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MITES KILLING A SNAKE

By

E. Elkan
62 Woodhall Gate, Pinner, Middx.
(*Received* 22/1/72)

A half grown N. American Garter Snake (*Thamnophis sirtalis*), arriving coiled up and well hardened in formaldehyde, at first sight does not present a promising object for investigation. It is difficult and time-consuming to dissect a snake which can no longer be straightened out. Since however this specimen's skin was dotted with many large patches 5-7 mm in diameter where the normally dark scales had been replaced by grey, amorphous matter, a start was made by investigating the skin. Naked eye inspection, even with the aid of a hand lens, showed nothing but local ulceration, tissue defects being disseminated over the whole length of the snake.

Selected pieces of skin were sectioned and stained to show bacteria and fungi. In all the patchy grey areas the epidermis was completely destroyed so that the basal membrane became the superficial layer. This was covered by a thick mixture of bacteria, fungi and cellular debris. Normally a snake's skin is dry, smooth and covered with hard scales, which are extremely resistant to bacterial or fungal invasion. Why then did this particular specimen become the victim of such a widespread and obviously lethal infection? The answer appeared a few sections further on where several scale pockets were found to contain the remains of insects which, on closer examination, revealed themselves as mites (Acari). In one instance two of these were found lying head to tail in one scale pocket (Figs 1 a and b).

It was not possible to detach whole mites from the skin but their size ($\pm$ 0.5 mm) and the fact that they were found on a snake which had been in captivity for some time, makes the diagnosis of *Ophionyssus natricis* appear as very likely correct.

Mites play a larger part in the pathology of snakes than is generally assumed. They belong to the Arthropods, in particular to the Acarina, near relations on the evolutionary scale of the spiders. The larger species, known as ticks which occur on sheep and cattle are well known. Smaller ones, known as mites, occur in the plumage of birds, under the scales of snakes and in the form of glasshouse pests. All of them seriously affect the health of their hosts.

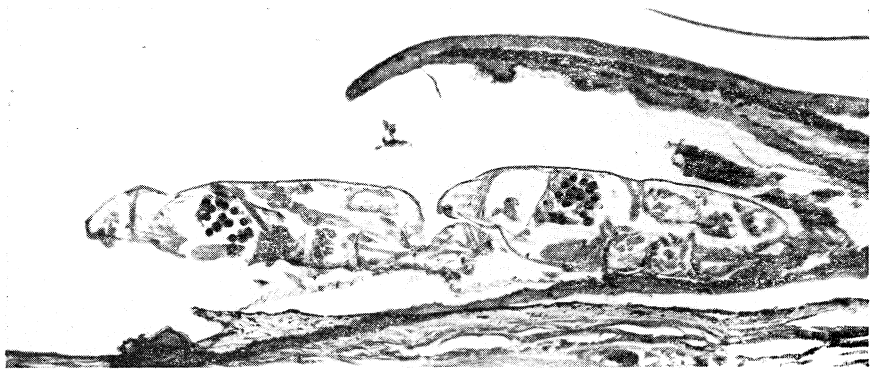
Ophionyssus natricis (Gervais), the snake mite, was first described in 1844 by two French authors, Walkenaer and Gervais in their " Natural History of the Wingless Insects ". Since then this mite has, from time to time, been redescribed as *Dermanyssus* or *Steatonyssus natricis,* also as *Ophionyssus variabilis, serpentium* and *easti,* all now thought to refer to the same species. Infection with this mite is usually observed in snakes which have been kept captive for some length of time at tropical temperatures. Illustrations of the external features may be found in the works of Camin (1953), Owen Evans and Till (1965-1966) and Reichenbach-Klinke and Elkan (1965).

The total length of this mite is 0.5 mm (males) and about 1 mm (females). It therefore fits easily into a scale pocket and, as Figs 1 a and b show, there is room for two mites under one scale. Two thirds of the total length are made up by the body and one third by the anterior part or *capitulum* which bears the mouth parts. In the unfed mite the skin shows itself as finely corrugated, allowing for considerable expansion during feeding. The complicated mouth parts enable the mite to pierce the skin of the scale pocket where the epidermis is thin and vulnerable. *Ophionyssus* is an obligatory blood-feeder. It inserts its mouth parts into a dermal capillary and, with the aid of a pharyngeal pump, then absorbs as much blood as the body will hold

