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Contributions should be addressed to the Editor, Dr. Harold Fox, Department of Zoology, University College, Gower Street, London, W.C.1. Articles should be typed in double spacing on *one side* of the paper only. Figures should be drawn in Indian ink on plain white paper, or preferably Bristol Board and suitably lettered for publication.

## WATER-RELATIONS OF THE YOUNG NILE CROCODILE

J. L. CLOUDSLEY-THOMPSON

Department of Zoology, University of Khartoum, Sudan.

(Received 28/12/68)

## INTRODUCTION

During recent years, the temperature-relations of reptiles have attracted considerable attention, and it has been shown that desert reptiles in particular thermoregulate by behavioural rather than by physiological means (Schmidt-Nielsen & Dawson, 1964). The reptilian integument is by no means as impermeable as has been suggested (Chew, 1961). In fact, according to Bentley & Schmidt-Nielsen (1966), cutaneous transpiration represents two-thirds or more of the total water-loss from *Caiman sclerops*, *Pseudemys scripta*, *Terrapene carolina*, *Iguana iguana* and *Sauromelus obesus*. Moreover, Krakauer, Gans & Paganelli (1968) found differences in the rates of cutaneous transpiration from ten species of burrowing snakes and amphisbaenians. These differences were correlated with the dampness of the normal habitats of the different species.

The water-relations of the Nile crocodile have not previously been investigated, although Cott (1961) discussed thermoregulation by habitat selection and behavioural adaptation. He found that, in their natural habitat, the proportion of crocodiles with their jaws agape tends to become greater as the ambient air temperature increases during the morning and to decline with falling temperatures in the afternoon. He concluded that mouth gaping must have a thermoregulatory function and increase transpiration by exposing the moist mucosa.

## MATERIAL

Three young Nile crocodiles, *Crocodilus niloticus* L.\*, were obtained for me in December, 1967, by my colleague Dr. Ahmed Abdel Magid from Ed Dueim on the White Nile, about 230 km. south of Khartoum. They had hatched the previous September and been kept in captivity since then. The animals were placed in a wooden cage measuring 55 x 175 cm. containing sand and an oblong water bath 22 x 60 cm. in size. They were fed chiefly on cockroaches and other insects, with occasional pieces of chopped meat.

The young crocodiles soon became moderately tame which facilitated handling, but bit quite frequently when desiccated or being subjected to other experimental conditions. Unfortunately they did not prove to be good research material, and they died before the experiments had been completed. Nevertheless, the data obtained is sufficient to elucidate a number of points not previously investigated and may therefore merit publication.

In July, 1968, the animals took to burrowing in the sand beneath their water trough or under pieces of wood placed in their cage. Before this they had spent most of their time lying on the surface of the sand. They appeared to have a good memory of location and, if their excavation was filled up, they would dig again in the same place unless prevented from so doing. I gained the impression that crocodiles are by no means unintelligent when compared with other kinds of reptile. According to Pooley (1962), juvenile crocodiles in Zululand took to burrowing at the onset of cold weather: in Sudan they did so in mid-summer. Perhaps in each case this was the most unfavourable season of the year for them.

When disturbed, the young crocodiles reacted by hissing and grunting. They grunted a great deal more than usual when subjected to desiccation. Modha (1967) has shown that the grunting of young crocodiles elicits the attention of adults which swim towards the sound.

\* According to Wermuth & Mertens (1961, p. 364-5) the correct name should be *Crocodylus niloticus* Laurenti, although *Crocodilus* is perhaps more commonly used.

## TOTAL TRANSPIRATION

Water-loss was measured first in room conditions ( $25 \pm 1^\circ\text{C}$  range;  $35 \pm 5\%$  Rel. H. range) during February, 1968, and later in dry still air ( $25^\circ\text{C}$  or  $35^\circ\text{C}$ ;  $5\%$  Rel. H.). The crocodiles were weighed on a sensitive balance and their water bath was then removed so that they were continually exposed to room conditions. They were re-weighed every 24 hours. After two days they were re-hydrated and fed, before their water-loss in desiccators over anhydrous calcium chloride was estimated in the same way. The results are given in Table I. Two of the crocodiles were maintained in an incubator at  $25^\circ\text{C}$ , the third at  $35^\circ\text{C}$ . This animal was killed by three days of desiccation at this temperature, by which time it had lost 43.5 per cent. of its original weight.

	(1)	(2)	(3)
	( $25 \pm 1^\circ\text{C}$ range; $35 \pm 5\%$ Rel. H. range)		
Initial wt. (gm.)	71.3	84.9	96.9
Water-loss during first day (per cent.)	3.8	4.3	4.3
Water-loss during second day (per cent.)*	4.4	5.5	4.8
	<i>Animals rehydrated and fed</i>		
	(5% Rel. H.)	(25°C)	(25°C) (35°C)
Water-loss during fifth day (per cent.)*	4.1	5.5	15.1
Water-loss during sixth day (per cent.)*	4.1	5.2	12.3
Water-loss during seventh day (per cent.)*	4.4	5.2	9.5 (Dead)

\* Per cent. of weight at the beginning of each 24-hour period.

Table I. Water-loss in room conditions, and in dry air at  $25^\circ\text{C}$  and  $35^\circ\text{C}$ , from young Nile crocodiles.

When the results of this work are compared with those of similar experiments carried out on Nile monitors, *Varanus niloticus*, it can be seen that water-loss from the latter averages 6 per cent/24 hour at  $35^\circ\text{C}$  (Cloudsley-Thompson, 1967) compared with double that figure from the Nile crocodile which is clearly far more dependent upon water.

## SITES OF WATER-LOSS

In order to separate respiratory and cutaneous losses, the crocodiles were weighed and then placed in plastic bags containing anhydrous calcium chloride to prevent possible loss of water vapour by diffusion. The bags were sealed around the necks of the animals with adhesive tape. The crocodiles in their bags were again weighed and placed in desiccators at various temperatures for 24 hours. They were then re-weighed to ascertain the amount of respiratory evaporation before being removed from the bags and weighed separately to determine total water loss. Cutaneous water-loss was calculated from the difference between this and respiratory loss (Cloudsley-Thompson, 1968). No attempt was made to allow for loss of weight in the form of respiratory carbon dioxide or for cutaneous water loss through the exposed head.

The crocodiles were deprived of food and water for 24 hours before each experiment in order to reduce the probability of urine or faeces being produced while they were in the bags. Whenever this did occur, the experimental results were discarded.

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The crocodiles were deprived of food and water for 24 hours before each experiment in order to reduce the probability of urine or faeces being produced while they were in the bags. Whenever this did occur, the experimental results were discarded.

In each experiment one crocodile served as experimental animal, the other as control. The rôles were alternated after each experiment and at least 24 hours of recuperation with food and water were allowed before another experiment was begun. The results obtained are given in Table II. From this it can be seen that, at the temperature range mentioned above, total water-loss increased from 5.1 to 18.8 per cent. of initial body wt. per 24 hours, and cutaneous transpiration represented an amount varying from about 10 to 75 per cent. of this total. The proportion of cutaneous water-loss was lowest in the middle of the temperature range. If this result is significant it may have been due to a reduction in respiration at the lower temperatures and to the fact that the higher temperatures were not great enough to induce mouth gaping. Unfortunately the last of the crocodiles died in October, 1968, before this point could definitely be settled.

