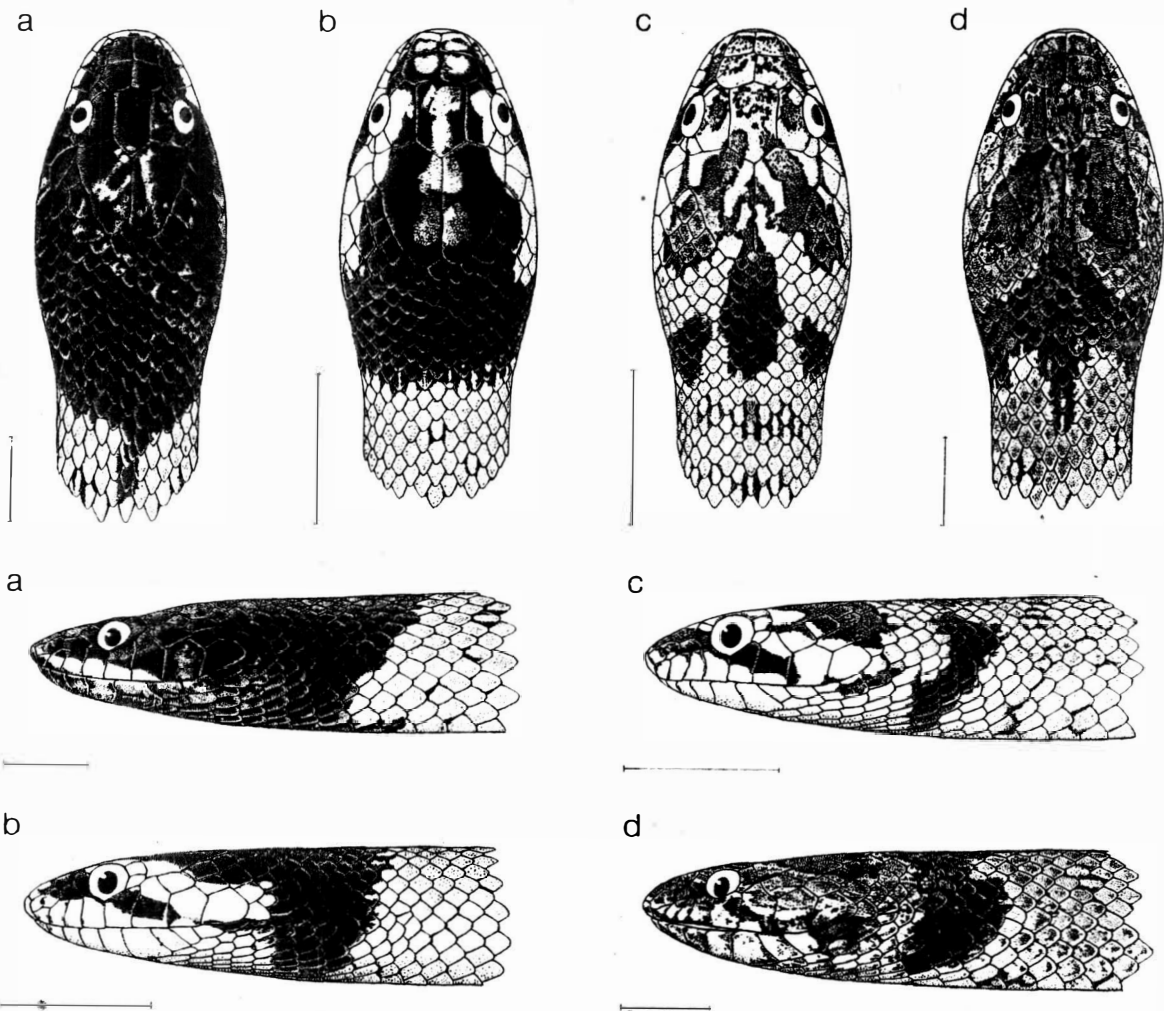


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ANNOUNCEMENTS

OPINIONS FROM THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE.

- (i) *Ichnotropis* Peters, 1854 (Reptilia, Sauria); conserved
- (ii) CAECILIIDAE Rafinesque-Schmaltz, 1814 (Amphibia, Gymnophiona) and CAECILIIDAE Kolbe, 1880 (Insecta, Psocoptera): a ruling to remove the homonymy
- (iii) De Lacépède, 1788-1789, *Histoire Naturelle des Serpens* and later editions: rejected as a non-binomial work

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FIRST WORLD CONGRESS OF HERPETOLOGY

Canterbury, United Kingdom • 11-19 September 1989

THE CONGRESS will be held at University of Kent and in Canterbury. H.R.H. Prince Philip, President of the World Wildlife Fund, will serve as Patron of our Congress and Professor Angus d'A. Bellairs as Honorary President. The Congress will also serve as the official 1989 meetings of Societas Europaea Herpetologica, Herpetologists' League, and Society for the Study of Amphibians and Reptiles. It will be co-hosted by the Zoological Society of London, Fauna and Flora Preservation Society, Societas Europaea Herpetologica, and The British Herpetological Society.

The Scientific Program, subject to modification, is listed below. Plenary speakers and Convenors are now being invited. *Persons who wish to participate in events should contact the Convenors*, whose names and addresses may be obtained from the Secretariat (see below). There will be poster sessions open to all persons but no oral contributed papers. All presentations will be in English, but discussions can be in other languages.

PLENARY LECTURES

THE STATE OF HERPETOLOGY • EVOLUTION AND ECOLOGY OF PARTHENOGENESIS • BIOGEOGRAPHY OF SOUTH AMERICA • INTERNATIONAL CONSERVATION • SEXUAL SELECTION • SYSTEMATICS AND PHYLOGENY • PALEOHERPETOLOGY • ECOLOGICAL PHYSIOLOGY • COMMUNITY ECOLOGY • BIOLOGY OF SALAMANDERS

SYMPOSIA (S), WORKSHOPS (W) and ROUNDTABLES (R)

Conservation

- S.1. CONSERVATION AND MANAGEMENT OF SPECIES
- S.2. EFFECTS OF POLLUTION ON HERPETOFAUNA
- S.3. CAPTIVE MANAGEMENT

- S.4. HEALTH AND DISEASE
- R.1. IUCN HERPETOLOGY SPECIALIST GROUPS
- R.2. CONSERVATION PROBLEMS

Behavior

- S.5. SEXUAL SELECTION AND COMMUNICATION
- S.6. ENVIRONMENTAL SEX DETERMINATION

- S.7. ORIENTATION, NERVOUS SYSTEM AND SENSES
- R.3. OPTIMAL SIZES OF EGGS AND CLUTCHES
- R.4. MIMICRY AND PREDATOR-PREY BEHAVIOR

Ecology

- S.8. LONG-TERM STUDIES
- S.9. SNAKE ECOLOGY AND BEHAVIOR
- S.10. ADAPTATIONS TO EXTREME ENVIRONMENTS
- S.11. AMPHIBIAN COMMUNITY ECOLOGY

- S.12. HERPETOFAUNAS: EXPLORATIONS AND STUDIES
- R.5. THE ECOLOGY OF THE TUATARA
- W.1. SKELETOCHRONOLOGY
- W.2. FIELD METHODS AND BIOTELEMETRY

Evolution

- S.13. EVOLUTION AND PHYLOGENY OF FROGS
- S.14. ORIGIN OF AMPHIBIA AND REPTILIA
- S.15. PALEOHERPETOLOGY

- S.16. ISLAND HERPETOFAUNAS
- S.17. LIFE HISTORY EVOLUTION OF TURTLES
- R.6. BIOGEOGRAPHIC REVIEW OF THE CONTINENTS
- R.7. CAECILIAN BIOLOGY AND EVOLUTION

Systematics and Genetics

- S.18. MOLECULAR SYSTEMATICS
- S.19. CYTOGENETICS
- S.20. PARTHENOGENESIS AND HYBRIDOGENESIS
- S.21. SYSTEMATICS AND PHYLOGENY

- S.22. BIOLOGY AND GENETICS OF PIPIDAE
- R.8. PHYLOGENY AND CLASSIFICATION OF LIZARDS
- W.3. MOLECULAR TECHNIQUES
- W.4. AMPHIBIAN LARVAE
- W.5. PHYLOGENETIC ANALYSIS

Physiology and Development

- S.23. ENERGETICS
- S.24. ECOLOGICAL PHYSIOLOGY

- S.25. FUNCTIONAL MORPHOLOGY
- S.26. REPRODUCTIVE PHYSIOLOGY
- S.27. DEVELOPMENTAL PROCESSES

General Topics

- R.9. FIELD RESEARCH AND NATIONAL REGULATIONS
- R.10. AMATEUR CONTRIBUTIONS TO HERPETOLOGY

- R.11. MEDICAL AND RESEARCH ASPECTS OF VENOMS
- W.6. PHOTOGRAPHIC TECHNIQUES

EXCURSIONS: Pre- and post-Congress trips are planned to Europe, Russia, the Mediterranean, Belize, Honduras, the Amazon, Ecuador, various sites in Africa, Indian Ocean, Pakistan, Malaysia, China and Australia, each led by professional herpetologists. Day or half-day trips to Darwin's home, London, Cambridge, Oxford and Paris are also planned.

FIRST CIRCULAR: The complete program and full details of excursions, including prices, are given in the First Circular, available from the Secretariat. This includes a Provisional Registration Form. Registration begins January 1988; £90 fee covers abstract book and program, refreshments, and costs of hiring meeting rooms and equipment. *Advance registration is strongly encouraged* for planning purposes and to insure that you receive all other announcements promptly.

SECRETARIAT: Address all inquiries to: First World Congress of Herpetology, Ecology Research Group, Rutherford College, University of Kent, Canterbury, Kent CT2 7NY, UK. Telephone: (0227) 764000, ext. 3501. Telex: 965449.

HABITAT SELECTION OF *LACERTA VIVIPARA* IN A LOWLAND ENVIRONMENT

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ABSTRACT

The habitat selection of *Lacerta vivipara* was studied in an area of inland dunes by comparing the relative occurrence of individuals with the relative presence of a number of potential habitats. Habitats with a strong spatial heterogeneity were clearly preferred, no matter whether they were humid or dry. The microhabitat of this lizard was always there where good possibilities for thermoregulatory behaviour were present within a very limited area. No differences in habitat selection were found for the age classes and sexes.

INTRODUCTION

Lacerta vivipara has an enormous distribution area which stretches from northern Spain and the Balkan peninsula to Arctic Scandinavia and from Ireland to the Pacific coast of Siberia. Many authors have already said something of the habitat selection by this animal. In general only macrohabitat selection is mentioned, however. In the southern parts of the area this species seems mainly montane, having a strong preference for humid or even wet habitats (e.g. Palaus, 1974; Andrada, 1980; Salvador, 1985; Livet & Bons, 1981; Bruno & Maugeri, 1976; Radovanović, 1964). In more northern regions this species also occurs in lowlands and there it can be found in a very wide range of habitats, from very humid to rather dry and from very open places to densely grown woods (e.g. Smith, 1973; Arnold, Burton & Ovenden, 1978; Street, 1979; van de Bund, 1964; Bergmans & Zuiderwijk, 1986; Frommhold, 1959; Blab, 1980; Nikol'skii, 1963; Terent'ev, 1965). Only few authors describe the habitats to such extent that conclusions about microhabitat can be drawn (Castroviejo, Castroviejo & Salvador, 1970; Glandt, 1976; Parent, 1979, 1984; Haslewood, 1981; Pilorge & Xavier, 1981; Heulin, 1985). The overall conclusion that can be drawn from these descriptions is that *L. vivipara* prefers the drier spots in humid environments, the more open spots in densely vegetated regions and the more shady spots in open habitats.

In the years 1976-1981 we studied *L. vivipara* in a lowland environment near Nijmegen in the Netherlands. It is the only lizard species occurring there, precluding interference from other lizards.

STUDY AREA

This study was made in the reserve 'Overasseltse & Hatertse Vennen' at 5° 48' E. Long., 51° 48' N. Lat. in the Netherlands. The reserve is part of the ridge of inland dunes on the eastern and north-eastern Maas border (cf. Strijbosch, 1982). About $\frac{2}{3}$ of this reserve

consist of woodland. The original forest type was oak-birch wood, but since the beginning of this century nearly 90 per cent of this forest type has been replaced by pine plantations. The remainder of the area consists of more open habitats: dry heathlands with some patches of open drift sand, humid heathlands with a great number of moorland pools and finally also cultivated lands. These are mainly grasslands but locally there are also arable fields. The pools in the cultivated part are eutrophic. In order to carry out the study described here we selected an area of 12 ha in which all macrohabitats of this region were represented viz.: some undisturbed small moorland pools, one eutrophic pool, a patch of peat-bog, some small deciduous woods and coppice strips, pine woods, some dry dune tops, dry and humid grasslands, fields and even a farmstead and its yard.

METHODS

During the years of study the study area was visited by one or two persons on nearly every day on which lizard activity might be expected. When visiting we tried to search all parts of the area with equal intensity. The lizards found were divided into three age classes viz.: juveniles (born in the running calendar year), subadults (born in the previous calendar year) and adults (at least in their third season). The adults were subdivided into ♂♂ and ♀♀. Every observation spot was accurately noted by means of coordinates (accuracy 1 metre). A vegetation map of the total study area was made (scale 1:500), on which 12 macrohabitats were distinguished. Maps 1:200 were drawn of five parts of this area in which lizards proved to occur in greater densities. These maps show trees, shrubs, bigger plants and other structures individually. By plotting the first 3500 sightings on the 1:500 map we established the macrohabitat selection. Now two types of macrohabitat proved to be highly preferred and we investigated the microhabitat selection in these two types with the help of the 1:200 maps, by plotting the first 1500 sightings of

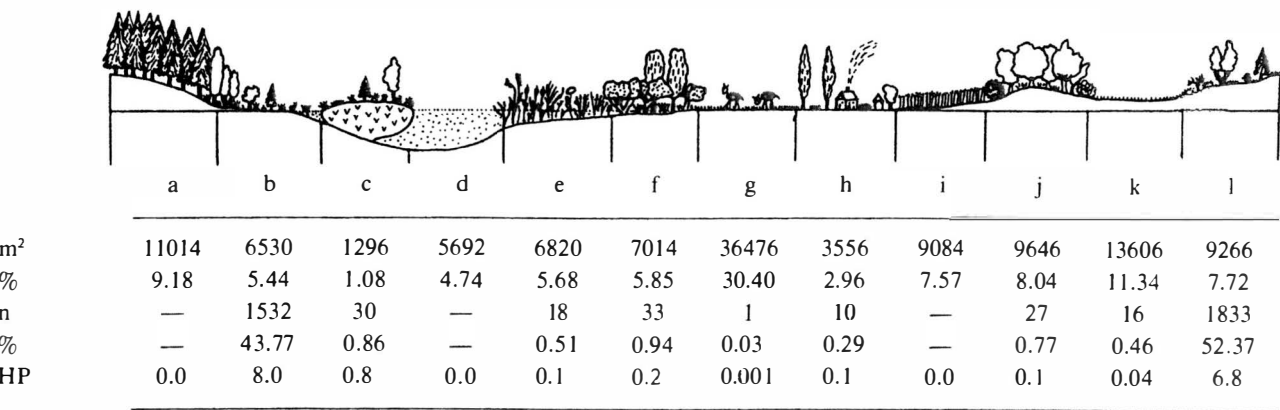


TABLE 1: Macrohabitat selection of *Lacerta vivipara* in an area of inland dunes (area = 12 ha, sightings = 3500). a = high and dense pine plantations. b = border zones of oligotrophic moorland pools. c = peat bog and floating *Sphagnum* mats. d = open water. e = border zones of eutrophic pools. f = *Salix* and *Alnus* coppice. g = pastures. h = roads, paths and farm yards. i = arable fields. j = deciduous forest and coppice strips. k = open, dry grasslands and abandoned fields. l = dune tops with open, dry grassland, heather, broom and isolated small trees.

each. We now calculated the total area of all the various habitats. For isolated trees or shrubs we took as area the vertical projection of their foliage circumference. As a standard of preference for a certain habitat (habitat preference = HP) we used the quotient of the relative part of the sightings within that habitat and the relative area of that habitat, in the

formula:
$$HP_i = \frac{\% \text{ sightings in } H_i}{\% \text{ area of } H_i}$$

RESULTS

Table 1 shows a survey of the macrohabitat selection. The high, dense pine woods, the corn fields and the open water are clearly totally avoided. The intensely trodden pastures are hardly selected. It is striking that those habitats that are neither very dense nor very open are preferred. They may be rather humid or even wet or rather dry. The common characteristic of these macrohabitats is that they have a great variation within a limited distance in open and closed

spots (spatial heterogeneity). The habitats that are not or scarcely used are sometimes traversed during migrations, even the open water. This could be established by marking the animals after capture and we found once that one lizard, marked on a bog island in a pool, was recaptured some days later on the pool border. Thus it also appeared that some individuals traversed pastures. These migrations apparently happen in such a short time span that the chance of sighting the animal during such a migration is very slight.

Table 2 gives a survey of the microhabitat selection within the macrohabitat ‘border zone of moorland pools’. It should be borne in mind, when considering the diagrams of the tables, that the order of microhabitats does not necessarily reflect their real distribution on the ground; in reality they are often intermingled. Open patches of *Molinia caerulea* which are not regularly inundated are distinctly preferred, especially if isolated trees are present. Then the birches are clearly preferred to the pine trees.

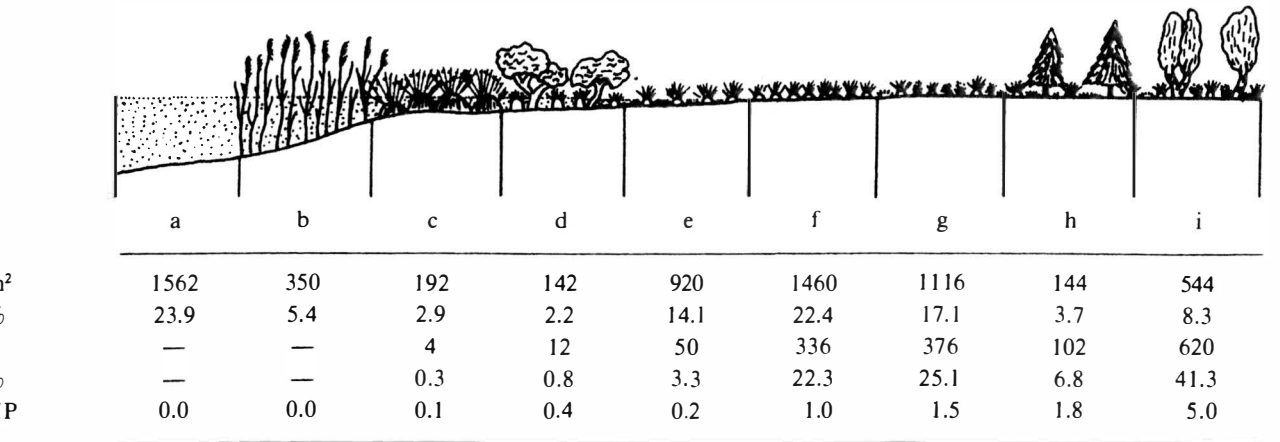
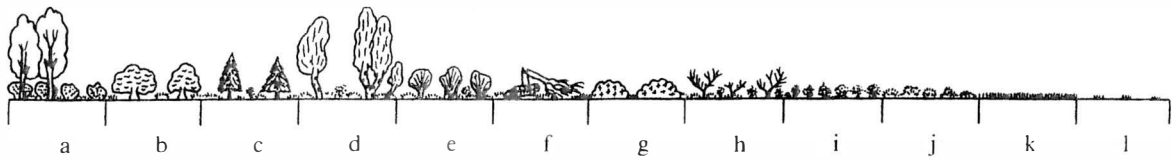


TABLE 2: Microhabitat selection of *Lacerta vivipara* in border zones of oligotrophic moorland pools (area = 6530m², sightings = 1500). a = open water. b = border zone vegetation, always inundated (mainly *Phragmites*). c = border zone vegetation, frequently inundated (mainly *Juncus effusus*). d = open willow groves (*Salix cinerea*). e = open *Molinia-Sphagnum* vegetation, frequently inundated. f = dense *Molinia* vegetation, rarely inundated. g = open *Molinia* vegetation with *Erica tetralix*, *Andromeda polifolia* and *Oxycoccus palustris*. h = isolated, small *Pinus sylvestris* in *Molinia* vegetation. i = isolated, small *Betula* trees in open *Molinia-Erica* vegetation.



m ²	310	512	29	77	130	74	166	392	261	3056	335	98
%	5.7	9.4	0.5	1.4	2.4	1.4	3.1	7.2	4.8	56.1	6.2	1.8
n	65	204	15	62	118	77	70	467	124	277	21	—
%	4.3	13.6	1.0	4.1	7.9	5.1	4.7	31.1	8.3	18.5	1.4	—
HP	0.8	1.5	2.0	2.9	3.3	3.6	1.5	4.3	1.7	0.3	0.2	0.0

TABLE 3: Microhabitat selection of *Lacerta vivipara* on dry dune tops (area = 5450m², sightings = 1500). a = groves of *Prunus spinosa* and/or *Robinia pseudo-acacia* (only present at the border zones of this macrohabitat). b = isolated, small *Quercus* trees. c = isolated, small *Pinus* trees. d = isolated, small *Betula* trees. e = isolated *Frangula alnus* shrubs. f = tree stumps and faggots. g = dense *Rubus* shrubs. h = open broom bushes (*Sarothamnus scoparius*). i = heather (*Calluna vulgaris*). j = closed, dry grassland of *Deschampsia flexuosa*. k = open, dry grassland of *Festuca ovina* and/or *Agrostis tenuis*. l = bare drift sand and open *Corynephorus* vegetation.

Table 3 gives a survey of the microhabitat selection within the open dune tops. In this macrohabitat the lizards show a more marked preference for shrubs (broom, alder buckthorn) than for isolated trees. The spots with old tree stumps and faggots score very highly as well. The difference between birch and pine trees is less marked than in the wetter border zones of moorland pools. The oaks score markedly lower than the other trees and the bramble bushes lower than the other shrubs. The dense combination of trees and shrubs in the *Robinia/Prunus* groves scores even lower.

Table 4 shows a survey of the correlation in habitat selection by the various age classes and the sexes. It is clear that the habitat selection by all groups is highly positively correlated.

DISCUSSION

All macrohabitats of Table 1, except the open water, are mentioned in literature as habitats of *L. vivipara*. The relative preference for the various habitats, however, shows marked and great differences. As far as humidity is concerned it appears that very humid as well as pronouncedly dry places are chosen, although the more humid places seem to house more animals. Those habitats that are structurally very uniform are more or less or even totally avoided, no matter whether they are either completely closed or completely open. A positive reaction to habitats with a greater structural diversity has been proved to exist for more lizard species (Pianka, 1967; Allen, 1977). Thus a tree in an open habitat provides a gradient in sun and shade, which is of great importance for an ectothermic animal as *L. vivipara*. For an organism of such small proportions a big *Molinia* tussock may also serve this

purpose. Besides this thermoregulatory advantage such structures mostly offer a good refuge for flight, too (antipredation function). Moreover the potential number and variety of prey species will be greater in a microhabitat with a greater diversity.

The differences in preference for certain tree and shrub species in Tables 2 and 3 can be explained by their very form. Thus the sun/shade gradient near a small pine tree with its low-hanging branches among high *Molinia* tussocks will be much shorter and more sudden than under a birch tree in the same environment. The small oaks growing on the dry dune tops (Table 3) are always more or less bulbous, i.e. the lower branches nearly always touch the surface. Therefore the area projected by their foliage circumference on the surface is mainly fully shaded, not allowing any of the other vegetation types which are present under most other trees and shrubs. Near and under the little pine trees there is a good sun/shade gradient on account of the absence of the tall *Molinia* tussocks as in the habitat of Table 2. The sun/shade gradient in the dry habitat of the dune tops is always better developed near the lower shrub groups, often comprising more individuals, than near the trees, where the sun often reaches the trunk foot.

ACKNOWLEDGEMENTS

I owe many thanks to the State Forestry Service for the possibility they offered to carry out this study on their property. Many students helped me collecting the field data of whom I want to mention Mrs. A. Reijnders-van der Rijdt, Miss M. Schifflers, Mr. P. van Heereveld and Mr. G. Schraven. My brother J. Strijbosch assisted me when translating.

