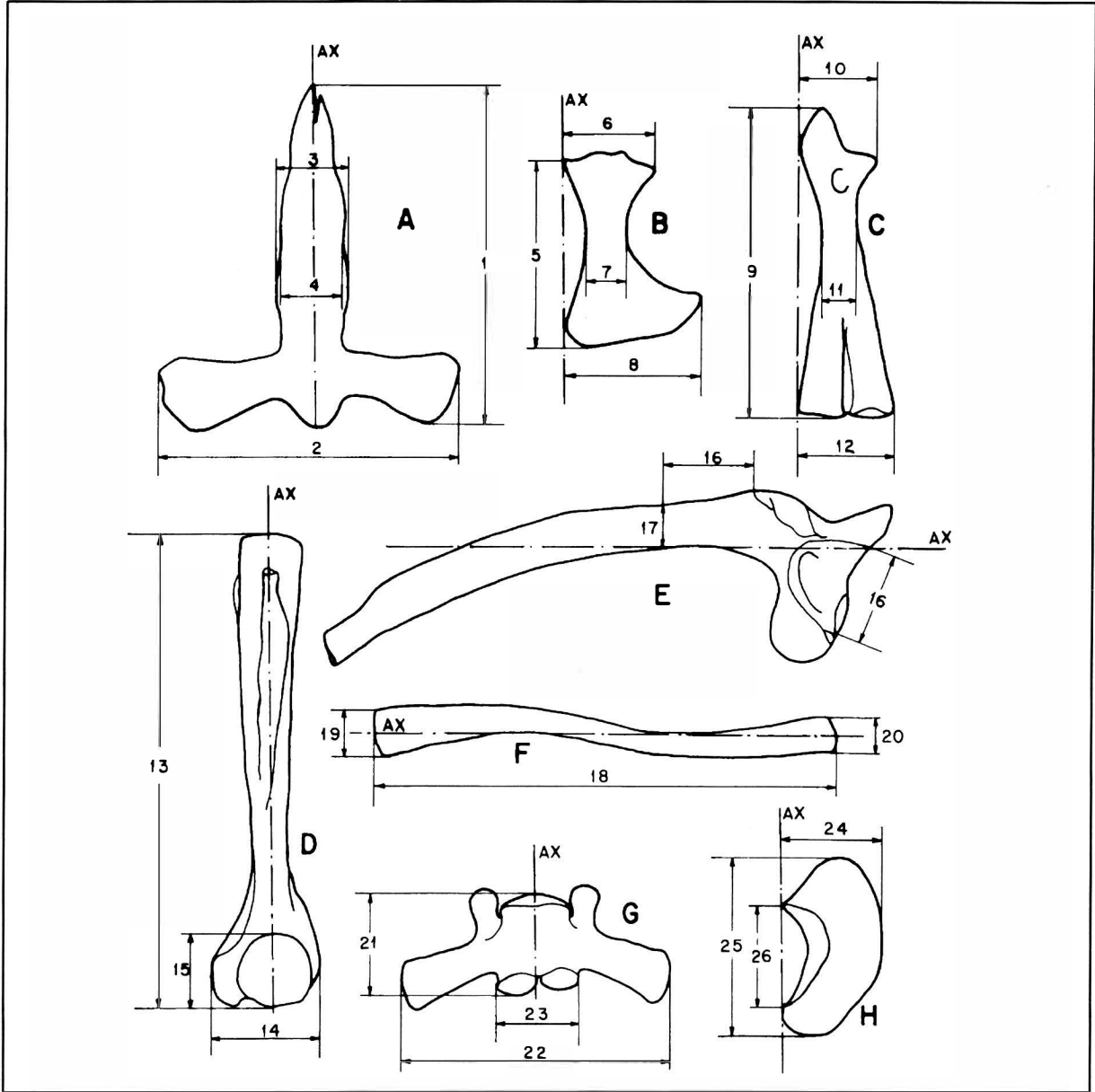


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FRONT COVER: Measurements of *Rana temporaria* bones (M. Esteban *et al.*).

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 Palaearctic 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

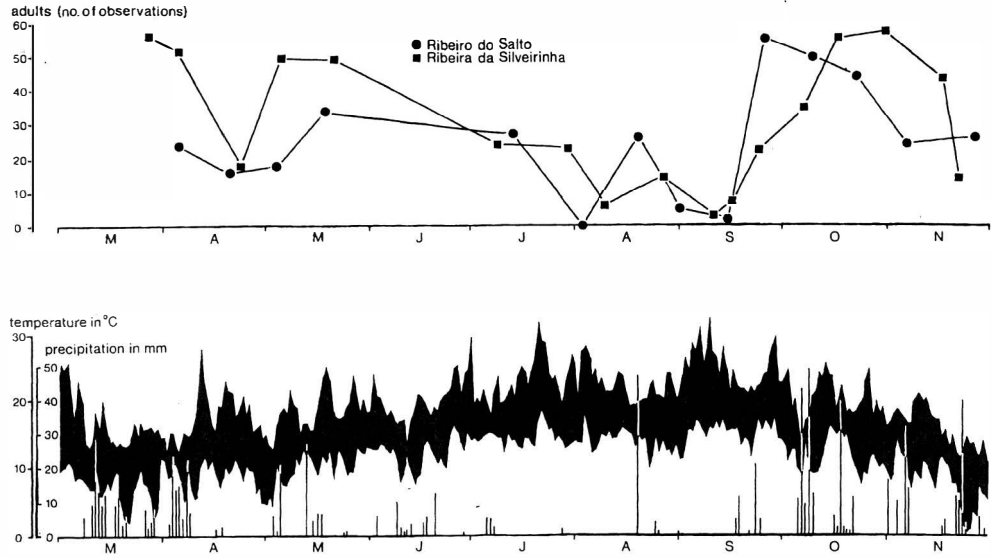


FIG. 1. Adult *Chioglossa lusitanica* observed in standard searches of set trajectories along Ribeira da Silveirinha and Ribeiro do Salto, in northern Portugal (top - details see text). Meteorological conditions (max. and min. temperature and rainfall) observed at Serra do Pilar, Vila Nova de Gaia (bottom).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

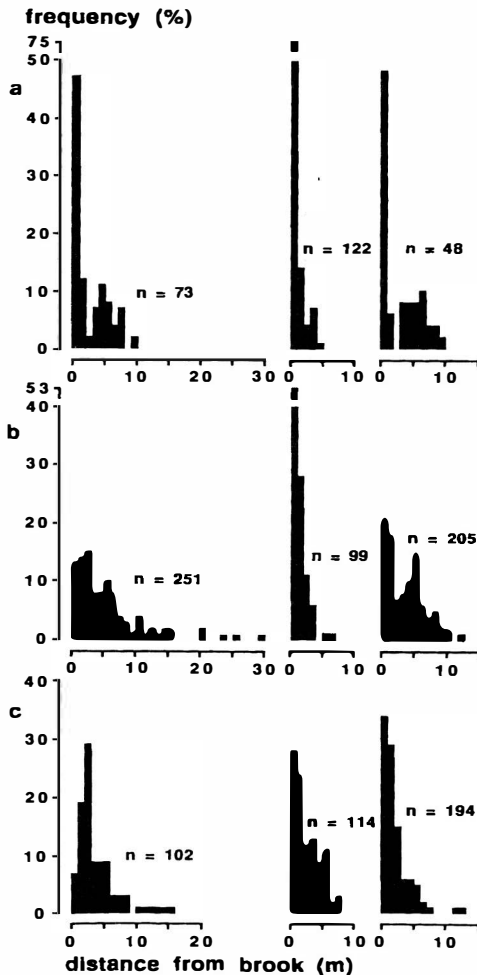


FIG. 2. Distribution of *Chioglossa lusitanica* along the axis perpendicular to the water source over the seasons (from left to right: spring, summer and autumn); (a) Ribeira da Silveirinha, juveniles; (b) Ribeira da Silveirinha, adults, and (c) Ribeiro do Salto, adults.

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 ≥ 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 ≥ 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

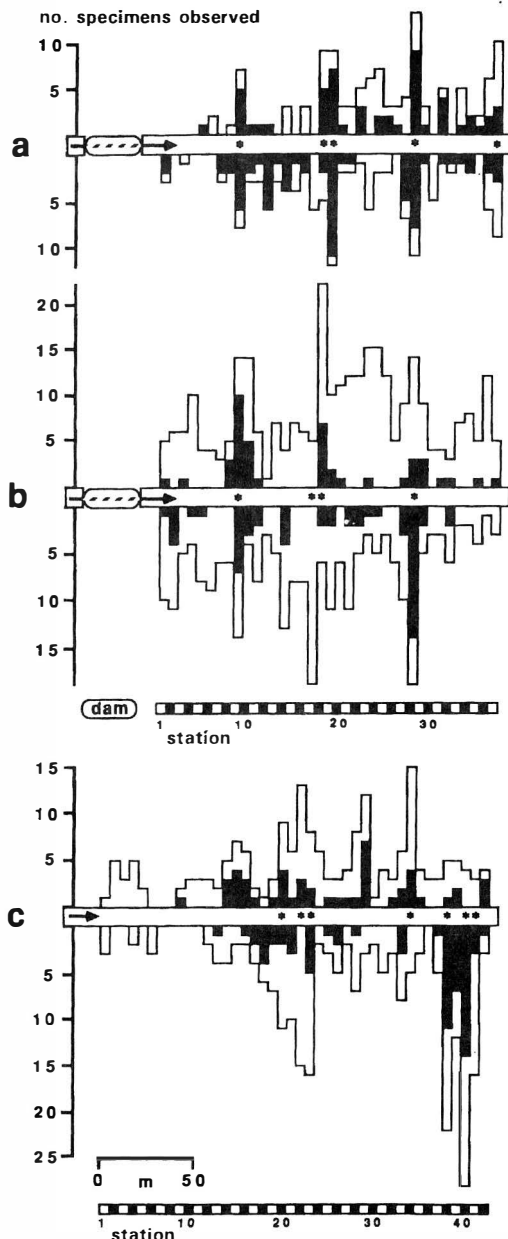


FIG. 3. Distribution of *Chioglossa lusitanica* along the water source in summer (solid bars) and in spring and autumn (open bars) at (a) Ribeira da Silveirinha, juveniles, (b) Ribeira da Silveirinha, adults, and (c) Ribeiro do Salto, adults. The arrow indicates the direction of flow. Asterisks indicate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

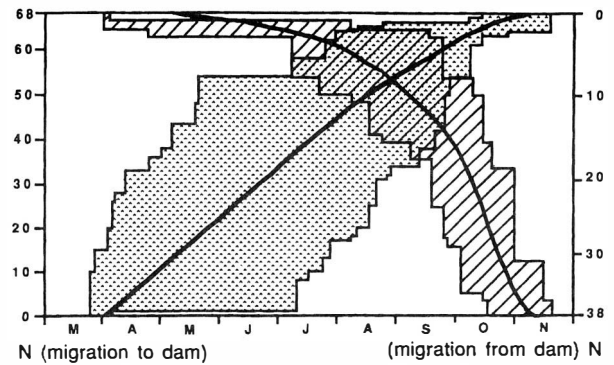


FIG. 4. Reconstruction of the migratory activity of adult *Chioglossa lusitanica* along Ribeira da Silveirinha. Observations are based on the capture - recapture of marked individuals. Sixty-eight observations were made on migration from stations 1-37 (cf. Fig. 3) to the dam (the shaded graph with dates 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.

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OBSERVATIONS ON SEASONAL AND DIEL SURFACE ACTIVITY OF THE AMPHISBAENIAN *BLANUS CINEREUS* IN SOUTH-WESTERN SPAIN

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The main activity period of *Blanus cinereus* occurred from March to July, and a second period with lower activity was detected in autumn. Individuals were mainly diurnal, but they also exhibited nocturnal activity in April, June and especially in July. Daily activity appeared to be related to air and surface temperatures, while the annual variation in activity was also related to underground temperature. Recaptured individuals showed little mobility, frequently persisting at the same location. The recapture rate between years was low.

INTRODUCTION

Amphisbaenians have traditionally been a little-known order, owing to their subterranean habits. Until recently, the only European amphisbaenian, *Blanus cinereus*, had been the object of few studies. Some comments on its activity pattern were made by Valverde (1967) and Busack (1978). Salvador (1981) reviewed and compiled the available information on the species. In recent years, more detailed studies have been published on some aspects of the biology of *B. cinereus*, including feeding habits (López, Martín & Salvador, 1991; Gil, Guerrero & Pérez-Mellado, 1993), reproduction (González de la Vega, 1988) and activity and thermal biology (Martín, López & Salvador, 1990; Gil *et al.*, 1993). The two latter papers describe the variation of body temperatures in populations of *B. cinereus* at two localities in central Spain. The species is considered to be a thigmotherm and a thermoconformist, since body temperatures were slightly higher than, but not significantly different from, ambient temperatures. Both studies describe the general daily activity pattern of the species, but do not consider its variation throughout the year. Surface activity was detected only during daylight hours, following a bimodal distribution, with one peak in the morning and another in the afternoon.

In the present study we recorded data on the activity pattern of *B. cinereus* at a southern locality in its range. The study site is situated at sea level and is climatically distinct from the areas where the two above mentioned studies have been carried out. Our aim was to determine the annual and daily activity period of *B. cinereus* in this area, as well as the variation of the latter throughout the year. Only surface activity was recorded, and no information was obtained on underground activity.