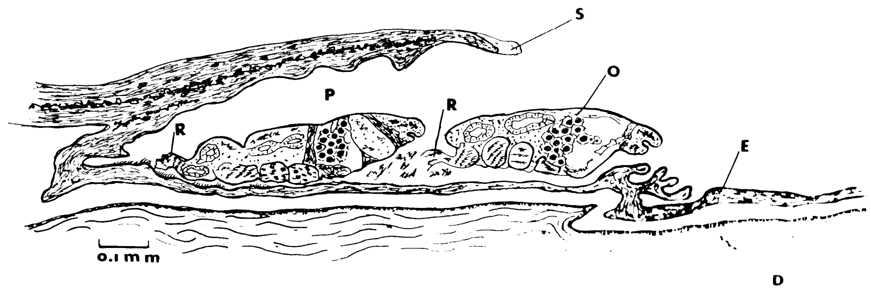
This activity may have two serious effects on the snake. Prolonged loss of blood causes anaemia and every breach in the skin permits entry of bacteria. If among those gaining entry there are members of the ubiquitous *Pseudomonas* group, which cause so much damage to lower vertebrates, the snake will soon die of septicaemia. Since bacteria occur anywhere on the skin of lower vertebrates it is of little value to argue whether or not the mites actually transmit such an infection from one snake to another. The fact that they breach the skin and gain access to dermal capillaries is quite sufficient to explain the ensuing sepsis and death of the snake.

The classical remedy in the fight against mites and ticks has been sulphur applied in the form of ointments and lotions. Nowadays more potent drugs are available and new ones are annually added to the list. (Reichenbach-Klinke and Elkan 1965). It is, however, not sufficient to treat the affected snake. The mites spend a large part of their lives and particularly of their developmental stages not on the snake but in small, almost inaccessible crevisses of the cage or of its furniture. Nor does it help much to leave an infected cage unused for some time, since the mites and their larvae are past masters at surviving long periods of starvation. No freshly imported snake should ever be admitted to a cage with other, healthy specimens. A long period of quarantine is required to show that no new infestation has been introduced.

For the microscopist however the Acari present a most interesting challenge. With their hard exterior and soft interior, processing is not easy and our knowledge of acarid anatomy has still many gaps which, we hope, will be filled by future generations of enquiring herpetologists.



FIGURES 1A AND 1B.



Two ticks, probably *Ophionyssus natricis* under one scale of *Thamnophis sirtalis*. Photograph and explanatory sketch.
D, Dermis; E, Epidermis; P, Scale pocket; O, Ovary; R, Rostral part of mite; S, Scale.

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PROTEOCEPHALUS ATRETIUMI N. SP. (CESTODA: PROTEOCEPHALIDEA) FROM THE WATER SNAKE, *ATRETIUM SCHISTOSUM*. (GUNTHER).

By
P. RAMA DEVI
Department of Zoology, Andhra University, Waltair. S. India.
(*Received* 11/5/72)

Water snakes are potential hosts for several species of proteocephalid cestodes. About nine species have been reported from different regions but none of these is from India. Two species of water snakes, *Tropidonotus piscator* Wall and *Atretium schistosum* (Günther) commonly occur in India. Both snakes from the family Colubridae can be distinguished externally by their colouration and slight differences in the arrangement of head scales. These snakes occur together in lakes and ponds in India and have the same feeding habits although *A. schistosum* is more terrestrial than *T. piscator* and is known to enter fields. Since these two species of snakes enjoy the same ecological niche it was felt that a comparative study of their parasite fauna would be of interest. It was found that their parasite fauna is quite distinct in respect of the occurrence of a proteocephalid cestode which occurs only in *A. schistosum* and not in *T. piscator*. The trematodes and nematodes of these snakes have been found to be identical although their incidence and intensity of infection were higher in *T. piscator*. Since the characters of the cestode from *A. schistosum* suggest the erection of a new species of the genus *Proteocephalus* a description of it is given below. Out of 30 snakes (*A. schistosum*) examined only 12 were infected with a total of 21 worms. Among the latter 15 were gravid and six were immature.

Specific diagnosis: Characters of the genus: Cestodes long and slender, observed length 160 to 190 mm; maximum breadth 1.15 to 1.17 mm. Segmentation distinct. Scolex globose, 190 to 240 mu in length by 210 to 280 mu in breadth. Suckers situated near broadest zone of scolex. Diameter of sucker 86 to 97 mu. Apical organ present, functional, 89 mu in diameter and 66 mu in depth. Neck not well differentiated from strobila, 5.5 to 6 mm. in length and 0.25 mm in breadth. Tegumental spines around scolex and strobila. First proglottids 600 mu long by 990 mu broad. Mature proglottids 0.96 to 1.12 mm broad by 0.88 to 1.1 mm long, rarely quadrate. Gravid proglottids quadrate or longer than broad, 1.15 to 1.36 mm long by 1.12 to 1.17 mm broad. No distinction of cortical and medullary regions can be made.