	♂/♀	♂/subad	♂/juv	♀/subad	♀/juv	subad/juv
A	0.97	0.96	0.82	0.93	0.73	0.86
I	0.97	0.90	0.86	0.92	0.77*	0.80
II	0.79	0.97	0.67*	0.74	0.55*	0.62*

TABLE 4: Correlation between the habitat selection by juveniles, subadults and adult males and females (Spearman rank corr. test; x = P<.05, in all other cases P<.01). A = macrohabitat selection. I = microhabitat selection in border zones of oligotrophic moorland pools. II = microhabitat selection in dune tops.

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BROODING IN THE MALAYAN PIT VIPER, *CALLOSELASMA RHODOSTOMA*: TEMPERATURE, RELATIVE HUMIDITY, AND DEFENSIVE BEHAVIOUR

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ABSTRACT

A female Malayan pit viper (*Calloselasma rhodostoma*) laid a clutch of 27 eggs and remained coiled atop them until hatching. Possible functions of brooding were evaluated; these include regulation of temperature, regulation of moisture, and protection. The brooding female was not found to regulate the clutch's temperature but was found to vary the degree of egg exposure in accordance with fluctuations in the level of relative humidity. Body-jerking movements could be elicited in the female while she was brooding but not while she was off the nest. Body-jerking was elicited by prodding with an inanimate object as well as from a conspecific, and it is felt that this behaviour could function to ward off a potential predator.

INTRODUCTION

This is a report on brooding of eggs by a female Malayan pit viper (*Calloselasma rhodostoma*). To elucidate possible functions brooding might have in *C. rhodostoma*, we collected data on temperature and humidity within the snake's enclosure. In addition, we observed the effect of physical disturbances on the brooding female.

Egg brooding has been observed in the lizards *Eumeces* and *Ophisaurus* (Noble & Mason, 1933; Evans, 1959; Vinegar, 1968). In snakes, brooding has been reported for various elapids and several viperids (Noble, 1935), boids (Vinegar *et al.*, 1970), and in a few colubrids (Bellairs, 1970; Oliver, 1955). Functions of brooding that have been explored include: defense of the nest (Noble & Mason, 1933; Noble, 1935; Pope, 1935; Oliver, 1956), behavioural regulation of nest temperature (Vinegar, 1968; Oliver, 1955; Cogger & Holmes, 1960), and physiological regulation of nest temperature (Hutchison *et al.*, 1966; Vinegar *et al.*, 1970).

MATERIALS AND METHODS

A large brooding female (snout-vent length: 802mm) was housed together with two smaller females in a 90 x 60 x 60cm wooden enclosure fitted with a glass top and front side. The inside of the enclosure included a cypress bark mulch substratum, three large rocks arranged to provide crevices, a bowl 'pool' for water, and plastic foliage. The cypress mulch provided a suitable substratum in which the snakes blended well due to their cryptically coloured patterns. The mulch also formed a suitable substratum for nesting.

The snakes were kept on a 12/12 reversed light-dark cycle. Three 25-watt red ceramic coated light bulbs used during the dark cycle provided acceptable illumination for both direct and video monitored observations. A 250-watt infra-red heat reflector situated 1m above and at a 45° angle to the enclosure was turned on for four hours each day during the 12 hour light cycle. This caused the temperature in the enclosure to vary between 23° and 29°C through a 24 hour cycle. Likewise, the humidity level was varied between 70 and 100 per cent R.H. through periodic watering of the mulch substratum as well as misting the inside of the enclosure.

In order to test the hypothesis that brooding has an effect on the temperature of the eggs, data on the egg, air, and substratum temperatures were collected. Temperature readings during brooding by the large female were obtained from 3 thermistors connected to a YSI Model 4002 switch box, which was in turn connected to a YSI telethermometer. Both the switch box and telethermometer were next to the outside of the enclosure. Temperature was recorded simultaneously from air, substratum, and clutch. Air temperature was obtained by a thermistor hanging 15cm above the brooding female. Substratum temperature was taken from a thermistor 10cm in front of the brooding female, and clutch temperature was recorded from a thermistor placed between the coils of the female and her eggs. Temperature was recorded for

26 consecutive days. Temperature was generally recorded during the dark cycle. In addition, temperatures were recorded at 15 minute intervals over a 24 hour period in order to obtain a continuous sampling of temperature changes through a complete day cycle.

Data on the brooding female's response to changing levels of humidity were obtained by an Abbeon Relative Humidity Indicator positioned 22cm directly above the female. A Sony black and white video camera in front of the enclosure was focused on the hygrometer; a second camera was suspended above the enclosure and was focused on the brooding female with the film plane parallel to the floor of the enclosure. The pictures from the two cameras were combined with a Sony Special-Effects-Generator. Twelve-hour continuous recordings were made on a Panasonic time-lapse surveillance video recorder during the dark cycle over a period of 8 days; egg exposure and humidity data were recorded from them. The data consisted of 189 egg exposure-humidity data comparisons made at one-half hour intervals. Egg exposure was determined by projecting the video image onto a 13.3cm diagonal black and white monitor screen divided into 3mm squares and counting the number of squares in which eggs were visible.

RESULTS

TEMPERATURE

Temperature means, standard deviations, and ranges overlapped. But a Friedman non-parametric test of differences between simultaneous temperature readings was significant ($\chi^2 = 71.7$, d.f. = 2, $p < 0.001$). Paired t-tests also showed that the mean substratum temperature was significantly lower from that of both the mean clutch ($t = 10.45$, d.f. = 152, $p < 0.001$) and air ($t = 7.66$, d.f. = 152, $p < 0.001$) temperatures, but that the mean clutch temperature did not differ significantly from that of air ($p < 0.05$).

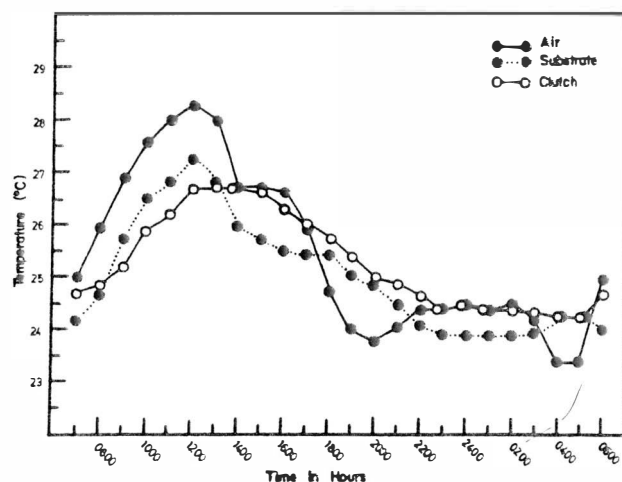


Fig. 1 Temperature changes over a 24 hour period during brooding in *Calloselasma rhodostoma*. Data points represent averages over 4 temperature readings taken at 15 minute intervals.

Fig. 1 shows changes in the temperatures of the substratum, clutch, and air over a 24 hour period. We obtained data points by averaging four consecutive temperature readings taken at 15 minute intervals from each thermistor.

HUMIDITY

We observed changes in the amount of eggs exposed occurring with changes in humidity. The female would often cover the eggs completely when the relative humidity decreased below 70 per cent. Spraying of the enclosure increased the relative humidity to 100 per cent. The female responded to the humidity rise with a loosening of her coils, thereby greatly increasing the amount of eggs exposed. On several occasions, relative humidity remained at or near 100 per cent for several hours. The female initially responded by loosening her coils but then decreased egg exposure by tightening them.

A plot of % R.H. and amount of egg exposure over time showed a consistent pattern of increased egg exposure following sharp rises in humidity. A 30 hour sample of this pattern is given in Fig. 2. High levels of egg exposure (egg exposure > 40) always lasted under two hours, regardless of % R.H.

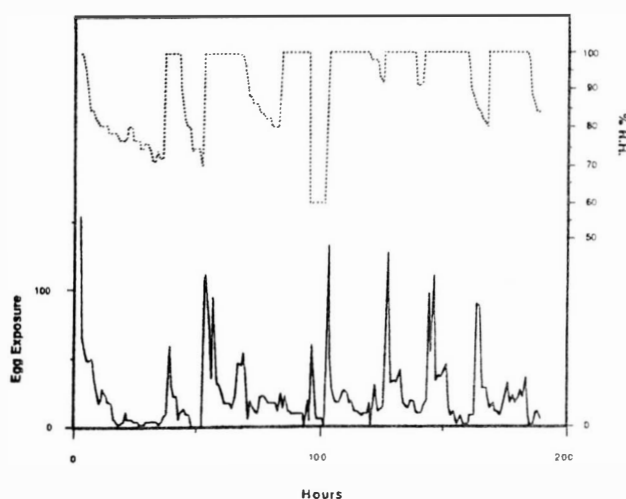


Fig. 2 One hundred and eighty hour sample of the amount of eggs exposed (see text) during brooding in *Calloselasma rhodostoma* (solid line) together with % R.H. (dashed line).

DEFENCE

We observed the brooding female to actively defend the nest by means of body-jerking. This behaviour was also observed by Matt Finstrom (unpublished manuscript) and appears to be similar to the 'body-jerking' of crotaline snakes in response to the presence of ophiophagous kingsnakes (Carpenter & Gillingham, 1975). In *Calloselasma rhodostoma*, body-jerking consisted of jabbing a short segment of the trunk against some intruding object and thereby forcing the object away from the snake. This response could be elicited by inanimate objects such as snake hooks as well as by conspecifics. Whenever body-jerking was directed against a conspecific, the latter initially reacted with a startle response, then froze for up to three minutes. During hatching, the female's body-jerking led to dispersion of the newly hatched

neonates. The body-jerking response disappeared two days after hatching of the neonates.

In one case the intruding conspecific was a gravid female who was very persistent in attempting to coil atop the already brooding female. We first observed these attempts on 3 September 1982, 27 days after the brooding female had laid her eggs. The non-brooding female was removed from the enclosure and was isolated in a small, separate terrarium. On 19 September 1982, the removed female laid eggs and coiled tightly around them. We lifted the second female off her nest so that the eggs could be weighed and measured, and she exhibited body-jerking to the snake hook as had the original female.

DISCUSSION

The temperature data do not indicate that brooding in *Calloselasma rhodostoma* has any effect on the subsequent temperature of the clutch except for decreasing the overall daily temperature variation. This temperature stabilising effect can be expected from any large covering body. Brooding female Indian pythons (*Python molurus bivittatus*) can maintain body temperatures as much as 7.3°C above either of the substratum or the ambient temperatures for extended periods (Hutchison *et al.*, 1966; Vinegar *et al.*, 1970). For the python, 33°C may be analogous to the 'lower critical temperature' of birds and mammals (Hutchison *et al.*, 1966); that is, the brooding animal only increases its rate of oxygen consumption once the ambient drops below 33°C.

The body temperature of the brooding female *Calloselasma rhodostoma* during the 24 hour sample was above ambient temperature for about 9 hours (see Fig. 1). This occurred during a steep decline in the air temperature after it had reached its peak at 0200 hours. During this period, the maximum temperature deviation between the air and clutch was only 1.4°C. It should be noted that as most temperature data were obtained during the cooler (dark) portion of the cycle, the bias was towards body temperatures warmer than ambient. Vinegar *et al.* (1970) suggest that the northerly distribution limit (circa 22° N. Lat.) of *Python reticulatus* was determined by the fact that it did not incubate its eggs; whereas *P. molurus* with its ability to increase its body temperature during brooding allowed it to extend its range into southern China (circa 27° N. Lat.). In contrast, the range of *Calloselasma rhodostoma* probably does not extend much further than Phitsanulok, Thailand (16.5° N. Lat.); a range which is more comparable to that of *P. reticulatus*. The mean temperature of a ten year period for the northerly part of *C. rhodostoma*'s range is 28.3°C during the period most likely for laying (World Weather Records 1950-60, Vol. 4, Asia). Bellairs (1970) mentions the possibility that brooding might protect reptilian eggs from chilling breezes, though the forested habitat of *C. rhodostoma* would lessen any such effect.

The calcareous shell of oviparous reptiles is an important adaptation associated with terrestrial reproduction (Spellerberg, 1982). The albumen layer

in *Amphibolurus b. barbatus* eggs reduces desiccation (Badham, 1971), however, humidity and moisture content of the surrounding substratum remain important factors in embryonic survival (Fitch & Fitch, 1967). Adaptation to the problem of desiccation of the porously membraned eggs is seen in the habit of some terrapins of moistening the nest with urine. The European terrapin (*Emys orbicularis*) drinks water when laying during hot weather thus replenishing her cloacal bladders with fluid which is used in moistening her nest and eggs (Bellairs, 1970).

Joshi (1967) showed the importance of humidity in the development of *Python sebae* eggs. He divided a single clutch into various groups and found that the groups kept at 65 to 80 per cent R.H. hatched, whereas the group kept below 40 per cent R.H. failed to hatch. A group kept in moist soil but in a dry and sunny place also failed to hatch.

Humidity may be only one of the factors determining egg exposure. Another factor might be egg turgidity, which might in turn be affected by humidity. In such a case, we postulate the following three sequences determining egg exposure: 1. Humidity high, egg turgidity low: expose eggs. 2. Humidity low, egg turgidity high (from excessive ground moisture): expose eggs. 3. Humidity low, egg turgidity low (or decreasing): cover eggs. In southeast Asia, where humidity levels are generally high, especially in forested areas, regulation of moisture might be more crucial than temperature regulation to the survival of the developing eggs. Deviations in precipitation level could have serious consequences on egg survival as eggs are laid during the period of greatest rainfall (Fig. 3).

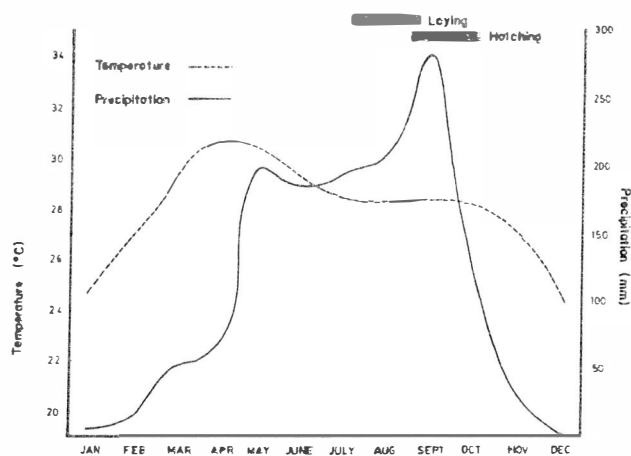


Fig. 3 Temperature and precipitation averages for a 10 year period at the Phitanulok, Thailand, weather station (16.50 N. Lat.) and approximate egg laying and hatching times for *Calloselasma rhodostoma*. (Weather information obtained from the U.S. Dept. Commerce, Environmental Sci. Services Admin., Environmental Data Service. World Weather Records 1950-60, Vol. 4, Asia.)

It is assumed that brooding in snakes serves to protect the eggs from predators, although the literature contains little direct evidence for this hypothesis. Oliver (1956) concluded that brooding in *Ophiophagus hannah* must be providing protection

since he found the female to be more concerned with covering the eggs (humidity maintenance?) than in driving off a potential predator. Noble (1935), after determining that certain female lizards that brood their eggs will actively defend them from predatory attacks, concluded that the same must be true for the majority of brooding snakes, as it would enhance their offsprings' survival with or without physiological thermoregulation.

Finally, it should be noted that brooding in *Calloselasma rhodostoma* can lead to passive defence provided by the camouflaging colouration of the brooding female. As the highly reflective white eggs are laid on top of the substratum floor, they would be very visible to a predator, but once covered by the brooding female they disappear under her body, whose colour and patterns blend in well with the ground.

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HERPETOFAUNA OF THE LATE DEVENSIAN/EARLY FLANDRIAN COW CAVE SITE, CHUDLEIGH, DEVON

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ABSTRACT

The late Devensian/early Flandrian Cow Cave Site, Chudleigh, Devon, yielded a herpetofauna consisting of *Bufo bufo*, *Bufo calamita*, *Rana temporaria*, *Anguis fragilis*, and *Vipera berus*. This is a depauperate 'Rana-Bufo' fossil assemblage with *Rana* comprising 20 per cent and *Bufo* 77 per cent of the fauna. The endangered species *Bufo calamita* is reported for the first time as a fossil from Devon and for the second time only as a British fossil.

INTRODUCTION

Other than a recent report on the Ightham Fissures, Sevenoaks Area, Kent (Holman, 1985) and Stuart (1979) on *Emys orbicularis*, the late Devensian and Flandrian herpetofauna of Britain has largely been neglected since the late 19th Century (Newton, 1879, 1894; Woodward, 1880). Nevertheless, a knowledge of late Pleistocene British herptiles is essential for the interpretation of their biotic responses to late Pleistocene environmental oscillations. Recently, through the kindness of Dr. Angela Milner of the British Museum (Natural History), I was allowed the privilege of studying the late Devensian/early Flandrian herpetofauna of Cow Cave, Chudleigh, Devon. The fossil herpetofauna of this site forms the subject of the present paper.

THE DEVENSIAN AND FLANDRIAN STAGES

The Devensian is the last cold stage of the Pleistocene in Britain, and is thought to have begun about 110,000 years before the present (b.p.), and to

have lasted about 100,000 years (Stuart, 1982). The Flandrian is that period of time in Britain that began about 10,000 radiocarbon years b.p., equivalent to the Holocene on a world-wide basis. Sutcliffe (1985, p.61) provides a chart that indicates terminology of Flandrian equivalents in different parts of the World. Quite important events that occurred in the Flandrian and strongly influenced the British herpetofauna include (1) British isolation from the European Continent early in the stage, (2) extinction of several large mammals through hunting and habitat changes by humans, and (3) later introduction of exotic species and further modifications of the environment of the native species.

The ecological history of the Flandrian, based on pollen, mollusc and beetle studies, indicates a change from Tundra about 10,000 b.p. to a rapid warming to a climate as warm as today in southern England by 9,500 b.p. The birch community was replaced by hazel scrub between 8,700 to 8,100 b.p.; then a hazel and pine mixture about 8,100 to 7,100 b.p.; and finally deciduous forest from 7,100 to 5,000 b.p. (Coope, 1977;

Hibbert *et al.*, 1971; Osborne, 1974; Pennington, 1977; and Yalden, 1982). After 5,000 b.p., the activities of humans caused great changes in habitats.

THE COW CAVE SITE, CHUDLEIGH, DEVON

The Cow Cave Site (National Ordinance Survey Grid Reference SX 864 787, Fig. 1) is one of a series of small caves in Chudleigh George, Devon, on the River Teign. The site was briefly mentioned by Sutcliffe and Kowalski (1976). Cow Cave is presently one of the few remaining roosting sites for the greater horseshoe bat (*Rhinolophus ferrumequinum*) J. W. Simmons, formerly of the British Museum (Natural History), made excavations at the site in 1962 and 1963 which yielded a fairly unremarkable late Devensian/early Flandrian mammal fauna (Andrew Currant, pers. commun., 9 March, 1987). The condition of the preservation of the fossil amphibian and reptile bones from Cow Cave is as good, and in many cases better, than those of the herpetological fossils of the Ightham Fissures, Kent, reported by Holman (1985).

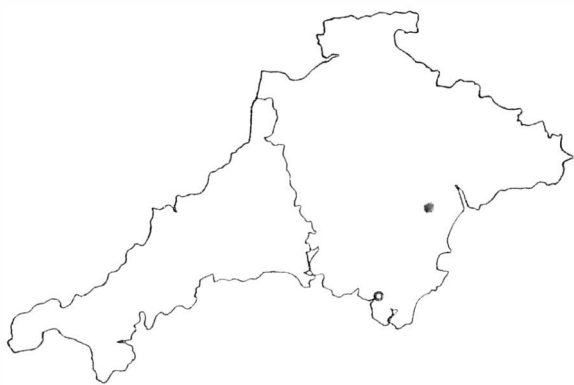


Fig. 1 Map of Devon and Cornwall showing location of Cow Cave Site at Chudleigh (closed circle) and the only historical record of *Bufo calamita* from Devon (open circle).

SYSTEMATIC PALAEOONTOLOGY

In the accounts to follow the abbreviation 'B.S.' refers to the 'back-section' of the cave. The other abbreviations 'F.S.' and 'R.S.' refer either to the front (F.S.) or rear (R.S.) of the back-section (B.S.) of Cow Cave. The Roman Numerals refer to layers within the specific front or rear sections. All of the specimen numbers, BM(NH) R-, are of the British Museum (Natural History).

MINIMUM NUMBER OF INDIVIDUALS

Minimum numbers of individuals of each species are based either on the largest number of either non-paired bones or of left or right elements. For instance, if a species was represented by four skulls, and by six left and four right ilia, the minimum number of individuals would be six. On the other hand, if a species was represented by three skulls and two left and one right ilia, the minimum number of individuals would be three. A small lot of vertebrae (as in *Vipera berus*) is considered a minimum number of one.

Class Amphibia

Order Salientia

The anuran ilium is a very good fossil element upon which to base identifications (Böhme, 1977; Holman, 1985). It is numerous in the fossil record; tends to reflect the mode of locomotion of the animals and in many cases reflects specific differences (Böhme, 1977). Other anuran bones that could be identified at the specific level in the present study include the frontoparietal and the sacrum. Böhme (1977) has also demonstrated the usefulness of these bones in fossil studies.

Family Bufonidae

Bufo bufo Laurenti

Identified Material. ILIA: B.S.F.S.I two right BM(NH) R-11157; B.S.F.S.II 38 left and 37 right BM(NH) R-10182; B.S.R.S.IV one left and three right BM(NH) R-8903, 54 left and 64 right BM(NH) R-10184, nine left and 18 right BM(NH) R-10194. FRONTO-PARIETALS: B.S.F.S.I eight left and four right BM(NH) R-11160; B.S.F.S.II 15 left and 12 right BM(NH) R-11158, pair of fused elements BM(NH) R-8899; B.S.R.S.IV two right BM(NH) R-11159. SACRA: B.S.F.S.I two BM(NH) R-11155; B.S.F.S.II and R.S. IV mixed 36 BM(NH) R-11156.

This is a minimum number of 124 *Bufo bufo* based on 124 right ilia.

Remarks. The ilia of *Bufo bufo* and *Bufo calamita* are readily distinguishable on the basis of an easily-observed character (Fig. 2). *Bufo bufo* has a low, rounded ilial prominence that develops a roughened area on it in some older individuals. *Bufo calamita* has a distinctive triangular ilial prominence.

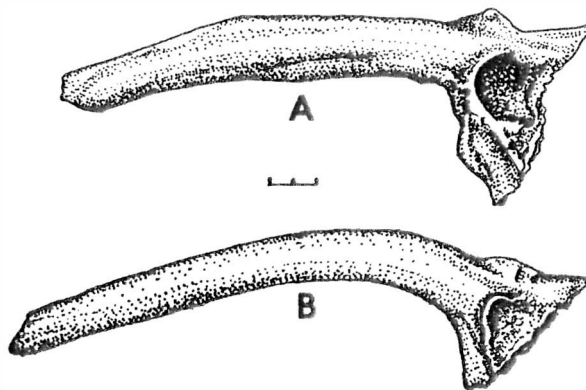


Fig. 2 Left ilia of modern *Bufo* in lateral view. A, *Bufo calamita*, Oxford University Museum (Zoology) Number 9532. B, *Bufo bufo*, Michigan State University Museum (Vertebrate Paleontology) Number 3380.

The frontoparietal has been shown to be a useful bone in distinguishing species of European *Bufo* (Böhme, 1977). The frontoparietal of *Bufo bufo* in dorsal view is distinct from *Bufo calamita* (Fig. 3) in lacking a linea transversalis (a curved linea transversalis is present in *B. calamita*), (2) in having a straight linea occipitalis (curved in *B. calamita*), (3) in having a smaller, more acute process occipitalis, (4) in having a truncate rather than an acute process occipitalis, (4) in

having a truncate rather than an acute pars frontalis, and (5) in having the posterolateral edge of the bone indented just anterior to the process prooticalis (straight in *B. calamita*). Character 4 is the most obvious one in the fossils examined. Böhme (1977, Fig. 2, p.4) provides a figure that illustrates the above terms.

The sacrum has also been shown to be a useful bone in distinguishing species of European *Bufo* (Böhme, 1977). The sacrum of *Bufo bufo* in dorsal view is distinct from that of *Bufo calamita* in (1) having less flared sacral diapophyses, and (2) in having much more anteriorly directed condyles (Fig. 4). Character 2 is the most obvious one in the fossils examined.

Bufo bufo occurs in the area today (Frazer, 1983).