METHODS

Field work was carried out at the Doñana National Park (SW Spain), from March 1991 to September 1992. The climate is Mediterranean, with overall mild

temperatures. Monthly rainfall and mean temperatures for the study period are described in Fig. 1.

B. cinereus is a common species in Doñana, being present in most biotopes of the area (Díaz-Paniagua & Rivas, 1987). We chose a pinewood of *Pinus pinea* as sampling site, placing a series of 35 cm square stone tiles at 5 m intervals in a 6x5 grid arrangement ($n=30$ tiles). The area is sandy, with no natural stones, and the tiles were used to attract individuals (Díaz-Paniagua & Rivas, 1987). On each sampling occasion all tiles were lifted, and active individuals of *B. cinereus* found beneath them were counted and identified. Each sampling day was normally divided into seven sampling occasions, with checks made every three hours from 06.00 to 24.00 hr, and only one check in the night interval from 24.00 to 06.00 hr. This last interval was omitted from October 1991 to February 1992. The frequency of individuals found was corrected for this difference in sampling effort according to the ratio of number of individuals captured in relation to the number of sampling occasions in a day. The number of sampling days totalled 57.

All individuals were measured (total length and snout-vent length), weighed and marked with subcutaneous alcian blue dots by using a panjet inoculator

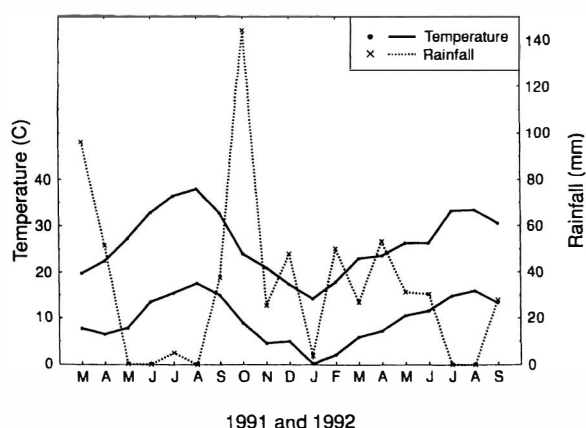


FIG 1. Monthly variation of temperature (minimum and maximum) and rainfall during the study period.

(Wisniewski *et al.*, 1981). On each sampling occasion the following environmental variables were recorded: air temperature (T_a), at open shade and 1 m above the ground; surface temperature (T_s), on the ground, in open shade; underground temperature (T_u), at the bottom of a perforated plastic tube buried 15 cm into the ground and with a closeable upper mouth; and undertile temperature (T_t), always measured under the same tile. Temperature was also measured under tiles where *B. cinereus* individuals were found. Data on relative humidity, daily incidence of radiation and rainfall were obtained from a meteorological station located 2 km away from the study site.

For the analysis of annual activity each animal was considered as one individual record for a sampling day, regardless of how many times it was recaptured on the same day. For diel activity and mobility analyses repeated observations of an individual on the same day were taken into account.

Daily distributions of the number of individuals captured were analysed as circular distributions (Zar, 1984) and their mean angles were calculated as mean activity time. The relationship between temperature and the number of individuals was analysed through non-parametric correlations. The importance of environmental conditions was assessed by comparing the distribution of data characterizing presence and absence of *B. cinereus* by means of χ^2 tests.

RESULTS AND DISCUSSION

ANNUAL ACTIVITY CYCLE

During the study period 31 different individuals were marked, making up a total of 72 individual records, not taking into account recaptures within the same sampling day. Fig. 2 shows the monthly variation of the number of individual records per sampling day (corrected for sampling effort). We found surface active animals from March to October, except in August, which is in accordance with data from central Spain (Gil *et al.*, 1993). The maximum number of individuals was recorded in April, with only a slight decrease in records up to July. No individuals were found under tiles in August, which could correspond with an aestival inactivity period, although maintenance of underground activity cannot be discounted. Martín *et al.* (1990) and Gil *et al.* (1993) also recorded the disappearance of *B. cinereus* under stones in August, and the former suggest that temperatures attain critical values in this microhabitat at that time of year. In Doñana we recorded temperatures of up to 42°C under tiles in August. The same reason could explain the absence of *B. cinereus* under tiles during the coldest months, from November to February, when under-tile temperatures down to 2°C were recorded.

Surface activity was low in September and October, with only a small number of individuals being detected. Bons & Saint Girons (1963) established a dependence between the occurrence of a second activ-

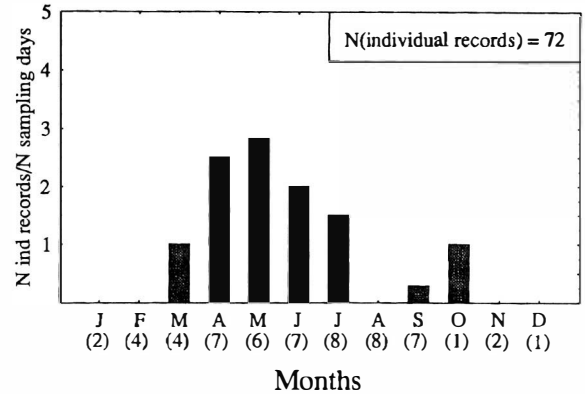


FIG 2. Monthly variation of the number of individuals observed/number of sampling days. (For each month the numbers of sampling days are indicated in brackets).

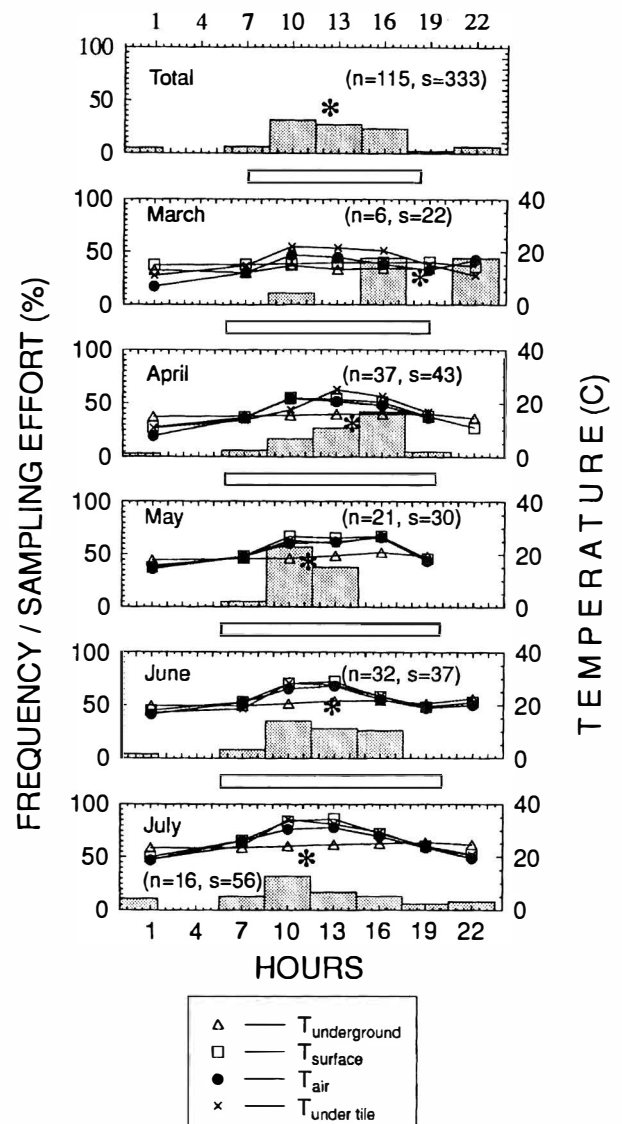


FIG 3. Distribution of the individual records of *B. cinereus* in relation to the number of samples (in %) and variation of temperature through the daily period (classified in 3 hr intervals). Mean activity time is indicated by an asterisk (*) showing the mean angles for each distribution. Bars above each graph indicate the length of the daylight period. (n =total number of observations, s =total number of samples).

ity period and autumnal rains for the related species *Blanus mettetalis*. Our data was recorded during a year of little autumnal rainfall, which could possibly have had a negative influence on autumnal activity.

DIEL ACTIVITY

The diel cycle of *B. cinereus* is shown in Fig. 3 for the total and monthly grouped data (only those months with $n > 2$ individuals are shown). The total distribution is unimodal, with the highest number of records concentrated around the warmest hours, the mean activity time being located at 12.30 hr. Individuals were observed in all time intervals considered.

In March and April the mean activity time and the peak of the distribution corresponded to afternoon hours. In the following months, as ground, tiles and air progressively reached higher temperatures, the number of animals found during morning hours increased. From May to July, the highest frequencies were found between 09.00 and 12.00 hr. The widest range of activity time occurred in July, when observations of individuals were widely dispersed over all sampling hours. This flexibility in diel activity seems to reflect an accommodation of habits to a range of favourable temperatures, as expected for a typical thermoconformist. Only three individuals were observed in September-October, all of them in the 09.00 to 12.00 hr time interval.

Night-active individuals were found in April, June and July, and could be expected to occur also in May. Nocturnal habits had not yet been described for *B. cinereus*, but have been suggested in general field guides (Salvador, 1985).

ENVIRONMENTAL FEATURES RELATED TO ACTIVITY

The mean variation of all temperature measures over a sampling day is presented for each month in Fig. 3. T_u showed the lowest variation and was only correlated with the distribution of individuals in March ($r_s = 0.777$, $P < 0.05$). T_a , T_s and T_l did vary noticeably, and time distributions of individuals were significantly ($P < 0.05$) related with T_s in April ($r_s = 0.786$), June ($r_s = 0.847$) and July ($r_s = 0.811$), with T_l in April ($r_s = 0.886$) and July ($r_s = 0.847$), and with T_a in June ($r_s = 0.847$) and July ($r_s = 0.811$). These significant relationships indicate that surface movements of animals in these months are influenced by thermoregulatory activity.

The distribution of temperatures recorded during the whole period and those associated with the presence of *B. cinereus* are compared in Fig. 4. Individuals were present under tiles within the following temperature ranges: $T_u = 13.4 - 27.8^\circ\text{C}$, $T_s = 12.6 - 37.0^\circ\text{C}$, $T_a = 11.0 - 38.0^\circ\text{C}$, and $T_l = 12.0 - 36.0^\circ\text{C}$. Significant differences between the absence and presence of *B. cinereus* were found for all temperature measures, except T_s , indicating that the species is active within a

specific temperature range. It is relevant that T_u showed its influence when considering the whole study period, since this parameter exhibited a wide annual variation but showed minimum variation throughout daily periods.

None of the other environmental variables affected the absence or presence of *B. cinereus* (radiation $\chi^2 = 12.6233$, $P = 0.246$, $df = 10$; relative humidity $\chi^2 = 7.164$, $P = 0.620$, $df = 9$). Incidence of radiation varied from 8.5 to 46 kw/cm^2 over the study period, and *B. cinereus* was only detected from 32.6 kw/cm^2 on. Regarding relative humidity, we found individuals within the range of 19 to 76%.

MOBILITY

B. cinereus was detected under 22 out of 30 tiles during the study period, averaging 1.16 different individuals/tile (range from 0 to 3). We normally found

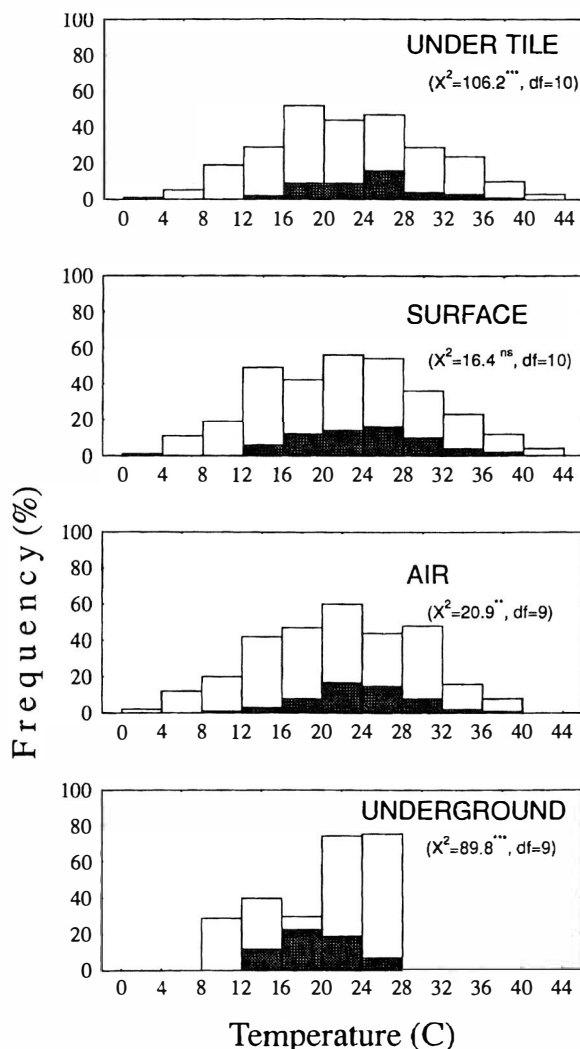


FIG. 4. Distributions of temperatures recorded under tile, at the soil surface, underground, and 1 m above the ground (air) during the study period. The dark bars indicate the data coinciding with detection of *B. cinereus*.

isolated animals, except for four occasions, when two specimens were observed together.