Temperature (°C)	Controls (Total)	Experimental animals		
		(Total)	(Respiratory)	(Cutaneous as a percentage of the total)
25	5.1	---	2.9	43
25	5.2	---	2.4	54
30	7.8	6.0	4.9	32
30	---	9.0	8.3	8
35	8.1	10.6	8.4	21
35	8.6	6.8	2.1	69
40*	18.8	---	4.8	75

\* Based on exposures of 6hr. only.

Table II. Water-loss from Nile crocodiles at different temperatures, expressed as Percentages of original body weight lost per 24 hrs.

According to Bentley & Schmidt-Nielsen (1965), caimans, *Caiman sclerops* (40-150g), lose water by evaporation in air (23°C; 25 per cent. Rel. H.) at a rate equivalent to  $13.3 \pm 1.9$  per cent. of their body weight in 24 hours, a rate nearly three times greater than that of the Nile crocodile.

#### EFFECT OF MOUTH GAPING

When they are lying ashore or partly submerged by day, crocodiles are frequently to be seen with their jaws agape, thus achieving thermoregulation by evaporation from the moist mucosa (Cott, 1961). In order to demonstrate the effect of this reaction on the rate of water-loss, two crocodiles were weighed. The jaws of one were tied firmly together to prevent gaping before they were both placed in an incubator at 50°C (10 per cent. Rel. H.) for 15 minutes and then re-weighed. During the period of exposure in the incubator the weight of the control animal fell from 68.45 g. to 67.20 g. (1.25 g. /15 min.), that of the crocodile with its jaws tied from 64.40 g. to 64.15 g. /15 min.). Both crocodiles appeared to be in some distress at the end of the experiment especially the one with its jaws tied and which had lost only about one-fifth as much water as the control.

Colbert, Cowles & Bogert (1946) found that in *Alligator mississippiensis*, a temperature of 38°C (37 per cent. Rel. H.) induces a loss of approximately 20 per cent. of body weight in 24 hours. The rates of water-loss from the crocodiles in the experiment described above were respectively 175 and 37 per cent. of body weight per 24 hours. It is clear therefore that the alligator at 38°C cannot have gaped for long, if at all, during its period of exposure.

#### WATER-UPTAKE

It was found that desiccated crocodiles, like monitor lizards (Cloudsley-Thompson, 1967), did not take up water through the skin from damp sand. Indeed, experiments in which the bodies of partly dehydrated animals were immersed in water for an hour except for their heads, and drinking was prevented, failed to disclose any increase in weight (Cloudsley-Thompson, 1968). In fact, under such conditions the young crocodiles continued to lose weight, presumably as a result of continued respiratory evaporation. The suggestion (Cott, 1961) that water may be absorbed via the cloaca or submerged surfaces and evaporated through the gaping mouth as a form of thermoregulation is therefore disproved.

Rehydration by drinking was comparatively rapid. For example, a crocodile desiccated to 88.7 per cent. of its original weight recovered 2.8 per cent. in 15 min., one desiccated to 91.2 per cent. recovered 6.1 per cent. in 15 min. and one desiccated to 91.0 per cent. recovered to more than its original weight in one hour. Rehydration was always complete within two or three hours of being returned to water.

There is a curious discrepancy between my observations and those of Bentley & Schmidt-Nielsen (1965) who found that *Caiman sclerops* gains water at the rate of 3.5 ml./kg./hr. or  $1.1 \mu\text{l}/\text{cm}^2/\text{hr.}$  of which 70 per cent. is taken in through the skin, the remainder being due to drinking. It is possible that the differences between the two sets of results may be due to the fact that my crocodiles were partially dehydrated whereas the caimans were fully hydrated and living in water. They were only losing water in urine and by respiratory evaporation and their total uptake was low. At the same time, Bentley & Schmidt-Nielsen used a different technique and measured water-uptake by dissolving phenol red in the bathing solution. After this had been recovered and made alkaline, they measured calorimetrically the amount that had accumulated in the alimentary canal.

On the other hand, as mentioned above, *C. sclerops* transpires very much more rapidly than *C. niloticus*. It is by no means impossible therefore that caimans may be able to take up water through the integument as fishes and amphibians do, whereas crocodiles like almost all other reptiles can only absorb water by drinking. The exceptional condition of caimans requires further investigation, nevertheless.

#### TIME OF WATER-UPTAKE

Nile crocodiles exhibit a weak diurnal rhythm of activity with a peak in the early hours of the evening (Cloudsley-Thompson, 1964). In nature, the night is usually spent in water and the haul out to land begins in the hour before sunrise. In the heat of the day there is a secondary return to the water or into shade (Cott, 1961). The young crocodiles which were the subject of the present investigation usually spent the night in water and passed the day on land. As already mentioned, until July, 1968, they would lie on the sand in the corner of their cage but, after this, they took to excavating a burrow beneath their water tank.

By means of a simple aktograph consisting of a float attached to a needle writing on a kymograph drum, the aquatic activity of the two smaller surviving crocodiles was recorded throughout 22 days (between 15 Aug.-16 Sept., 1968). The water tank was sufficiently small for the presence of the crocodiles to be detected by the position of the float, even when the animals were motionless. Distinct movements of the crocodiles resulted in vertical strokes on the smoked record which were analysed over 3-hour periods and plotted as block histograms.

When the histograms are aggregated (Fig. 1) it is quite clear that the crocodiles scarcely entered their water-tank during the first half of the day and that rehydration must have taken place almost entirely in the afternoon and at night.

## SUMMARY

Young *Crocodilus niloticus* transpire at a rate of about 5 per cent. of body wt./24hr. at 25°C and of about 12 per cent. at 35°C (double that of *Varanus niloticus*). In dry air at temperatures from 25° to 40°C, water-loss varies from about 5 to 20 per cent. of initial body wt. per 24 hr.: the lethal limit of water-loss is about 40 per cent. Cutaneous transpiration represents an amount varying from about 10 to 75 per cent. of the total. Transpiration increases sharply when crocodiles thermoregulate by mouth gaping. During exposure to 50°C in dry air, a control animal (weighing 68.45g.) lost 1.25 g. /15 min. whilst one of comparable size (64.40 g.) but with its jaws tied firmly together lost only 0.25 g. /24 hr. Rehydration is achieved only by drinking and water is not absorbed through the skin (as it is in the case of *Caiman sclerops*). Crocodiles tend to pass the day on land and spend the night in water, at which time they become rehydrated.