Bufo calamita Laurenti

Identified Material. ILIA: B.S.R.S. IV seven left and four right BM(NH) R-10183, seven left and seven right BM(NH) R-10188, one left and one right BM(NH) R-10197, and one left BM(NH) R-11161. FRONTO-PARIETALS: B.S.R.S.IV one left BM(NH) 11163. SACRA: B.S.R.S.IV four BM(NH) R-11162.

This is a minimum number of 16 individuals of *Bufo calamita* based on 16 left ilia.

Remarks. Characters for distinguishing the ilia, frontoparietals, and sacra of *Bufo calamita* from *Bufo bufo* have been given in the section on *Bufo bufo*. *Bufo calamita* has only once before reported as a fossil from Britain from the Ightham Fissures Site in Kent (Holman, 1985).

Bufo calamita is probably extinct in Devon today, as the single record for the county is more than twenty-

five years old (Frazer, 1983). Why the fossils are restricted to one level (B.S.R.S.IV) is not known, but it might be because of some selective taphonomic phenomenon. Fig. 1 shows the single historic record of *Bufo calamita*, as well as the location of the Cow Cave Site.

Family Ranidae

Rana temporaria Linnaeus

Identified Material. ILIA: B.S.F.S.II three left and two right BM(NH) R-10181, five left and one right BM(NH) R-11164; B.S.R.S.IV 18 left and 13 right BM(NH) R-8901, one left BM(NH) R-10193, one right BM(NH) R-10195, and 8 left and 15 right BM(NH) R-10196. FRONTO-PARIETALS: B.S.F.S.II right BM(NH) R-11169; B.S.F.S.II left BM(NH) R-11168. SACRA: B.S.R.S.IV two BM(NH) R-11164.

This is a minimum number of 36 individuals based on 36 left ilia.

Remarks. The ilium of the genus *Rana* may be separated from that of *Bufo* on the presence of an ilial blade (vexillum of Böhme, 1977) in *Rana* and its absence in *Bufo* (compare Figs. 1 and 2 of Holman, 1985). The ilial blade of *Rana temporaria* differs from those of other species of European and American *Rana* in having the ilial blade depressed and reduced anteriorly.

The frontoparietal of *Rana* may be separated from that of *Bufo* in that it has the lateral edge of the bone (in dorsal view) gently curved, whereas in *Bufo* it forms almost an acute angle (Fig. 3). *Rana temporaria* appears to have one of the most gently curved lateral edges of this bone of any European species (see Fig. 5 of Böhme, 1977).

The sacrum of *Rana* is easily distinguished from that of *Bufo* (Fig. 4) in having an anterior condyle (a cotyle in *Bufo*) and in having cylindrical diapophyses (flared in *Bufo*). The sacrum of *Rana temporaria* has the sacra: diapophyses directed more posteriorly than in other European species.

Rana temporaria occurs in the area today (Frazer, 1983).

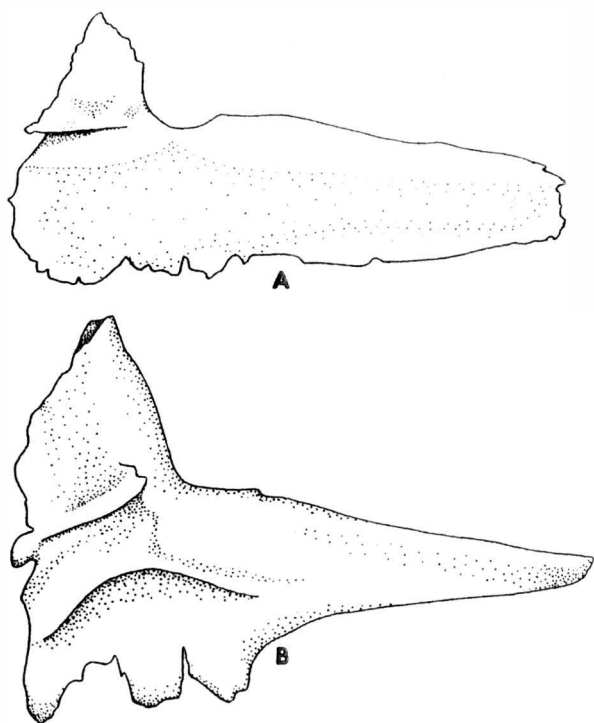


Fig. 3 Left frontoparietals of modern *Bufo* in dorsal view redrawn from Böhme (1977). A, *Bufo bufo*; B, *Bufo calamita*. No scale provided.

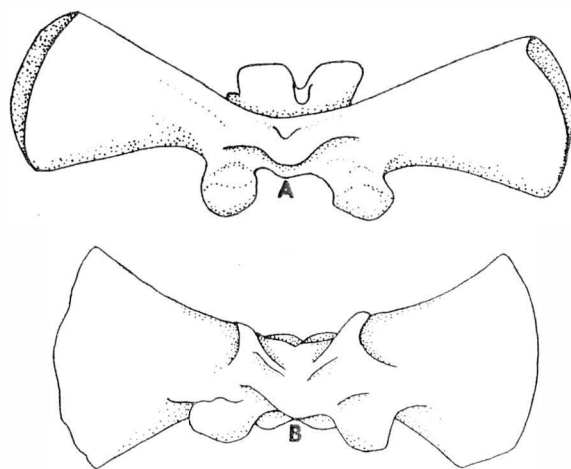


Fig. 4 Sacra of modern *Bufo* in dorsal view redrawn from Böhme (1977). A, *Bufo bufo*; B, *Bufo calamita*. No scale provided.

Class Reptilia
Order Squamata
Family Anguidae

Anguis fragilis Linnaeus

Identified Material. JAW ELEMENTS: B.S.F.S.II four left and two right dentaries and three maxillary fragments BM(NH) R-8907; B.S.R.S.IV one left dentary BM(NH) 8904. VERTEBRAE: B.S.F.S.II 26 BM(NH) R-10191; B.S.R.S.IV eight BM(NH) R-10199.

A minimum number of five individuals is indicated by the five left dentaries.

Remarks. Skeletal elements of *Anguis fragilis*, including skull bones, jaw bones, vertebrae, osteoderms, and even ribs are quite distinguishable from those of other British and European reptiles. This is due to the many modifications for a limbless, fossorial condition. Smith (1973, Fig. 58) provides fine illustrations of the skull, and another illustration (Fig. 57) of a middle caudal vertebra of *Anguis fragilis* compared with that of a *Lacerta vivipara*.

Anguis fragilis occurs in the area today (Frazer, 1983).

Family Viperidae
Vipera berus (Linnaeus)

Identified Material. VERTEBRAE: B.S.F.S.II one BM(NH) R-11154; B.S.R.S.IV two BM(NH) R-10198.

A minimum number of one individual is indicated.

Remarks. *Vipera berus* has a longer, more slender hypapophysis and a lower neural spine than in *Natrix natrix* (see Fig. 3 in Holman, 1985). Szyndlar (1984) discusses additional vertebral characters that separate *Vipera berus* from other snake species.

Vipera berus occurs in the area today (Frazer, 1983).

DISCUSSION AND SUMMARY

The late Devensian/early Flandrian Cow Cave Site, Chudleigh, Devon, has yielded a rather depauperate 'Rana-Bufo' dominated, fossil herpetofauna. *Bufo bufo* (Table 1) is clearly the dominant faunal element, with *Rana temporaria* being the next most abundant species.

has been collected in Devon from only one locality during historic times, and this was over twenty-five years ago.

Table 1 compares the Cow Cave, Devon, herpetofauna with that of the Ightham Fissures, Kent, herpetofauna. Dr. A. S. Cooke (pers. comm.) has informed me that it would be unusual to find a herpetological assemblage in Britain today as large as that of the Ightham Fissures. Holman (1985) suggested that the Ightham Fissures herpetofauna might indicate a time very early in the Flandrian when the climate had just become about as warm as it is in southern England today.

It is tempting to suggest that the depauperate Cow Cave herpetofaunal assemblage may suggest a somewhat earlier, cooler time than the Ightham Fissures fauna. But it also may be possible that the Cow Cave assemblage is the result of some unknown taphonomic event. Does the fact that *Bufo bufo* and *Bufo calamita* at Ightham Fissures have a one to one ratio to each other, and that Cow Cave *Bufo bufo* is about 10 times as abundant as *Bufo calamita* bear on any climatic or ecological changes, or was this situation also produced by unknown taphonomic events? Only additional stratigraphically-controlled studies are likely to answer these questions.

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Cow Cave Species and Minimum Number of Individuals		Ightham Fissures Species and Minimum Number of Individuals	
<i>Bufo bufo</i>	124	<i>Triturus</i> sp.	3
<i>Bufo calamita</i>	16	<i>Bufo bufo</i>	12
<i>Rana temporaria</i>	36	<i>Bufo calamita</i>	12
<i>Anguis fragilis</i>	5	<i>Rana temporaria</i>	391
<i>Vipera berus</i>	1	<i>Anguis fragilis</i>	19
		<i>Natrix natrix</i>	8
		<i>Coronella austriaca</i>	2
		<i>Vipera berus</i>	2
TOTAL	182	TOTAL	449

TABLE 1: Fossil herpetofauna of Cow Cave, Devon, compared with that of Ightham Fissures, Kent.

This is only the second record of the endangered species *Bufo calamita* as a British fossil. This species

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DATA ON AGE AND LONGEVITY IN *GALLOTIA GALLOTI* (SAURIA, LACERTIDAE) ASSESSED BY SKELETOCHRONOLOGY

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ABSTRACT

Femurs of 73 *Gallotia galloti* caught in different localities and belonging to two subspecies living in Tenerife (Canary Islands) were analysed by skeletochronology. The bones possessed annual rings like in many other lizards. For a high percentage of individuals, a remnant of the embryonic bone and a birth line of arrested growth remained present throughout life because cortical resorption never completely removed the first annual rings. Thus the age of an individual can be directly calculated from the number of lines of arrested growth. In the sample studied here, the oldest lizards were at least 8 or 9 years old. They reached sexual maturity during their second or third year of life.

INTRODUCTION

There are many papers on distribution, systematic, phylogeny, microevolution (e.g. Böhme & Bings, 1975, 1977; Böhme & Bischoff, 1976; Böhme *et al.*, 1981; Molina Borja, 1981; Bischoff, 1982, Castroviejo *et al.*, 1985; Baez & Thorpe, 1985; Thorpe *et al.*, 1985) and some behavioural aspects (Böhme *et al.*, 1976) of the extant lizards of the genus *Gallotia* (Arnold, 1973) from the Canary Islands. In a special symposium, recently held in Germany (Böhme & Hutterer, 1985), on the herpetofauna of Canary Islands, more than half of the twenty six papers presented dealt with the extinct and living species of *Gallotia*. Studies on the ecology of these lizards are still scarce though.

In this preliminary paper, the subspecies *G. g. galloti* from the south slope of Tenerife Island and *G. g. eisentrauti* (Bischoff, 1982), from the north slope of the Island were studied. The species occupies the most diverse habitats on the island, from the seashore up to the highest peaks (maximum altitude: 3717 m). The density of the populations is normally very high. These lizards are omnivorous although adults are predominantly frugivorous, whilst young are predominantly insectivorous. The reproduction in *G. galloti* begins in spring and continues throughout the summer when the first young animals appear. The number of eggs laid by the two subspecies studied varied between three and six.

The method used to assess age, longevity, time of maturity and growth pattern was skeletochronology (Castanet *et al.*, 1977). This method has already been used in many other lizards studies (e.g. Smirina, 1974; Pilorge *et al.*, 1981; Castanet, 1982; Nouria *et al.*, 1982; Cheylan, 1984; Castilla & Castanet, 1986).

MATERIAL AND METHODS

The genus *Gallotia* is endemic to the Canary Islands and comprises four extant species: *G. simonyi*, *G. stehlini*, *G. atlantica*, and *G. galloti*. The latter inhabits the islands of Tenerife, La Palma, La Gomera and Hierro. For more information see Baez (1984). A total of 76 *G. galloti* (39 adult males, 23 adult females, 14 juveniles of unknown sex) of various sizes were caught in different months of the year and from different places and altitudes on Tenerife (Fig. 1). The lizards were preserved in 70 per cent alcohol and were also used for other biological studies. All specimens were of unknown age. A preliminary skeletochronological analysis was made on four lizards (not included here) to determine whether the femur, the humerus or the phalanges had the most reliable bones growth pattern for the purposes of this study. The femur, where skeletal growth marks have the most legibility, was chosen for the whole sample analysis but use of phalanges in future ecological studies remains a real possibility in this species. After removing the muscles, the femurs were demineralised for 10 hours in 5 per cent dilute nitric acid. A section measuring about a quarter of the length of the bone was removed with a razor blade at the level of the diaphysis. The bones were cut with a freezing microtome into sections of twenty μm thick. They were stained for thirty minutes with Ehrlich's hematoxyline. The mid diaphysis had the highest ratio of external diameter to medullary cavity and so provided the best definition of the lines of arrested growth. About twenty sections from the mid of each individual diaphysis were mounted with

aquamounting medium for microscopic examination. For accurate comparison, one slide of each individual was photographed at the same magnification.

RESULTS

The bone structure of *G. galloti* was similar to that of many other Lacertidae. In the femoral or humeral diaphysis the periosteal cortex was avascular and consisted of a compact parallel-fibred bone tissue. In some old individuals this bone can become sub-lamellar. In the phalanges, the diaphyses were commonly composed of a true lamellar bone tissue. This histological difference (e.g. Amprino, 1947; Ricqlès, 1968, 1975, 1976; Castanet, 1982; Castanet *et al.*, 1987) indicated that the rate of bone deposition was lower in the phalanges than the femur or the humerus.

All three bones showed an endosteal resorption process. For juveniles younger than one year and some older lizards, this resorption process was seen in only one part of the medullary cavity. On the other part we observed the deposition of endosteal and typical lamellar bone laid down after a small bit of resorption (e.g. Fig. 7). A typical scalloped cementing resorption line separated this endosteal bone from the outer periosteal cortex (Fig. 6). This overall remodelling process lead to the progressive drift of the bone centre during growth.

On the reconstructed side, the embryonic bone was always partially preserved, even in the oldest specimens. As in many other lizards, this embryonic cortex was made of a rather woven fibred bone tissue and appeared clearer (i.e. less hematoxylinophilic) than the other part of the outer periosteal cortex (Figs. 3, 4, 7). Hematoxylinophilic Lines of Arrested Growth (LAGs) were present in every bone and showed different patterns of spatial arrangement (Figs. 3, 4, 5, 6, 7). For the species used in this study we lack data concerning the exact periodicity of the LAGs, but previous studies with temperate reptiles and amphibians (e.g. Francillon, 1979; Buffrénil, 1980; Hemelaar, 1981; Castanet, 1985; Francillon & Castanet, 1985; Hutton, 1986; Zug *et al.*, 1986) have shown the annual (winter) LAG deposition. We assume *a priori* that LAGs were also annual for *G. galloti*. In most of the lizards examined, LAGs are generally well defined. Sometimes they appear as a double line (e.g. Fig. 7) which generally indicates a single year of growth (Castanet, 1982).

In all specimens we observed a first dense hematoxylinophilic line surrounding the embryonic bone. There was the single LAG present for the three lizards caught in November (No. 456 — Fig. 2), February (No. 96) and March (No. 160). On the basis of their size, proportions and date of capture these lizards were considered to be less than one year old. We presume that in the genus *Gallotia*, this line which surrounds the embryonic bone corresponds to a hatching line, as in other lizards previously examined (e.g. Smirina, 1974; Castanet, 1985). For lizards No. 96 and No. 160, osteogenesis probably had not started when they were caught. This might explain why the LAG of the first winter (which probably corresponds

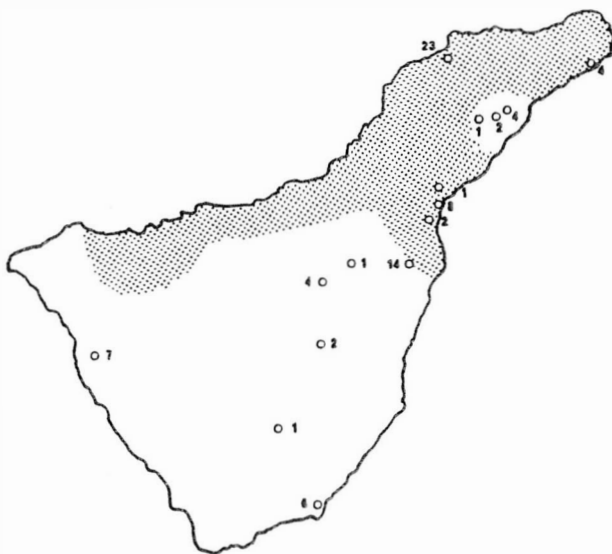
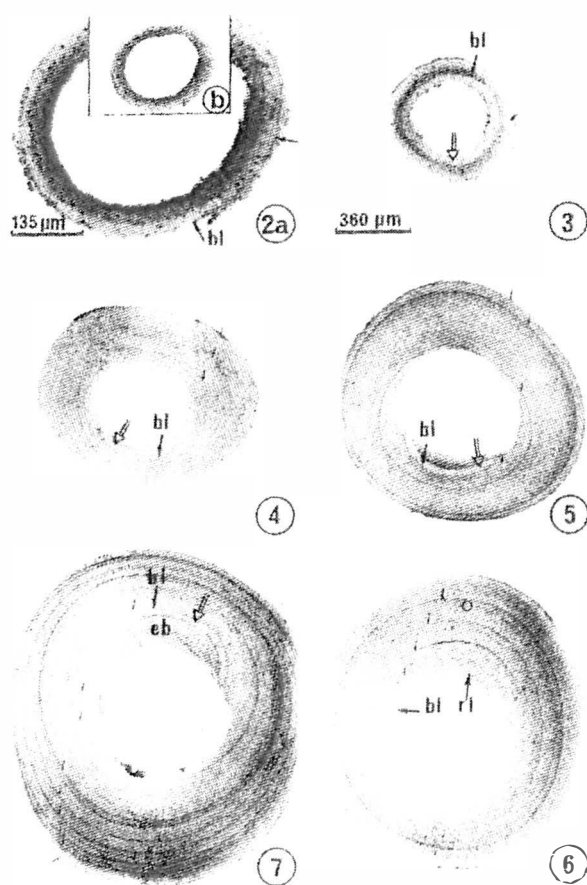


Fig. 1 Tenerife. Number of lizards from each site. Shaded area = distribution of the subspecies *G. g. eisentrauti* (38). *G. g. galloti* are in the white area (42).



Figs. 2 to 7 *Gallotia galloti* Successive growth stages of the femoral shaft. Each picture except for No. 2a is at the same magnification. Fig. 2a and 2b Lizard No. 456. Young of the year caught in November. A single LAG, birth line (bl), can be seen near the periphery of the bone. Fig. 3 No. 12, Juvenile caught in July and probably about one year old. The birth line and this of the first winter can be seen. The white arrow shows the embryonic bone. Fig. 4 No. 210, caught in April. Three LAGs. 2 to 3 years old (according to the unknown birth date). The third is very near the periphery of the bone. Embryonic bone is present. Endosteal bone deposition is just at the beginning (e. b.). Fig. 5 No. 172, caught in March, 4 LAGs. 3 to 4 years old. Fig. 6 No. 44, caught in August. 4 LAGs. About 4 years old. The spatial sequence of year rings is different from that of Fig. 5. Bone deposition is probably not yet finished at the periphery. Notice an additional hematoxylinophilic line close to the LAG No. 4 (circle). Fig. 7 No. 32. One of the oldest lizards caught in August. 8 LAGs can be counted. The LAG of the first winter is thin. The fourth and the eight are double. This specimen is at least an 8 year old one. e.b. = endosteal bone.

to the time of decreasing growth rate for *G. galloti*) is not yet distinct from the bone periphery.

For all the other individuals which had experienced at least one winter and which were caught during their growth period (April, May, June ...), the bone beyond the birth line generally showed a LAG which corresponds to the first winter (Fig. 3). Depending on the individual, the birth line and the first winter LAG appeared close together or well separated. Below we discuss the significance of this feature. In general, LAGs 1 to 3 or 1 to 4 were separated by a large increment of bone due to the very fast bone growth from the first to the third (or fourth) year of life. After

the third or fourth LAG, the bone thickness between successive LAGs decreased (Fig. 7). This phenomenon was related to the decrease in growth rate of adults. This 'break' in the spatial sequence of the LAG (e.g. Castanet, 1982) suggests that in *G. galloti* sexual maturity is reached before the third or the fourth year of life.

In the present sample, the oldest lizards (Nos. 30; 32) showed 8 (or 9) LAGs (Fig. 7). Therefore ecological longevity of *G. galloti* was at least 8 or 9 years.

DISCUSSION

In the present study we noticed that the size of lizards progressively increased with age until the third to fourth age group (Fig. 8). After this age we observed very little further growth in adults. This is a general phenomenon in poikilothermic animals after sexual maturity. It indicates once again that size cannot be a reliable criterion for age determination in lizards.

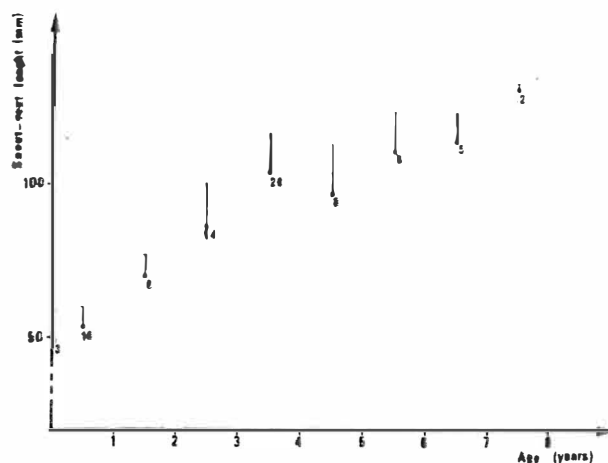


Fig. 8 Growth curve of *Gallotia galloti* from Tenerife. Each point corresponds to the average of individual sizes (and standard deviation) for the different age groups estimated by skeletochronology. Because of the small number of animals and their heterogeneity (2 subspecies, different altitudes, males and females) it was not possible to separate the different categories.

One of the main problems encountered in this analysis and already discussed in relation to many other species of lizards was the position of the first year LAG and its relation to the birth line. The thickness of the bony crown between these two lines corresponds to the duration and intensity of growth during this period (Pilorge & Castanet, 1981; Nouria *et al.*, 1982; Castanet & Gasc, 1985). As growth stops at the same time of the year (generally in winter), it appeared that the hatching period was spread throughout much of the early spring up to the beginning of autumn. However, in few individuals, the distance between the birth line and the first LAG was so large that it can only correspond to a full one year growth. In these conditions, the first LAG encountered would belong to the second season of arrested growth. Two hypotheses can be proposed here. First, the lizard was hatched late in autumn and no osteogenesis occurred until the first winter. In this situation the birth line and

the first winter LAG would be merged. Second, as already stated before, the LAG of the first winter is generally less distinct than the later ones (Castanet & Gasc, 1985; Castilla & Castanet, 1986) or, sometimes, completely lacking. This phenomenon could be related to the continuation of the growth during the first winter, owing to the strong intrinsic growth of the juveniles, which would reduce the influence of the adverse environmental conditions. However, presently there are no rigorous data to test these hypotheses although based on lizards 160, 456 and 96, the first hypothesis seems here better than the second one. Consequently, for some individuals, the age of the first LAG beyond the birth line remains uncertain, and their age is estimated with a potential margin of error of one year.

In our sample, males and females from both high and low altitudes sometimes showed double randomly distributed LAGs (Fig. 6, 7). The cause of this remains uncertain (Castanet, 1982). Briefly, it may be related to individual variations, pathologic injury or atypical climatic conditions. It may also correspond to two periods of arrested growth in a year (hibernation and a estivation; see Caetano *et al.*, 1985). We suggest that the latter explanation is plausible for at least some individuals but confirmation would have to come from appropriate field observations. Anyway, taking account of previous results and experimental data on lizards (e.g. Castanet, 1982, 1985), each double LAG observed can be counted as one year without ambiguity. Thus the error in age determination for individuals with such supplementary LAGs cannot exceed one year.