We marked 13 animals in 1991 and 18 in 1992. Only one animal was captured in both years. Thirty-one individuals were observed on 115 occasions, 17 only once and 14 were recaptured from 1 to 13 times. There was low mobility between tiles, since 71.4% of individuals were always recaptured under the same tile, and only 28.6% moved between tiles, covering a maximum distance of 11 m.

Several individuals were found under the same tile over long periods. The strongest site fidelity was recorded from 19 March 1991 to 30 June 1992 for one individual, and from 19 March to 20 June 1991 for another. Time elapsed between first capture and last recapture under the same tile of all other individuals did not surpass 2.5 months.

A very low recapture rate was observed between the first and second study years. One possible cause could be a high mortality; however, no other evidence supported such a hypothesis, since most new individuals captured in 1992 were adults of similar or larger weight and size than those of 1991. Otherwise, mobility could be another possible cause of such high renewal, assuming that, in contrast with the sedentary habits observed for certain individuals, others could be characterized by a higher degree of mobility.

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A COMPARISON OF SURVEY METHODS FOR CRESTED NEWTS (*TRITURUS CRISTATUS*) AND NIGHT COUNTS AT A SECURE SITE, 1983-1993

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Breeding crested newts (*Triturus cristatus*) were studied in two ponds at a privately-owned secure site. Numbers counted at night were found to be positively related to numbers trapped or netted using standardized techniques. Night counting was used to monitor changes in breeding numbers from 1983 to 1993. In one pond, counts declined to zero by 1990 as a result of siltation and drought conditions. In the main breeding pond, considerable year-to-year fluctuations occurred, with annual mean counts ranging from 3 to 183. A significant rise was recorded in 1985, that was attributed to exceptional recruitment to the adult population. Counts remained high until 1988, but then declined. Numbers decreased even further during the drought years of 1991 and 1992, despite small pools being dug. These small pools were evidently unattractive and were mainly ignored. After heavy rain recharged the pond in autumn 1992, counts returned to a similar level in 1993 to that recorded at the start of the study, 9-10 years before. Catches of larvae varied considerably from year to year. Larval numbers were not related to counts of adults, but were positively correlated with catches of larvae of smooth newts *T. vulgaris*, which also breed at the site. Implications for the conservation of crested newts are discussed.

INTRODUCTION

In Britain the crested newt (*Triturus cristatus*) receives protection as a Schedule 5 species under Part I of the Wildlife and Countryside Act, 1981. In addition, exceptional populations may be protected under Part II of the Act by their breeding sites and immediate terrestrial habitat being notified as Sites of Special Scientific Interest (SSSIs). This latter approach requires the ability to recognise populations worthy of protection in SSSIs. Counting in the breeding site at night with a powerful torch is frequently used as an assessment technique and has enabled at least some of the best populations to be identified (Oldham & Nicholson, 1986; Swan & Oldham, 1993). Night counting is an example of a visual encounter survey technique (Crump & Scott, 1994). One problem during the 1980s, when guidelines for SSSI selection were being formulated, was that little information was available on population stability as indicated by night counting. The guidelines (Nature Conservancy Council, 1989) eventually recommended that populations in sites that exceeded the appropriate threshold (100 newts counted at night) should be checked for stability over three breeding seasons.

Numbers and ranging of a population of crested newts at Shillow Hill in Cambridgeshire were studied in 1984 and 1985 (Cooke, 1985, 1986). During the period 1984-1986, night counting was compared with other survey techniques, particularly bottle trapping (Griffiths, 1985) and netting. From 1986, it was decided to continue with night count surveillance of this population to monitor gross changes in the long-term. The site is privately owned and is free from most of the urban, agricultural and other pressures that affect

many British crested newt sites (Hilton-Brown & Oldham, 1991). This work has assumed extra importance in view of the recent global interest in declines of amphibian species and long-term monitoring to look into the perceived problem (Wake, 1991; Pechmann *et al.*, 1991; Beebee, 1992; Griffiths & Beebee, 1992). The decline of the crested newt in Britain continues to give cause for concern (Hilton-Brown & Oldham, 1991; Griffiths & Beebee, 1992). This is the first report of a population of this species being monitored annually for a period of ten or more years. Published population studies on crested newts on the European mainland extend to four (Glandt, 1982) or six consecutive years (Hagström, 1979; Arntzen & Teunis, 1993).

SITE DESCRIPTION

The Shillow Hill site (grid reference TL28-82-) extends to about 2 ha, and is a mosaic of woodland, scrub, hedge, marsh, orchard, grassland, gardens and buildings. It comprises two domestic properties, the owners of which are sympathetic to the needs of the newts and other wildlife. There are four semi-natural ponds, probably resulting from clay-digging earlier this century. Two of these ponds rarely hold water in the breeding season and will not be referred to again. The principal breeding site has been Top Pond (48 m perimeter at high water) with some breeding in Wood Pond (20 m perimeter) during the 1980s; these two ponds are about 60 m apart. On the eastern side of the site is a main road, the B1040; no newt casualties have been found on this road (Cooke, 1985). Beyond the road and also on the other three sides of the site is arable farmland. No pond is shown on the local 1:25 000 map closer than 500 m and no other crested newt site is known within 1 km. At other sites, while immature

newts are known to travel up to 500 m, few adults are found more than 250 m from their breeding ponds (Oldham & Nicholson, 1986). Newts are sometimes found on the arable farmland around the Shillow Hill site in summer (Cooke, 1986). Therefore, while some emigration may occur across the arable land at Shillow Hill, significant immigration is extremely unlikely. Smooth newts (*Triturus vulgaris*) also breed at the site and some comparative information is provided in this paper.

FIELD METHODS

DEVELOPMENT STAGES

Crested newts lay their eggs during the spring and early summer. The larvae develop over a period of months, with the efts emerging in late summer; overwintering as larvae is rare at this site. The efts attain a maximum length of 64-69 mm by late autumn in their first year (Cooke, 1986). An immature stage can be recognized with a maximum length of 89 mm. The duration of this stage has not been quantified at Shillow Hill. Information from populations on the European mainland demonstrates that, while crested newts can mature at two years of age, some or most individuals require longer (Hagström, 1979; Dolmen, 1983; Arntzen & Teunis, 1993). In the autumn at Shillow Hill, males in the length range 90-99 mm can be found with secondary sexual characteristics and these are termed sub-adults, following Oldham & Nicholson (1986). Sub-adult females are assumed to

be of the same size, with adults of both sexes being 100 mm and longer.

NIGHT COUNTING AND COMPARISON WITH OTHER METHODS

Changes in abundance of adult newts in the breeding sites were followed by means of night counts. Such counts may be affected by changes in the ease with which individuals can be seen because of fluctuations in turbidity and density of water plants. A stick was used while counting, to move aside submerged and floating vegetation. Visual estimates of turbidity and plant cover were routinely recorded in order to check whether changes in numbers of newts counted might be explained by such factors. Throughout the study, access to the entire perimeters of both Top and Wood Ponds was always possible. To facilitate recording since 1984, the edge of Top Pond was divided into 16 sections of equal length (3 m with the pond full). To minimize the effects of behavioural changes, counts were restricted to peak breeding season and were undertaken during 50-120 min after sunset.

During 1984-1986, bottle trapping (Griffiths, 1985) was compared with night counting in order to determine whether a totally different method supported the results obtained by torch counting. Bottle traps were used by Griffiths & Mylotte (1987) to indicate seasonal changes in numbers of crested newts in the water at a pond in Wales, and to provide information on the relative use of pond microhabitats. At Top Pond, night counting

TABLE 1. Rainfall prior to summers when Top Pond retained water ($n=6$) or desiccated ($n=5$). Notes: ^a Arbitrarily taking July as month when pond desiccated. ** significantly different by t test from mean rainfall when pond retained water, $P<0.01$; *** $P<0.001$.

period covered	months before July in the summer under scrutiny ^a	mean rainfall in period $\pm$ SE (mm)	
		pond retained water	pond desiccated
April - June of that year	1-3	198 $\pm$ 12	131 $\pm$ 15**
January - March of that year	4-6	106 $\pm$ 12	112 $\pm$ 9
October - December of previous year	7-9	176 $\pm$ 13	114 $\pm$ 14**
July - September of previous year	10-12	161 $\pm$ 27	115 $\pm$ 22
January - June	1-6	304 $\pm$ 7	243 $\pm$ 12**
October - June	1-9	480 $\pm$ 19	357 $\pm$ 5***
July - June	1-12	641 $\pm$ 34	472 $\pm$ 18**

was undertaken mid-week and bottle trapping at week-ends. Total catches during trapping regimes of 64 traps for one night or 32 traps for two nights were compared with the mean of night counts undertaken during the previous and the following weeks. Traps were evenly distributed around the edge at 0.75 or 1.5 m intervals.

Counts made in Top Pond at roughly weekly intervals throughout the breeding seasons of 1984-1986 indicated that peak season could be regarded as extending from the second week of April to the first week of June (nine counts). Accordingly weekly counts were made during this nine week period in 1987. Thereafter, five counts per season were undertaken with a count made in weeks 1, 3, 5, 7 and 9. Single counts were made in Wood Pond each breeding season except 1985. Whenever possible, counts were made under favourable conditions (calm, mild, dry nights). In 1986, to determine whether this seasonality could be confirmed by an alternative method, daytime netting was undertaken in Top Pond at weekly intervals from mid-March to early July; a pond net was used to make 2 m sweeps from deep to shallow water at each metre station around the 48 m perimeter.

OTHER OBSERVATIONS

As a supplementary activity, information indicative of relative larval abundance was obtained for Top Pond from 1986 onwards by netting during July and August, prior to emergence (Cooke & Cooke, 1993). For each metre of edge, a 2 m sweep was made with a pond net. In 1991 and 1992, when the pond was much reduced in size, one sweep was made per 2 m² of water surface. There were netting sessions on four different days each summer.

Records have been kept about when the breeding sites dried out. This information has been compared

with precipitation records gathered at the meteorological station at Monks Wood, 9 km away.

RESULTS AND OBSERVATIONS

DESICCATION AND RAINFALL

Top Pond desiccated by late summer in five years during the study period: 1984, 1989, 1990, 1991 and 1992. Examination of meteorological records from Monks Wood revealed the importance of rainfall in early summer (Table 1) but also indicated that rainfall for up to at least the previous year could influence whether desiccation occurred.

This area of Britain suffered prolonged drought from early 1990 to mid 1992. Rainfall in 1990 and 1991 was 63% and 78% respectively of annual mean rainfall during the 1980s. Top Pond dried during the summer of 1990, but unlike previous drought years, it was not recharged during the following winter. Because of the conservation importance of this population (during 1985-1988 it had one of the highest night counts documented in Britain) a decision was taken before the 1991 season to excavate a new small pool with 10-12 m of edge in the dry bed of the pond. By 1992, the water table had lowered still further (in January 1992, 1.5 m below high water compared with the original water depth of 0.7 m) necessitating deeper excavation. This pool was lined with plastic and filled with rain water; it had an area of 3-3.5 m² (equivalent to about 3% of the original pond) and a shoreline of 8 m (17% of the original). Heavy and persistent rains during the second half of 1992 refilled the original pond completely by January 1993, i.e. the water table rose by 1.5 m in one year.

The second pond, Wood Pond, was never more than 50 cm deep and suffered from progressive siltation. During the 1980s it became shallower. With the additional effects of the drought, Wood Pond was dry

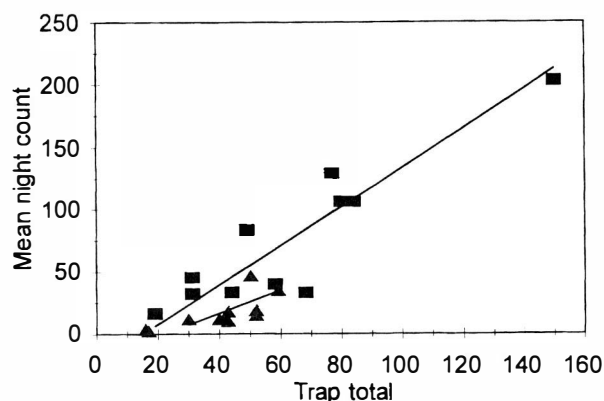


FIG 1. Relationships between total numbers of newts caught in bottle traps in Top Pond and the mean of the previous and following night counts. See text for further details. Equation of line fitted to crested newt data (squares): $y = 1.57x - 23.7$; line for smooth newt data (triangles): $y = 0.92x - 20.2$.

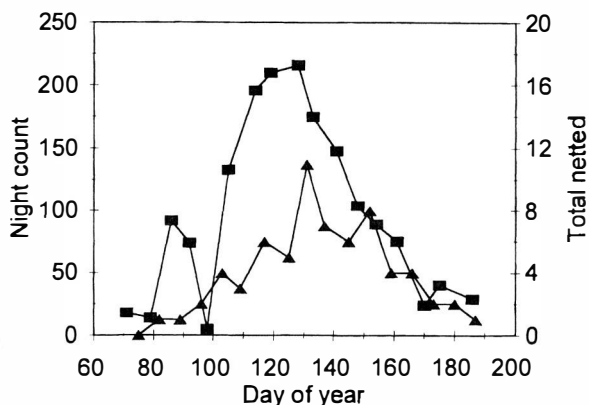


FIG 2. Night counts (squares) of crested newts in Top Pond, March-July 1986, compared with daytime netting totals (triangles). Day 100 = 10 April, day 200 = 19 July.