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## DIURNAL RHYTHM OF ACTIVITY IN THE NILE MONITOR

J. L. CLOUDSLEY-THOMPSON

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(Received 28/12/68)

When kept in an aquarium containing water and a flat-topped stone onto which they could climb, young Nile monitors, *Varanus niloticus* (L.), spend most of their time in the water and show a marked circadian rhythm with peaks of activity during the daytime (Cloudsley-Thompson, 1967). A less marked rhythm is apparent in the Nile crocodile *Crocodilus niloticus* Laurenti, confined under comparable conditions (Cloudsley-Thompson, 1964). When crocodiles have access to land, however, they spend much less time in water than if provided only with a stone slab to lie on. Indeed, when kept in a cage filled with sand into which they could burrow, young crocodiles seldom entered their water-tank during the first half of the day (Cloudsley-Thompson, 1969). Similar experiments, using the same technique, were therefore carried out on a young Nile monitor to see if the same applies to this species. The animal, which was captured in November, 1968, weighed 88.8 g. and had a length of 48 cm. Its total activity over a period of one week is shown in Fig. 1. The animal remained on the sand in its cage throughout the day and night, except for brief visits to water: it did not attempt to burrow as the baby crocodiles did. The aggregate number of such visits, analysed quite clearly that the monitor visited water most often during the early afternoon, even during comparatively cool weather. This is the time of day at which baby monitors are normally most active when they are confined in an aquarium. The

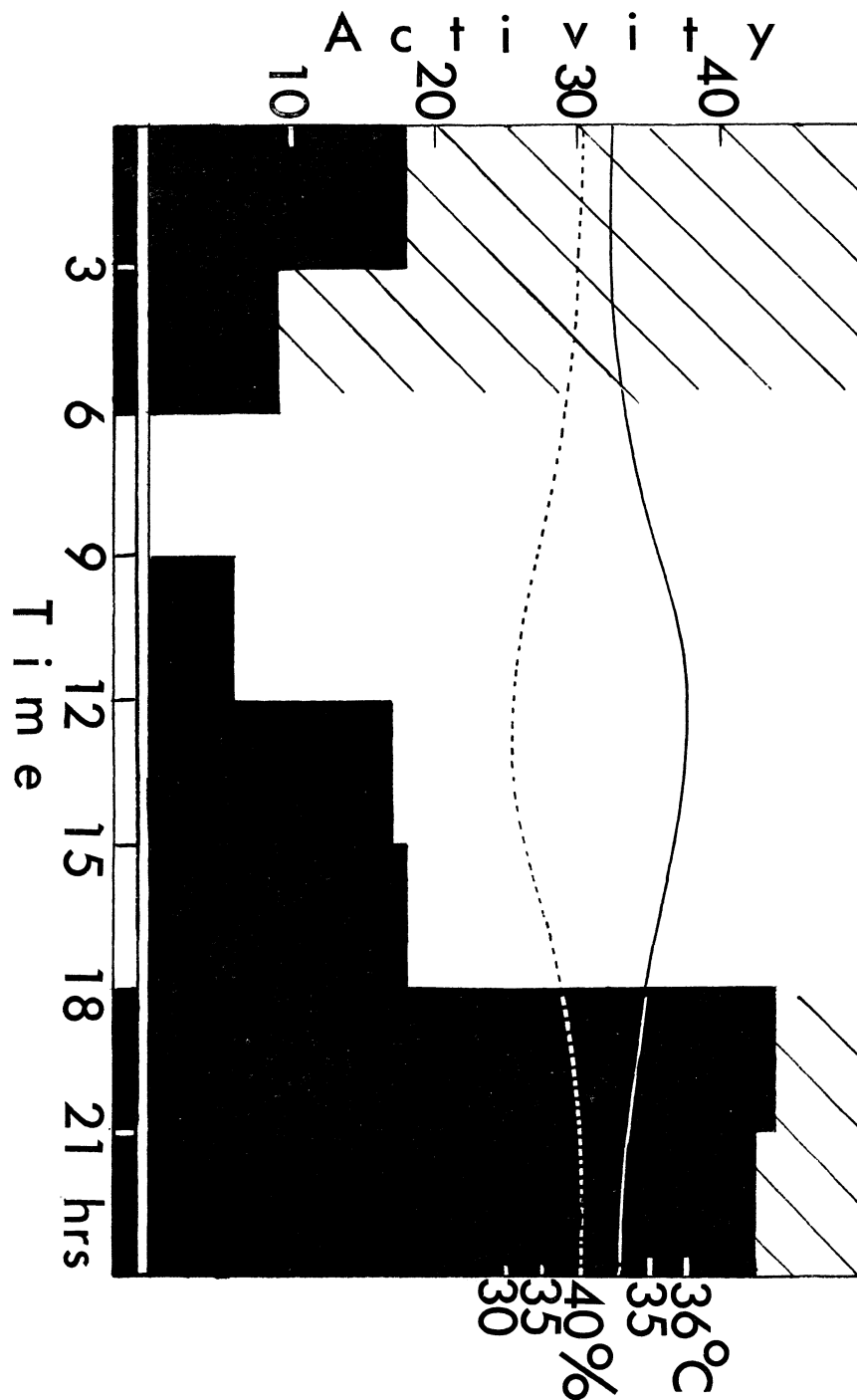


Fig. 1. Rhythm of aquatic activity in the Nile crocodile. Aggregate of 20 day's activity by two young crocodiles. Ordinates: activity on the left, mean air temperature (solid line) and relative humidity (broken line) on the right. Abscissa: time in hours.