Another phenomenon encountered in this histological analysis was the great variability of the spatial arrangement of the LAGs. Two main patterns were recognised. In the first case, all LAGs were relatively close together, and in the second case they were very far apart. It is difficult to interpret this variability between the different individuals and to propose some causal relation with any particular parameter such as sex or environmental conditions because the two patterns are shown by a rather equal number of males and females or lizards from different altitudes, or from the south and the north of the Island. Of course several factors may explain such features. One of them is the variation of growth rate directly related to the genetical programme of each individual. Another factor may be connected with the individual competition for food. In fact, in Tenerife, the population density of *G. galloti* is very high (in some places it reaches more than 500 individuals/ha), and perhaps the supply of food is insufficient for all the lizards, although Molina Borja (1985) found a great food availability in the areas where he studied *G. galloti*. Moreover we must not forget that the sample studied here does not come from a homogenous population and finally that in the various places where the lizards were caught, the microclimates are often different and can lead to some differences in the individual growth patterns. In order to make a more meaningful comparison of the spatial sequence of LAGs, it would be better to use individuals from the same locality.

The intensity of endosteal resorption in *Lacerta lepida* (Cheylan, 1984; Castilla & Castanet, 1986) leads to the removal of the first and sometimes the second LAG, and occurs along the entire border of the medullary cavity. In *G. galloti*, the endosteal resorption was eccentric (Fig. 7) and consequently a part of the embryonic bone and the LAGs beyond it, permanently remain in some regions throughout life, except in 2 per cent of the lizards. In *L. lepida* the endosteal bone deposition is scarce or lacking, but in *G. galloti* some lamellar endosteal bone occurs just beside the embryonic bone in adults. This fact is interesting because: first, for *G. galloti* no 'back calculation' to assess the age of the first line encountered is necessary (e.g. Castanet & Cheylan, 1979); second, this histological difference probably constitutes a distinctive character between two species (*L. lepida* and *G. galloti*) closely connected by size, growth and longevity. This character could be very useful in the case where only the bones from fossils specimens would be available.

ACKNOWLEDGEMENTS

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DIEL PATTERNS OF ACTIVITY AND VERTICAL MIGRATION IN TADPOLES OF THE COMMON TOAD, *BUFO BUFO*

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ABSTRACT

The diel pattern of activity and vertical migration of common toad tadpoles, *Bufo bufo*, was studied at Llysdyndnam pond in mid-Wales in 1985 and 1986. Toad tadpoles were predominantly day-active with peaks mainly occurring between 1400 h and 2000 h. The diel activity pattern corresponded with daily cycles of illumination and temperature, but no consistent relationship with the activity of predatory dytiscid beetles was observed. Differences between 1985 and 1986 in the pattern of vertical migration within the water column could be related to the distribution of submerged plants in the pond. In both years, however, tadpoles occurred mainly in the middle of the water column during the day.

INTRODUCTION

Although it is well-known that anuran tadpoles may form aggregations around the edges of ponds during the day, and disperse into deeper water by night (Mullally, 1953; Beiswenger, 1977; Beebee, 1985; Griffiths, 1985a) other aspects of their daily activity patterns have been little studied. As well as horizontal movements from shoreline to deep water within a pond, amphibian larvae may display vertical movements within the water column, as demonstrated by a number of urodele larvae (Anderson & Graham, 1967; Anderson & Williamson, 1974; Branch & Altig, 1981; Holomuzki & Collins, 1983). Daily cycles of illumination and temperature are certainly important in regulating tadpole activity patterns (Beiswenger, 1977; Griffiths, 1985a), but also of importance are the activity cycles of potential predators. The larvae of tiger salamanders (*Ambystoma tigrinum*), for example, alter their activity patterns in the presence of dytiscid beetles and this may minimise the risk of predation (Holomuzki, 1986).

At Llysdyndnam pond in mid-Wales common toad (*Bufo bufo*) tadpoles suffer heavy predation from both larval and adult great diving beetles (*Dytiscus marginalis*), and in some years the tadpole population may be eliminated completely (Harrison, 1985). Preliminary qualitative observations revealed that during the daytime tadpoles could be seen actively swimming in the pond. At night, however, this swimming activity became much less evident, with tadpoles remaining immobile or swimming short distances only. This suggested that catches of tadpoles in funnel traps might reflect activity.

In this paper we (1) examine the diel activity patterns of common toad tadpoles in relation to microhabitat, illumination, temperature, and great diving beetle activity and (2) describe the stratification of tadpoles within the water column.

MATERIALS AND METHODS

Llysdyndnam Pond, Newbridge-on-Wye, is situated about 200m above sea level, has a surface area of just under 900m², and had a maximum depth of 0.7m at the time of the study. Open water occupies about 300m² of the total surface area of the pond, the remaining 600m² consisting of *Glyceria maxima* swamp. The pond is completely surrounded by a plastic barrier and pitfall trap system and the breeding migrations of amphibians at the pond have been monitored annually since 1981 (Harrison, *et al.*, 1983; Gittins, 1983; Griffiths *et al.*, 1986).

The study sites within the pond were (1) the shoreline of the open water, which was about 30m in length and lined with *Glyceria maxima*, and (2) the deep, central area of the pond which was about 0.7m deep. In 1985 the water column in the deep area of the pond was free of vegetation. This was a result of the drought during the previous year, which eliminated a large proportion of the submerged plants. By 1986, however, the vegetation had recovered and the water column was occupied by a dense growth of submerged plants (mainly *Ceratophyllum demersum*).

The funnel traps described by Griffiths (1985b) were used for monitoring tadpole behaviour in each of the two study areas. In the shoreline area, ten traps were submerged close to the edge of the pond in about 0.15m of water. The traps were spaced out at 3m intervals and were positioned so that they faced towards the pond centre. In the deep water area tadpoles were captured at different depths using sets of three traps strung together vertically. Each vertical set consisted of one trap positioned just below the water surface, the second at about 0.35m depth, and the third resting on the pond bottom at 0.7m. Four sets of traps were suspended about 3m apart from a 0.2m wide wooden bridge which spanned the open water area of the pond. To reduce shading effects, the traps were

suspended from the ends of 0.5m long rods placed at right-angles to the bridge. A further four sets of traps were placed along the edge of the *Glyceria* swamp where it bordered the open water area. Here the traps were attached to canes driven into the pond bottom with access being gained by a dingy. This trapping regime therefore covered all the microhabitats available to tadpoles in the open water areas of the pond.

Toad tadpole behaviour was studied during May and June of 1985 and 1986 by checking the traps every 2h over several 24h periods. In 1985 these were 27-28 May and 31 May-1 June (i.e. two 24h periods), whilst in 1986 the dates were 27-28, 29-30 May, 1-2, 5-6, 11-12 and 17-18 June (six 24h periods). Trapping sessions conducted after these dates revealed very few tadpoles. The toad tadpoles captured in each trap were counted and then released. It was assumed that the number of tadpoles captured per 2h interval reflected tadpole activity over that period. All tadpoles were at Gosner (1960) stages 26-30 and were between 15 and 20mm in length.

Over the last three days of the study in 1986 the number of adult and larval stage great diving beetles, *Dytiscus marginalis*, captured in the traps was also recorded. Measurements of water temperature at the top and bottom of the water column were taken using a mercury thermometer, and illumination at the pond surface was recorded using a portable illuminometer.

RESULTS

In 1985 the total number of tadpoles captured was 1429 on day 1 and 379 on day 3. This dramatic drop in numbers over a few days was also observed in 1986. On days 1 to 5 in this year the number of tadpoles captured ranged from 1366 (day 2) to 3162 (day 5) and then fell

to only 38 on day 6. In total, 11,643 tadpoles were captured over the six days in 1986.

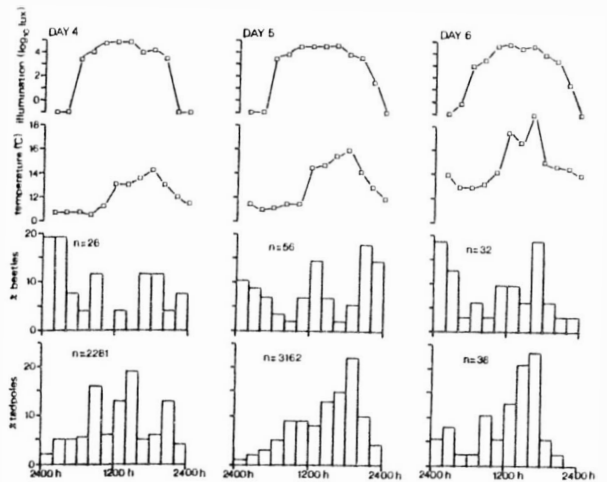


Fig. 2 The diel activity pattern of toad tadpoles on days 4, 5 and 6 1986, displayed in relation to illumination, temperature (mean of measurements taken at the top and bottom of water column) and dytiscid beetle activity.

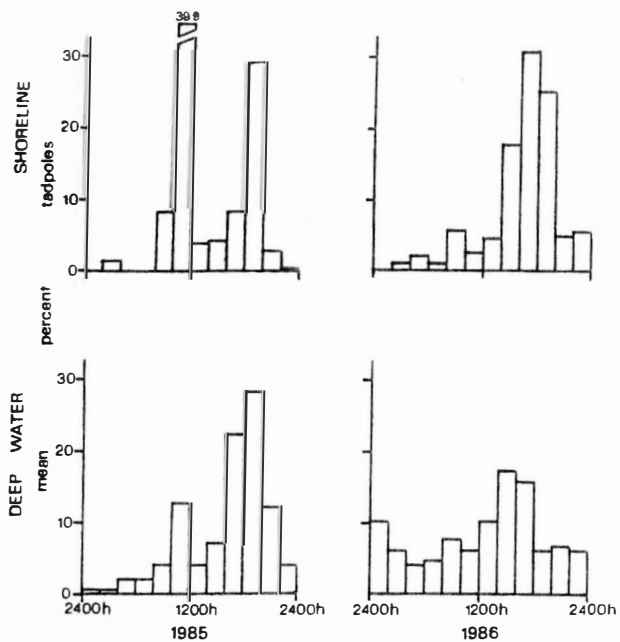


Fig. 1 Diel patterns of activity of toad tadpoles in different regions of Llysdyrnau pond in 1985 and 1986. Percentage activity every 2h was averaged over 2 days (1985) and 6 days (1986).



Fig. 3 Diel patterns of toad tadpole stratification in the water column in 1985 and 1986. The percentage captured at each level was averaged over 2 days (1985) and 5 days (1986). Data from day 6 in 1986 were omitted from the analysis as few tadpoles were captured in the deep water area on this day.

Toad tadpoles were mainly day-active with most captures being made in the afternoon and early evening (Fig. 1). With the exception of the shoreline in 1985, tadpole activity peaked between 1400h-2000h. The overall diel activity pattern appeared to be related to both illumination and water temperature (Fig. 2). The activity of dytiscid beetles varied from day to day and was neither clearly nocturnal or diurnal. No clear relationship between tadpole activity and dytiscid beetle activity was evident. However, on all three days beetle captures were high from 2400h-0400h, a period when there was little tadpole activity.

In the deep water areas most tadpoles were captured in the middle of the water column in both years (Fig. 3). However, there were clear differences between the two years in the pattern of vertical migration. In 1985 the majority of tadpoles spent the night on the bottom of the pond. During the morning there appeared to be a steady migration into the middle of the water column where most tadpoles stayed until nightfall. This was followed by a return to the pond bottom. The following year, however, tadpoles were captured in midwater throughout the diel cycle and a clear pattern of vertical migration was much less evident. Rather more tadpoles were captured at the top of the water column in 1986 than in 1985 although this surface-dwelling behaviour was largely confined to the afternoon hours.

Over days 4-6 in 1986 the percentage of tadpoles captured in deep water ranged from 32 to 91 per cent, whilst that of beetles was 48-69 per cent. Thus the distribution of both tadpoles and beetles between shoreline and deep water varied from day to day and no consistent relationship between the two could be established. The number of beetles captured was too low to obtain a meaningful picture of their diel vertical distribution pattern. However, pooling data over days 4-6 suggested that beetles preferred the upper layers of the water column both by day and by night (Table 1), although statistical analyses of these data showed that this trend was not significant.

	N	Top	Middle	Bottom
DAY (0600-2000h)	45	36%	36%	29%
NIGHT (2200-0400h)	19	63%	21%	16%

TABLE 1: The distribution of *Dytiscus marginalis* (larval and adult beetles pooled) within the water column during daytime and night-time. Differences between the three regions were not significant (Friedman two-way analyses of variance: day, $\chi^2_r = 1.31$, $P < 0.05$; night, $\chi^2_r = 4.87$, $P < 0.05$).

DISCUSSION

There is some evidence to suggest that toad tadpoles may display changes in microhabitat selection during development (Beebee, 1985). Unfortunately, it was not possible to monitor ontogenetic changes in behaviour during the present study as no tadpoles beyond Gosner

(1960) stage 30 were captured in the pond in either year. This was a result of the dramatic drop in tadpole numbers observed in June of both years. A possible explanation for this decline is that tadpoles move into the swamp area of the pond at this stage of development and are consequently no longer captured around the shoreline and in deep water. However, traps placed in the swamp after the decline captured very few tadpoles. A much more likely cause of the drop in numbers is predation by invertebrates, especially by larvae and adults of the beetle *Dytiscus marginalis*. These have been shown to be responsible for heavy predation of toad tadpoles in the pond over short periods of time (Harrison, 1985).

Occasionally, certain traps captured exceptionally large numbers of tadpoles which may have reflected social aggregations. As these aggregations would have resulted in fewer tadpoles available for capture at other trap sites it seems unlikely that the daytime peaks in trap catches were a reflection of aggregation rather than general swimming activity. Indeed, the diel pattern of trap catches corresponds with direct observations of tadpole activity during the day and the night.

Unlike salamander larvae (Holomuzki, 1986), the activity pattern of toad tadpoles was not clearly related to that of great diving beetles. Although the present study was based on fairly low captures of beetles, and larval and adult beetles were pooled in the analysis, the clear-cut nocturnal/littoral habits observed in other species of *Dytiscus* (Aiken, 1986; Holomuzki, 1986) were not apparent in *D. marginalis* at Llysdyinam pond.

Wassersug (1973) describes two modes of schooling in tadpoles. The '*Xenopus*' mode consists of aggregations of polarised tadpoles in midwater, and contrasts with the '*Bufo*' mode, in which tadpoles form up in shallows or on the pond bottom. These two modes of schooling can be related to the morphology, palatability and ecology of tadpoles, and whereas *Xenopus* are well-adapted for filter-feeding in midwater, *Bufo* tadpoles are better adapted for a scavenging existence on the pond bottom (Wassersug, 1973). It was not clear whether the toad tadpoles observed in midwater in Llysdyinam pond were in polarised schools, but in other respects their daytime behaviour conformed more closely to the *Xenopus* mode. Interestingly, these results are consistent with those obtained on *Bufo americanus* by Heyer (1976), who netted most tadpoles in the middle of the water column during the day.

The clear difference between 1985 and 1986 in the diel pattern of vertical migration of tadpoles can be related to the growth of submerged plants over the two years. In 1985, when the water column was devoid of vegetation, toad tadpoles could rest at night only amongst dead vegetation on the bottom of the pond. In 1986, however, inactive tadpoles could rest amongst the vegetation which filled the water column, and thus maintain their midwater position throughout the diel cycle (even during this 'resting' period, however, tadpoles are not completely inactive and may intersperse long periods of immobility with short swims).

Why tadpoles should congregate at all in midwater is less clear. Salamander larvae have been observed to stratify at the pond surface and on the pond bottom at different phases of the diel cycle (Holomuzki & Collins, 1983). Movement into warm water at the surface or in shallows during the daytime may be a result of behavioural thermoregulation, whilst stratification at the surface at night may be associated with feeding activity (Anderson & Graham, 1967; Heath, 1975; Branch & Altig, 1981). If behavioural thermoregulation was taking place in Llysdim pond, toad tadpoles would be expected to congregate at the highest temperatures (i.e. shoreline and pond surface) during the day, but this was not the case. Most toad tadpole activity is probably concerned with filter-feeding and vertical migrations may follow those of the plankton upon which the tadpoles feed. Indeed, the midwater congregation observed at Llysdim pond is consistent with a study of toad tadpole gut contents from the same site, which has shown that the diet contains a high proportion of motile plankton but little detritus (Harrison, 1985). Alternatively, as *Bufo bufo* tadpoles are lungless until just before metamorphosis (Savage, 1961), variations in oxygen concentration within the water column may influence activity.

ACKNOWLEDGEMENTS

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CRYOSURGERY IN THE TREATMENT OF SKIN DISORDERS IN REPTILES

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ABSTRACT

Cryosurgery has been used for the treatment of skin disorders in two lizards and a chelonian. The results of this and a previous application (Green *et al.*, 1977) indicate that cryotherapy may be a valuable surgical tool for use in reptilian veterinary science.

INTRODUCTION

Cryosurgical techniques, employing ultra low temperatures to destroy unwanted tissues, have a long history in medical practice (Baxter, 1977a; 1977b). Reports, however, of their application in the treatment of reptilian ailments are rare indeed. In a review (Cooper & Jackson, 1981) only a single reference was cited for the use of cryotherapy on a reptile (Green *et al.*, 1977). This dealt with the treatment of necrotic stomatitis in a python (*Python molurus*) using a liquid nitrogen spray (see Baxter, 1977b). The results of this application lead the authors to suggest cryotherapy as an alternative to conventional methods for treating chronic lesions of the reptilian integument and buccal cavity. However, since this report no further descriptions of cryosurgery on reptiles have appeared in the literature, although Frye (1981) suggested the possibility of using cryosurgery in cases where excision is inappropriate. This paper gives details of the case histories of its use in the treatment of skin disorders in two lizards and a chelonian.

METHODS AND MATERIALS

SPECIMENS

1. *Lacerta viridis*. A female about 4.5 years old was brought to the surgery of J.S.B. with a large irregular keratinised growth immediately anterior to the left shoulder area (Fig. 1a). The growth resembled the papillomas of the skin often observed in Lacertid lizards (e.g. Koch, 1904; Stolk, 1953; Lopez & Bons, 1981), although their most frequent occurrence appears to be in *L. viridis* (Blanchard, 1890; Plehn, 1911; Schnabel, 1954; Raynaud & Adrian, 1976; Harshbarger, 1965-1977). The owner reported that it has developed over the previous 18 months and was now at the stage where it seriously interfered with limb movement.

2. *Tupinambis teguixin*. An adult female on display at the Department of Pure & Applied Zoology, University of Leeds with a skin lesion on the left rear foot. This had been present for approximately 3 weeks and the only previous treatment had been the protection of the area from abrasion by the application

of an elastoplast dressing. There was a scale deficit of approximately 10mm x 8mm, exposing underlying tissue and the margins of the lesion were under-run. The whole area exhibited a degree of 'sub-cutaneous' oedema.

3. *Terrapene carolina*. A female belonging to a local pet shop had a tense, inflamed, dome-shaped swelling, some 10mm in diameter (Fig. 2a). This was diagnosed to be the result of an infection behind the tympanic membrane of the ear and is a common site for abscess formation in chelonians (Jackson & Lawrence, 1985).

ANAESTHETIC TECHNIQUE

1. *L. viridis*. After a totally ineffective attempt to produce anaesthesia with an 0.05ml/m injection of Saffan (Alphaxalone/Alphadolone 15mg/ml/kgm) the animal was anaesthetised using the gas box principle. A gauze swab was taped to the lid of a cylindrical glass container. Four millilitres of Fluothane was injected into this pad and the lid replaced over the chamber into which the lizard was placed. Between 5-8 minutes the animal was deeply sedated and easily handled but still showed signs of pain sensation. We replaced the lizard in the chamber and an overall time of around 19 minutes was assessed to be sufficient for surgical anaesthesia. However, when cryosurgery was commenced it was found necessary to 'top-up' the anaesthetic by placing the end of a corrugated gas-pipe over the lizard's nose and feeding it a 3 per cent concentration of Fluothane in a 50/50 oxygen nitrous oxide mixture.

2. *T. teguixin*. Due to the superficial nature of this lesion and the relatively pain-free qualities of cryosurgical technique, it was decided that no anaesthesia was required in this case.

3. *T. carolina*. With due consideration to the site of the lesion and its inaccessibility if the animal should withdraw into its shell, adequate anaesthesia was deemed essential. The animal weighed 290 grams and using a recommended dose of 60mg/kg (Green, 1979) 20mgm of Ketamine was injected, using a twenty-five gauge needle, into the quadriceps group of muscles. Although adequate sedation was achieved by 30 minutes, depth of anaesthesia for surgical purposes was reached at closer to 69 minutes post administration.

RESULTS

L. viridis. A PCG 12 nitrous oxide cryo-gun was used to freeze the flattened base of the tumour as it was pulled laterally. Three freeze-thaw cycles were effective in achieving an ice-ball across the whole tissue thickness of the base and extending one or two mm into normal body tissue. After freezing, a crack appeared in the upper part of the tumour making it possible to de-bulk the upper third. The portion removed was submitted for pathology. The exposed base bled a little too freely and following further freezes with a flat faced cryoprobe, the base was ligated to prevent post-operative haemorrhage.

Healing was complete in approximately 4 weeks leaving only a fine grey scar (Fig. 1). Pathology confirmed the lesion to be a papilloma with heavy surface keratinisation. After approximately six months, the patient was represented with a small regrowth of the papilloma on the upper right quadrant of the scarred area. The lesion measured 2mm in diameter and because of the painfree properties of cryosurgical technique in most situations we were able to refreeze the regrowth without anaesthesia, applying a triple freeze-thaw cycle using a nitrous oxide cryogun (PCG 12). In the ensuing three months there has been no recurrence but since cryosurgery can be repeated without major stress to the animal the technique is admirably suited to the treatment of such cases.

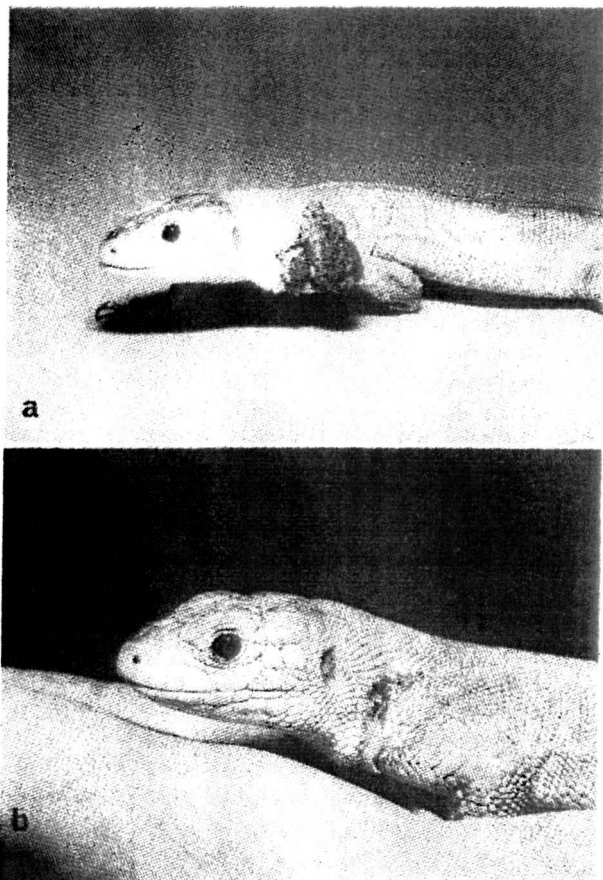


Fig. 1 A green lizard *Lacerta viridis* with a large keratinised papilloma (Fig. 1a). The same animal is shown post-operatively in Fig. 1b; only a minor grey scar marks the area of the lesion.

T. tequixin. A flat probe on the Spembyl PCG 12 cryo-gun was used to destroy the diseased and damaged tissue. The moist nature of the lesion made this freezing technique most effective. Four freeze-thaw cycles were used and following the final thaw, the area was dusted with an antiseptic powder to prevent surface infection. Finally the lesion was lightly covered with a gauze and elastoplast dressing. Four days after the operation the lesion had formed a dry black eschar and from then healing proceeded uneventfully to completion in approximately four weeks. There was no pathological examination made of this lesion. The lizard has been regularly examined over a nine month post-operative period and there has been no recurrence at the site of the original lesion.

T. carolina. The swelling was incised and a caseous core together with a quantity of white creamy purulent fluid expressed (Fig. 2). Swabs were taken from inside the resulting cavity and submitted for bacteriological examination. In the majority of cases, the expression of purulent material together with the establishment of adequate drainage would be sufficient to achieve a cure. In this case however, it was decided that the careful application of a nitrous oxide cryoprobe would contribute significantly to the outcome. Certainly, the cryo-surgical destruction of the infected lining of the cavity and the resultant pain reducing qualities of the technique could only be useful. This was done using four freeze-thaw cycles with the PCG 12 cryo-gun.