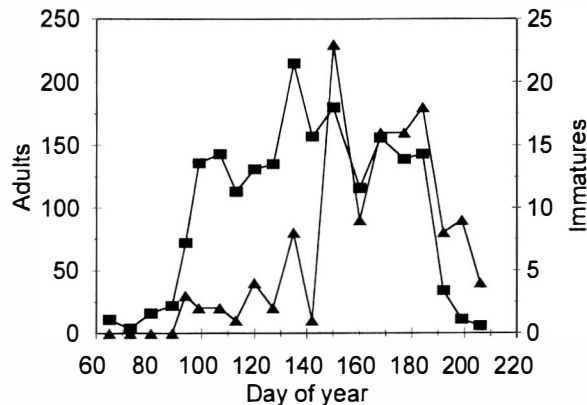


FIG 3. Night counts in Top Pond, March-July 1985, for adult crested newts (squares) and immatures (triangles). Day 100 = 10 April, day 200 = 19 July.

throughout the second half of 1991 and the beginning of 1992, despite having been deepened by about 30 cm the previous winter. Rains at the end of 1992 recharged this pond to a depth of 40-50 cm by early 1993.

COMPARISON OF NIGHT COUNTING WITH OTHER METHODS

A comparison of night counting with bottle trapping is shown in Fig. 1 for both newt species. The trapping regimes of 64 traps for one night or 32 traps for two nights yielded comparable results and are not distinguished in Fig. 1 or in the analysis. There was no significant difference between mean catches on the first and second nights when 32 traps were used (t test, $P > 0.05$). Because night count and trap total could not be regarded as dependent/independent variables, reduced major axis analysis was undertaken, as this treats both variables comparably. Night counts for both species were positively associated with trap totals (slopes significantly different from zero: crested newt $P < 0.001$, smooth newt $P < 0.01$). Trapping seemed more efficient with low numbers of crested newts in the pond, but night counts were more productive at high densities. For a given increase in trap total there was a proportionately greater increase in night count. To give an example, from the regression line, a five-fold increase in trap total from 20 to 100 would have been associated with a seventeen fold increase in night count from 8 to 134.

Results for night counting and netting are shown in Fig. 2 for crested newts in Top Pond. The smoothness of the seasonal curve for night counting was interrupted by freezing conditions in early April. Apart from early April, the ratio of numbers counted to numbers netted was higher in the early part of the season than later on. For data for the whole season, there was a positive relationship between netting total and the mean of the previous and following night counts (slope significantly different from zero: $P < 0.001$).

ANNUAL VARIATION IN NIGHT COUNTS

During the 11 year period under study, mean crested newt counts fluctuated considerably in Top Pond, with significant differences between two pairs of years: 1984 and 1985; 1988 and 1989 (Table 2). There was no evidence to suggest that these differences had been caused by changes in turbidity or weed cover. For each of these four years, plant cover at the surface developed from less than 20% in April to up to about 50% in early June, with only intermittent periods of turbidity (often following heavy rain). During 1984-1993, there were no significant differences between consecutive years for counts of smooth newts (Table 2).

For the crested newt, there was almost a five-fold rise in mean numbers counted from 1984 to 1985. Numbers remained high till 1988, then decreased in 1989 to roughly the 1984 level. From 1984 to 1989, apart from the water level being about 30 cm down in 1986, spring levels were high. Mean counts declined progressively to a minimum of only three in 1992, despite attempts to create small pools in the drought years of 1991 and 1992. Spring water levels returned to normal in 1993 and numbers of crested newts recovered to a level not significantly different from that at the start of the study. The mean in 1987 was sixty times higher than the mean in 1992 (i.e. comparing the highest with the lowest). In contrast, comparable data for the smooth newt showed a fluctuation of less than four fold (apart from the single count in 1983). Only in the small plastic-lined pool in 1992 was the mean count for the smooth newt higher than that for the crested newt. Analysis of count data for Top Pond, 1984-1993, revealed that time of peak count occurred significantly earlier in the season as the monitoring study progressed (Spearman Rank Correlation Coefficient $r_s = 0.66$, $P < 0.05$).

In Wood Pond, numbers of both species declined to zero as the pond silted up and ultimately desiccated completely during the drought (Table 2). No newts were recorded in 1993 despite the pond holding water.

Immature crested newts were recorded separately from adults from 1985 onwards (Table 2). Mean numbers recorded in the water during the breeding season counts decreased progressively from 1985, reaching zero in 1991. A special study was made of immatures in 1985 by extending the weekly night counts through till the end of July (Fig. 3). Peak counts of immatures occurred from late May to early July, a period during which they represented about 10% of the total number of newts counted in the water.

CATCHES OF LARVAE

Details of larval catches in Top Pond are summarized in Table 3. For any particular year, replicate catches were relatively similar, so standard errors were small. For neither species was there a significant relationship between mean number of adults counted in spring and mean number of larvae counted in summer.

TABLE 2. Night counts in Top Pond and Wood Pond. *Notes:* ^a Adults and immatures not differentiated. * significantly different by *t* test from mean of previous year, $P < 0.05$; *** $P < 0.001$.

year	Top Pond: mean count $\pm$ SE				Wood Pond: count	
	no. of counts	crested newts		smooth newt adults	crested newts	smooth newts
		adults	immatures			
1983	1		25 ^a	1	11	11
1984	9		33 $\pm$ 4 ^a	26 $\pm$ 6	4	8
1985	9	150 $\pm$ 11***	7.3 $\pm$ 2.6	22 $\pm$ 4	No count	
1986	9	145 $\pm$ 18	4.7 $\pm$ 1.4	21 $\pm$ 4	6	4
1987	9	183 $\pm$ 17	3.9 $\pm$ 0.6	10 $\pm$ 3	8	2
1988	5	136 $\pm$ 32	3.6 $\pm$ 1.4	7 $\pm$ 3	3	0
1989	5	39 $\pm$ 12*	1.0 $\pm$ 0.4	13 $\pm$ 2	2	1
1990	5	34 $\pm$ 11	1.0 $\pm$ 0.3	8 $\pm$ 2	0	0
1991	5	19 $\pm$ 5	0.0	9 $\pm$ 3	0	0
1992	5	3 $\pm$ 1	0.0	13 $\pm$ 1	Pond dry	
1993	5	43 $\pm$ 14	0.2 $\pm$ 0.2	24 $\pm$ 5	0	0

TABLE 3. Larvae caught in Top Pond. *Notes:* * significantly different by *t* test from mean of previous year, $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

year	no. of netting sessions	mean larval catch $\pm$ SE	
		crested newt	smooth newt
1986	4	33 $\pm$ 4	12 $\pm$ 3
1987	4	16 $\pm$ 2**	21 $\pm$ 5
1988	4	71 $\pm$ 3***	43 $\pm$ 5*
1989	4	19 $\pm$ 3***	10 $\pm$ 3**
1990	0	pond dry	
1991	4	6 $\pm$ 3	6 $\pm$ 4
1992	4	0.3 $\pm$ 0.3	3 $\pm$ 2
1993	4	53 $\pm$ 4*	31 $\pm$ 7

There was, however, a significant positive relationship between mean numbers of larvae of the two newt species (Spearman Rank Correlation Coefficient $r_s = 0.93$, $P < 0.01$). Not surprisingly, larval catches were significantly higher in years when Top Pond did not dry out (*t* test, $P < 0.05$). There was, however, probably some emergence each year except 1990, when the pond desiccated by July.

DISCUSSION

FLUCTUATIONS IN COUNTS 1983-1993

Night counts have been used to indicate gross changes in breeding numbers of newts over a period of years. Night counts were found to be positively related to trap total (Fig. 1), an independent quantitative measure. This gives some assurance that night counting can be used to detect change, especially when attempts are made to standardize the method. The marked and consistent seasonality in numbers counted and netted (Fig. 2) provides further confidence in the ability of the technique to detect changing numbers in the breeding pond. The proportion of the population using the pond at any one time and their duration of stay will presumably depend on the pond's suitability, weather conditions and newt behaviour. Numbers counted will depend not only on the actual number

present when the count was made, but also on the ease with which newts could be seen due to plant cover, turbidity, newt behaviour etc. Capture/mark/recapture studies during both aquatic and land phases in 1984 (Cooke, 1985) concluded that the average night count in Top Pond represented 6% of the whole site's adult population with the peak count representing 10%. The adult population at the site was estimated at about 500 in 1984, giving a terrestrial density of roughly 250 per hectare.

In 1985, the mean night count in Top Pond increased significantly. Indeed the mean *count* in 1985 of 150 in Top Pond (Table 2) exceeded the mean *mark-recapture estimate* in 1984 of 141 (Cooke, 1985). Conditions for counting differed little between the two years; there was no significant difference in counts for smooth newts (Table 2). While there is little doubt that numbers of crested newts in Top Pond in 1985 considerably exceeded those in 1984, trapping newts in the pond revealed that the increase may not have been as great as suggested by night counting. Trapping in 1984 caught a mean of 39 per session ($n=5$, $SE\pm 8$), while in 1985 the mean was roughly double at 80 ($n=3$, $SE\pm 2$).

The most likely explanation for significantly increased breeding numbers in 1985 is exceptional recruitment to the adult population that year. Pitfall trapping at the site (Cooke, 1985, 1986 and unpublished data) indicated that immatures and sub-adults caught on land in summer and autumn were at least as numerous in 1984 as in 1985. Yet the latter year appeared better than any subsequent year in terms of numbers of immatures seen in Top Pond (Table 2).

From 1985 to 1988 inclusive, counts of adult crested newts remained at a high level (Table 2). In contrast to the relative stability shown by the crested newt counts, mean counts for smooth newts decreased progressively from 1985 to 1988. Mean numbers were significantly lower in 1988 than in 1985 (t test, $P<0.05$). This decline in numbers counted may have been due to high levels of predation or competition from the larger species. Over the years, several instances were noted of crested newts devouring adult smooth newts. There was no evidence of an adverse interaction between larvae; on the contrary, there was a significant positive relationship between numbers of the two species netted (Table 3). Neither were numbers of larvae inversely related to the numbers of adult crested newts, indicating that predation or cannibalism were not grossly affecting larval numbers. The year when the most larvae were netted was 1988, when counts of adult crested newts were still high. Elsewhere, studies on the food and feeding habits of newts have revealed adult crested newts to be mainly benthic while their larvae are pelagic (Dolmen & Koksvik, 1983; Griffiths & Mylotte, 1987). Although smooth newt larvae prefer a benthic habitat, their remains have not been reported in the stomachs of adult crested newts (Dolmen & Koksvik, 1983; Griffiths & Mylotte, 1987). Griffiths,

de Wijer & May (1994) reported that, when confined in the laboratory or field at densities higher than likely to be found in the field, crested newt larvae predated significant numbers of smooth newt larvae. However, in a semi-natural pond such as Top Pond, the importance of interspecific larval predation appears to have been negated, probably mainly by microhabitat segregation and the ready availability of refugia, as suggested by Griffiths *et al.* (1994).

Mean night counts of adult crested newts declined significantly in 1989. There were no obvious changes in pond conditions that might explain the reduction in terms of newts being more difficult to detect or the pond being less attractive to them (smooth newt counts did not decrease). Night counts in 1989 did not differ significantly from those in 1983 and 1984. Larval catches were particularly poor for crested newts in 1987 (especially in relation to numbers of adults counted) and this may have contributed to a decrease in breeding numbers two years later in 1989. The decrease in mean night counts of adults from 1988 to 1989 was 71%. In view of the comments above about the extent of the increase from 1984 to 1985, as indicated by trapping, the decline between 1988 and 1989 may have been rather less than 71% and might be explained by a combination of poor recruitment and adult survival in 1989. Adult survival has been reported to range from 36 to 80% per annum (Hagström, 1979; Bielinski, 1986; Arntzen & Teunis, 1993). In the studies on crested newts on the European mainland, Hagström (1979) and Glandt (1982) found their populations to be reasonably stable. However, Arntzen & Teunis (1993), working on a population that had colonized a newly-created quarry pond, reported a reduction from an estimated 182 adults five years after colonization to only 16 adults in the following year. A range of factors was suggested as perhaps contributing: recruitment failure due to fish predation on larvae, collection of adults by people, loss of adults due to landscape reconstruction. Although Arntzen & Teunis (1993) estimated annual adult survival for the whole of their study at 49%, it was clearly markedly less than this during the year the population crashed.

In 1990, water levels in Top Pond were low in the spring, but night counts of crested newts differed little from those in 1989. However, the pond dried out in the summer and breeding newts were then dependent on the small hand-dug areas in 1991 and 1992. Night counts of crested newts declined to a minimum in 1992. During that year, because of the small size of the plastic-lined pool and because a cane was used to move aside water plants, it should have been possible to count all newts in the water (see Beebee, 1986). The mean night count in 1992 represented less than 2% of the mean number counted during 1987. Larval catches were minimal during the period 1990-1992.

In contrast, smooth newt night counts were maintained at a moderate level during the drought years.

1992 was the only year when smooth newt counts exceeded those of crested newts. During that year Top Pond more closely resembled a small highly-artificial garden pond rather than a semi-natural field pond. That crested newts found the small pools of 1991 and 1992 unattractive was confirmed in 1993 when numbers similar to those recorded in 1989 and 1990 returned to breed in the restored pond. From larval catch data (Table 3) most adults on the site in 1993 would be expected to be four years of age or older. The monitoring will continue; counts may decline in 1994 due to mortality of these older adults, but may increase again in 1995 as some newts from the 1993 cohort mature.