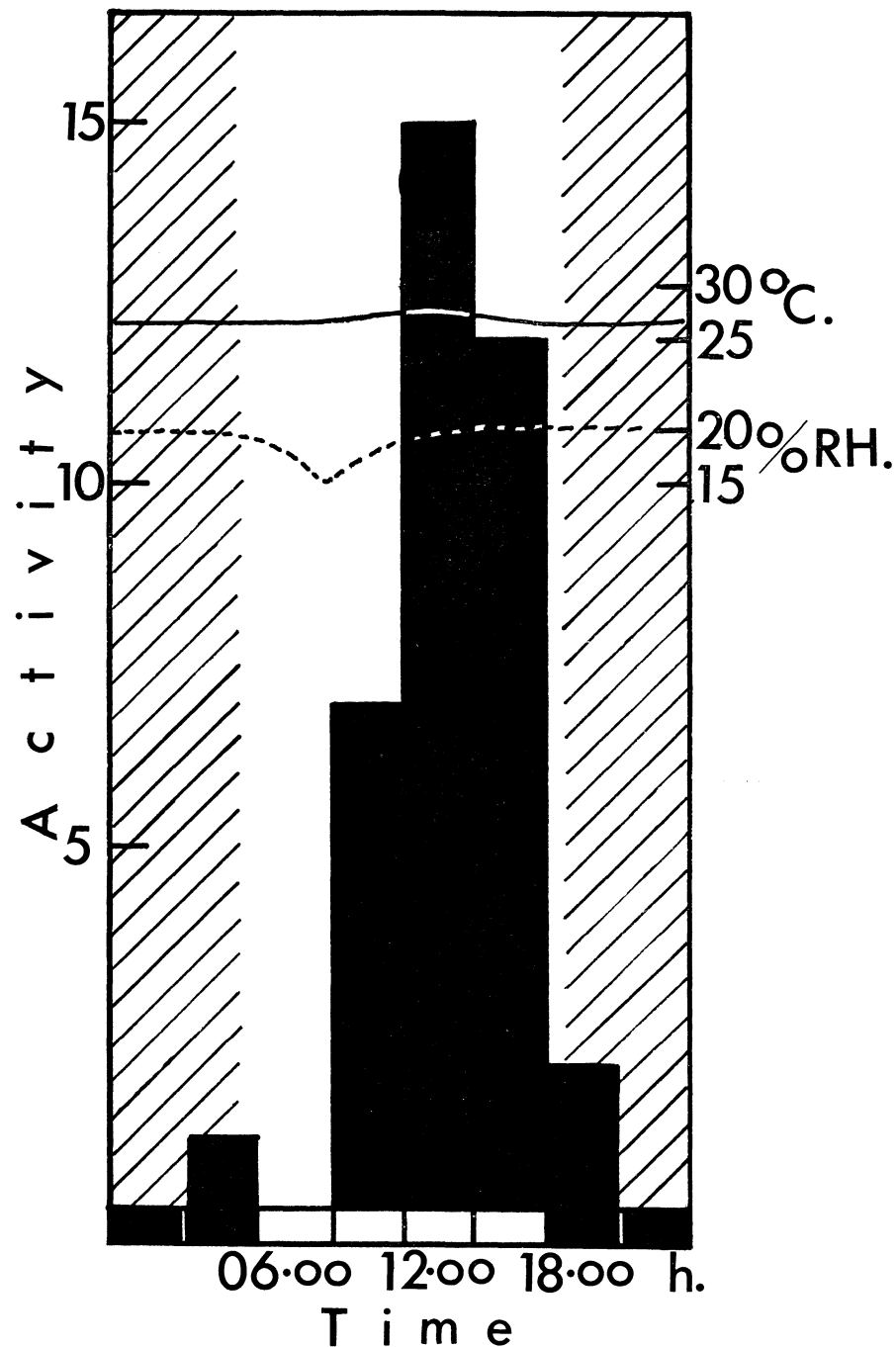


Fig. 1. Total activity in water over a period of one week. Ordinates: activity on the left; average air temperature and relative humidity (broken line) on the right. Abscissa: time. The black strips represent the period from midnight until 06.00 h. and from 18.00 h. until 24.00 h.

animal in question never became tame as many individuals seem to do. When it was handled, it invariably puffed itself up, hissed, lashed with its remarkable prehensile tail, bit fiercely so as to draw blood and then would not let go.

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## COMMENTS ON THE MALTESE HERPETOFAUNA

By

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(Received 11/10/68)

These observations were made when I visited the Maltese islands of Malta and Gozo in early April (5-15th), 1968. The time of year was early and some species were not very active. The weather was variable; warm and sunny mostly, but overcast and wet for a proportion of the time. The geology is primarily limestone, very dry, with many cracks and crevices that afford refuge for a number of reptiles and an amphibian. Malta is heavily cultivated and much built-upon; while Gozo is less so with exposed promontories of limestone pavement, covered by scanty scrub and annual, Spring-flowering plants which are generally goat-grazed. The herpetofauna is primarily European, typically Mediterranean with some North African affinities and included in the list of Mertens and Wermuth (1960).

## Amphibia:

## Discoglossidae:

*Discoglossus pictus pictus* Otth:

Malta: Chadwick Lakes, near Rabat—larvae and metamorphosed juveniles in stagnant pool with a rusty substratum.

Gozo: Ramla Bay—male, under a damp piece of cardboard in dried-up creek with growth of *Arundo donax*. Marsalforn Valley—larvae and metamorphosed juveniles in wells and irrigation tanks, T. Cross, U.C.C. Wied il Pergla, 1 mile E. of Marsalforn. 2 males 1 female, by stream and well amongst *A. donax* and bananas, T. Cross, U.C.C.

The Painted frog is confined on the Maltese islands to damp situations, or near water whose lime content is reduced somewhat by decaying vegetation. It is the only amphibian known to occur on Malta.

## Reptilia:

## Scincidae:

*Chalcides ocellatus tiligugu* (Gmelin):

Malta: Chadwick Lakes, near Rabat—1 male, seen under a small rock in a damp valley. Mgarr, 2 miles E.—male and female caught alive, many seen burrowing at base of man-built, dry-stone walls and rocks on edges of terraced fields by coast.

Effieha Bay—frequent among dry rocks and vegetation of coastal cliffs. Marsaxlokk—frequent in dry-stone walls of fields and buildings.

Gozo: Between Marsalforn and Ramla Bay—frequent in dry-stone walls of fields (absent from exposed seaward plateau). Mgarr Harbour, just N.—single animal, seen entering crevice in a dry-stone wall. Xlendi Bay; Xaghra; Inland Sea, Dwejra Point; Qala—single animals, base of dry-stone walls, T. Cross, U.C.C.

This subspecies of the Eyed skink, also represented in Tunisia and N.E. Algeria, was characteristically to be seen abundantly on Malta. In early Spring the species passed most of the day basking in the sun, quickly retreating into subterranean burrows at the base of man-made, dry-stone walls often near habitation, with violent wriggling movements and a final flick. It was not to be seen in very exposed situations. An experiment was performed in London over a period of two months on the selection of different-coloured prey by two adult animals. These ate voraciously III to V instar locust hoppers (*Locusta*—black and brown; *Schistocerca*—pale green to yellow) without any regard to colour and increased somewhat in weight and obesity.

Gekkonidae:

*Tarentola m. mauritanica* (L.):

Malta: M'Sida, near Valletta—several on wall by road basking in sun and seeking refuge. M'Dina, just N.—single animal, on dry-stone wall by footpath.

Gozo: Mgarr Harbour—single animal, on wall basking in sun near quay by the sea. Marsalforn—in house; Ggantija—in megalithic ruins; Mgarr Ix-Xini—beneath large stone in field, single specimens, T. Cross, U.C.C.

The Moorish gecko, widely distributed over much of the Mediterranean area, was seen abundantly on Malta. Geckos spent much time in Spring basking in the sun during the day and were not seen so frequently at night which is cool at this time of year. A single animal was obtained (Gozo: Xaghra—dry-stone wall, T. Cross, U.C.C.), perhaps being more secretive, of the Turkish gecko (*Hemidactylus t. turcius* (L.)) also known to occur on Malta.

Lacertidae:

*Lacerta filfolensis maltensis* (Mertens):

Malta and Gozo: Ubiquitous, rare in damper regions. The Wall lizard was to be seen mating at this time of year. The male with a vivid green colour on the dorsal surface approached the female from the side vibrating his tail and attracting her attention. At the suitable moment of a passive behavioural response, he grips her neck region from the side with his jaws and brings the cloacal region into juxtaposition with that of the female by rotating his body to one side and thus effecting copulation.