Genital atrium marginal, near middle of proglottid, irregularly alternating. Testes number 70 to 95 (always less than hundred). in single dorsal continuous layer, irregularly arranged between vitellaria, 62 mu in diameter. Vas deferens thick, straight mass of coils reaching to middle of proglottid; cirrus pouch 210 mu long by 78 mu wide, lying at right angles to margin of proglottid, extending 1/5 to 1/6 across proglottid breadth; cirrus coiled.

Vaginal opening dorsal, anterior or posterior to cirrus pouch; vaginal sphincter absent. Vitellaria lateral, follicular extending from anterior to posterior margins of proglottid and massive near ovary; each follicle 19 to 23 mu in diameter. Ovary bilobed, posterior, 208 mu long by 600 mu broad. Uterus, when fully developed with 10 to 15 lateral diverticula on each side, egg 15 mu in diameter.

Type host: *Atretium schistosum.*
Locality: Gudivada, Andhra Pradesh, India.
Habitat: Anterior part of intestine of *Atretium schistosum.*
Type specimen: Deposited in the department of Zoology, Andhra University, Waltair.

DISCUSSION

Yamaguti (1959) reviewing the data of proteocephalid cestodes noted only six specimens from reptilian hosts. Of these, only two species were recorded from India, namely, *Proteocephalus beddardi* (Woodland, 1925) from *Varanus bengalensis* and *P. woodlandi* (Moghe, 1926) from *V. bengalensis.*

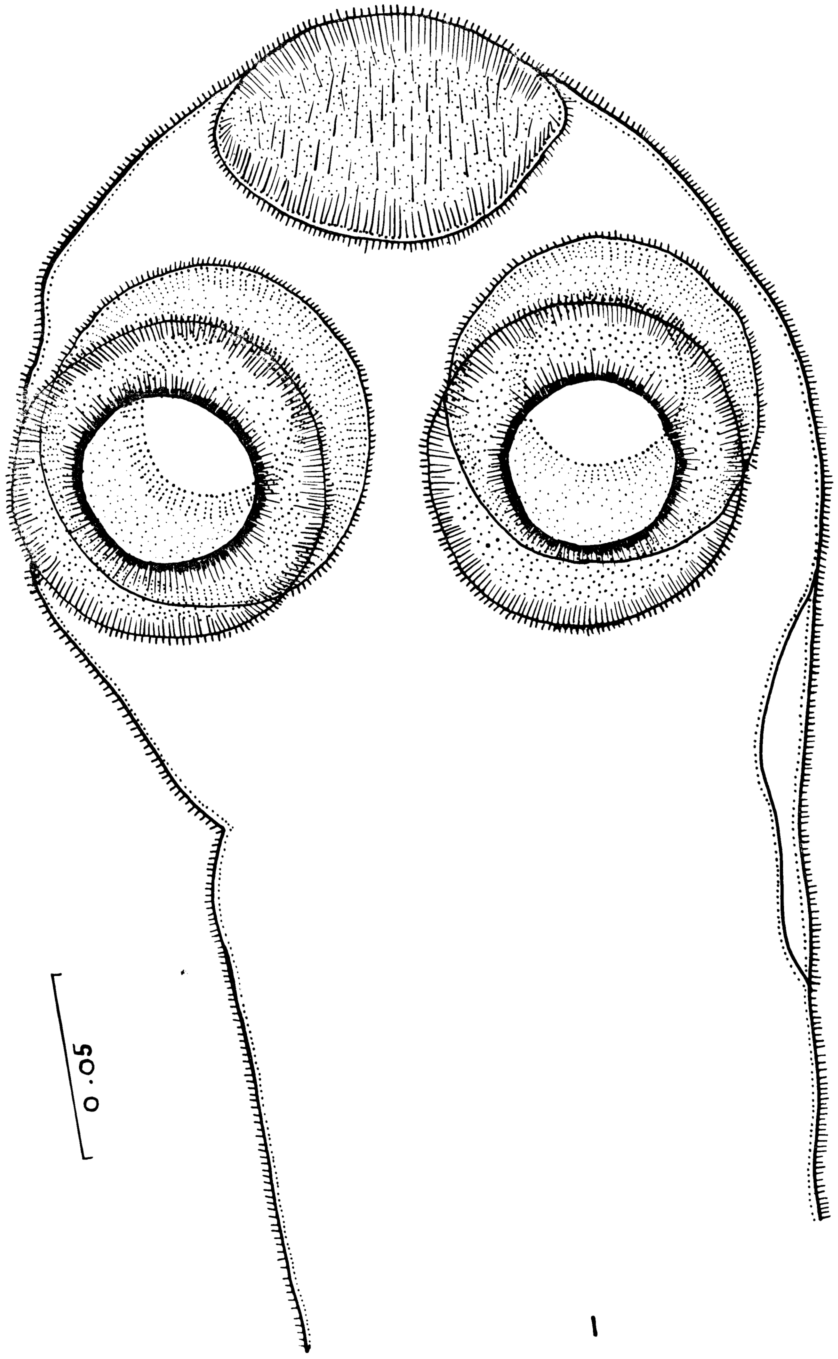
P. atretiumi resembles *P. beddardi* in the presence of spinuous tegument, a median, marginal genital pore and other generic characters. The later form differs from *P. atretiumi* in having 60 to 80 testes and 15 to 20 uterine diverticula instead of 70 to 95 testes and 10 to 15 uterine diverticula as in *P. atretiumi. P. beddardi* is also distinguished from *P. atretiumi* in the length of the worm (40 to 80 mm) and the presence of pyramidal scolex with a piercing organ topped by the small depression and with upwardly directed suckers. The length of the present worm is 160 to 190 mm and has a globose scolex with well developed suckers and an apical organ.