Avoidance of the small pools in 1991 and 1992 raises the question of the extent to which adult newts avoided the breeding ponds during other years. In all other years except 1986 and 1990, spring water levels were high; but counts did not decline in 1986 or 1990 (Table 2). In 1984, total numbers at the site estimated to be breeding in the spring were similar to numbers of adults estimated, from pitfall trapping, to be present in summer and autumn (Cooke, 1985). Thus there is no evidence of a significant level of non-breeding by adults in other years.

Counts in Wood Pond (Table 2) indicated a steady decline from moderate populations of both species in 1984 to zero in 1990. Countrywide, many populations of crested newts have become extinct as their breeding sites have been neglected, and have become overgrown and silted up (Hilton-Brown & Oldham, 1991). As Wood Pond is close to Top Pond and has been deepened, it is likely that it will be colonized again in the near future.

NEWT CONSERVATION

The study has provided a number of conclusions relevant to the conservation of crested newts. It has shown that site security has not been enough to prevent considerable fluctuations in count numbers. In Top Pond, the reductions in counts of adults in 1991 and 1992 could probably have been avoided by excavating the pond with machinery. Had that been done, however, when the pond recharged in 1993, this might have resulted in an excavation that was too deep and permanent in the long-term. Among the potential problems of such a pond are increased losses of larvae to vertebrate and invertebrate predators (Cooke & Frazer, 1976; Bell, 1979; Beebee, 1985; Arntzen & Teunis, 1993). Fish are particularly important predators (e.g. Swan & Oldham, 1993); fish have never been recorded in the Shillow Hill breeding ponds, presumably because of the ponds' propensity to desiccate. This study has indicated that more or less total breeding failure in Top Pond over three consecutive seasons has had no detectable long-term effect on numbers of adults counted at night. Exactly how many years of breeding failure can be tolerated before population decline or extinction results is not known, but will be

related to longevity. It seems that up to three years need elicit no great alarm from managers of crested newt sites, unless there is evidence to the contrary.

With regard to SSSI notification, the study has shown that counting >100 adult crested newts over three consecutive breeding seasons is no guarantee that a population of SSSI standard will be maintained. Conservationists should view with suspicion sites with much lower peak counts in (some) previous years, for which there is no obvious explanation (eg. 1984 at Top Pond). Recent analysis by Griffiths & Raper (1994) has demonstrated considerable variation between ponds in the percentage of newts trapped or counted at night. It is not possible to predict accurately actual population sizes from such survey data. As more information becomes available, it may be necessary to refine the process by which SSSIs are selected.

As a contribution to long-term monitoring in the light of global concern over declining amphibian populations, this study has indicated that, although counts at the beginning and end of the period differed little, there was considerable fluctuation in the intervening years. It has also confirmed the role of rainfall in causing low reproductive output in dry years (see Banks *et al.*, 1994) and temporary breeding population reductions during more prolonged droughts (see Pechmann *et al.*, 1991). Hopefully the recording scheme launched in 1994 by the Joint Nature Conservation Committee and the Institute of Terrestrial Ecology will *inter alia* help promote the monitoring of crested newt sites throughout Britain.

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SIZE INFERENCES BASED ON SKELETAL FRAGMENTS OF THE COMMON EUROPEAN FROG *RANA TEMPORARIA* L.

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Based on a museum collection of skeletons of adult *Rana temporaria* (Ranidae) from a single population in the French Doubs region, equations for regression that predict the size (total length) and mass (total weight) of the animals are presented. Twenty-six measurements based on skeletal elements were selected as independent variables for the regressions, representing the most common fragments recovered in ecological and palaeontological studies. Equations are given for males on all variables, and for males and females jointly in the 11 variables that showed no significant sexual dimorphism in the three-year age class subsample. Proximo-distal lengths are better predictors in general than transverse.

INTRODUCTION

The common frog, *Rana temporaria* L., is widespread throughout Europe, and is probably the most frequent amphibian prey item (Martín & López, 1990). It also has a substantial fossil record in the European Quaternary (e.g. Rage, 1974). Nevertheless, remains of predated frogs, as well as fossils, are usually broken and composed of disarticulated skeletal elements, and until now an estimate of frog size has rarely been possible with such material.

Based on a collection of numerous skeletons from a single French population of the nominal subspecies, it is the purpose of this paper to give some estimates of the regression parameters that could be used for determining frog size, if only skeletal fragments are available.

MATERIALS AND METHODS

The *Rana temporaria temporaria* sample was from a population in the French region of Doubs, near Besançon (altitude 550 m) and was collected in late autumn just before their hibernation. It comprises 49 dry skeletons of adult frogs (32 males and 17 females), stored at the Laboratory of Comparative Anatomy, University of Paris VII. A detailed account of the techniques used for the preparation of the skeletons, previously used for other research purposes, is given in Castanet & Caetano (in press) and no specimen has been sacrificed for our study. The data collected include the snout-vent lengths (SVL) and total weight (TWeight) of the specimens, taken immediately after death, as well as their age class inferred from skeletochronology. The skeletons are disarticulated and nearly complete, but some elements (in particular, tibiofibulae) were used for histology and bone density estimations and are not available.

The different bones were measured either directly using a digital Nikon Measurescope 10 (up to 0.01

mm) or indirectly through scale projections made with a binocular drawing tube. The twenty-six selected variables are represented in Fig. 1, and were described in Sanchiz (1984) and Esteban & Sanchiz (1985) (ilium). On account of their potential preservation as prey remains or fossils, only bone fragments are considered, but not their surrounding cartilaginous or calcified tissues. The complete data are available from the Secretary, Department of Biodiversity, at the address of one of the authors (BS).

Least squares regressions for predicting size were selected following Smith (1994). The statistical package Statgraphics (Anonymous, 1991) was used for the calculations (significance level, $P = 0.05$). The osteological criteria of Rage (1974) and Böhme (1977) were used for species determination. Sexes were determined directly in the cases of humeri and radioulnae (males having sexual crests) or indirectly through measurements (Table 1).

RESULTS

As the age class of individual frogs is known from previous skeletochronological studies, the estimation of the sexual dimorphism of the different measurements can be tested for the same age class, in our case the three-year-old cohort, having two lines of winter-arrested growth. Testing of dimorphism at the same age class contributes to the elimination of a biased representation of unequal age subsamples. Kolmogorov-Smirnov tests indicate that none of the selected variables significantly differ from normality (grouped, by sexes or by sexes and age classes). Nevertheless, since the female sample is rather small, non-parametric approaches (Mann-Whitney U tests) were used to compare males and females. Significant differences ($P < 0.05$) were found in 15 variables, including, as expected, all those functionally related to amplexus. There are no significant size (SVL) differences between sexes in the three-year-old subsample.

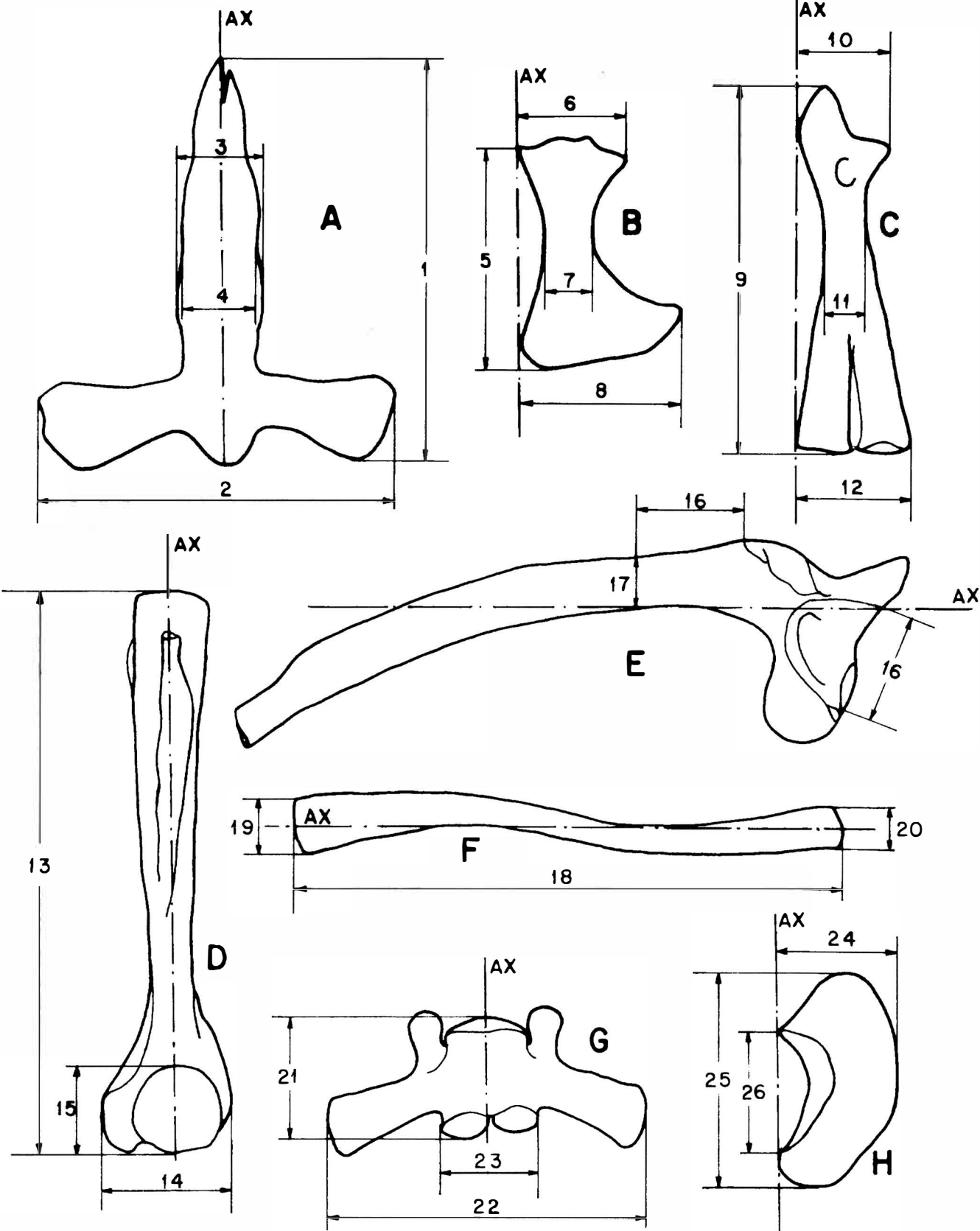


FIG 1. Schematic shapes showing the measurements used. (Their numbers are in parentheses in Table 1). AX: main orientation axis for each bone. With the exception of the ilium, measurements are either orthogonal or parallel to the axis. A: parasphenoid. B: coracoid. C: radioulna. D: humerus. E: ilium. F: femur. G: sacrum. H: ischium. Not to scale.

TABLE 1. Basic statistics of the sample. *n*: number of specimens. SD: standard deviation. T: type of measurement (L: length, W: width at the proximal or distal ends of the bone, Z: other measurements). P_D : approximate two-tailed probability in the Mann-Whitney *U* test for sexual dimorphism. Variables are defined in Figure 1; numbers in parentheses correspond to those in the drawings. In the names of the variables, L refers to length, W to width, and p, m, c and d to, respectively, the proximal, middle, central and distal parts of the bone fragment.