Colubridae:

*Coluber viridiflavus carbonarius* Bonaparte:

Gozo: Marsalforn, just E.—single animal, about 4½ feet in length basking on dry vegetational remains of *A. donax* by a dry-stone wall in which it sought refuge, on the side of a cliff promontory. Mgarr Ix-Xini; W. of Xlendi Bay, single specimens seen, T. Cross, U.C.C. Ramla Bay, ¼ mile from coast in dry creek (M.R.K.L.); Wied il Pergla, 1 mile E. of Marsalforn; Ta'Bordin, 1 mile W. of Nardur, T. Cross, U.C.C. Skin remains only, probably of this species, were found.

The black form of the ferocious Dark-Green Whip snake was seen at times on Gozo. It was not observed on Malta. It is probably this species, not a viper, that bit Saint Paul when he was ship-wrecked on Malta and was carrying a pile of sticks to make a fire. It has been thought to be a Smooth snake, but unlikely as *Coronella* has not been found on the islands. The Wall lizard makes up the bulk of the diet of this snake being the most easily obtainable.

In conclusion, the Spring herpetofauna of Malta is conspicuous in the number of individuals to be observed; but seems inconspicuous in the number of species represented, totalling only five, although twelve are known to be present on the islands.

ACKNOWLEDGMENTS

Specimens collected alive or preserved are now in the Departments of Zoology, Trinity College, Dublin (A. B. West) and University College, Cork (T. Cross), Eire, and in the Anti-Locust Research Centre, London. I am grateful to Professor H. Micallef of the Department of Biology, the Royal University of Malta, M'Sida for furnishing me with a list of the reptiles known to have been found on Malta.

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AN UNUSUAL SPECIMEN OF THE NEOTROPICAL VINE SNAKE,  
*OXYBELIS AENEUS* (WAGLER), FROM ZACATECAS, MEXICO

by

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(Received 1/6/68)

Published records of the Neotropical Vine Snake, *Oxybelis aeneus* (Wagler), from the Mexican state of Zacatecas, are apparently non-existent. A specimen in the collections of the Museum of Zoology, University of Michigan, represents the first record of this species from Zacatecas and is unusual in the size and morphology of its hemipenes. The snake, UMMZ No. 118445, was collected on 1 July 1957, 8 mi. S Moyahua, elev. ca. 5,600 feet, in an area characterized by the data as "Tropical moist forest." The specimen was collected by a native and given to the University of Michigan by Dr. Richard B. Parker.

Baker, Webb, and Dalby (1967) reported a vertebrate fauna with coastal tropical affinities existing at 1,100 m. elevation in a deep "island canyon" of the Río Juchipila of southern Zacatecas. The locality for the *O. aeneus*, a wide-ranging species that in western México has a coastal distribution, is in the vicinity of the same canyon. The nearest locality records for this species are those of Dugés (1869) for Guadalajara, Jalisco; and of Grant and Smith (1960) for Rancho Primavera, 10 miles west of Guadalajara. The Zacatecas record represents a northeastward range extension of approximately 40 miles. The presence of the species in southern Zacatecas is thus not entirely unexpected.

UMMZ 118445 is a male with a snout-vent length of 803 mm. and a nearly complete tail of 545 mm. Scutellation: oculars 1+2, temporals 1+2, loreal absent, supralabials 8-8 with 4,5,6 in eye, infralabials 9-9, anterior chin shields 2, posterior chin shields 2, ventrals 192, caudals 184+, anal plate divided. The dorsal scale reduction pattern for *aeneus* has not been reported previously. The pattern for this specimen is as follows:

$$\begin{array}{ccccccc} & 8+9(135) & 3+4(139) & 7 & & & \\ 17 & \text{-----} & 16 & \text{-----} & 14 & \text{-----} & 13 \quad (192) \\ & & & & 3+4(139) & & +7(140) \end{array}$$

This pattern is unusual for Mexican specimens of *aeneus* in that the first reduction is 8+9 rather than 3+4 or 7+8. I have found similar vertebral-paravertebral primary reductions on occasional specimens from other parts of the range however, and I consider the above pattern to be within the normal limits of variation for the species.

The hemipenes of this species were characterized by Bogert and Oliver (1945:385) as having basally located, recurved, claw-like spines staggered in about 10 rows. The hemipenes of the Zacatecas specimen are very small for the size of the snake, and basally-located, enlarged spines are absent. I have examined the hemipenes of over 400 male *O. aeneus* from Arizona, México, Central America, and South America, and the only specimens having hemipenes similar to those described for the Zacatecas individual are 25 males from within the distant state of Sinaloa on the western coast of México (Keiser, 1967). I have located only one male from the intervening areas of Nayarit and Jalisco. This specimen (United States National Museum, No. 46455) is a small adult from Navarrete on the coastal plain of Nayarit, just south of the Río Grande de Santiago. This snake has hemipenes of normal size for the species, and the basally-located spines are present but only slightly enlarged. It is possible that specimens with reduced hemipenes and hemipenial spines may eventually be found in areas bordering the Río Juchipila in Zacatecas and the regions adjacent to and north of the Río Grande de Santiago in Jalisco and Nayarit. Field studies are pending in these areas in the near future, and a detailed discussion of this problem is anticipated when additional specimens and data are available.

## ACKNOWLEDGMENTS

I wish to thank Dr. Charles F. Walker and Dr. James A. Peters for supplying the two specimens discussed herein, and Dr. Hobart M. Smith for verifying the state record.

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## RECOLONISATION OF BURNT HEATH BY LIZARDS

*Lacerta vivipara* Jacquin

By

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(Received 18/12/68)

## INTRODUCTION AND METHODS

A study area at Strensall Common (SE 637601) was visited at least twice weekly from March to October inclusive. Strensall Common is a largely unreclaimed fragment of the lowland heath developed on the York moraine complex, and lies six to seven miles north of York. Soils are sandy, with a high water-table, and the climax vegetation of birch-oak woodland has been traditionally denied by grazing and burning schedules and also, since late last century, by military use. A gorse-heather heath has resulted (Fig. 1).

A standard route was used to cover the area as fully as possible during short visits in suitable weather conditions; totalling some 150 hours per season. Lizards were caught by hand, code-marked at initial capture by toe-clipping, and described for size, gross morphology, weight, sex and breeding condition at initial capture and at each succeeding recapture.

The locations of 'territories' and of hibernacula shown on the sketch-plans were established by the repeated recapture there of a known individual; those of the deposition of the young were inferred from repeated observations of the same gravid female at one point as well as capture of the young before they had dispersed. In several cases observation established the identity of parents and it was noted that the aggressive behaviour typical of 'territorial' encounters was later displayed by gravid females towards their erstwhile mates.

## TABULATED RESULTS

Season	Total Hours (approx.)	Estimate of Population (Sept.)	Number of Litters	Average size of Litter	Litters in 1965 Centre
1965	110	84	6	5.2	4
1966	160	38	4	5.8	0
1967	150	60	7	5.2	0
1968	150	88	8	5.3	1+

Table I: Summarised results of population investigation.

+—three other litters nearby, in new locations.

N.B.—numerical estimates of population are based on the ratio of recaptured to fresh captures at different stages of the season and are considered more likely to be under-estimates than over-estimates.

Locations	Recaptures				Notes.
	1965	1966	1967	1968	
Burnt	17	1	1	1	The same individual 65-68
Unburnt	6	4	5	2	

Table II: Survival of 1965-marked individuals in the burnt and unburnt parts of the Study Area compared. See Figs 2 and 3.