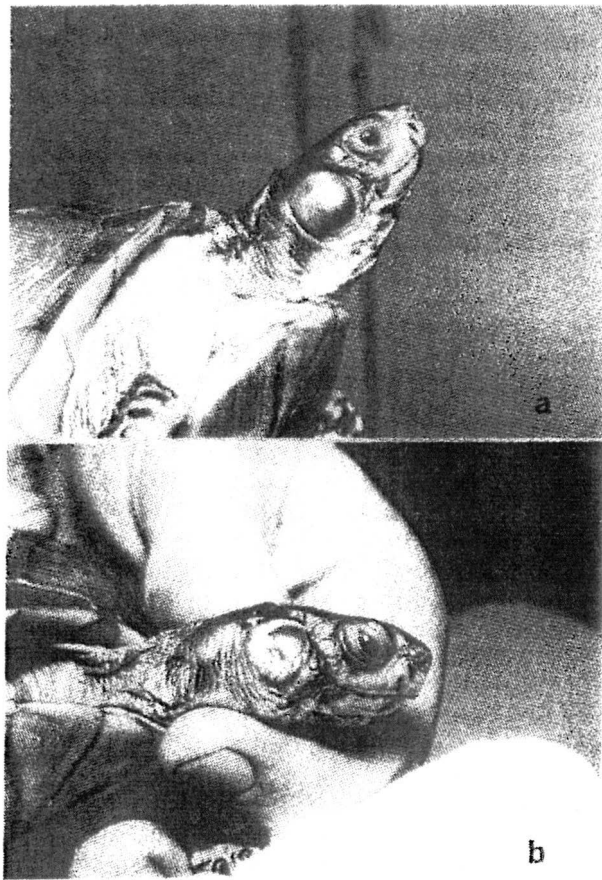


Fig. 2 A tense inflamed lesion on the neck of a *T. carolina* (2a). The lesion immediately after drainage and treatment by cryosurgery (2b).

Healing was again uneventful and the bacteriological examination revealed a profuse growth of beta-haemolytic streptococci.

DISCUSSION

Historically the development and application of cryo-surgery in veterinary science has concerned the physiology of endothermic vertebrates, however, as the results of this paper and the previous application by Green *et al.*, (1977) show it would appear to be an attractive addition to the armoury against accessible disease conditions of reptiles. Cryo-surgery, the use of extremely low temperatures to destroy undesirable tissue, can basically be considered to be nothing more or less than controlled frost-bite in which the frozen tissue dies and is removed by the body itself — either by absorption or sloughing (usually the latter). With its qualities of virtually painless application, lack of haemorrhage, minimal scarring and no need for stitches it could have a lot to offer the field of reptilian medicine, thus for ectotherms and endotherms, it may be the cold cure that really works.

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EGGSHELL STRUCTURE OF LIZARDS OF TWO SUB-FAMILIES OF THE GEKKONIDAE

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ABSTRACT

The aim of this study was to describe and compare shell structure of parchment-shelled and rigid-shelled eggs of gekkonid lizards. Scanning electron microscopy was used to describe eggshells of two species of gecko of the Eublepharinae and four species of Gekkoninae. Eggshell from a lacertid lizard was also described. The crystalline nature of calcium carbonate deposits on eggshells was studied; an aragonitic chelonian eggshell was used as a control. Eublepharine eggshells consist mainly of a fibrous membrane with an external layer of calcite. They resembled lacertid and other lizard shells described previously. Gekkonine eggshells have thin, fibrous shell membranes overlain by a relatively thick layer of calcite and resemble other hard-shelled gecko eggs reported elsewhere. A layer of fibres in a matrix coats the external surface of the calcite layer of gekkonine shells. Shell structure is considered important in determining water loss from gecko eggs, nest location and embryonic development. A more detailed examination of the reproductive biology of gekkonid eggs could help in assessing the role of the shell in reptilian development.

INTRODUCTION

In recent years interest in the structure of reptilian eggshells has increased for two reasons. First, the shell has been used as a taxonomic character (Bustard, 1968) that may also shed some light on the evolutionary relationships between reptiles and birds (Erben, 1970; Packard and Packard, 1980). Second, studies on gas exchange of reptilian eggs have led to research into the role of the shell during incubation (Packard, Taigen, Packard and Shuman, 1979; Packard, Packard and Boardman, 1982a; Packard, Burns, Hirsch and Packard, 1982b).

Oviparous lizards and snakes (Squamata) typically lay soft, parchment-shelled eggs (Halliday and Adler, 1986). Gekkonid lizards are exceptional in this respect; lizards in two sub-families of the Gekkonidae (Gekkoninae and Sphaerodactylinae) lay rigid-shelled eggs (Bustard, 1968), whereas in the other sub-families (Eublepharinae and Diplodactylinae) soft-shelled eggs are laid (Kluge, 1967; Bustard, 1968; Werner, 1972). Published descriptions of eggshell structures have been limited to the Gekkoninae. Light microscopy was used to study *Lepidodactylus lugubris* eggshells (Schmidt, 1943) and scanning electron microscopy was used to examine the shell structure of *Tarentola mauritanica* (Krampitz, Erben and Kriesten, 1972; Erben and Newesley, 1972) and *Hemidactylus turcicus* (Packard, *et al.*, 1982a). This study was therefore undertaken to provide information on the eggshell structure of representatives of two sub-families of gekkonid lizards, the previously unstudied Eublepharinae with soft shells and the Gekkoninae with hard shells. It was

hoped that this would provide information on the functional and taxonomic significance of shell structure in the Gekkonidae.

MATERIALS AND METHODS

Eggshells from six species of gecko were examined. For comparison, a single representative of the family Lacertidae and a single species of the Testudinidae were also studied. The details of the sources of these eggs, the species represented and the number of specimens available are shown in Table 1.

The particular crystal morph of any CaCO_3 present in the shell was identified by using Meigen's reaction (Deer, Howie and Zussman, 1966). This involves boiling shell fragments for two minutes in 0.5 mole.l⁻¹ cobalt nitrate ($\text{Co}(\text{NO}_3)_2$). In this reagent aragonite stains a pink-purple colour whereas calcite remains colourless.

Eggshell structure was studied by immersing fragments in liquid nitrogen for a few seconds so that they could easily be fractured. Two pieces of each shell were mounted on brass stubs using a conductive silver paint and were sputter-coated *in vacuo* with gold (Edwards S150B). The shells were then examined using a JEOL T300 scanning electron microscope at an operating voltage of 25 or 30 kilovolts. The effect of acid treatment to remove any calcium carbonate was assessed by etching fragments of *Eublepharis* and *Chondrodactylus* shell in 1 mole.l⁻¹ hydrochloric acid for thirty seconds prior to examination.

Family Sub-family Species	N	Embryo	Source of eggs
Gekkonidae			
Eublepharinae			
<i>Eublepharis macularius</i>	12	Hatched	The Zoological Society of London, England.
<i>Hemitheconyx caudicinctus</i>	8	Hatched	The Zoological Society of London, England.
Gekkoninae			
<i>Chondrodactylus angulifer</i>	6	Hatched	The Zoological Society of London, England.
<i>Gehyra mutilata</i>	1	Dead	The Jersey Wildlife Preservation Trust, Channel Islands, U.K.
<i>Phelsuma agalegae</i>	1	?	British Museum (Natural History), London. (Specimen Number BMNH 1975. 1165).
<i>Phelsuma guentheri</i>	1	Dead	The Jersey Wildlife Preservation Trust, Channel Islands, U.K.
Lacertidae			
<i>Lacerta lepida</i>	4	Hatched	The Zoological Society of London, England.
Chelonia			
Testudinidae			
<i>Geochelone radiata</i>	1	Infert.	The Jersey Wildlife Preservation Trust, Channel Islands, U.K.

N = Number of specimens; Hatched = Embryo hatched successfully; Dead = Embryo dead in shell at late stage of incubation; Infert. = Infertile egg.

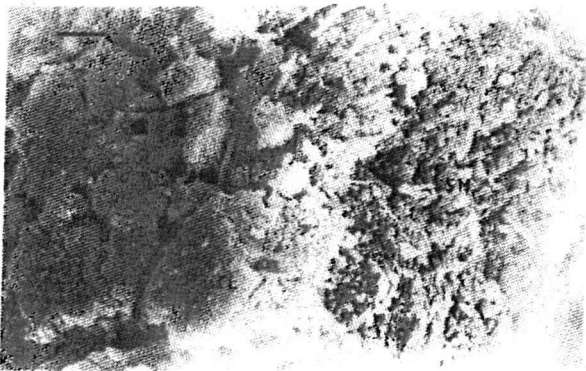
TABLE 1: Details of the numbers and sources of lizard and tortoise eggshells used for structural examination.

RESULTS

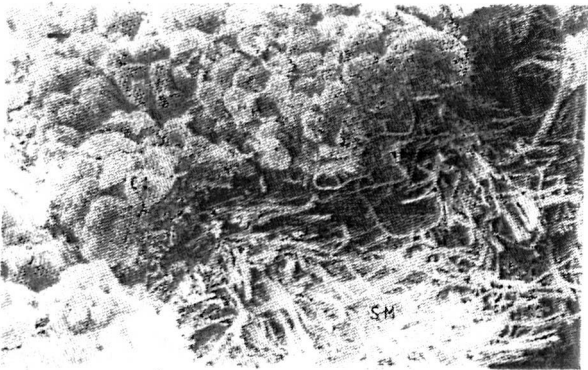
Staining eggshells with cobalt nitrate showed that all the shells in the study were calcitic except that of the tortoise, *Geochelone radiata*, which was aragonitic thus serving as a control for the method.

The structure of eggshells from eublepharine geckos (*Eublepharis macularius* and *Hemitheconyx caudicinctus*) were similar and resembled that of *Lacerta lepida*. The bulk of the shell (90 per cent of the total thickness) consists of fibres (Plates 1a and 1b) with a thin layer of calcite, less than 10µm thick, on the shell's outer surface. The external appearance of the calcium carbonate differs among the three species; the calcite is nodular in *Eublepharis* and *Lacerta* shells (Plate 1a and 1b) whereas plaques of calcite are seen on *Hemitheconyx* eggshells (Plate 1c). Hydrochloric acid

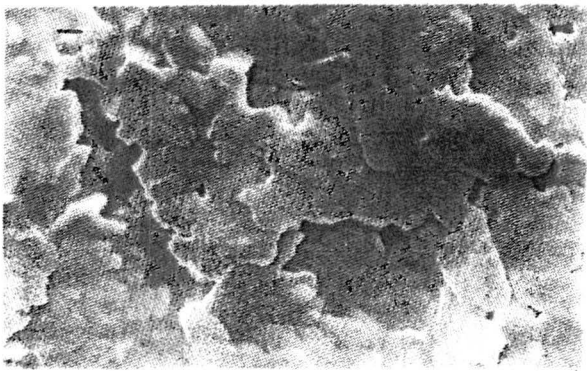
removed the mineralised layer from the surface of *Eublepharis* shells exposing the upper surface of the fibrous layer (Plate 1d).



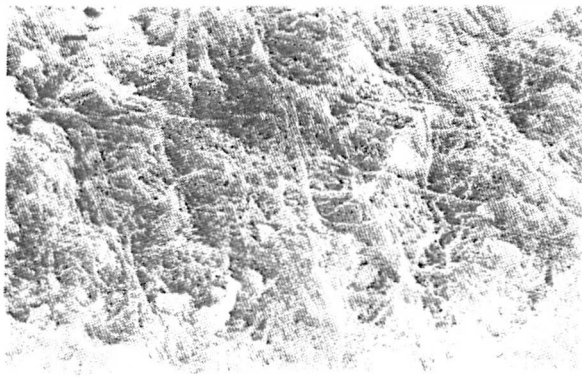
1a



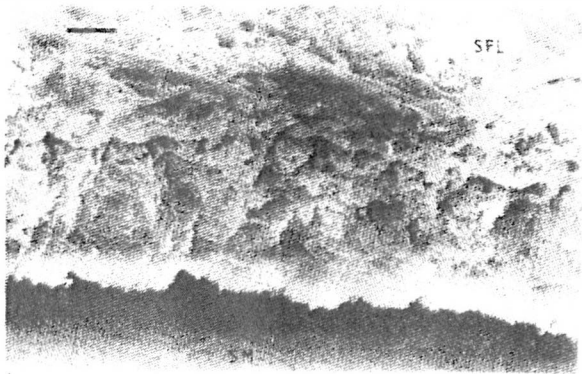
1b



1c



1d

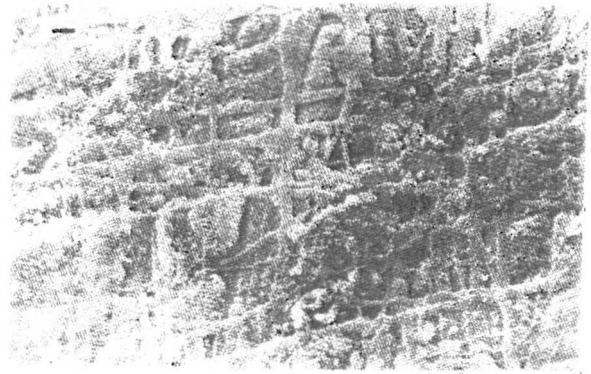


1e

Plate 1. Scanning electron micrographs of eggshells from geckos of the Eublepharinae, a gecko of the Gekkoninae and a lizard of the Lacertidae. (a) *Eublepharis macularius*. Surface of a radial fracture showing the fibrous membrane (SM) which forms the bulk of the shell. The outer shell surface is covered by a thin layer of calcite (CL). (b) *Lacerta lepida*. Surface of a radial fracture showing the fibrous shell membrane (SM) and the thin layer of calcite (CL) covering the outer shell surface. (c) *Hemiteconyx caudicinctus*. Outer shell surface showing calcite deposits. (d) *Eublepharis macularius*. Outer shell surface after etching in 1 mole. l⁻¹ hydrochloric acid for 30 seconds. The fibres of the shell membrane are exposed. (e) *Chondrodactylus angulifer*. Radial fracture of the eggshell showing the fibrous shell membrane (SM) which is detached from the calcite layer (CL). The arrows indicate holes in the top of the calcite layer. There is an external covering of fibres in a spherulitic matrix (SFL). Scale bars = 50 μ m.

The eggshell structure of the four gekkonine lizards, *Chondrodactylus angulifer*, *Phelsuma agalegae*, *P. guentheri* and *Gehyra mutilata* are shown in Plates 1e and 2. Each shell consists of a fibrous shell membrane (10 per cent of total shell thickness) covered by an outer, continuous layer of calcite. A layer of fibres in an unidentified matrix is found external to the calcite layer. The continuity of the calcite layer of *Chondrodactylus angulifer* shells is broken by series of holes near the external surface of the shell (Plate 1e). The external surface of *Chondrodactylus* eggshell is covered by numerous fibres embedded in a matrix (Plate 2a). Etching the shell with hydrochloric acid simply removed a superficial layer of the matrix exposing the surface of the fibres (Plate 2b). The surface layer of *Phelsuma agalegae* shell consists largely of the matrix (Plate 2c). Fibres appear to be

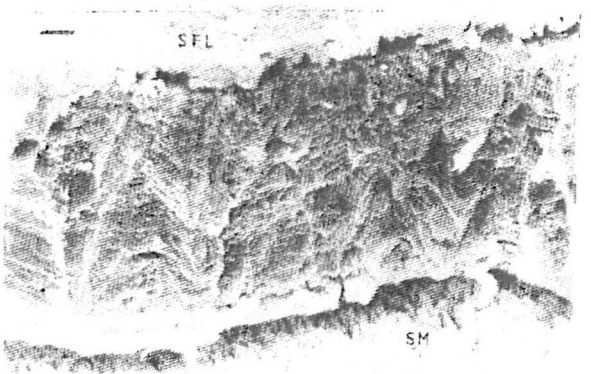
more numerous in *Phelsuma guentheri* shells and can be seen protruding from the surface layer in Plate 2d. The surface layer of *Gehyra mutilata* shell is not illustrated but it has few fibres and consists mainly of matrix. The calcite layer of *Gehyra* has numerous crystals covering its internal surface (Plate 2f).



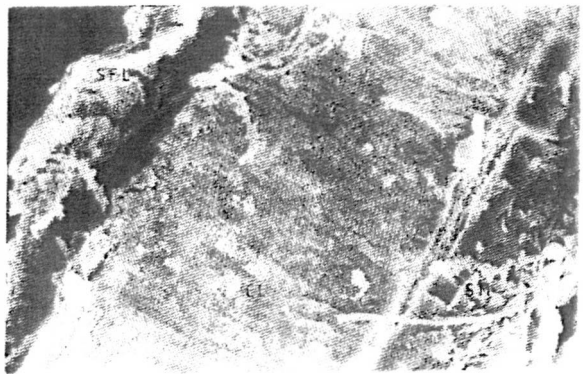
2a



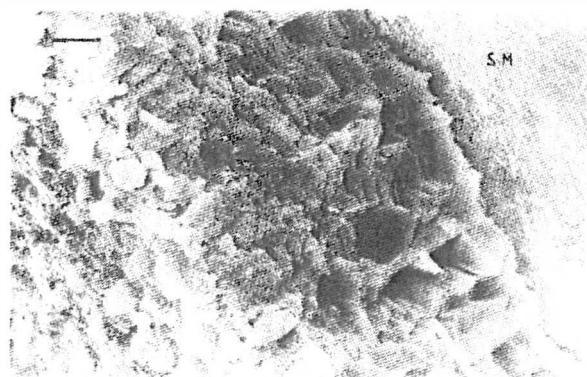
2b



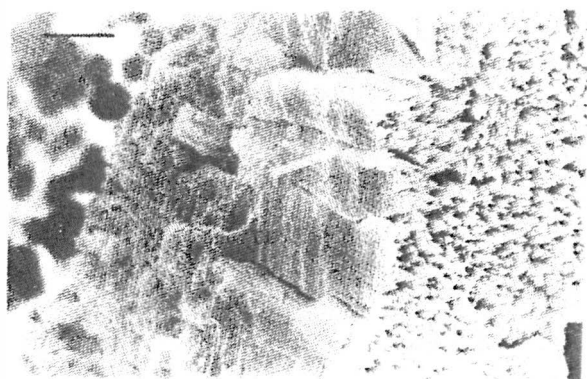
2c



2d



2e



2f

Plate 2. Scanning electron micrographs of gekkonine eggshells. (a) *Chondrodactylus angulifer*. The surface of a shell showing fibres embedded in a matrix. (b) *Chondrodactylus angulifer*. Outer shell surface after etching in 1 mole.l⁻¹ hydrochloric acid for 30 seconds. (c) *Phelsuma agalegae*. Radial shell fracture showing the upper surface of the shell membrane (SM). This is covered by a layer of calcite (CL) which is covered in turn by a surface fibrous layer (SFL). (d) *Phelsuma guentheri*. Radial eggshell fracture showing the fibrous shell membrane (SM) beneath the calcite layer (CL). The arrows show the fibres that protrude from the surface fibrous layer (SFL). (e) *Gehyra mutilata*. Radial fracture of the shell showing the external surface of the shell membrane (SM). The surface fibrous layer was lost in this preparation exposing the upper surface of the calcite layer (CL) which is covered with small spheres (arrowed). (f) *Gehyra mutilata*. A radial shell fracture showing the under surface of the calcite layer (CL). Numerous crystals can be seen (arrowed) on the under surface of the calcite layer. Scale bars = 50 μ m.

DISCUSSION

The presence of two types of eggshell in one squamate family is unique. The parchment-like eggshells of *Eublepharis* and *Hemiteconyx* consist of a fibrous shell membrane with an outer covering of calcite. This study confirms the similarities in the structure of shells of eublepharine geckos, lacertid eggshells (present study), several iguanid eggshells (*Anolis sagrei*, *A. limifrons*, *A. carolinensis*, *Callisaurus draconoides*, *Dipsosaurus dorsalis* and *Iguana iguana*; Kriesten, 1975; Sexton, Veith and Phillips, 1979; Packard and Packard, 1980; Packard *et al.*, 1982a; Packard *et al.*, 1982b), and teiid lizards (*Cnemidophorus sexlineatus*; Trauth and Fagerberg, 1984) as these shells are also fibrous membranes overlaid by a thin

layer of calcite. Parchment-shelled eggs only occur in about a quarter of the total number of genera of geckos (Kluge, 1967; Bustard, 1968) and contrary to the impression given by some reports (Packard *et al.*, 1982b) calcareous, rigid-shelled eggs predominate within the Gekkonidae.

The structures for gekkonine eggshells reported in the present study (Schmidt, 1943; Krampitz *et al.*, 1972; Packard *et al.*, 1982a) are similar to those reported previously. The gekkonine shell membrane forms a thin fibrous layer outside which the calcite layer forms the bulk of the shell making it comparable to the palisade layer of the avian shell (Erben and Newesley, 1972; Krampitz *et al.*, 1972). The surface fibrous layer is unique to gekkonine eggshells (Packard *et al.*, 1982a; present study). The appearance of the outer surface of *Chondrodactylus* eggs was found to be almost identical to that reported for *Hemidactylus* (Packard *et al.*, 1982a). Similar layers of fibres in a matrix were found for all of the other species in the present study though the numbers of fibres was variable. The role of this fibrous layer is not clear. Other reports of deposits on reptilian shells are limited to a single description of a thin amorphous layer on *Chelonia mydas* eggshells (Baird and Solomon, 1979). In contrast, thin, amorphous cuticular coverings are common on avian eggshells (Tullett, 1984).

Poorly calcified eggshells are generally thought to be highly permeable. Squamate eggshells, including *Eublepharis*, have water vapour conductance values 100 times higher than equivalent avian eggs (Ackerman, Dmi'el and Ar, 1985). Pliable-shelled *Chelydra* eggs had shells that were 55 times more permeable than avian eggs of comparable size whereas rigid-shelled turtle (*Trionyx*) and *Alligator* eggs have shells five times more permeable (Packard *et al.*, 1979). In contrast, rigid-shelled eggs of sphaerodactyline geckos have rates of water loss half that of predicted rates (Dunson, 1982).

Reptilian nest sites are usually characterised by their high humidity and are often found in soil or compost (Packard and Packard, 1980). Gekkonine nest sites are unusual in that the eggs are stuck to walls and crevices (Arnold and Burton, 1978) and are exposed to low humidities during incubation. Water retention by the egg would be advantageous in such conditions and calcareous gecko eggs appear to have developed relatively impermeable shells. This may be associated with the external fibrous layer which may act in a similar way to the avian cuticle which reduces water loss from the egg (Christensen and Bagley, 1984; Peebles and Brake, 1986; Deeming, 1987).

The rigid-shelled gecko eggs are an interesting development in vertebrate eggshell structure. The eggshell can be used as a good taxonomic character for classifying different types of gekkonid lizards (Bustard, 1968). The same is not true of chelonid eggshells as structure can vary within the class and particular families (Ewert, 1979). The importance of the eggshell in gecko biology extends well beyond its taxonomic use. The similarities and differences between the rigid eggshells of chelonians, crocodilians, gekkonid lizards, dinosaurs and birds (Erben, 1970;

Erben and Newesley, 1972) may be important in determining the patterns of eggshell evolution. Further investigations may allow us to test the significance of the use of shell structure in evolutionary analyses of the major groups of reptiles (Packard and Packard, 1980).

The existence of two shell types in a group of closely related lizards provides a useful opportunity to investigate the functional significance of the eggshell. A detailed comparative study of the reproductive biology of eublepharine or diplodactyline and gekkonine or shaerodactyline geckos could provide information that would allow the relationships between eggshell structure and various aspects of incubation of the egg to be understood. In particular, initial egg composition has been shown to be related to the degree of calcification of the eggshell (Tracy and Snell, 1985) and it could be predicted that rigid-shelled eggs have a higher initial water content. Nest location and incubation conditions will differ according to shell permeability and shell structure may have some influence on the development of the embryo. A study of gas exchange across rigid and soft shells could provide useful information concerning the role of shell permeability in the physiology of the embryo.

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AN IDENTIFICATION KEY TO THE AMPHIBIANS AND REPTILES OF THE CHILKA LAKE, INDIA

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ABSTRACT

A key to the identification of twenty species of amphibians and reptiles recently recorded from the waters, the islands and the hills of the Chilka Lake, India is presented.