Variable	T	males					females					males + females					P_D
		<i>n</i>	mean	SD	min	max	<i>n</i>	mean	SD	min	max	<i>n</i>	mean	SD	min	max	
TWeight		32	24.37	5.03	15.14	34.45	17.0	30.73	5.62	19.91	37.51	49	26.57	6.02	15.14	37.51	0.600
SVL		32	62.97	4.32	54.00	71.00	17.0	68.53	3.76	63.00	75.00	49	64.90	4.89	54.00	75.00	0.861
Lparas (01)	L	32	11.49	0.81	9.97	12.88	16.0	12.22	0.84	10.83	13.91	48	11.73	0.88	9.97	13.91	0.383
Wtparas (02)	W	32	9.94	0.70	8.56	11.20	16.0	10.63	0.69	9.20	11.91	48	10.17	0.76	8.56	11.91	0.541
Wcparas (03)	W	32	2.45	0.25	2.03	2.99	16.0	2.59	0.22	2.24	2.97	48	2.50	0.25	2.03	2.99	0.190
Wmparas (04)	Z	32	2.10	0.27	1.63	2.61	16.0	2.14	0.24	1.62	2.47	48	2.11	0.26	1.62	2.61	0.512
Wcorac (05)	L	32	6.23	0.48	5.38	7.22	17.0	6.61	0.62	5.55	7.38	49	6.36	0.56	5.38	7.38	0.116
Lpcorac (06)	W	32	3.10	0.26	2.66	3.56	17.0	2.95	0.25	2.49	3.40	49	3.05	0.26	2.49	3.56	<0.01
Lmcorac (07)	Z	32	1.44	0.17	1.03	1.79	17.0	1.40	0.15	1.08	1.56	49	1.43	0.16	1.03	1.79	0.116
Ldcorac (08)	W	32	4.81	0.36	4.08	5.46	17.0	4.64	0.47	3.98	5.54	49	4.75	0.40	3.98	5.54	<0.01
Lradul (09)	L	31	11.86	1.02	10.37	14.03	17.0	10.83	0.98	8.94	12.53	48	11.49	1.11	8.94	14.03	<0.01
Wpradul (10)	W	31	3.23	0.29	2.69	3.78	17.0	2.97	0.25	2.55	3.35	48	3.13	0.30	2.55	3.78	<0.01
Wcradul (11)	Z	31	1.67	0.19	1.36	2.04	17.0	1.39	0.13	1.16	1.64	48	1.57	0.22	1.16	2.04	<0.01
Wdradul (12)	W	31	3.66	0.35	3.14	4.45	17.0	3.61	0.27	3.11	4.16	48	3.64	0.32	3.11	4.45	0.032
Lhumer (13)	L	21	16.66	1.09	14.30	19.18	6.0	15.03	1.15	13.43	16.44	27	16.30	1.28	13.43	19.18	0.028
Whumer (14)	W	21	3.75	0.36	3.18	4.49	6.0	3.25	0.22	2.99	3.54	27	3.64	0.39	2.99	4.49	0.028
Lcondyle (15)	Z	21	2.50	0.26	2.07	3.02	6.0	2.14	0.26	1.82	2.48	27	2.42	0.30	1.82	3.02	0.028
Acetab (16)	Z	30	3.33	0.32	2.79	4.01	17.0	3.37	0.24	2.89	3.77	47	3.35	0.29	2.79	4.01	0.116
Hilia (17)	W	30	2.08	0.23	1.70	2.60	17.0	1.99	0.22	1.68	2.51	47	2.05	0.23	1.68	2.60	0.274
Lfemur (18)	L	32	27.62	2.32	23.53	32.25	16.0	27.93	2.16	23.81	31.15	48	27.73	2.25	23.53	32.25	0.029
Wdfemur (19)	W	32	2.84	0.22	2.37	3.34	16.0	3.06	0.18	2.83	3.34	48	2.91	0.23	2.37	3.34	0.512
Wpfemur (20)	W	32	2.13	0.21	1.72	2.59	16.0	2.30	0.18	1.95	2.57	48	2.19	0.21	1.72	2.59	0.541
Lsacrum (21)	L	30	3.22	0.32	2.66	3.85	11.0	3.32	0.32	2.80	3.74	41	3.25	0.32	2.66	3.85	0.019
Wsacrum (22)	W	30	9.26	0.87	7.07	11.13	11.0	9.67	1.06	8.28	11.34	41	9.37	0.93	7.07	11.34	0.049
Wdsacrum (23)	Z	30	2.83	0.22	2.40	3.34	11.0	2.90	0.19	2.61	3.25	41	2.85	0.21	2.40	3.34	0.339
Lischium (24)	L	32	3.15	0.34	2.50	3.99	17.0	3.24	0.31	2.80	3.67	49	3.18	0.33	2.50	3.99	<0.01
Hischium (25)	W	32	5.52	0.57	4.38	6.50	17.0	5.69	0.55	4.62	6.52	49	5.58	0.56	4.38	6.52	<0.01
Hcischium (26)	Z	32	3.19	0.37	2.47	3.85	17.0	3.22	0.24	2.72	3.69	49	3.20	0.33	2.47	3.85	0.040

TABLE 2. Equations for the estimation of size (SVL=Y) based on measurements on skeletal fragments. Linear regression, $Y = A + BX$, being (A: intercept, B: slope, SE: standard error of the estimate). Power function model, $Y = aX^b$, being Ln a: intercept in natural logarithms, b: slope, SE: standard error of the estimate). R: coefficient of determination.

Variable		males							males + females						
		R	A	B	SE	Ln a	b	SE	R	A	B	SE	Ln a	b	SE
Tweight		0.92	42.86	0.82	1.223	3.12	0.32	0.017							
Lparas	(01)	0.76	9.50	4.65	2.125	2.06	0.85	0.033	0.76	8.19	4.83	2.494	1.99	0.89	0.038
Wtparas	(02)	0.53	18.28	4.49	3.011	2.50	0.72	0.047	0.62	13.11	5.09	3.084	2.30	0.80	0.047
Wcparas	(03)	0.42	35.51	11.19	3.318	3.74	0.45	0.051	0.45	31.44	13.40	3.690	3.69	0.53	0.056
Wmparas	(04)	0.18	49.08	6.62	3.994	3.98	0.21	0.064	0.18	47.81	8.10	4.521	3.98	0.26	0.070
Wcorac	(05)	0.74	14.05	7.85	2.211	2.71	0.78	0.035	0.72	17.27	7.48	2.598	2.82	0.73	0.041
Lpcorac	(06)	0.62	22.01	13.22	2.716	3.42	0.64	0.044							
Lmcorac	(07)	0.53	35.67	18.93	3.007	3.99	0.43	0.048	0.27	42.24	15.88	4.221	4.05	0.35	0.065
Ldcorac	(08)	0.64	16.22	9.71	2.626	3.00	0.73	0.042							
Lradul	(09)	0.71	20.07	3.62	2.402	2.42	0.70	0.038							
Wpradul	(10)	0.64	23.73	12.17	2.668	3.41	0.62	0.041							
Wcradul	(11)	0.50	35.18	16.65	3.135	3.91	0.45	0.048							
Wdradul	(12)	0.56	28.79	9.35	2.933	3.40	0.57	0.045							
Lhumer	(13)	0.76	5.42	3.37	2.150	1.56	0.91	0.034							
Whumer	(14)	0.88	20.11	11.05	1.515	3.23	0.68	0.025							
Lcondyle	(15)	0.79	26.03	14.23	1.953	3.60	0.57	0.032							
Acetab	(16)	0.49	32.60	9.20	3.106	3.54	0.50	0.049	0.40	30.99	10.21	3.775	3.52	0.55	0.057
Hilia	(17)	0.53	35.34	13.40	2.942	3.83	0.43	0.048	0.15	48.70	8.03	4.471	3.99	0.25	0.069
Lfemur	(18)	0.79	17.13	1.66	1.985	1.68	0.74	0.031							
Wdfemur	(19)	0.52	22.58	14.24	3.064	3.47	0.65	0.048	0.46	22.79	14.43	3.614	3.46	0.66	0.055
Wpfemur	(20)	0.30	39.43	11.03	3.677	3.85	0.39	0.058	0.44	32.08	14.95	3.714	3.77	0.50	0.057
Lsacrum	(21)	0.55	31.00	9.95	3.023	3.54	0.52	0.047							
Wsacrum	(22)	0.79	21.31	4.51	2.044	2.69	0.65	0.033							
Wdsacrum	(23)	0.38	28.00	12.38	3.492	3.55	0.57	0.054	0.40	22.43	14.76	3.892	3.47	0.67	0.060
Lischium	(24)	0.64	31.20	10.08	2.647	3.56	0.51	0.041							
Hischium	(25)	0.69	28.16	6.31	2.425	3.20	0.55	0.038							
Hcischium	(26)	0.77	29.89	10.36	2.107	3.53	0.52	0.033							

TABLE 3. Equations for the estimation of the total weight (TWeight=Y) based on measurements on skeletal fragments. Abbreviations as in Table 2.

Variable		males							males + females						
		R	A	B	SE	Ln a	b	SE	R	A	B	SE	Ln a	b	SE
SVL		0.92	-46.03	1.12	1.424	-8.91	2.92	0.052							
Lparas	(01)	0.77	-38.28	5.45	2.419	-3.16	2.60	0.097	0.76	-43.56	5.98	2.995	-3.41	2.71	0.114
Wtparas	(02)	0.61	-31.34	5.60	3.201	-2.17	2.33	0.127	0.71	-41.10	6.66	3.356	-2.76	2.60	0.127
Wcparas	(03)	0.46	-8.71	13.48	3.757	1.90	1.42	0.147	0.52	-17.47	17.65	4.240	1.68	1.73	0.157
Wmparas	(04)	0.24	5.46	9.01	4.466	2.62	0.76	0.184	0.22	3.46	10.97	5.419	2.62	0.86	0.209
Wcorac	(05)	0.71	-31.30	8.93	2.737	-1.07	2.32	0.110	0.76	-33.40	9.42	2.994	-0.98	2.29	0.115
Lpcorac	(06)	0.58	-21.90	14.94	3.306	1.06	1.88	0.138							
Lmcorac	(07)	0.55	-7.75	22.27	3.456	2.70	1.32	0.139	0.31	-3.47	21.05	5.038	2.84	1.18	0.188
Ldcorac	(08)	0.64	-29.77	11.25	3.083	-0.30	2.21	0.124							
Lradul	(09)	0.79	-28.49	4.46	2.335	-2.24	2.19	0.099							
Wpradul	(10)	0.66	-21.69	14.29	3.050	0.93	1.92	0.120							
Wcradul	(11)	0.50	-7.88	19.33	3.652	2.47	1.39	0.143							
Wdradul	(12)	0.64	-17.65	11.50	3.136	0.83	1.82	0.123							
Lhumer	(13)	0.83	-47.16	4.20	2.195	-5.12	2.93	0.089							
Whumer	(14)	0.86	-26.42	13.12	1.890	0.36	2.08	0.078							
Lcondyle	(15)	0.81	-20.18	17.22	2.213	1.47	1.80	0.088							
Acetab	(16)	0.62	-16.55	12.37	3.114	1.14	1.71	0.130	0.48	-20.04	14.01	4.371	1.05	1.84	0.164
Hilia	(17)	0.52	-7.70	15.54	3.553	2.23	1.31	0.148	0.17	4.94	10.70	5.506	2.65	0.86	0.209
Lfemur	(18)	0.86	-31.10	2.01	1.913	-4.49	2.31	0.078							
Wdfemur	(19)	0.50	-21.97	16.34	3.619	1.17	1.93	0.146	0.36	-19.01	15.60	4.787	1.31	1.82	0.178
Wpfemur	(20)	0.35	-5.06	13.79	4.136	2.23	1.26	0.167	0.40	-11.93	17.51	4.650	2.09	1.49	0.176
Lsacrum	(21)	0.61	-14.67	12.18	3.267	1.28	1.63	0.130							
Wsacrum	(22)	0.79	-24.05	5.25	2.339	-1.24	1.99	0.093							
Wdsacrum	(23)	0.50	-21.77	16.37	3.648	1.18	1.92	0.149	0.48	-28.24	19.06	4.321	1.01	2.13	0.166
Lischium	(24)	0.69	-14.18	12.23	2.836	1.32	1.62	0.111							
Hischium	(25)	0.74	-17.32	7.55	2.628	0.24	1.72	0.106							
Hcischium	(26)	0.77	-14.37	12.13	2.403	1.33	1.60	0.097							

The use of one subsample of the same age is here merely restricted to the determination of which variables should be analysed jointly or separately by sexes. Having determined the dimorphic status of the variables, all the available material is incorporated in the regressions, regardless of their age.

The parameters for the linear ($Y = A + BX$) and power ($Y = aX^b$) estimated regressions (Tables 2 and 3), and their standard errors, are given for males in all the variables and for the whole population (males + females) in the 11 variables that showed no sexual dimorphism. The complete female sample ($N = 17$) is not large enough to provide adequate estimations by itself. Dependent variables are total length or weight in all cases. Adequacy of the model to be chosen depends on the context of the study and the further use of the inference in particular cases. Nevertheless, the power function models obtained here, with related allometric slopes close to isometry (in the corresponding equations where size is the independent variable instead of the dependent one; e.g. Gould, 1966), give similar results to the linear one when applied to this rather homogeneous group of adults.

In a general way, lengths over the main axis of bones (usually proximo-distal lengths) are better predictors of size or mass than transverse measurements (widths). This result can be verified through the comparison of the correlation coefficients of both groups, which are significantly different ($P < 0.05$ in the Mann-Whitney U test). This result has been described in mammals (Alberdi, Prado & Ortiz-Jaureguizar, in press) and probably derives from mechanisms of growth control, not only from a bias in measurement errors. Lengths are probably less environmentally affected than widths during growth. If a range of skeletal material is available from the same specimen, the most appropriate measurements to estimate its size or weight can be selected, based on the coefficients of determination (Tables 2 and 3).

DISCUSSION

The composition of the sample imposes several limitations to the results. In the first place, the sample incorporates only adult frogs that hibernated for up to three winters. These cohorts correspond to the most frequent ages in the populations from which the frogs were sampled (Augert & Joly, 1993). Froglets are not included and our regressions should not be used to predict juvenile sizes. For similar reasons, values obtained by extrapolation to larger sizes should be considered merely as tentative, and not to be used in other statistical calculations.

Another possible limitation of the data derives from the taxonomic differentiation of the species. It is presently unknown, but it could be expected that the other described subspecies of *Rana temporaria*, namely *R. t. parvipalmata* (northwest Iberia), *R. t. canigonensis* (Pyrenees) and *R. t. honnorati* (Alps) could have ontogenetic and growth trajectories different from the

one represented by our sample. This distorting effect is more likely to occur in the case of *R. t. parvipalmata*, genetically well differentiated and approaching full species status (Arano, Esteban & Herrero, 1993) than in the other subspecies, whose validity is open to question (Dubois, 1982, 1983).

Both limitations mentioned above apply to the fossil *Rana mehelyi*, a rather common but controversial Pleistocene taxon in central Europe. This fossil has been considered as an extinct species, closely related to the living common grass frog (Dely, 1955), or merely as an extreme large-sized morphotype of *R. temporaria* (Rage, 1972; Bailón & Rage, 1992). Extreme caution should be taken for inferences in this context, as well as in other Quaternary cases characterized by the very large size of the fossil remains (Böhme, 1982).

