 28 and 42 days respectively) their lengths had increased by 1mm, the second time they were recaptured (after 14, 28, 35 days) they had not grown any more.

	February	*March*	*April*	*May*
Males	33.8 ± 2.9 28 ÷ 40 (n = 30)	34.4 ± 2.0 31 ÷ 38 (n = 35)	35.4 ± 1.9 31 ÷ 39 (n = 29)	35.4 ± 2.0 32 ÷ 39 (n = 15)
Females	34.7 ± 4.4 28 ÷ 42 (n = 10)	35.0 ± 2.0 31 ÷ 40 (n = 24)	35.8 ± 2.2 33 ÷ 41 (n = 14)	36.0 ± 2.1 33÷ 39 (n = 10)

TABLE 2: Mean of the body sizes, in mm, (± s.d.), range and sample size of the newts caught monthly in 1988/89.

DISCUSSION

The Timing of Migration

Our newt population was present in the water from November to May, much earlier in the year compared to populations of northern countries. For instance in England immigration starts in February-March and emigration lasts from July to December (Harrison *et al*., 1983, Verrell and Halliday, 1985). Different water seasons have also been observed in Italy according to latitude and altitude of the breeding sites (Lanza, 1983). Temperature certainly has an influence on the annual reproductive cycle (Galgano, 1944, Mazzi, 1982). In our study area rainfall is also important: in autumn 1988 rain was very scant limiting pond refill (Fig. 2), thus immigration started later than the previous year. Early pond drought due to lack of spring rainfall is widely known to be a limiting factor for larval survival, and may prevent metamorphosis occurring at all. In very dry areas one must also consider that scarce autumn rainfall may dangerously delay reproduction.

Bell (1977) and Blab and Blab (1981) refer to autumn migrations of newts which spend winter in the water and breed in advance. Lanza (1983) states that a breeding period has occasionally been observed in late autumn in Italy. In sea level ponds in central Italy Smooth newts start breeding usually in late January-beginning of February. In our study area reproduction may also occur earlier (In 1987 Smooth newt eggs were first observed on 16th December, in 1989 egg laying started at the end of February).

The increase in the number of newts caught continued until March. Immigration lasted at least one month longer than that observed by Verrell and Halliday (1985). When weather conditions were unfavourable, i.e. scarce rainfall affecting pond refill (water level < 15cm), few newts reached the pond and their number did not increase continuously. As soon as water level steadily exceeded 25cm mass migration occurred (our case in 1988-89).

Emigration lasted for a short period (April-May), probably because environmental conditions became unfavourable for newts. We believe water temperature to be a very important factor in the determination of emigration time; animals started to leave the pond when maximum water temperature approached 15°C. It is relevant to note that adults leave water long before desiccation, when the water level is higher (50cm) than that observed when immigration starts. Desiccation is therefore a limiting factor for larval survival but not for adult activity.

Pond Residency and Sex Ratio

At Castelporziano estivation lasts from June to September. On both years newts were caught in the water over a period of six months, but each individual was never recaptured for a period of over three months. In England each individual spends an average of five months in the water (Verrell and Halliday, 1985), and hibernation is only two months long. The average time spent in water, calculated using the mean recapture intervals (Griffiths, 1984), is not as reliable a method as the use of a fence. Our data (underestimated due to the method used) show that newts spend a shorter period in the water at the southern border of their distribution area.

Males and females migrate at different times. Males were caught earlier and in greater numbers than females, this is in agreement with Harrison *et al.* (1983), Griffiths (1984), Giacoma (1985). The sex ratio varies during pond residency, in 1987/88 initially males exceeded females, later the trend was inverted, whereas in 1988/89, even though the number of both males and females grew, males always exceeded females.

In literature data on the sex ratio of *Triturus vulgaris* are contradictory. Glandt (1978) and Hagström (1979) find a 1:1 ratio in water. Harrison *et al.* (1983) and Verrell and Halliday (1985) find an excess of females that is less marked as the aquatic period progresses. Griffiths (1984) catches an excess of males in the water but the opposite happens on land. Two hypotheses are suggested (Griffiths, 1984, Gill, 1978, 1979 for *Nothophtalmus viridescens*) to explain the excess of males in the aquatic population: 1) mortality is higher among females than among males, 2) females do not breed every year. A shorter period of pond residency by females might also explain why the sex ratio appears to be male biased. Our observations suggest that the sex ratio of the population is not affected by mortality. The females' rate of increase was lower than that of males in 1988-89, whereas during the previous year the number of females exceeded that of males during most of the aquatic period. A similar pattern was observed over the two years in a sympatric population of *Triturus carnifex*. A possible explanation of this phenomenon (not breeding of females) might be the exceptionally dry weather of the year 1988/89. Biennial sexual cycles have been observed in female populations of Plethodontidae by Maiorana (1976). They were related to energetic reasons due to limited activity in unfavourable dry weather conditions.

Growth Rate and Body Size

Triturus vulgaris is known to have indeterminate growth (see Verrell, 1987). Adults spend part of the aquatic season to feed and grow. Throughout this season not every single individual grows, nevertheless at the level of the population average body size increases. An increase in mean snout-vent length of +1.6 in males and +1.3 in females was observed in the newts caught. At individual level the growth rate was approximately 1mm. These data are in agreement with those reported by Verrell (1987), although 40 per cent of the newts recaptured had increased in size, while this author found an increase in 77 per cent of them. Differences between these results may be due to the shorter recapture interval in our case, or to different approximation in the measurements (0.5mm vs 1mm). The short recapture interval probably also explains the lack of relationship between size at first capture and increase in size.

Adult growth rate varies among populations and years (Hagström, 1977). No data on this rate within a year are available except Verrell's (1987). A 1mm increase in *Triturus vulgaris meridionalis* 35mm long is greater in percentage than the same increase in *Triturus* *vulgaris vulgaris* 45mm long. (2.85 per cent vs 2.22 per cent). However growth rate slows after attainment of sexual maturity (Hagström, 1977, 1980), scarcely affecting adult body size. Tilley (1973) reports altitudinal size clines in adult *Desmognathus ochrophaeus* as a consequence of: '1) constant age at maturity and variable juvenile growth rates, 2) constant juvenile growth rates and variable age at maturity, or 3) both.' In *Triturus vulgaris* sexual maturity is determined by age, not size (Verrell and Francillon, 1986), thus body size reflects mainly juvenile growth rate.

The mean body size registered in Castelporziano is the smallest among other populations of central and northern Italy. Unfavourable weather and habitat conditions, i.e. coastal and xeric habitats, make food consumption irregular during the terrestrial juvenile phase. In cooler and higher breeding sites, surrounded by moist litter, faster growth probably occurs. This assumption is based only on ecological surveys, we are not aware of the degree to which this phenomenon has a genetic basis.

Fecundity in *Triturus vulgaris* is size-specific: larger females lay more and larger eggs which hatch earlier (see Bell, 1977 and Verrell *et al.*, 1986). A smaller body size may also affect several features of the population: size, age distribution, egg and larval survival. Further research on this topic would be of interest.

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