INTRODUCTION

Information concerning the herpetology of the Chilka Lake is scanty. The only published reports are those of Annandale (1915, 1921). Between June 1985 and December 1986 I was able to explore the vast expanse of the Chilka Lake including its islands and hills as part of the Zoological Survey of India's expedition to the Chilka lagoon, and succeeded in recording six species of amphibians and fourteen species of reptiles. Of these, the rock-lizard *Psammophilus blanfordianus*, the smooth snake *Enhydrina enhydris* and the beaked sea snake *Enhydrina schistosa* are new records for the area. The unique limbless skink *Barkudia insularis* is now apparently very rare; no specimens were found on Barkuda Island, the type-locality.

Probably the great majority of amphibians and reptiles found in the Chilka lagoon are represented in the collection. It is felt, therefore, that this work will enable the biologists/naturalists interested in the herpetofauna of the Chilka Lake region to identify the amphibians and reptiles of the area and thereby facilitate future recognition of species not previously recorded for this region.

GEOGRAPHY OF THE LAKE

The Chilka Lake (Fig. 1) is a vast, shallow expanse of brackish water situated on the east coast of India between latitudes $19^{\circ} 28'$ and $19^{\circ} 54' N$ and longitudes $85^{\circ} 6'$ and $83^{\circ} 35' E$. It is roughly pear-shaped and spreads over an area of $1165^2 km$ in the Puri and Ganjam Districts of the State of Orissa and is

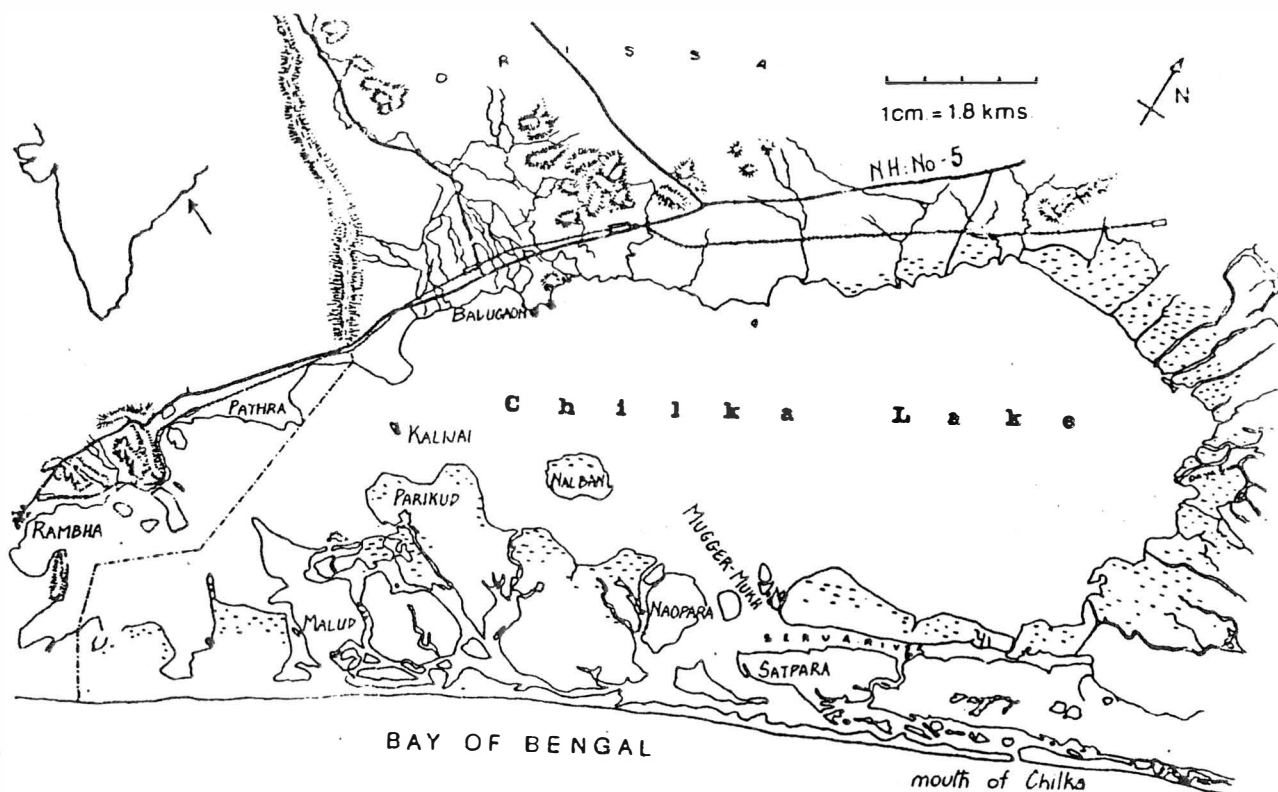


Fig. 1 The Chilka lake region.

connected with the sea (Bay of Bengal) through an outlet at its northeast and is subjected to tidal fluctuations. It receives freshwater from the two rivers, Daya and Bhargavi, the branches of the River Mahanadi as well as from several local streams. The lake at its western side is embraced by a group of low hills and dotted with several rocky islands in the southern portion. The depth of water ranges from 0.5m to 3m; the northern part is quite shallow and the deepest area is near the Kalidai. The lake's water imparts a saltier taste during the summer, less so in winter and nearly fresh during the rains. The surface temperature ranges from 16°C to 36°C. The cooler water is found in the central sector, while nearer the shores and in the neighbourhood of rocky islands, the temperature is remarkably higher.

THE KEY AMPHIBIA

1. Fingers and toes with discs. *Polypedates maculatus* (Gray) 1834.
Fingers and toes without discs. 2.
2. Skin warty. Elevated parotid glands on shoulder. Hind legs short. Generally living on land. *Bufo melanostictus* Schneider 1799.
Skin slimy. No parotid glands on shoulder. Long hind legs. Generally living in or near water. 3.
3. Toes completely webbed. 4.
Toes half to two-thirds webbed. 5.
4. Skin of back with prominent longitudinal folds. Inner metatarsal tubercle large, compressed, and crescentic. Colour olive-green or brown, with dark spots and a yellow middorsal stripe. *Rana tigerina* Daudin 1803.
Skin of back without folds. Inner metatarsal tubercle small. Colour olive or brown with dark markings; no middorsal stripe. *Rana cyanophlyctis* Schneider 1799.
5. Form stout and tending to be toad-like. Inner metatarsal tubercle large, compressed, and crescentic. Colour light brown or olive above with dark brown spots and often with a middorsal streak. *Tomopterna breviceps* Schneider 1799.
Form neither stout nor tending to be toad-like. Inner metatarsal tubercle small, oval or rounded. Colour brown or olive usually with distinct dark markings and a V-shaped band from eye to eye. *Rana limnocharis* Weigmann 1835.

LIZARDS

1. Tongue very long, slender, and forked. *Varanus bengalensis* (Daudin) 1802.
Tongue not so. 2.
2. Eyes without movable eyelids. Digits clawed. 3.
Eyes with movable eyelids. Digits free. 5.
3. Back covered with numerous, large tubercles which are strongly keeled and regularly arranged. Colour light brown on greyish, with dark brown spots and a dark eye streak. *Hemidactylus brooki* Gray 1845.
Back covered with few rounded tubercles which are feebly keeled and irregularly arranged. 4.

4. Tail feebly depressed. Colour grey or pinkish-brown or uniform or with dark longitudinal stripes and a pair of eye streaks. *Hemidactylus frenatus* Schlegel 1836.

Tail strongly depressed. Colour grey, with distinct dark markings which may be either wavy crossbars or rhomboidal spots and a dark eye streak. *Hemidactylus leschenaulti* Duméril and Bibron 1836.

5. Body depressed. Colour brown, with a series of elongated white spots on each side of the back. *Psammophilus blanfordianus* Stoliczka 1872.
Body compressed. 6.
6. Dorsi-nuchal crest present. Hind foot with five toes. Colour brown, with more or less distinct markings, especially in juveniles and females. *Calotes versicolor* (Daudin) 1802.
Dorsi-nuchal crest absent. Hind foot with four toes only. Colour light or dark-brown, with a series of dark-brown, dark-edged diamond-shaped spots. *Sitana ponticeriana* Cuvier 1844.

SNAKES

1. Size small and worm-like. Eyes diminutive, covered by shields. *Typhlops acutus* (Duméril and Bibron) 1844.
Size variable and not worm-like. Eyes certainly large and exposed. 2.
2. Tail very flat and paddle-like. 3.
Tail cylindrical and pointed or rounded on nearly so but not as above. 4.
3. End of snout curved and hooked. Colour olive or grey with dark bars; adults sometimes bluish grey. *Enhydryna schistosa* (Daudin) 1803.
End of snout neither curved nor hooked. Colour more or less uniform grey above and yellowish below. *Hydrophis obscurus* (Daudin) 1803.
4. Body covered with numerous small wart-like scales and head with granules. Ventrals absent. *Chersydrus granulatus* (Schneider) 1799.
Body covered with moderately large and fewer number of scales and head with shield-like scales. Ventrals distinct. 5.
5. Nostrils on the side of snout, not valve-like. Ventrals large. Eye large, with round pupil. Back with a pattern of distinct checkered spots. *Xenochrophis piscator* (Schneider) 1799.
Nostrils on the upper surface of snout, valve-like. Ventrals reduced in size. Eye small, with vertical pupil. 6.
6. Scales smooth. Lower jaw not prominent. Belly with a pattern of stripes. *Enhydryn enhydryn* (Schneider) 1799.
Scales strongly keeled. Lower jaw prominent. A pattern of dark bars above and dark spots or crossbars on the belly. *Cerberus rhynchops* (Schneider) 1799.

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INTRASPECIFIC VARIATION IN THE COLUBRID SNAKE GENUS *MACROPROTODON*

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ABSTRACT

The current status of the forms of *Macroprotodon* is summarised. Among the characters that were investigated the head patterns showed differences that were surprisingly consistent. The two recognised taxa, *Macroprotodon cucullatus cucullatus* and *Macroprotodon cucullatus brevis*, are reappraised and the existence of a third, *Macroprotodon cucullatus mauritanicus* is confirmed. An attempt has been made to determine the affinities of the isolated populations and a brief resume of the habits together with some personal observations is presented.

INTRODUCTION

The genus *Macroprotodon* consists of a single species with two currently recognised races. The high degree of intraspecific variability has long been recognised. The two races have been distinguished from each other on what would appear to be little more than differences in number of midbody scale rows.

The situation may be summarised as follows: *M. c. cucullatus* Geoffroy possesses normally 19 scale rows at midbody, 20 and 21 rows being occasionally met with in individuals from Algeria and Tunisia. The range extends from S. Palestine to Eastern Morocco including Lampedusa and the Balearics with relict populations in Rio de Oro and the Hoggar (Bons, 1967). Kramer and Schnurrenberger (1963) noted 'within the nominate race' and increase from East to West in the number of ventrals.

The other race *M. c. brevis* Günther is characterised by higher midbody scale counts of from 21-25 in Morocco and 21 and 23 in Iberia (Bons *op. cit.*). Recently however Almeida and Almeida (1986) remarked on two individuals from North Portugal (well to the north of the known range) as both possessing only 19 midbody scale rows.

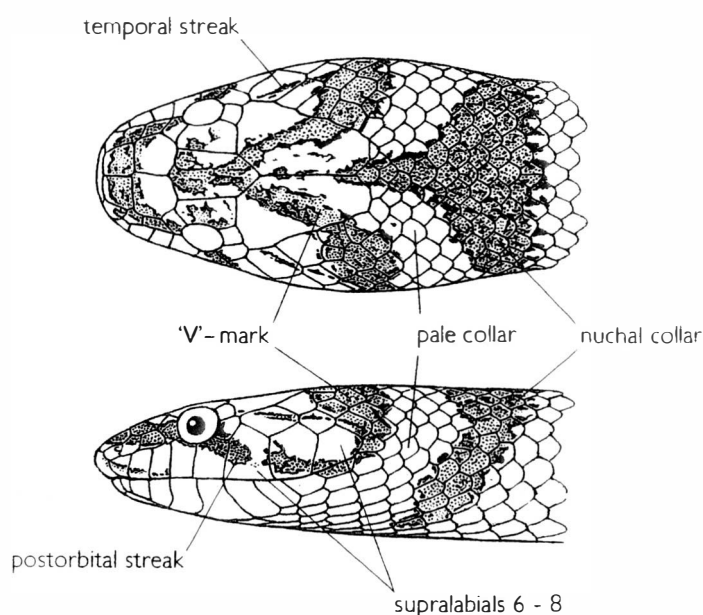


Fig. 1 Head of *Macroprotodon cucullatus mauritanicus* (BM 53.2.4.23, Algiers) showing typical scutellation and characters used in the study of the genus.

Bons (1973); Pasteur and Bons (1960) suggested the existence of a third race comprising the Iberian population which could be differentiated from the

Moroccan by the scales in the lowest dorsal row on each side being enlarged.

With regard to the head pattern Boulenger (1913) recognised one combination of elements for Iberia and a multiplicity of them throughout the rest of the range. He also noted that black-headed individuals occurred in Morocco and Algeria. Subsequent authors notably Lanza and Bruzzone (1960); Kramer and Schnurrenberger (*op. cit.*) demonstrated in Lampedusa and Lybia respectively that dark headed individuals may be found alongside those in which a contrasting head pattern is manifest.

Material acquired by the author from Spain and the Balearics revealed in the latter population a curious deviation from the normal condition of 8 supralabials in that an additional scale was wedged between the 6th and 7th (Fig. 5) in most individuals. Examination of this material together with that in the British Museum (Natural History) while confirming much of the foregoing gave indications that the populations from Northern Algeria, Northern Tunisia and the Balearics manifested a distinctness comparable with those of *M. c. cucullatus* in the South and East and *M. c. brevis*

in the West. The main object of this account is the recognition of the N. Algerian/N. Tunisian population as a third taxon *Macroprotodon mauritanicus* Guichenot 1846 and also the determination of the relationships of the isolated populations.

Material Examined. This consisted of a total of 90 specimens, 62 of which comprise the collection of *Macroprotodon* in the British Museum (Natural History) (BM), 5 from the Museum National d'Histoire Naturelle, Paris (MHNP), 21 from the author's collection (EW), one from the Norwich Museum (NM) and another in the possession of Mr. N. Smith of Southampton University.

CHARACTERS EXAMINED

GENERAL REMARKS

Head Scallation. The head shields apart from the supralabials were not formally investigated. The frontal however, whilst variable in shape, was noted amongst some of the specimens from the West as being rather narrow with the posterior apex more attenuated

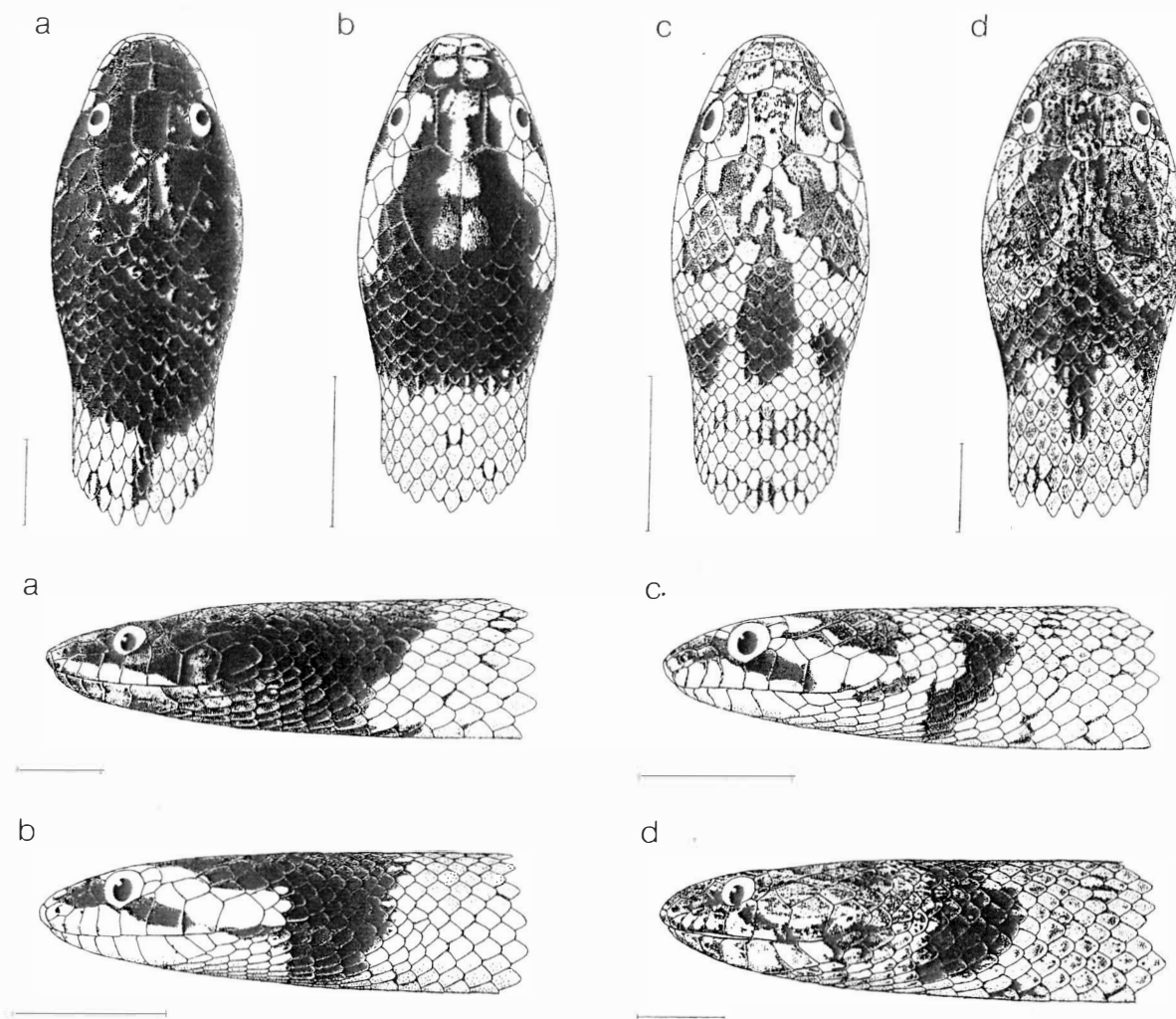


Fig. 2 Dorsal and lateral views of the heads of *Macroprotodon cucullatus brevis* showing the variations in head patterns. (a) BM 92.4.18.3 'Morocco'. (b) BM 89.12.16.11.116.7 and (c) BM 89.12.16.110.116.4 'City of Morocco' = Marrakesh. (d) EW 20.3.67 El Bosque, Cadiz, Spain.

Scale line = 5mm

(in those from the Balearics, North Algeria and North Tunisia).

Body Scallation. The dorsal, ventral and subcaudal scales were counted using the method of Dowling (1951a).

Head Pattern. Here was found a baffling assortment of seemingly unstable pattern elements, further complicated by the presence of examples in which the head is black in varying degrees (= melanocephaly) particularly in North Africa. The individuals in which the pattern elements were sufficiently discrete as to permit evaluation were isolated and the elements are itemised in Table 2. These include the nuchal collar, the 'V' mark (= 'Y' mark of Lanza and Bruzzone 1960), a postorbital streak and sometimes an interspace between the nuchal collar and the anterior pattern elements (the 'pale collar', Fig. 1).

Body Pattern. This consists essentially of a series of more or less prominent vertebral spots or flecks with lesser ones — usually on the posterior margins of the scales — alternating on the sides (Fig. 4, a). These in varying degrees (sometimes manifest only when the

skin is distended) are connected diagonally. This condition may merge into one in which the spots expand to form a reticulated — tessellated pattern consistent with a darkening of the ground colour leaving the spaces so formed as pale patches (the 'textilis' pattern) (Fig. 4b). A third condition may occur in which the ground colour differentiates into pale and dark longitudinal stripes (the 'taeniatus' pattern), (Fig. 4, c). Intermediates exist between all three conditions.

The first condition seems to occur mostly in the West while the 'taeniatus' pattern is manifest in most of the Balearic and some North Algerian and North Tunisian examples. The 'textilis' pattern (and modifications thereof) is conspicuous in material from South Tunisia eastwards whilst also occurring in specimens from the West, Morocco in particular.

Belly Pattern. This character is seen here as falling into two categories namely checkered pattern, or variations of such, and one in which the ventrals, save for some darkening near their lateral margins, are either immaculate or show a few spots scattered at random. There is evidence here also of intergrading.

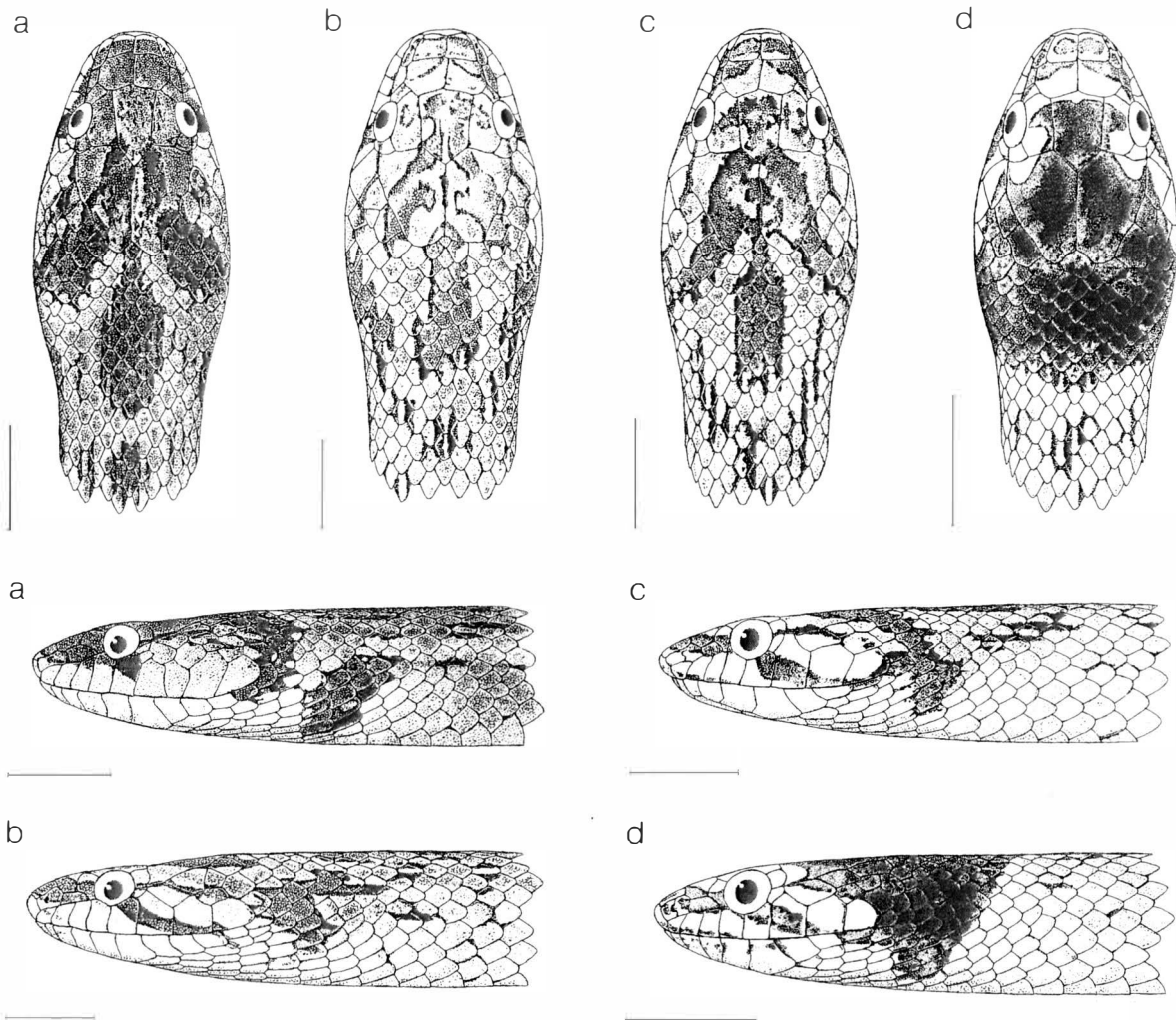


Fig. 3 Dorsal and lateral view of the head of (a) *Macroprotodon cucullatus mauritanicus* Menorca, EW 19.6.78.4 and *Macroprotodon cucullatus cucullatus*. (b) BM 1920.1.20.3859 Bir Oum Ali, Algeria. (c) BM 58.4.20.53 Tripoli. (d) BM 58.4.20.55 Tripoli.