## DISCUSSION OF RESULTS

Throughout the study there have been two main foci of lizard distribution;—the 1965 centre and along an arc from the fence to the southern-most bushes (compare Figs 2 and 3). Both foci offered undisturbed cover and the relative proximity of suitable hibernacula; and whilst some individuals were occasionally seen in the open, no 'territory' was taken up which did not include some deep scrub cover. In this respect it is significant that the burnt area was not re-populated until the ground flora had recovered sufficiently to provide some retreats.

The westward movement in 1966-68 was piecemeal and achieved by lizards taking up 'territories' progressively outward in all directions from the fence focus. It was clear from the 1966 recaptures that individuals tended to maintain their 'territories' of the previous season and that males in their first season of sexual maturity tended to 'leap-frog' these. Often they were followed by females whose offspring tended to be few in number; suggesting that they, also, were newly mature. Males are known to become sexually mature at 22 months (Smith, 1954), and so we might expect the 1967 litters to include the first offspring of the two 1965 litters born in the unburnt area and so providing a sudden increase in the number of litters over that of the year before. This was confirmed by the marking scheme (compare Table II with Figs 2 and 3).



The Study Area is effectively isolated from other known centres of distribution of *Lacerta vivipara* in the neighbourhood, due to the natural barriers of unsuitable habitats. Although the heath extends to the east, at present there is a broad and open stretch which has no lizard population before another favoured locality is reached. The conclusion is therefore offered that natural repopulation and breeding of *Lacerta vivipara* can in three seasons restore a population reduced to a third or a quarter of its numerical strength.

SUMMARY

Investigations of the distribution, population density and breeding success of viviparous Lizards on a four-acre strip of sandy lowland heath were started in 1965. Late in the season about two acres, including the areas most favoured by the lizards, were severely burnt for over eighteen hours and subsequent search indicated that most of the population had perished. Recovery of the flora, mainly grasses (*Graminae*), Heather (*Calluna*), and a shrub element of Gorse (*Ulex*) and Black-berry (*Rubus*), restored ground cover by the end of the 1966 season. Lizard recolonisation was from the unburnt area, where a minority of the 1965 population had been found.

The recovery and re-distribution of the lizard population was followed by plotting the movements of marked individuals from re-capture data. From 1966 to 1968 locations favoured for breeding sites and hibernacula, as well as the "territories" (*sensu lato*) of individual lizards, increasingly approximated to those used in 1965. Population increase, based on estimates only, indicates that three breeding seasons were required to reach a level comparable to that of 1965, and there are clear signs that most of the recovery was brought about by young lizards in their first breeding seasons. Similar stations were taken up by the newcomers to those used by the 1965 population for basking, deposition of the young, and for hibernation, despite a changed flora in some of these situations. This suggests that functions of aspect and of micro-geomorphology might be of critical significance.

The author has been unable to find reference to any previous observations on this subject.

ACKNOWLEDGMENTS

Much of the fieldwork was carried out during the course of a morphological investigation of *Lacerta vivipara* at the Yorkshire Museum, York. Mr. P. R. Balch has given considerable and patient assistance in the field.

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FIG 1 THE STUDY AREA, 1965. SE 637 601.

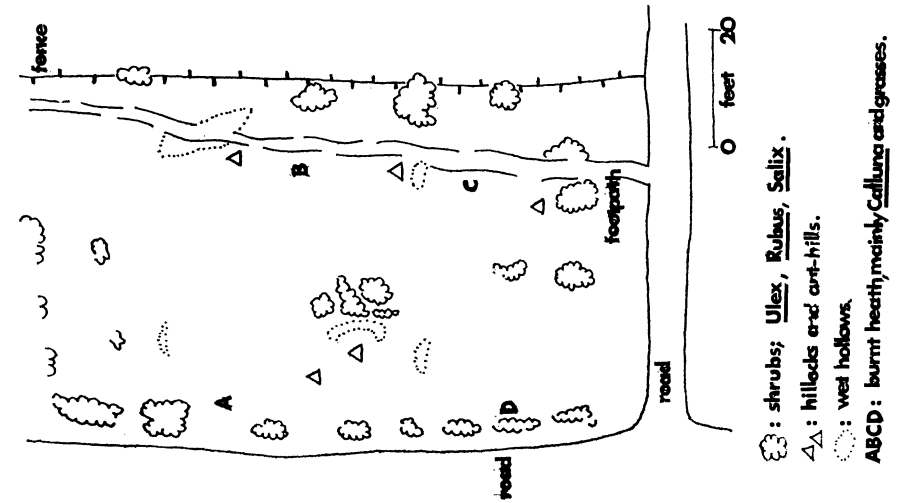


FIG 2 THE 1965 and 1966 DISTRIBUTIONS.

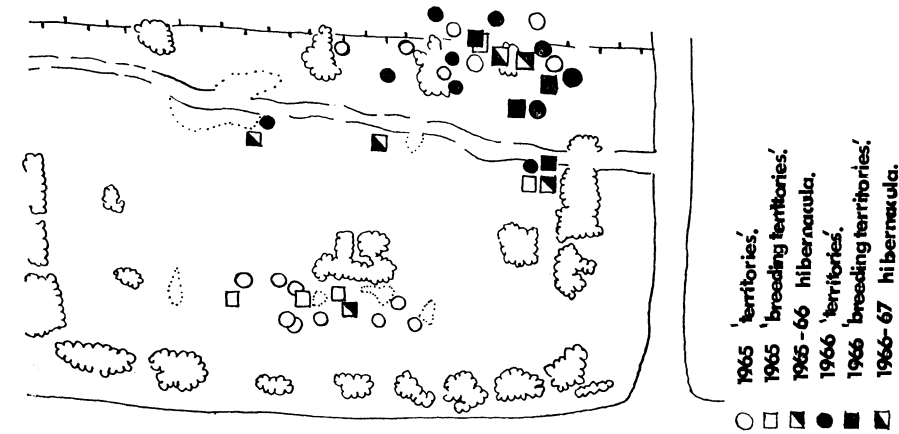
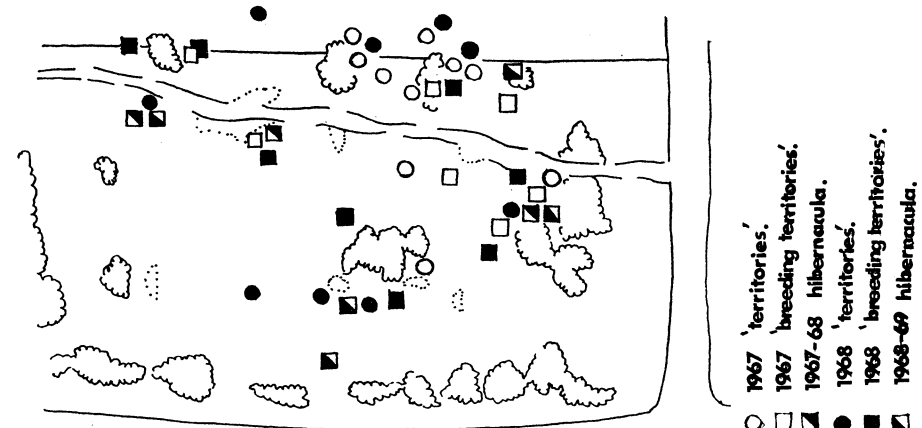


FIG 3 THE 1967 and 1968 DISTRIBUTIONS.