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SHORT NOTES

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COMPARISON OF THE DIET OF
ADULT TOADS (*BUFO BUFO* L.)
WITH PITFALL TRAP CATCHESC. A. CORNISH¹*, R. S. OLDHAM²,
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As part of a wider study (Oldham & McGregor in prep.), food availability for the toad in terrestrial habitats around a breeding lake in Leicestershire was estimated. A method of sampling invertebrates at risk of toad predation was needed, enabling habitats to be ranked in terms of their importance as feeding areas.

Adult toads are generalist predators, feeding on a wide range of invertebrates, with Formicidae and Coleoptera often forming the major components of the prey (Cott, 1940; Mathias, 1971; Swan, 1986; Wheeler, 1986; Gittins, 1987; Denton, 1991). Foraging strategy was assumed to be 'sit and wait', as seen in the frog *Rana temporaria* (Blackith & Speight, 1974).

Pitfall traps are commonly used for capturing cursorial invertebrates, especially Coleoptera (e.g., Mitchell, 1963; Greenslade, 1964; Luff, 1975) and Formicidae (Greenslade, 1973), and in their action they may be regarded as analogous to a 'sit and wait' predator. The use of pitfall traps to compare invertebrates in different habitats has been criticized because catch size does not correlate with abundance (Greenslade, 1964; Topping & Sunderland, 1992); catch is dependent on abundance and activity, so represents an 'activity abundance index' (Tretzel, 1965, quoted by Thiele, 1977). Activity abundance, however, could correlate well with prey encounter rate for toads. The aim of this preliminary study was to assess the suitability of pitfall trapping as an analogue of feeding toads.

The study site was a poplar (*Populus* sp.) plantation with occasional alders (*Alnus glutinosa*), immediately adjacent to a toad breeding lake (0.8 ha) at Osbaston Estate, Leicestershire (SK424046). It ranged from relatively dry areas of *Arrhenatherum elatius* domi-

nated grassland, through to a marsh dominated by *Fillipendula ulmaria* and *Carex acutiformis*.

The pitfall trap was a plastic cup (90 mm diameter x 80 mm deep) placed in an outer glass jar (90 mm diameter x 100 mm deep) and covered by an aluminium sheet (203 mm x 203 mm) at a height of 50 mm to protect it from rainfall, accumulation of debris, and predation by vertebrates. A killing solution (50 ml) of 50% ethane diol, 30% distilled water and 20% ethanol was used in each trap (Lewis, 1988). Traps were sited in a two by five grid with five metre spacing and run for two weeks (21 June-5 July 1991). Due to constraints on time, only five of the traps were analysed (alternate trap, alternate line); but Cornish (1993) found no significant loss of information in reducing sample size from 10 to 5 in other habitats: sizes of invertebrates and numbers of different orders caught were comparable. Catches were stored in 70% ethanol.

Thirteen adult toads (nine males, two females; body length (snout-urostyle) range 47.5-69.0 mm) were caught in the proximity of the traps on 10 July 1991. Five of the toads were sitting on the basal swellings of tree trunks or associated vegetation, 20 to 30 cm above ground level. Toads' stomachs were flushed (Legler & Sullivan, 1979) and the contents transferred to 6% formaldehyde and later stored in 70% ethanol.

All invertebrates were identified to order and the Coleoptera to family. Fragmented invertebrates from the stomach samples were identified and counted using the key system of Tatner (1983), adapted by Wheeler (1986). The length of each invertebrate (head to abdomen tip) was measured and assigned to one of eleven

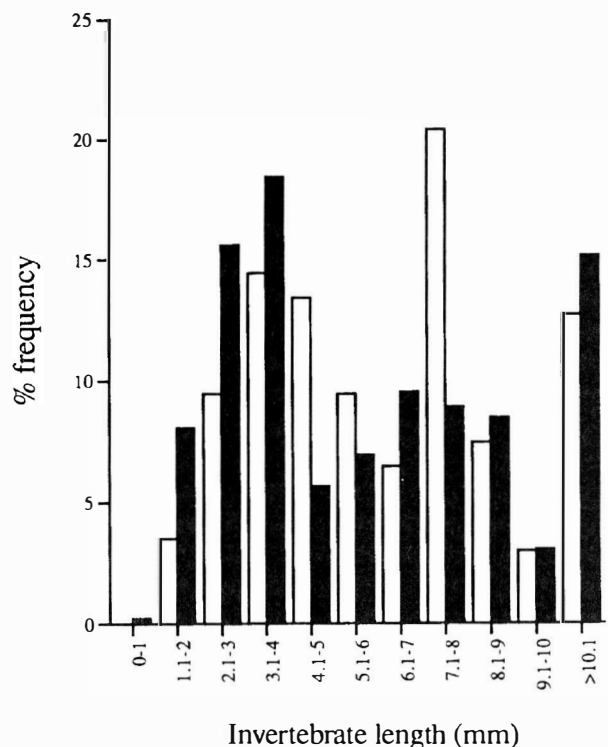


FIG 1. Length of invertebrates in toads' diet (unshaded bars) and pitfall traps (shaded bars).

TABLE 1. Percentage frequency occurrence and abundance of invertebrate taxa in pitfall traps (total catch = 461) and toads' diet (total catch = 383). Modified data excluded groups unlikely to be fed on by toads or caught in pitfall traps.

Invertebrate taxa	% occurrence		% abundance			
	pitfall trap	toads' diet	pitfall trap	modified	toads' diet	modified
Oligochaeta	100	0	2.39	5.05	0.00	0.00
Araneae	80	70	3.48	0.46	4.44	7.06
Opiliones	60	54	0.65	0.46	1.83	1.76
Acari	80	8	3.04	-	0.26	-
Isopoda	80	16	3.26	6.88	7.31	16.47
Diplopoda	80	47	2.83	5.96	4.18	9.41
Chilopoda	20	23	0.43	0.92	0.78	1.76
Collembola	100	16	14.35	-	0.78	-
Dermaptera	0	85	0.00	-	16.45	-
Heteroptera	0	8	0.00	0.00	0.26	0.59
Homoptera	40	77	0.65	1.38	4.18	7.65
Lepidoptera (larva)	0	39	0.00	0.00	1.31	2.94
Diptera (adult)	100	100	11.09	-	19.06	-
Diptera (larva)	0	8	0.00	0.00	1.04	2.35
Hymenoptera	60	77	1.30	1.83	4.18	8.82
Carabidae	100	70	3.70	7.80	4.18	9.41
Staphylinidae	100	70	20.65	42.66	3.66	7.65
Curculionidae	20	85	0.22	-	12.79	-
Other Coleoptera	100	100	6.74	6.42	9.66	18.24
Coleoptera (larva)	100	54	9.57	20.18	2.61	5.88
Pulmonata	100	31	15.65	-	1.04	-
			<i>n</i> =218		<i>n</i> =170	

size classes (i.e. 0-1 mm, 1.1-2.0 mm 9.1-10.0 mm, >10.1 mm).

No significant correlation was found between the invertebrates in the pitfall trap catches and those in the toads' stomachs, either in terms of frequency occurrence ($r_s=0.13$; $P>0.05$) or abundance ($r_s=0.11$; $P>0.05$) (Table 1). The major differences were: (1) the widespread capture of Oligochaeta, Acari, Collembola and Pulmonata in the pitfall traps compared with the toads' diet, and vice versa for Dermaptera and Curculionidae; and (2) the most numerous taxa in the pitfall traps were Collembola, Staphylinidae and Pulmonata, whereas in the toads' diet Dermaptera, adult Diptera (mainly Tipulidae) and Curculionidae were the most abundant.

Toads fed on significantly larger invertebrates than those caught in pitfalls (Kolmogorov-Smirnov two-tailed test for large samples, $D_{m,n}=0.149$; $P<0.01$). The modal length class in the toads' diet was 7.1-8.0 mm (due mainly to the Dermaptera) and in the pitfalls it was 3.1-4.0 mm (Fig. 1).

Differences between the two sets of catches may be ascribed to four causes:

(1) The pitfall trap is an inappropriate device for sampling some invertebrates. Some species of Araneae, Isopoda and Coleoptera are not caught because the trap is detected and avoided (Adis, 1975; Lewis, 1988).

Certain spiders can escape from traps (Topping, 1993) as can carabids with adhesive tarsi (Benest, 1988; Halsall & Wratten, 1988). Many dermapterans and curculionids have adhesive tarsi so may avoid capture in pitfall traps.

(2) Adult toads avoid small invertebrates such as the Acari, Collembola and some Staphylinidae because they are below the size threshold taken (Kuzmin, 1990), and pulmonates are taken infrequently because of their heavy mucous secretions (Cott, 1940; Mathias, 1971; Swan, 1986; Wheeler, 1986).

(3) The pitfall traps captured invertebrates throughout the day and night, whilst the toads' main feeding activity was crepuscular and nocturnal.

(4) Toads are not restricted to cursorial feeding, but climb on to vegetation as noted in the present work and also by Denton (1991). Dermapterans and curculionids, well represented in the toads' stomachs (Table 1), are herbivores found on vegetation, and adult tipulids, the main dipteran component of the toads' diet, are low flying insects which commonly clamber on vegetation.

Significant discrepancies were found between the toads' diet and pitfall trap catches, suggesting that the traps do not provide a satisfactory model of toad foraging strategy in the situation tested. However, the absence of correlation may be the result of the inclu-

sion in the analysis of inappropriate invertebrate groups. If the small (<3 mm) organisms, pulmonates, and the groups unlikely to be found in pitfall traps, Dermaptera, Diptera and Curculionidae, are excluded, the level of correlation between percentage abundance of invertebrate taxa in pitfall trap catches and toads' diet improves ($r_s=0.587$; $P<0.05$) (Table 1). There is a need to repeat the study using a larger number of toads over a longer period, and in a wider array of habitats, with pitfall traps closed during the day. Invertebrate sampling may be augmented using a series of techniques in tandem with pitfall traps: suction-trapping, sweep netting and sticky traps, which will sample invertebrates on vegetation and in flight as well as those on the ground.

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COMPARATIVE LONGEVITY OF ISRAELI CHAMAELEONS (REPTILIA: SAURIA: CHAMAELEO CHAMAELEON SSPP.)

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Most chamaeleons (*Chamaeleo*) are relatively short-lived in captivity (Flower, 1925; Wagner, 1958; Bustard, 1963; Slavens & Slavens, 1993).

In Israel, there are two subspecies of chamaeleons: *Chamaeleo chamaeleon recticrista* (Boettger, 1880) in the Mediterranean (mesic) zone and *Chamaeleo chamaeleon musae* (Steindachner, 1900) in the Negev desert.

Slavens & Slavens (1993) gave two longevity records of *Chamaeleo chamaeleon*, without specifying the subspecies: 3 years 7 months and 3 years 6 months. We traced both of these reports to a single record of Flower (1925:958): 3 years, 6 months and 21 days for an animal from Wadi Natron [Natrun], Egypt. According to Hillenius & Gasperetti (1984), this locality is inhabited by *C. c. chamaeleon*. We found no previous longevity reports of the two Israeli subspecies in captivity.

We checked records of 62 *C. chamaeleon* in the Herpetological Collection at the Hebrew University of Jerusalem, caught during 1968-1991: 52 *C. c. recticrista*; 10 *C. c. musae*. Of these, we used the longevity records only of the 18 specimens for which we had complete data, and which had lived in captivity for over a month. We presumed that those which died within a month of arrival had been brought in bad condition, or were killed for preservation. The chamaeleons were held in the gecko vivarium as described by Werner *et al.* (1993).

The results (Fig. 1) show two maximal records: The longest lived *C. c. recticrista* was a female, captured in Tel-Aviv on 3 May 1979, which lived for 1 year, 5 months and 20 days (HUJR 14335). In contrast, a fe-

male *C. c. musae* from the Negev, captured on 3 June 1988, lived for 3 years and 16 days (HUJR 18367).

The mean longevity of *C. c. recticrista* was lower than that of *C. c. musae* and the *t*-test (Table 1) showed that the difference between the two subspecies was significant (even if we exclude two borderline specimens that lived only a little longer than one month).