Scale line = 5mm

		Dorsals							Ventrals					Subcaudals					
Taxon	Population	n	19	20	21	23	25	n ♂♂	range	mean	n ♀♀	range	mean	n ♂♂	range	mean	n ♀♀	range	mean
<i>M. c. brevis</i>	Iberia	11	1	—	9	1	—	5	160-168	163.8	6	173.5-185	177.1	5	46-51	48	6	41-48	43.7
	Morocco	23	—	—	7	15	1	9	154-171	163.9	7	172 -185	178.1	9	44-50	47.2	7	41-49	44.6
<i>M. c. mauritanicus</i>	N. Algeria & N. Tunisia	18	14	1	3	—	—	9	164-174	169.6	9	177 -188	183.8	9	51-55	52.6	8	45-53	49.4
	Balearics	14	14	—	—	—	—	9	163-173	165.4	5	176.5-182	178.5	8	54-60	56.9	5	51-54	52.4
<i>M. c. cucullatus</i>	Rio de Oro	2	2	—	—	—	—	2	157-159	158	—	—	—	2	48	48	—	—	—
	S. Algeria & S. Tunisia	3	3	—	—	—	—	1	154-	—	2	164 -168	166	1	48	—	2	45-46	45.5
	Lybia	12	12	—	—	—	—	7	151-162	156.7	5	164 -174	169	4	44-52	48	5	43-47	45.6
	Egypt & Palestine	6	6	—	—	—	—	4	151-154	152.3	2	165 -166	165.5	4	47-49	48	2	43-44	43.5

TABLE 1: Body scalation of *Macroprotodon*

The checkered condition with its attendant variations were found in all regional samples although only one Balearic individual out of fourteen exhibited this condition. In the other Balearic specimens and some from Northern Algeria and Northern Tunisia the belly was either unmarked or sparsely spotted.

Pupil Shape. Contrary to the current concept of genus *Macroprotodon* as possessing a vertically elliptical pupil, the condition in nearly all examples was found to be circular or at best subcircular. In only two exceptions, both from Spain, could the condition be described as anything approaching elliptical. In one an individual (EW 20.3.67) from El Bosque, Cadiz Province, the pupil in life became distinctly subelliptical when exposed to bright sunlight. In the other (BM 1973.3430 San Pedro) the pupils although dilated were more or less pointed at their apices.

CHARACTERS FOUND TO BE USEFUL

Head Scales. The supralabial counts except for most of the Balearic specimens and one from Tangier were 8-8 throughout the range. This specimen (BM (RR)

1987.890) exhibited 8-9 supralabials with a cuneate shield wedged between the 6th and 7th on the left side of the head. A small cuneate shield was also found in a specimen from Ain Draham, Tunisia (BM 1906.8.29.20). The Balearic material exhibited the spectrum of irregularities shown in Fig. 5.

Body Scales. (Table 1). While the dorsal scale counts revealed little additional that was noteworthy it was the ventrals which gave the indications of the distinctness of the N. Algerian/N. Tunisian population. The subcaudals showed little that was significant other than high counts for North Algerian-North Tunisian and particularly the Balearic populations.

Head Pattern. The character states are symbolised as they appear in Table 2.

'V' mark. A = Usually more or less convex on outer margins, the 'arms' separated from the postorbital streak and the nuchal collar (except in dark-headed examples), (Fig. 2 c & d).

B = More or less concave on outer margins, each arm curling around the last supralabial where it unites with the postorbital streak should the latter extend that far (Figs. 1 & 3, a).

Taxon	Population	n	'V' mark	Post-orbital streak	Nuchal collar	Pale collar	Melanocephaly
<i>M. c. brevis</i>	Iberia	11	A	3	I	yes	no
	Morocco	23	A	2 & 3	I & II	yes	yes
<i>M. c. mauritanicus</i>	N. Algeria & N. Tunisia	18	B	1, 2 & 3	I & II	yes	yes
	Balearics	14	B	1 & 3	II	yes	no
<i>M. c. cucullatus</i>	Rio de Oro	2	C	3	III	no	no*
	S. Algeria & S. Tunisia	3	C	3	III	no	yes
	Lybia	12	C	2 & 3	III	no	yes
	Egypt & Palestine	6	C	2 & 3	(III)*	no	yes

* = not yet seen but of probable occurrence. () = not yet seen as a discrete state.

TABLE 2: Head pattern states in *Macroprotodon*. For explanation of symbols see text.

C = Variable; may be short and discrete (Fig. 3, b) or 'arms' uniting with the lateral portions of the nuchal collar although not truly continuous with the postorbital streak, (Fig. 3, c).

Postorbital Streak. I = Vestigial, situated on the 5th supralabial or extending marginally beyond the suture between the 5th and 6th (Fig. 3, a).

2 = Interrupted in varying degrees but never vestigial (Figs. 1 & 2, b & c).

3 = Entire or more or less so extending from the 5th to the 8th supralabial or the opposing infralabial and/or even beyond (Figs. 2 d & 3, b & c).

Nuchal Collar. I = Entire, separated from the postorbital streak and the 'V' mark, (Figs. 1 & 2, d).

II = Divided into a median dorsal and two lateral portions separated from the postorbital streak and the 'V' mark, (Figs. 2, c & 3, a).

III = Divided, the lateral portions often fragmented (Fig. 3, b & c). (Two specimens, BM 97.10.28.583 Maryut, Alexandria and EW 1984-1 Benghazi, possess a complete nuchal collar but in both the 'V' mark is firmly united with it and the 'pale collar' (see below) is lacking. This condition is viewed as an early progression towards melanocephaly).

Pale Collar. An interspace between the nuchal collar and the 'V' mark + postorbital streak (Figs. 1, 2, c & d and 3, a).

Melanocephaly. Used as a character state when darkening of the head is pronounced to a sufficient degree as to obscure the pattern elements (Figs. 2, a & b and 3, d).

DISCUSSION

Macroprotodon cucullatus brevis: The discovery of the two individuals with 19 scale rows well to the North of the known range of a taxon characterised hitherto by 21-25 scale rows at midbody could be dismissed on account of their isolation as being of little significance were it not for the existence of a specimen from Marbella (EW 6.80.2), and another indicated by Bons 1967 in his histogram in Fig. 16, from Morocco. The taxonomic value of these dorsal scale counts is therefore somewhat diminished.

The type specimen of *Coronella brevis* Günther agrees with the Iberian and some of the Moroccan material in possessing 23 midbody scale rows; head pattern states A, 3 and I and a reticulate ('*textilis*') body pattern. The belly however is without spots.

The uniformity of the head pattern in Iberian examples (Figs. 2, d) as Boulenger (1913) pointed out is not always maintained in those from Morocco in which the nuchal collar is subject to division (head pattern state II) and the postorbital streak to interruption (state 2) usually on or at the 7th supralabial. Melanocephaly also occurs here.

Notwithstanding the suggestions of Bons (1973); Pasteur and Bons (1960) that the Iberian population constitutes a third race little could be found to distinguish this population from the Moroccan other than the midbody scale count not being known to exceed 23 (— and that found in only one individual, BM 72.8.23.2). Busack (1986) provides electrophoretic evidence for retaining the two populations as one race. The unique joint possession of head pattern state A and the absence of state I serves to reinforce the unity of the Iberian and Moroccan populations of *M. c. brevis* with which *Macroprotodon maroccanus* Peters is probably a synonym whilst readily separating them from the following forms.

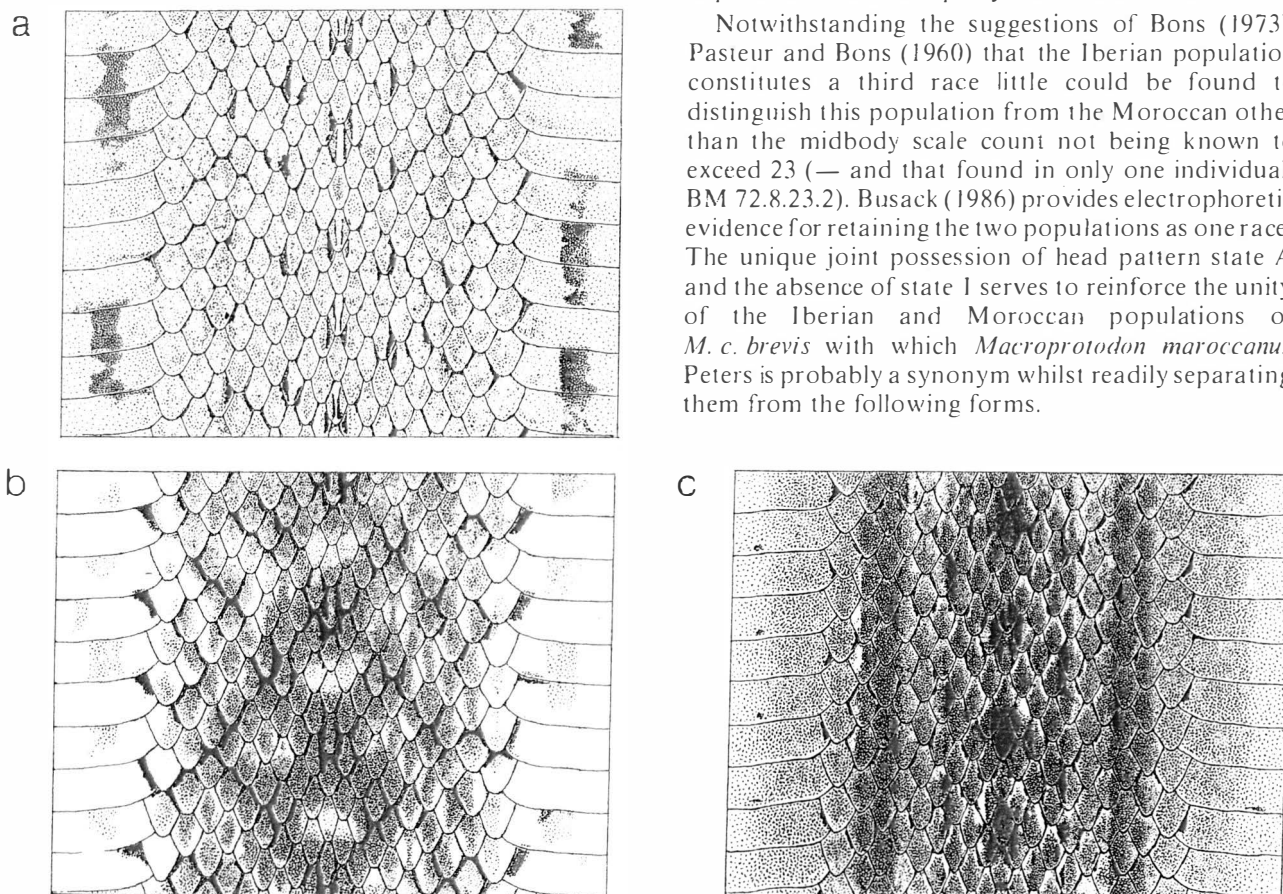


Fig. 4 Variation in the dorsal pattern in *Macroprotodon*:

(a) *M. c. mauritanicus* BM 1920.1.20.1186. Bône, Algeria, showing the undifferentiated ground colour.

(b) *M. c. cucullatus* EW 1982.2. El Agheila, Lybia, showing the 'textilis' pattern.

(c) *M. c. mauritanicus* EW 19.6.78.2. Menorca, showing the 'taeniatus' pattern.

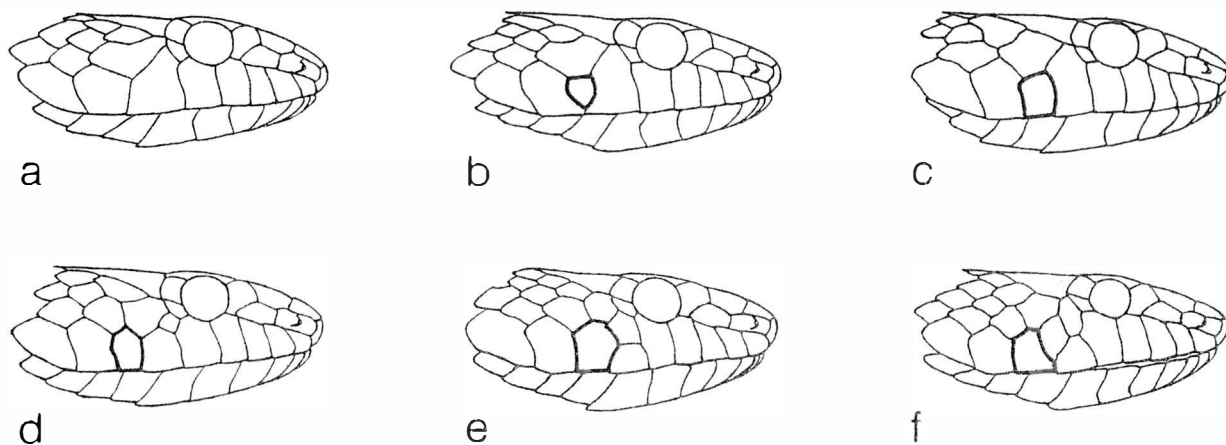


Fig. 5 Variation in the head scutellation in *Macroprotodon cucullatus mauritanicus* from the Balearics. (a) EW 28.1.79, Mallorca. (b) EW 10.7.80.3 Menorca. (c) EW 19.6.78.3 Menorca. (d) EW 10.7.80.2 Menorca. (e) EW 19.6.78.1 Menorca. (f) NM 78.144.

The Additional supralabial is shown in bold outline.

Macroprotodon cucullatus mauritanicus: The form under consideration here from Northern Algeria and Northern Tunisia has been hitherto considered within the nominate race. It shares with *M. c. brevis* the pale collar, head pattern states I: II, 2 and 3. It differs from that race as follows: the dorsal scale count is normally 19 (exceptionally 20 or 21) as opposed to 21-25 (exceptionally 19), the ventral and subcaudal counts are higher on average, head pattern state B is manifest as opposed to state A and state I occurring only in some members of this group alone. In addition to Boulenger Hediger (1935) also found melanocephaly in material from Algeria.

The earliest name available for this group is *Macroprotodon mauritanicus* Guichenot 1846: type locality = 'Algeria'. The four syntypes MHNP 2172 and 2172 A-C agree completely with the British Museum material from the regions in question. The midbodyscale counts in all four was 19; the ventral and subcaudal counts are as follows: ♂♂ 164, 174: 52.55 and ♀♀ 184, 186: 48, 52. All were found to exhibit the pale collar and head pattern states B and II; two possessed state I and two state 3. The body patterns approximated that shown in Fig. 4, a. The belly was checkered in three individuals but virtually immaculate in one.

Although the type specimen of *Lycognathus taeniatus* Duméril & Bibron, 1854 'must be considered as lost' (Prof. E. Brygoo in litt.) the original description would indicate that this taxon belongs with *M. c. mauritanicus*.

The Balearic population exhibited the head pattern states B, II and a pale collar in every one of the fourteen specimens seen. All except one — in which state 3 occurred — state I was shown. The striated (= 'taeniatus') pattern (Fig. 4, c) was strongly manifest in all except two specimens in which the ground colour contrasts were reduced in one and virtually absent in the other. Melanocephaly has not been recorded in the Balearics.

This population is remarkable in that its members exhibit the anomalous supralabial condition of the specimen BM (RR) 1987.890 from Tangier to the

extent of it being the norm there (Fig. 5). Nine out of the fourteen exhibited supralabial counts of 9-9, three 9-8 and two 8-8 but even in both these a cuneate shield was wedged between the 6th and 7th on one side. The 6th supralabial is subject to fragmentation (Fig. 5, d, e & f). The average ventral counts are rather lower than those in material from Northern Algeria and Northern Tunisia (♂♂ 165.4; ♀♀ 178.5 as opposed to ♂♂ 169.6, ♀♀ 183.8) yet the subcaudal numbers (already high in that form) in the Balearic population exceed those found anywhere in the range of *Macroprotodon*.

The above notwithstanding, the possession of 19 midbody scale rows, head pattern states B in all and state I in all except one individual argue for the inclusion of the Balearic population within *M. c. mauritanicus*.

Macroprotodon cucullatus cucullatus: The increase in the number of ventrals from East to West within the nominate race (as Kramer and Schnurrenberger understood it) is abrupt with North Algerian and North Tunisian animals having markedly higher counts. The implication of taxonomic separation between these populations and those further East is supported by the dissimilarity of the head patterns.

The material from Southern Tunisia eastwards to Southern Israel (*M. c. cucullatus* s. str.) in contrast to *M. c. mauritanicus* lacks the pale collar and the head pattern states B and I while possessing instead states C & III. Melanocephaly frequently occurs in this form particularly in specimens from Cyrenaica to Israel.

Although neither ventral nor subcaudal counts were given the black headed individual from Gafsa described by Mosauer and Wallis (1927) as *Macroprotodon cucullatus* subsp. *melanocephala* would seem to belong here.

Lycognathus textilis Duméril and Bibron 1854; type locality: 'deserts of Western Algeria' is clearly a synonym of *M. c. cucullatus* s. str. The holotype MHNP 849 — a ♀ — has 19 scale rows at midbody, 168 ventrals and 45 subcaudals. The 'V' mark is very faint but the head pattern state C is just discernable. The pale collar is absent and the nuchal collar is represented by state III.

The two above mentioned specimens together with BM 1920.1.20.3109 from Périana (= Fériana) and 1920.1.20.3859 from Bir Oum Ali (= Oum Ali, Algeria?) show a Westerly extension of *M. c. cucullatus* s. str. inhabiting the more arid regions of Tunisia and in all probability a substantial part of Algeria also.

Amongst the Lybian material two specimens had been collected in sand. In these and some others (Fig. 3, c) the head is deeper and shorter than is usual, and the eye larger (not necessarily being an artefact of juvenility) and more centrally placed in relation to the line of the south.

Two two specimens from Rio de Oro, BM 1903.16.13.42 and 43 are best viewed as faded representatives of *M. c. cucullatus* agreeing with this form in all essentials. No specimens from the Hoggar were seen but that population likewise is probably assignable to this race.

No material from Lampedusa was seen but from the account of Lanza and Bruzzone (1960) two individuals exhibited 9-9 supralabials, in another the internasals were fused as one and the upper postocular was united with the supraocular. The ventrals were admittedly high, even allowing for any difference in the method of counting. They range in ♂♂ from 156-176 (mean 163.8) and in ♀♀ 173-178 (mean 175). The head markings however, match those of the Bir Oum Ali specimen and two from Lybia so closely (compare Lanza and Bruzzone, Fig. 2, A, B, and C with Fig. 3, d, c and b respectively) as to argue for the assignment of the Lampedusa population to *M. c. cucullatus*.

It would seem from the foregoing that the validity of *M. c. brevis* is upheld while the nominate race s. lat. is divisible into two subspecies, *M. c. mauritanicus* and *M. c. cucullatus* each producing their island isolates in the Balearics and Lampedusa respectively. The author shares the opinion expressed by Bons supra cit. that the

specimens from Rio de Oro and the Hoggar represent relict populations of a formerly much wider distribution before the Sahara became desertified.

Some intergrading between the character state combinations would not be unexpected. The only example seen from any of the critical areas of range contact was a specimen of *M. c. mauritanicus* from Batna, BM 1920.1.20.108 in which the 'V' mark failed to curl round the 8th supralabial on the left while it only just did so on the right. Although the nuchal collar was divided as in head pattern state II the lateral portions were reduced in size. The right pale collar was bisected by a thin shaft issuing from the backward extension of the 'V' mark. This approach to head pattern states C and III would be consistent with the intergrading of habitats. According to Leviton and Anderson (1970) the Batna region is a grassy plain, though sufficiently arid as to be suitable for such xeric species as *Lytorhynchus diadema*.

HABITS

Information on the habits of *Macrotodon* is relatively scarce. Almeida and Almeida summarise the feeding habits of the species in Iberia and Morocco. They state that other authors (Salvador, 1974, Arnold and Burton, 1978, etc.) give small lacertids and geckos as the principle prey. Whilst recording the slow worm (*Anguis*) as an item of prey in one of the North Portuguese individuals they stress the dependence of *M. cucullatus* largely on amphisbaenians on account of their sharing nocturnal and crepuscular habits.

The finding of *Acanthodactylus erythrus* and *Psammodromus algirus* in the stomachs of two Moroccan examples and a $\frac{3}{4}$ — grown *Lacerta pater* in a specimen from Ain Draham may indicate that *Macrotodon* is crepuscular and nocturnal. All three lizards are active diurnal species the last named being a

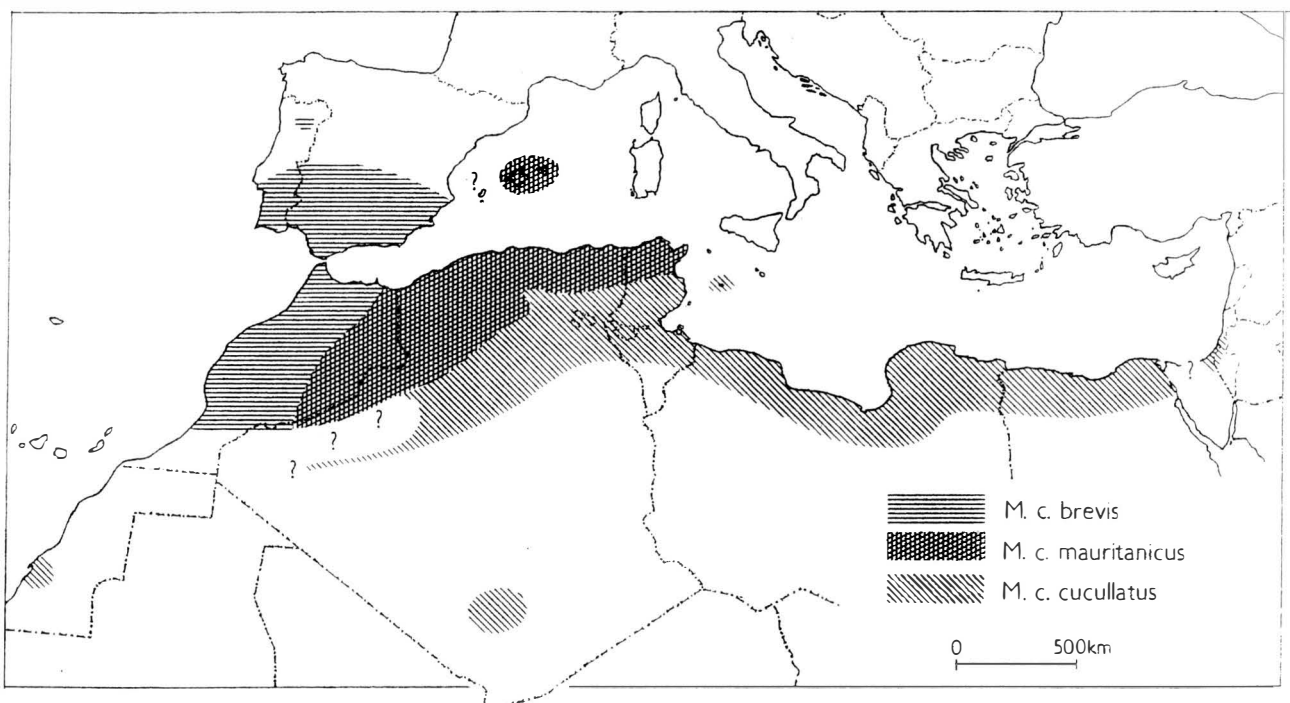


Fig. 6 Distribution of the subspecies of *Macrotodon cucullatus*.

powerful animal and would be unlikely to be overcome in its full daytime vigour even if the snake used its venom.

Rasmussen (1985) discovered a pure cone retina in a specimen from West Morocco. This indicates that *M. c. brevis* may be at least partially or occasionally diurnal there.

Of those kept in captivity the Balearic individuals were found to be the least secretive often active in broad daylight. Individuals of *M. c. brevis* from Southern Spain and especially *M. c. cucullatus* from Lybia normally remained in hiding during the day.

Out of four Iberian individuals three readily accepted *Lacerta vivipara* and of these one would eat slow worms. The Fourth could not be induced to feed — possibly due to a dependence on *Blanus*.

Although mammals are not as a rule included in the list of food items there is at least one mention — that of Duméril and Bibron (1854) in which small rodents head the list. Whilst none of the Iberian specimens could be induced voluntarily to accept small mice nine out of twelve Balearic adults did so readily. In addition to mice all the Balearic specimens accepted lacertid lizards: two, however showed sudden cannibalistic tendencies — one individual actually succeeded in swallowing its tankmate.