IAH ABNORMALITIES IN REPTILES RESULTING FROM  
HIGH TEMPERATURE EGG INCUBATION

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(Received 12/11/68)

Reptile eggs can be successfully incubated in the laboratory over a range of constant temperatures or at a temperature that fluctuates within certain limits. Temperature tolerances (both upper and lower limits) show marked interspecific variation in reptiles and these differences are correlated with geographical distribution. Thus the eggs of the tropical and sub-tropical green turtle (*Chelonia mydas*) do not develop at temperatures much below 27°C (Bustard and Greenham, 1968), whereas eggs of chelid terrapins in southern Australia normally incubate at mean temperatures of 16-23°C, and those of *Chelodina expansa* over-winter at near freezing temperatures (Goode and Russell, 1968).

It is well known that effective control of moisture is important for successful incubation of parchment-shelled eggs, which are prone to fungoid infections. I have successfully incubated many parchment-shelled reptile eggs in sterilized sand moistened with 8% water (by weight) (Bustard, 1967). Lynn and Ullrich (1950) have demonstrated the critical nature of adequate moisture at certain developmental stages of chelonian eggs and shown that many gross morphological abnormalities are due to moisture deficiency. In the present work all eggs were maintained at the adequate 8% water content by weekly additions, when necessary, of weighed amounts of water to the sand medium throughout the incubation period.

Ten eggs of the gecko *Oedura ocellata* Boulenger, which like all members of the sub-family Diplodactylinae lays parchment-shelled eggs (Bustard, 1968), were incubated at a constant temperature of 30°C. This was much higher (of the order of 10°C) than would be normal for this gecko in nature. Incubation period for those eggs which hatched was 54-55 days. Four eggs developed fungus. All the remainder developed to full term. One gecko slit the egg-shell but failed to emerge, two died without slitting the shell, one emerged with its yolk-sac extruded and two were normal hatchlings. The three which did not emerge from the eggs all possessed stumpy deformed tails. Failure to emerge from the egg, despite successful slitting of the egg-shell often occurs with eggs incubated near their upper temperature limit. A newly hatched individual and a full term embryo, with normal and deformed tails respectively, are shown in Plate 1A.

During work on temperature tolerances of incubating crocodile eggs, several eggs of the New Guinea freshwater crocodile (*Crocodylus novaeguineae*) were maintained at a constant temperature of 38°C. Of the five eggs at this temperature at least two proved to be infertile. Two of the remaining eggs failed to hatch. These eggs showed a normal weight gain initially, due to water uptake, but when subsequently opened were found to be decomposed with no trace of an embryo. Probably the embryos died during very early development. The remaining egg appeared to develop normally. The young crocodile slit the egg in the usual way but failed to emerge. After forty-eight hours it was removed, alive, and in apparent good health except for a deformed and stunted tail. This individual is illustrated together with a normal hatchling in Plate 1B.

This crocodile was the only specimen out of several dozen successfully incubated at a series of lower temperatures with a tail abnormality. It was incubated at 38°C, the highest temperature to produce a hatchling. The fact that it failed to emerge after slitting the egg-shell suggests that it was near its upper lethal temperature as mentioned above.

The crocodile situation closely paralleled that described for *Oedura* although the crocodile eggs had a considerably higher temperature tolerance as is to be expected on the basis of their geographical distribution. High temperature for each species produced a deformed (stunted) tail.

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Plate 1A. Abnormal and normal *Geckos* (see text).

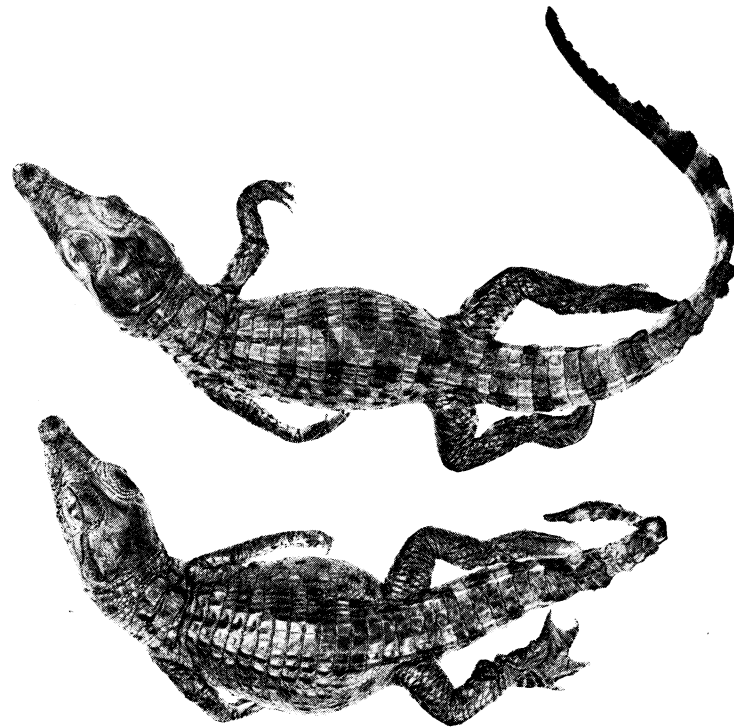


Plate 1B. Abnormal and normal *Crocodylus* specimens (see text).

OBSERVATIONS ON THE STRUCTURE OF THE ADRENAL IN *NAJA NAJA*  
(LINNE) AND *NATRIX PISCATOR* (SCHNEIDER) (REPTILIA: OPHIDIA)

By

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College of Science, Nagpur, India

(Received 30/5/68)

INTRODUCTION

The histology of the adrenal glands of snakes has received little attention except for the description by Janequiera (1944) and Benzedeczy *et al.* (1966). This study was made in order to contribute further information on the structure of the ophidian adrenal.

MATERIAL AND METHODS

Several Specimens of each of the following species were investigated:

Ophidia—Family—Colubridae: *Natrix piscator*

„ —Elapidae: *Naja naja*

Specimens were collected in vicinity of Nagpur. In all cases tissues were fixed in neutral formalin and dehydrated in graded alcohols, embedded in paraffin wax and sectioned at 5 to 10 microns. Sections were stained either with Ehrlich's haematoxylin and counter stained with eosin, or with Masson's trichrome method.

OBSERVATIONS

The adrenals of *Naja naja* and *Natrix piscator* are elongate bodies, tapered at both ends, situated near the caudal end of the gonad and enveloped in mesovaria or mesorchia. In *Naja* there are interesting sex differences; in males each adrenal has a caudal appendage which is absent in *Natrix* (Fig. 1). In the normal adult *Naja* 114.5 cms. long, the length and breadth of the adrenal are 12 mm. and 4 mm. respectively and in *Natrix* 98 cms. long, the adrenal is 8 mm. long and 3 mm. wide.