One of the effects on the chamaeleons' longevity could have been the temperature: animals living in a warmer temperature grow faster and die younger than

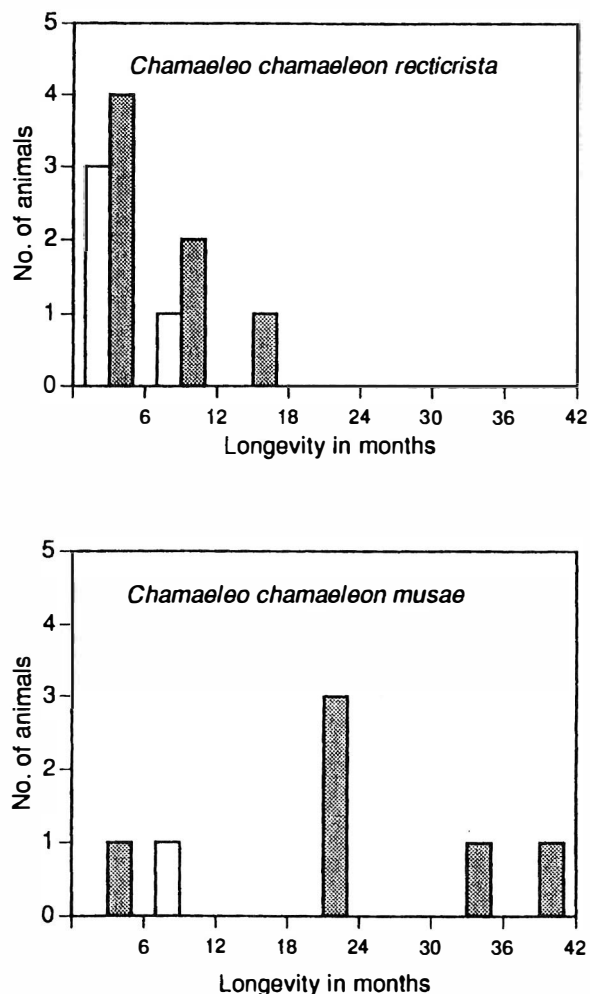


FIG. 1. Longevity in months of *C. c. recticrista* and *C. c. musae*. White: males. Shaded: females

TABLE 1. Statistics of captive longevity in *Chamaeleo chamaeleon* spp. (with and without the two doubtful specimens). Living time should be read: years.months.days.

	n	mean	Range		significance of difference from <i>musae</i>
			min	max	
<i>C. c. musae</i>	7	1.7.11	0.2.25	3.0.16	
<i>C. c. recticrista</i>	11	0.5.25	0.1.02	1.5.20	$P < 0.01$
<i>C. c. recticrista</i>	9	0.6.25	0.2.0	1.5.20	$P < 0.05$

those living in colder conditions (Holcik, 1970). In Israel *C. c. recticrista* lives in a more northern and less warm area than *C. c. musae* (geographical ranges of mean temperature of hottest month, August: 21-27°C, 26-28°C respectively - Atlas of Israel, 1970). Hence the uniform temperature in captivity was relatively higher for *C. c. recticrista* than for *C. c. musae*, possibly causing the difference between the two subspecies, as has been suggested earlier for congeneric gecko species or even conspecific populations (Werner *et al.*, 1993).

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BOOK REVIEW

A Fieldguide to the Amphibians and Reptiles of Madagascar. Frank Glaw & Miguel Vences. (1994). 480 pp. Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn.

'Compromises were necessary...' begin Frank Glaw and Miguel Vences in this the second edition of their much praised fieldguide to the herpetofauna of Madagascar. Here is a book that some will criticize for not being perfect, for containing errors (some of which are repeated from the often inaccessible scientific literature), and even perhaps, for trying to do too much. However, this is also the *only* fieldguide to Madagascar's often extraordinary herpetofauna and, regardless of the authors' perceived compromises, it performs this role admirably.

The fieldguide represents a significant improvement over the first edition, containing the same detailed information on Malagasy frogs, but with the addition of a revised and enlarged reptile section; expanded collection of colour plates (that also appear to have been reproduced with a higher quality); and even chapters on Malagasy mammals and freshwater fish. These latter chapters are surprisingly useful. Information on some of Madagascar's smaller mammal species such as the tenrecs, bats, rodents and even carnivores is simply unavailable in popular publications. The authors do, however, stress that this book should first and foremost be considered a guide to the reptiles and amphibians of Madagascar. The chapters on mammals and fish are simply a bonus.

The book opens with the obligatory introduction to Madagascar, the world's fourth largest island. Madagascar has been separated from the African continent for at least 40 million years, resulting in a unique assemblage of plants and animals. Succinct accounts of Madagascar's much threatened natural heritage are given, together with the current status of conservation and some useful contact addresses.

The authors clearly have a great love of their subject that is particularly evident in their chapters on identification features and frog reproductive diversity. The diagrams accompanying these chapters are excellent, clearly illustrating external morphological features that are important for accurate frog species determination; again with significant printing improvements over the first edition. It is a pity that the reproduction of some of the black and white photos in these sections is not of the same high quality. However, these are offset by the easy to navigate keys. More cross-referencing would have been useful. It would be a simple matter to include the page on which a species is described next to its couplet within a key. Unfortunately this has not been implemented, resulting in much thumbing of pages to locate an entry.

For frogs, the species description chapters follow the same format as that of the first edition and the au-

thors make a valiant attempt to fulfil their aim of providing descriptions to aid identification for approximately 170 different species. Due to a lack of data, this is not always possible and there is obviously a great need for more field work. Species descriptions include distribution (complete with dot map of Madagascar), description, habits, eggs and tadpoles, call, and similar species. Also included are general determination tables to genera, subgenera and species groups together with genus level keys, providing identification to species. Having used the first edition in the field, I can say that although initially cumbersome (in particular the determination tables), as one becomes more familiar with both the tables and the species under study the tables do provide a fairly rapid method for, at least, initial determinations. Although the site names in the distributions are useful, Malagasy names can be exceedingly complicated. Different maps of the same region may include either the French or Malagasy place names. The authors have attempted to overcome this often frustrating situation by including a locality gazetteer and locator map. This gazetteer includes both French and Malagasy spellings of all important collection sites together with the most recurrent spellings of those same localities in the literature. The locator map can then be used in conjunction with FTM maps, widely available in Madagascar, to establish exactly where the particular locale may be found. Useful indeed! Appendices containing sonograms and oscillograms for a number of frog species are also included, although these probably have limited use.

Although expanded from the first edition, the reptile section still only provides short summaries of important species characters and biology. Again there are diagrams illustrating the most important identification characteristics, but these are limited in comparison to the frog section. Keys are liberally distributed throughout this chapter and appear to cover all groups. Of particular note are the two keys for the identification of Madagascar's chameleons. These represent an English translation of Brygoo's standard monographs and are especially welcome.

In conclusion the authors are right: this book is a compromise. It does not represent a *complete* guide to the Malagasy herpetofauna. What it does provide is a well designed and produced field guide, containing an excellent summary of the scientific literature, workable determination tables to the frogs and concise keys to both frogs and reptiles. It also represents the only English language fieldguide to Malagasy amphibians and reptiles (along with fish and mammals). For that reason alone I would recommend it to anybody interested in the herpetofauna of this quite unique island.

Lee Brady
University of Kent

ANNOUNCEMENTS

DR KEITH CORBETT

The British conservationist, Keith Corbett, a well-known field herpetologist, has been conferred with an Honorary Doctoral Degree at the Göteborg University in Sweden, for his efforts to protect species of amphibians and reptiles and their habitats.

Dr Corbett has been working with nature conservation organizations, both on a national and international level, and particularly with the Berne Convention (Council of Europe). He is one of the most important people promoting the protection of rare and endangered amphibians and reptiles in Britain and Europe today. Due to his efforts, many heavily threatened animals and important habitats have now received the attention necessary for their protection.

The Swedish King, His Royal Highness Carl XVI Gustav, had already honored Dr Corbett in 1991 with the "Global 500 Award", a very prestigious recognition. Much of the work has been carried out in close co-operation with the Conservation Committee of the European Herpetological Society (SEH), which is also the IUCN Specialist Group for European Amphibians and Reptiles. On 29 October 1994, Dr Corbett was conferred with his Honorary Academic Doctoral Degree, during a ceremony at the Göteborg Concert Hall. Later, a banquet was held in the City Hall for 500 people, where Dr Corbett and his wife were prominent guests.

As members of the SEH Conservation Committee and close friends of Keith, we wish to make this event known in the herpetological world and we hope he will continue his important work with the same dedication. Congratulations.

Claes Andrén and Dr Göran Nilson
Göteborg University, Sweden

Richard Podlousky,
Niedersächsisches Landesamt für Ökologie,
Hannover, Germany

Anton Stumpel
Institute for Forestry and Nature Research,
Wageningen, The Netherlands

BOOKS RECEIVED

The following books have been received and placed in the Society's library. Copies may be purchased from the Publications Unit, National Biological Survey, 1849 C. Street, N.W., Mail Stop 130, Webb Bldg., Washington, D.C. 20240, USA.

Biology of North American Turtles. R. B. Bury & D. J. Germano (eds.). (1994). Fish & Wildlife Research 13, U.S. Dept. of the Interior National Biological Survey, Washington, D.C.

Recreational-boating Disturbances of Natural Communities and Wildlife: An Annotated Bibliography. D. York. (1994). Biological Report 22. U.S. Dept. of the Interior National Biological Survey, Washington, D.C.

Effects of Section 404 Permits on Wetlands in North Dakota. N. R. Sexton. (1994). Resource Publication 200. U.S. Dept. of the Interior National Biological Survey, Washington, D.C.

Acrolein Hazards to Fish, Wildlife and Invertebrates: A Synoptic Review. R. Eisler. (1994). Biological Report 23. U.S. Dept. of the Interior National Biological Survey, Washington, D.C.

Herpetofaunal Diversity of the Four Holes Swamp, South Carolina. R. J. Hall. (1994). Resource Publication 198. U.S. Dept. of the Interior National Biological Survey, Washington, D.C.

EDITOR'S NOTE

The editor is grateful to the following for refereeing manuscripts submitted to the *Herpetological Journal*:

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ERRATUM

The pagination of Vol. 5, no. 1 of the *Herpetological Journal* started at page 173 (a continuation of vol. 4) rather than page 1. To maintain consistency for the volume, the three remaining issues will maintain this system in sequence.

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THE HERPETOLOGICAL JOURNAL

INSTRUCTIONS TO AUTHORS

(revised January 1992)

1. The *Herpetological Journal* publishes a range of features concerned with reptile and amphibian biology. These include: full papers (no length limit); reviews and mini-reviews (generally solicited by a member of the editorial board); short notes; controversies, under 'Forum' (details available from the Editor); and book reviews. Faunistic lists, letters and results of general surveys are not published unless they shed light on herpetological problems of wider significance.
2. Three copies of all submissions, and illustrations, should be sent to the Editor. All papers will be subject to peer review by at least two referees
3. Authors should consult a recent issue of the Journal regarding style. Papers should be concise with the minimum number of tables and illustrations. They should be written in English and spelling should be that of the *Oxford English Dictionary*. Papers should be typed or produced on a good-quality printer (at least near-letter quality, avoid worn ribbons), and double-spaced with wide margins all round. Typesetting is greatly assisted if accepted manuscripts can be supplied on microcomputer diskettes. Authors are therefore strongly encouraged to produce manuscripts using a wordprocessor (preferably on a PC-compatible microcomputer).
4. For all papers the title page should contain only the following: title of paper; name(s) of the author(s); address of the Institution where the work was done; a running title of 5 words or less. The text of the paper should begin on page 2 and be produced in the following order: Abstract, Text, Acknowledgements, References, Appendices. Full papers and reviews should have the main text divided into sections. Short notes (generally less than six manuscript pages and accompanied by a single data set) should be produced as continuous text. The first subhead will be centred in capitals, the second shouldered in lower case, and the third run on in italics. Footnotes are not permitted.
5. The usual rules of zoological nomenclature apply.
6. Tables are numbered in arabic numerals, e.g. Table 1; they should be typed double spaced on separate sheets with a title/short explanatory paragraph underneath.
7. Line drawings and photographs are numbered in sequence in arabic numerals, e.g. Fig. 1. Colour photographs can

only be included at cost to the author. If an illustration has more than one part each should be identified as (a), (b), etc. The orientation and name of the first author should be indicated on the back. They should be supplied camera-ready for uniform reduction of one-half on A4 size paper. Line drawings should be drawn and fully labelled in Indian ink, dry-print lettering or laser printed. A metric scale must be inserted in micrographs etc. Legends for illustrations should be typed on a separate sheet.

8. References in the text should be given as in the following examples: "Smith (1964) stated —"; "—as observed by Smith & Jones (1963)." "—as previously observed (Smith, 1963; Jones, 1964; Smith & Jones, 1965)". For three or more authors, the complete reference should be given at the first mention, e.g. (Smith, Jones & Brown, 1972), and *et al.* used thereafter (Smith *et al.*, 1972). For the list of references the full title or standard abbreviations of the journal should be given. The following examples will serve to illustrate the style and presentation used by the Journal.

Bellairs, A. d'A. (1957). *Reptiles*. London: Hutchinson.

Boycott, B. B. & Robins, M. W. (1961). The care of young red-eared terrapins (*Pseudemys scripta elegans*) in the laboratory. *British Journal of Herpetology* 2, 206–210.

Dunson, W. A. (1969a). Reptilian salt glands. In *Exocrine glands*, 83–101. Botelho, S. Y., Brooks, F. P. and Shelley, W. B. (Eds). Philadelphia: University of Pennsylvania Press.

Dunson, W. A. (1969b). Electrolyte excretion by the salt gland of the Galapagos marine iguana. *American J. Physiol.* 216, 995–1002.

9. Final acceptance of a paper will depend upon the production by the author of a typescript and illustrations ready for the press. However, every assistance will be given to amateur herpetologists to prepare papers for publication.
10. Proofs should be returned to the Editor by return of post. Alterations should be kept to the correction of errors; more extensive alterations will be charged to the author.
11. Twenty-five offprints and one complimentary copy of the Journal are provided free of charge. Further copies (minimum of twenty-five) may be purchased provided that they are ordered at the time the proofs are returned.
12. All submissions are liable to assessment by the editorial board for ethical considerations, and publication may be refused on the recommendation of this committee. Contributors may therefore need to justify killing or the use of other animal procedures, if these have been involved in the execution of the work.

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