Three out of four specimens of *M. c. cucullatus* s. str. from Lybia, readily accepted mice whereas the fourth from the El Agheila dunes could only be induced to eat *Hemidactylus turcicus* having refused, in addition to mice, *Lacerta vivipara*, *Mesalina guttulata* and *Sphenops sepsoides*.

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HERPETOLOGICAL JOURNAL. Vol. 1, pp. 245-246 (1988)

SHORT NOTE:

ON THE TYPE LOCALITY OF *CHTHONERPETON CORRUGATUM* TAYLOR (AMPHIBIA: GYMNOPIHIONA)

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(Accepted 24.11.86)

Chthonerpeton corrugatum Taylor is known only from the holotype, No. A00265 in the Zoologische Museum, Hamburg, and the paratype, a specimen without data in the Academy of Natural Sciences of Philadelphia (No. 13948). When Taylor described *C. corrugatum*, he suggested that the type locality was erroneous (Taylor 1968:289-292). Two labels are associated with the holotype, one, in the specimen jar, indicated 'Kamerun', a second, attached to the specimen indicated 'Tedda b. Mekka'.

On a map of Africa dated 1912, Taylor found a territory marked 'Teda' in what is now Chad, almost directly west of Mecca, but he considered this interpretation to be unlikely because all other species of *Chthonerpeton* are known only from South America. No genus of caecilians is known with certainty from both land masses.

Recent examination by us of another caecilian from the Hamburg Museum, No. A00252, proved illuminating. It is clearly a specimen of *Herpele squalostoma* (Stutchbury), a species known to occur widely in Equatorial West Africa, including Cameroon. The

locality data accompanying this specimen is Brazil. It also seems most unlikely that *Herpele squalostoma* occurs in South America.

The records of the Zoologische Museum reveal an interesting history for the specimen of *Herpele squalostoma*. The original determination is recorded as *Chthonerpeton indistinctum* (Reinhardt and Lütken). Dunn (1942) examined the animal and erroneously identified it as *Caecilia tentaculata* Linnaeus. He also erroneously identified the holotype of *Chthonerpeton corrugatum* as a species of *Bdellophis* (= *Scolecophorus*), an African genus, probably being misled in both instances by the locality data. Dunn (1942) wrongly described the range of *Caecilia tentaculata* as including Brazil based on his misidentification.

One interpretation of these facts is that the locality data associated with these two specimens were switched after the original determination of the Brazilian specimen as *Chthonerpeton indistinctum* and before Dunn (1942) mistakenly determined the then erroneously labelled *Herpele squalostoma* as

Caecilia tentaculata. Sometime before Dunn's examination, the two specimens probably found their way into each others containers. The tag attached to the holotype of *Chthonerpeton corrugatum* remains anomolous, and there seems no way to be sure when it was attached or to what it refers. We have searched for a 'Tedda b. Mekka' in Brazil and other South American countries without success.

If this scenario is correct then two anomolous distribution records are explained and a type locality, Brazil, can be assigned to *Chthonerpeton corrugatum*.

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SHORT NOTE:

ALLOMETRY IN *TESTUDO SULCATA*: A REAPPRAISAL

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INTRODUCTION

In a recent paper published in this Journal. Mahmoud, Naïem and Hamad (1986) described the relationship between selected shell dimensions and body mass in the desert tortoise, *Testudo sulcata* from Sudan. After transforming their data into logarithmic form they presented their results for the relationship between carapace length and body mass as model 1 allometric equations of the form,

$$y = ax^b$$

where carapace length y is related to body mass x by the intercept a and exponent b (b describes the slope of the log transformed data). Their analysis for two groups of captive *T. sulcata* produced exponents of 0.81 and 1.66. In addition, they quantified a set of measurements of carapace length and body mass given by Cloudsley-Thompson (1970) for *T. sulcata* and calculated an exponent of 0.91. Their equations for *T. sulcata* are thus significantly different from those previously described in the literature for this type of information (e.g. Meek, 1982; Iverson, 1984); indeed the differences are of such a magnitude that they prompted us to re-examine Cloudsley-Thompson's (1970) data.

METHOD

Model 1 allometric equations were obtained from the data by least squares regression after transformation to logarithmic form (Bailey, 1981). As in Mahmoud *et al.* (1986) carapace length has been treated as the dependent variable y and body mass the independent variable x . Model 2 regression would be a more appropriate analysis for this data since body

mass may be subject to error (Sokal & Rohlf, 1981) but the correlation coefficients (r) for the data are high and thus there would be no difference in the exponents between the two methods (Alexander, Jayes, Maloiy & Wathuta, 1979). The t -distribution has been used to calculate 95 per cent confidence intervals for the exponents (Bailey, 1981).

RESULTS AND DISCUSSION

Fig. 1 shows the measurements of carapace length (mm) and body mass (g) from Table 1 of Cloudsley-Thompson's (1970) paper plotted on logarithmic coordinates, with an additional data point taken from a juvenile *T. sulcata* mentioned on page 19 of his paper. The line taken through the data is derived from the equation.

$$y = 13.5x^{0.36 \pm 0.01} \quad (r = 0.99, n = 8) \quad [1]$$

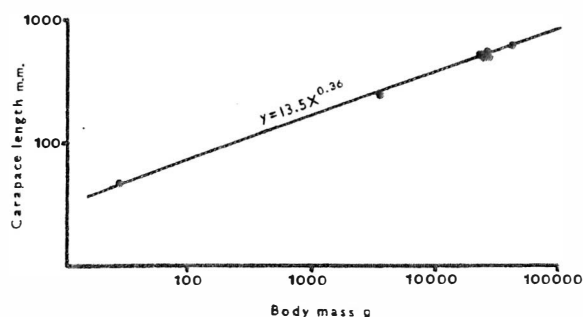


Fig. 1 A graph on logarithmic coordinates of body mass plotted against carapace length in *Testudo sulcata*. The line taken through the data was calculated using equation [1] as shown.

However, Mahmoud *et al.* used only the data from Cloudsley-Thompson's Table 1 but this makes little difference between the equations giving

$$y = 10.05X^{0.39 \pm 0.02} \quad (r = 0.99, n = 7) \quad [2]$$

Mahmoud *et al.* analysed their data in units of cm and kg but this makes no difference to the value of b in the equations. Equation [1] is probably the more accurate description of the relationship since the measurement of the juvenile considerably extends the range.

As can be seen, these exponents are significantly different from the exponent of 0.91 calculated by Mahmoud and his co-workers for the Cloudsley-Thompson data; indeed they are in much better agreement with the 0.33 required for geometric similarity and exponent of 0.34 for four species of chelonians given in Meek (1982) which implies a retention of shape as growth proceeds. It would appear that Mahmoud *et al.* have committed errors in calculation, at least for Cloudsley-Thompson's measurements since as can be clearly seen in Fig. 1, an exponent of 0.36 is in good agreement with Cloudsley-Thompson's data. Equation [1] would therefore disagree with the conclusion of Mahmoud and his co-workers that 'the exponents for *T. sulcata* are higher than the exponents given for other tortoises'. An interesting point concerns the slope predicted by equation [1]. This would be in good agreement with the slope of Mahmouds *et al.*'s data in their Fig. 1 (at least

in comparison to the slope for group B) if the labelling on their Figure was reversed — that is, if the horizontal axis was labelled as body mass and the vertical axis as carapace length. A further error is the incorrect plotting of variables in Figs. 2a and 2b; since the variables on which the plots are based are logarithmic (Tables 1 and 2) the arithmetic plots in the Fig's cannot give linear relationships as drawn.

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SHORT NOTE:

CAPTIVE REPRODUCTION OF KEMP'S RIDLEY *LEPIDOCHELYS KEMPI*

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(Accepted 4.2.87)

ABSTRACT

Captive mating, nesting and hatching of the critically endangered Kemp's ridley sea turtle, *Lepidochelys kempi* has been achieved among a colony maintained at Cayman Turtle Farm in the Cayman Islands. The minimum age of sexual maturity was five years. Mating behaviour and nesting parameters are discussed in relationship to the captive green colony of the Farm.

INTRODUCTION

The single known aggregate nesting population of the endangered Kemp's ridley sea turtle has declined in

recent years despite extensive protection and monitoring efforts by international organisations (Groombridge, 1982). Attempts to establish an additional population are ongoing on Padre Island off the Texas gulf coast (Klima and McVey, 1982). The mating, nesting and hatching in 1984 of Kemp's ridleys held in captivity provided increasing evidence that such a project could indeed prove successful (Wood and Wood, 1984). Cayman Turtle Farm (CTF) maintains a captive breeding population of green sea turtles, *Chelonia mydas*, (Wood and Wood, 1980) and has added to its facilities a small group of Kemp's ridleys for the purpose of establishing a captive breeding colony. The limited success of the 1984 season has been followed with nesting and hatching in 1986.

METHODS AND MATERIALS

In July 1980, CTF received 96 yearling and 67 hatchling Kemp's ridleys. The yearlings had been raised by the U.S. National Marine Fisheries Laboratory at Galveston, Texas. These turtles had been returned to the Mexican government and then, along with the 67 hatchlings from Rancho Nuevo, Mexico, transferred to Grand Cayman. Only a few of the hatchlings survived the transfer to Grand Cayman and approximately half of the yearlings survived the first year at CTF. The turtles received commercially available feeds and at the present time are maintained on a modified trout chow (Ralston Purina) (Wood and Wood, 1986).

The current breeding herd consists of 30 seven year olds, 3 six year olds and 4 four year olds (previously held by Key West Municipal Aquarium, Key West, Florida with permission of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service). The female to male ratio is 1.2:1. The turtles are held in a fenced section, 9 x 23m with an adjacent beach 9 x 11m, of CTF's breeding pond (Wood and Wood, 1980). The pond slopes from the beach to a depth of 2.8m. Water surface area per turtle is 6m² and water turnover occurs every 2 hours.

During nesting, eggs were collected as laid and incubated in a temperature controlled hatchery in sand packed styrofoam boxes (Wood and Wood, 1979). Hatchery temperature was maintained at 28.0°C throughout incubation.

RESULTS AND DISCUSSION

Age and size data are summarised for the nesting turtles in Table 1. Thirty per cent of the females have begun nesting by the age of seven years at a size previously suggested for sexual maturity (Pritchard and Marquez, 1973). For the captive green turtle population at CTF, the average age of sexual maturity

is 13 years (unpublished data). One of the ridleys has nested more than one season at an interval of 2 years. The Kemp's ridley population at Rancho Nuevo, Tamaulipas State, Mexico, exhibits a one or two year renesting cycle as opposed to other sea turtle species that typically nest every three years (Marquez *et al.*, 1982). The nesting cycle of CTF's captive green colony averages 1.6 years (Wood and Wood, 1980).

The mating results of 1984 reported previously (Wood and Wood, 1984) are summarised together with the results of the 1986 season in Table 1. Only two of the nesting females had observed mating activity, but in each season there was some observed mating between turtles whose tags could not be clearly identified. In 1984, 271 minutes occurred between unidentified turtles and in 1986, 76 minutes. In 1985, only limited mating activity was observed among the ridleys, totalling 427 minutes of observed mounting activity. Beach activity in 1985 was limited to crawls only for four females and one male.

Typically, the mating behaviour of the Kemp's ridley was characterised by a single male pursuing a female or, in several instances, pursuing another male. The aggressive male would circle the other turtle and actively approach the head. For the green turtle, the female continually circles and presents her head to the male as a refusal activity. The aggressive ridley male would continually bite the neck and shoulders of the non-aggressor. If not restricted by size, the male would then swing his body around into the mating position while biting. The mating position was the same as observed for the green sea turtle with the claws of the male's foreflipper secured over the anterior edge of the carapace and the male's rear flipper secured over the posterior edge of the carapace. Noticeably reduced in the mating behaviour of the ridleys were attendant males or females during the pursuit and mating periods. Refusal activities by the female of closing the rear flippers, staying in shallow waters, and vertically positioning to prevent mating were not observed. The ridley population begins its limited observed activity

Turtle No.	Age (yr)	Weight (kg)	CCL (cm)	Mating (min)	Nesting Date	Nesting Time	Eggs Laid No.	Days to Hatch	Eggs No.	Eggs %
1324	7	23	56	0	02.V.86	1130	69	55	31	45
					18.V.86	1230	69	—	0	0
1335	7	24	56	0	10.V.86	0445	11	—	0	0
					18.V.86	0510	61	—	0	0
1336	5	24	53	0	10.VI.84	2325	7	—	0	0
	7	28	57	129	08.V.86	2000	103	—	0	0
1349	7	27	56	0	18.V.86	1330	75	54	26	35
1353	7	27	56	139	05.V.86	0215	68	54	18	26
					18.V.86	1545	79	—	0	0
1359	5	20	48	0	05.V.84	0005	62	62	3	5

TABLE 1: Breeding results for Kemp's ridley in captivity. Curved carapace length is abbreviated CCL; mating is defined as total observed mounting lasting five or more minutes.

earlier in the season than the greens, consequentially, some activity may go unobserved as a continual 24 hour watch is not begun on the breeding herd until the first of April.

Table 1 summarises nesting activity for the six nesting Kemp's ridleys. Clutch size for the captive ridleys, average 60 eggs, range 7-103, is considerably less than observed for wild populations, 105 eggs (Marquez *et al.*, 1982). Decreased egg production has been observed for neonates among the captive green population at CTF. Low hatchabilities in the ridleys also parallels observations made for the captive green population which has been primarily attributed to lack of mating (Wood and Wood, 1980). Of the non-hatching eggs, 54 per cent showed no signs of development, 28 per cent died early in development and 18 per cent died late in development.

The Kemp's ridley's, like the olive ridley's, nesting behaviour is characterised by aggregate nesting known as 'arribadas', in nesting areas where the number of nesting turtles is sufficient. Of particular interest is the nesting of three ridleys on 18 May, 1986 within a period of three hours. Two of these, were repeat nesters for the season, with internesting intervals of 16 and 13 days, suggesting a 'mini arribada', considering the captive population size. Of the 10 nesting emergences listed in Table 1, 4 occurred during daylight hours, including the three nesting emergences of the 'mini arribada'.

The Kemp's ridley exhibited unusual beach activity by occasionally coming onto the beach and covering themselves with sand and seemingly sleeping for extended periods, up to eight hours, both during the day and night. This behaviour was paralleled in the water where the turtles would burrow into the coarse sand bottom of the breeding pond to the extent that they would become almost invisible.

The short time period, as compared to other sea turtle species, for sexual maturity demonstrated for the

Kemp's ridley and successful captive reproduction under conditions that can be met in other locations, offer avenues for recovery of this critically endangered species in addition to protection of wild populations.

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BOOK REVIEWS:

(1) *Atlas of Elapid Snakes of Australia*. Edited by Richard Longmore. Bureau of Flora and Fauna, Australian Flora and Fauna Series (Number 7). Australian Government Printing Service, Canberra. 1986. ISBN 0 644 04887 5. Price \$19.95 Australian

The domination of the snake fauna of Australia by elapids (cobra relatives), including some of the world's most lethal snakes, is extraordinary. There are about 77 species of Australian elapid currently recognised, representing nearly 70 per cent of the country's land snake fauna and this atlas makes a major contribution to the understanding of their distribution patterns.

The book is spiral-bound and 80 of its 115 pages are devoted to distribution maps; 24 species are illustrated by colour photographs. There is relatively little text; the introduction by Richard Longmore is followed by articles by Henry Nix on biographic analysis of Australian elapids while the biogeography of south-eastern and northwestern Australia is covered by Harold Cogger and Jeanette Covacevich.

Nix's article describes the pioneering BIOCLIM computer package which categorises the climatic regions in Australia and examines the match between actual and predicted elapid distributions on the basis of bioclimate. As Nix observes, this is 'the first major application of this new technology'; he acknowledges that many other factors, besides climate, influence distributions and further development of the system plans to take more environmental indicators into account. Nevertheless, perusal of the maps shows a most impressive match between actual records (depicted by red asterisks) and predicted distributions (shown by black symbols). The short, but masterly, essays by Cogger and Covacevich explore some of the historical factors which shaped some of the distribution patterns. The book would have been still further enhanced by similar essays on the other parts of Australia, especially the west.

It is, in many respects, a praiseworthy book demonstrating the high priority that the Australian Government Publishing Service has been giving to co-ordinating information on Australian plants and animals. The work also underlines the crucial value of museum collections as a data-base for distributional studies (the 17,000 records in the Atlas are based on specimens held by 19 institutions). In his introduction, Longmore expresses the hope that the maps might 'stimulate keen active herpetologists into the field to corroborate BIOCLIM predictions. If we can validate even one unexpected but predicted site then it has been worth the effort'. There can be little doubt that, in future years, his hope will be fulfilled many times over.

C. J. McCarthy

(2) *Gekkony fauny SSR i sopredelnykh stran (Geckos in fauna of the USSR and neighbouring countries)*. N. N. Szczerbak and M. L. Golubev (1986). Naukova Dumka, Kiev, 231pp., 98 figs.

This monograph is the result of the authors' 12 years investigations of geckos living in the USSR and neighbouring countries. A systematic review, which is a part of this book, has been previously presented by the senior author during the 3rd Ordinary General Meeting of Societas Europea Herpetologica in Prague, 1985 (Szczerbak, 1986). Apart from the description of 53 species (and many subspecies) from 9 genera, the authors also present a short history of the investigations of geckos in the USSR, and discuss their phylogeny and zoogeographical relationships. The literature cited consists of 328 items. In addition, the book includes keys to the genera, subgenera, species and subspecies of geckos as well as maps of their distribution. Information on the particular species generally has the same scheme — the latin name, terra typica, karyotype (if known), synonyms, diagnosis and description, colour of living and preserved specimens, sexual dimorphism, distribution, 24-hour and seasonal activity cycles, ecdysis, feeding, breeding, ethology and protection. Data concerning less known species are most scanty. The book is illustrated with black and white photographs of morphological details of geckos and of their biotopes, although their quality is rather poor. The same goes for 24 colour photographs which are technically even worse. Nevertheless, the vast spectrum of information about little studied and rare or endangered species makes the book especially valuable. Some controversies arise around the new generic name *Tenuidactylus*, which according to Böhm should be rather considered as a subgenus of *Cyrtopodion*, however, for students of gekkonid lizards the information on the biology of species living in the USSR will be probably more important than possible inaccuracies in nomenclature. The book should be recommended to every herpetologist interested in lizards and therefore its rather short edition of 1,200 copies will presumably make it difficult to obtain.

Piotr Sura

(3) *Ecology and Natural History of Desert Lizards*. Eric R. Pianka (1986), xi + 208pp. Princeton, New Jersey: Princeton University Press. £32.30 (cloth); £14.20 (pbk).

In these draconian economic times there are few herpetologists who can justify carrying out research simply because their subject of study is intrinsically interesting. In order to obtain funds for research, the

reptiles or amphibians of interest must either be of some economic or environmental importance, or be able to shed light on problems of much wider biological significance. Because only a small proportion of herpetofauna falls into one or other of these categories, herpetological ecologists are often tempted to work on more 'relevant' organisms which are more likely to attract an appropriate sponsor. As this book demonstrates, however, the study of lizard ecology is one of herpetology's success stories. The study of lizards has been at the forefront of ecology and has broadened our understanding of how communities are organised and how their delicate balance is so easily perturbed.

This book is a synthesis of Eric Pianka's research between 1962 and 1979 on three independently-evolved lizard systems in the deserts of North America, South Africa and Australia. With up to 42 species, the Great Victoria Desert of Australia supports the most diverse lizard community on earth. The Kalahari in South Africa holds about half as many species, whilst the deserts of the North American southwest are the most impoverished at between 6 and 11 species. Pianka set out to compare these three desert systems with a view to elucidating the structure of the lizard communities they contained.

After a general overview in which the study sites and methods are described, Pianka discusses the relationships between climate, productivity and lizard diversity. The productivity of deserts is dependent upon rainfall, and Pianka shows how the number of lizard species is related to the variability in rainfall. This emphasises the role of environmental variability in promoting species diversity. The next three chapters of the book compare microhabitat selection, thermal relations, activity patterns, foraging and reproductive tactics in the three desert systems. Chapter 6, entitled 'Natural History Miscellanea' is a pot-pourri of lizard facts and figures, in which Pianka discusses the function of lizard tails, mimicry, lizard burrows, and following the spoor of Australian varanids. Subsequent chapters deal with community structure and introduce the reader to the niche concept and how it can be applied to field data. How do lizard communities change over time? Pianka addressed this question by revisiting a study site in Australia 10 years after his initial study there. Some species increased in abundance over this period by a factor of 3 or more, while others displayed a decrease of similar magnitude. These changes are attributed to changes in food supply. Fire may also be important in maintaining diversity, and Pianka speculates about the possibility of fire occurring on a cyclic basis and thereby controlling community succession. In the penultimate chapter the author discusses how morphological measurements may be used to make inferences about lizard ecology.

This book is primarily a scientific treatise, and analysed field data is liberally presented in the form of tables and figures. Indeed, those who are statistically squeamish may find it heavy going at times. Those who have read Pianka's scientific papers, however, will find the style familiar. The book includes some 29 colour

photographs, and line drawings of lizards accompany each chapter heading.

For those already acquainted with Pianka's work, the book provides a cohesive summary of his findings and some new conclusions are reached in the light of recent data. In a series of appendices comprising about one quarter of the book, the author presents his extensive field data sets, so that other workers may have the opportunity of reanalysing and reinterpreting his data. For the ecology student the book provides a first-class introduction to community ecology and the niche concept. The book takes the introduction of these topics further than most general ecology texts, and its strength lies in how it demonstrates the application of ecological concepts to ecological data.

It is clear from this book that the organisation of desert lizard communities is highly complex. There are similarities between the three systems Pianka has studied, but equally, there are differences. As in any long-term study of this sort, answering one question invariably raises several more. It is therefore difficult to summarise Pianka's conclusions, a fact the author acknowledges in the final chapter, in which he muses, 'Perhaps all symphonies are doomed to remain unfinished!'.
R. A. Griffiths

(4) *Reptiles del Centro, Centro-Oeste y sur de la Argentina Herpetofauna de las Zonas Áridas y Semiaridas*. J. M. Cei (1986). 528pp., 114 figs. Price 90,000 Italian lira.

Reptile fauna from the geographic area below the 27th parallel in Argentina is described in this book. Two different parts are included. In the first introductory part, general considerations on reptiles are given. Firstly a description of the area to which the work relates is given and comments on extant studies of the Argentine herpetofauna are presented. The next chapter synthesises, in a succinct way, the origin and evolution of reptiles, and from this basis the author introduces current taxonomical classification, describing the main morphological characteristics and their determining importance. The next section consists of a synthesis of general biology of reptiles, including the skeletal, muscular, circulatory, digestive, excretory, respiratory and nervous systems and general remarks on reproduction. A special interest is the chapter on non-morphological characters used in current taxonomy, in which methods relating to immunological and cytogenetical techniques are described in detail, with concrete examples on the taxonomy of some Argentinian iguanids. Interesting comments on the biogeography of reptiles in the area concludes this part of the book.

In general, this first part seems to have been elaborated as an obligatory introduction, in which special care is not observed. It consists mainly of general remarks, with some aspects appearing with abundant and compact information whereas others are presented in too summarised a way. Regarding the study area, a more detailed description is omitted, though it can be found in 'summary and conclusions', at the end of the book.

The second part constitutes the main interest of the book. It is initiated by bilingual (Spanish and English) keys for the identification of species and genera. The use of the two languages may be a great aid for those who are not fluent in the Spanish language, and are to use the book as an identification guide. References of the species in the key to the later descriptions of each one and to the plates are missed. For each genus, information on its taxonomical status is given, with remarks on the main characteristics contributing to it, such as morphology and biochemical properties and historical events concerning it. Maps are used to show the distribution of the species reported for each genus, frequently indicating also the area occupied outside the limits imposed for the study. In particular, for each species, synonyms, identification, description, detailed comments on distribution and biological notes are included, and a great deal of information is given, at

least for those species for which it is available. The precise description of the species is accompanied by colour photographs for most of them (of 137 species, subspecies or forms considered, only 27 do not have illustrations). However, difficulties are produced by the fact that the plates are sometimes presented in a different order from the species in the text and by the lack of reference numbers relating them.

Concluding, the large amount of information provided on the species makes the book highly recommended for all those interested in the study of South American herpetofauna. The use of Spanish language is suitable, since the book may have a great readership among South American, and especially Argentinian, herpetologists. A better editing in order to reduce the great number of mistakes in the text would have been greatly profitable.

C. Diaz-Paniagua

THE HERPETOLOGICAL JOURNAL

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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.
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