HISTOLOGY

In both species the adrenal gland is composed of a ventral interrenal and a dorsal chromaffin encapsulated component (Fig. 2 A and B). The chromaffin region is approximately one third to one quarter as thick as the interrenal tissue. It is usually thickest mid-centrally, and thin at each pole. The chromaffin tissue is compact and not arranged in cords as in the case of the interrenal substance. In *Naja* the caudal appendage is composed of chromaffin tissue only. Single cells or small groups of chromaffin tissue frequently are seen between the interrenal cells.

The chromaffin tissue is composed of two types of cell, one peripheral, and the other situated more centrally, adjacent to the interrenal tissue. Both cell types are roughly spherical in diameter (12  $\mu$  in *Naja* and 9  $\mu$  in *Natrix*), and contain granules coloured a characteristic yellowish brown. Occasionally in an outer zone cells include a few large eosinophilic granules. The nucleus of all types is 4  $\mu$  to 5  $\mu$  in diameter. It is of interest that acidophilic chromaffin type cells are found mixed with interrenal cells.

The interrenal tissue is composed of irregularly anastomosing cords of radially arranged columnar cells separated in *Natrix* by venous channels. The interrenal non-anastomosing cords of *Naja* are formed of cuboidal cells. In non-anastomosing areas the cord is about 45  $\mu$  in diameter in *Naja* and 57  $\mu$  in *Natrix*.

The adrenal gland is enclosed completely by a thin connective tissue capsule.



## LETTERS TO THE EDITOR

On 9th September, 1968, a Spanish wall lizard (*Lacerta vivipara*) in my possession behaved in an unusual manner. A number of grasshoppers had been placed in a vivarium and at first the female ignored them, instead warming herself on a rock under an electric light. Suddenly she threw herself at the nearest hopper, which she missed, and then she rushed around the cage, mouth open lunging at everything in her path, including another lizard.

After some minutes she became calm and managed to kill a grasshopper by shaking it vigorously.

She then played with it like a cat with a mouse, shaking it, putting it down and walking around it, and the seizing it again as though it were a live insect. She even nudged it with her snout and paws, to make it move before attacking it.

Eventually she lost interest and leaving the insect uneaten she returned to the rock.

About thirty minutes later the lizard ran straight to the motionless hopper and ate it. It was not visible from her situation on the rock, therefore she must have memorised its position in order to have found it so quickly. This particular animal has accepted dead food on several occasions.

ELIZABETH SHALLCROSS,  
13, Derwent Drive,  
Hayes,  
Middlesex.  
28/9/68

An adult specimen of *Xenopus laevis*, maintained in an aquarium 18 in. x 10 in. x 10 in., was fed 4 earthworms at 6.30 p.m. 27th June, 1968. Two specimens of newly-metamorphosed *Rana temporaria* and *Bufo bufo* were introduced into the tank at 7 p.m. These were ignored by the free-swimming *Xenopus*. At 8 p.m. only one frog was noticed in the tank. Soon afterwards the *Xenopus* swam towards the remaining frog, seized it by the head and immediately swallowed it.

At 10 p.m. two dead specimens of *Rana* and *Bufo* of about the same size as previously, were put into the tank. They were seized and swallowed in the same manner as just described.

Slightly bigger specimens of the common frog and toad have been kept with *Xenopus* before, when no incidents like these occurred.

M. DAVIES,  
10c, Tevery Close,  
Stapleford,  
1/8/68

With reference to Mr. C. Simms' note, 'Burrowing of the Sand Lizard,' *Lacerta agilis* (*Brit. J. Herpetol.* 4, No. 3, Dec. 1968), I have noticed that female sand lizards kept in captivity in wooden-bottomed vivaria, when burrowing before egg-laying, make a rather half-hearted attempt at digging a deep hole whatever the depth of sand. They do however, spend considerable time and effort in adequately covering the hole after eggs are laid. They often scrape in sand from the surface up to six inches away from the hole.

They even build a little mound over the eggs, if the depth of sand in the cage is not great.

IAN K. ANDERSON,  
Department of Biological Sciences,  
Wye College,  
Near Ashford,  
Kent.  
6/2/69

If one looks up "British Herpetological Society" in Fitters' Dictionary of British Natural History one reads that we are the national society for the study and protection of reptiles and amphibians. I was surprised to find therefore that a recent meeting on World Conservation raised very little interest and that the proposal that interested members might like to form a conservation group was politely ignored.

The negative point was raised that as a society we do not have the resources to open up B.H.S. nature reserves but surely this should not stop us approaching those organisations who do have reserves and wherever possible co-operating in conservation schemes.

Many members are doubtless aware that 1970 is European Conservation Year when all the National and International conservation organisations will be stressing the importance of conservation in Europe; conservation based not on sentiment but on vital ecological common sense. It is up to members of the B.H.S. to speak up concerning the conservation of British species; we cannot expect anybody else to do so. Over the past year I have been gathering letters on reptile conservation from many parts of the world, among the letters received is one from Frederick Gehlbach in Texas who writes of American herpetologists "in general the vast army of amateurs don't know and don't care about conversation"; is it the case with this society too?

I would be interested to hear from any members who have thoughts, ideas or comments on the subject of conservation.

V. F. TAYLOR,  
47, Baden Road,  
Gillingham,  
Kent.  
14/4/69

## BOOK REVIEW

SNAKES OF AFRICA. BY R. M. ISEMONGER. Books of Africa (Pty) Ltd., Cape Town, 1968, pp. 263.

A facile description of this book could be that it is a pocket edition of Fitzsimmon's "Snakes of Southern Africa". It deals more exhaustively with the snakes of the southern areas than of the northern, omits a number of species such as for example the Viperine Snake *Natrix maura* which is common in North-west Africa, and for a number of species surprisingly mentions only some subspecies and not others.

It does, however, cover all the more common species south of the Sahara and a lot more besides, gives excellent descriptions of these together with information on their habits, ranges and habitats, and includes some very good photographs and illustrations.

In any case, no-one has previously attempted to cover all the snakes of Africa in one book, and this is certainly the best field guide for a traveller in most parts of Africa who wants to identify the snakes he meets and know something about them.

J. W. STEWARD

## ERRATUM

Reference: R. J. Clark (1969). A Collection of snakes from Greece. *Brit. J. Herpetol.* 4, 45-8.

Mr. Clark writes that: "He intended that it should be said that for *Malpolon monspessulanus insignatus* and *Coluber najadum dahlii*, the records were for POROS (Argo-Saronic group) and not PAROS (Cyclades). The "Errata" says "Poros" only, which implies that all the localities in the table were wrongly included.

It should be clearly seen that the confusion between Poros and Paros resulted from a printer's error.

Thus table I, the record of *Malpolon monspessulanus insignatus* is for the island of Poros in the Argo-Saronic group, and not Paros in the Cyclades. In table 2, the same species and *Coluber najadum dahlii* are again for Poros and not Paros."