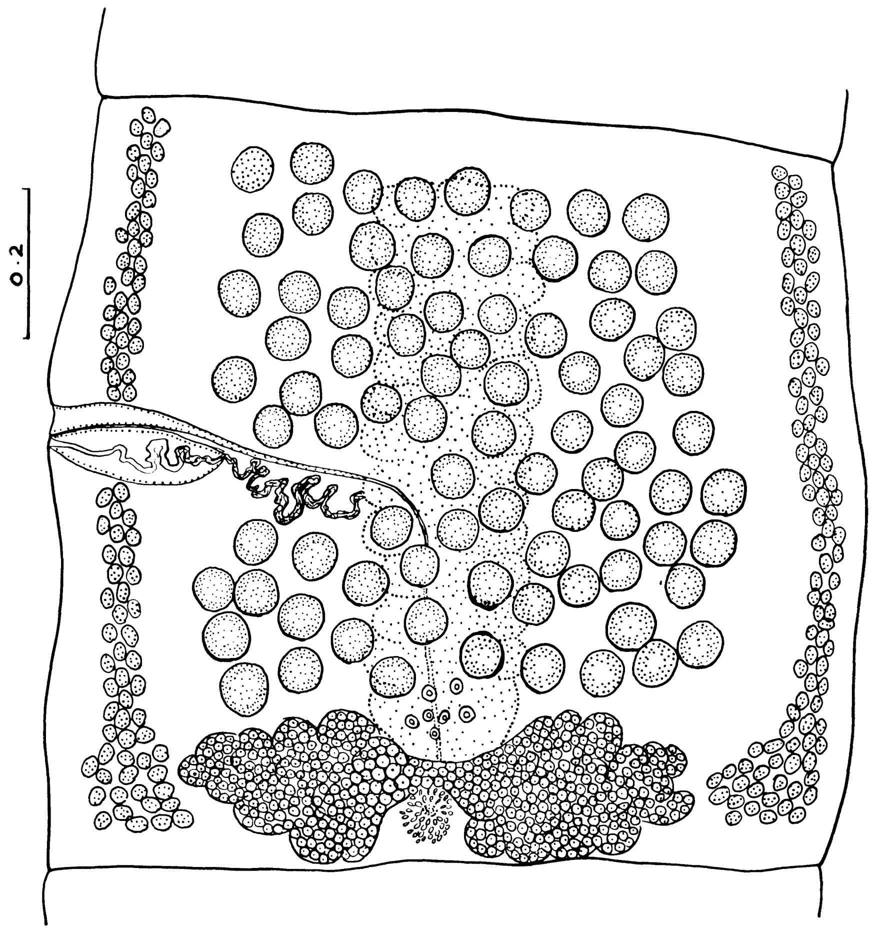
P. atretiumi can be differentiated from *P. woodlandi* in the number of testes and the position of the genital pore. In *P. woodlandi*, the latter lies behind the middle of the segment and the number of testes varies between 90 to 130. As Moghe (1926) could report only the length of three fragments of *P. woodlandi* it is impossible to compare the present worm from *P. woodlandi* in this respect. Finally, the present worm can be differentiated from both *P. woodlandi* and *P. beddardi* in the arrangement of vitellaria and their hosts. In *P. atretiumi* the vitellaria are distributed as two lateral bands extending from anterior to posterior end. They become massive near the ovary. This type of arrangement does not occur in the other two species. The present form can also be distinguished from the genus *Ophiotaenia* (in which six species of cestodes from water snakes were included) in the arrangement of the testes.

It is of interest to note that *Protocephalus atretiumi* was found only in *A. schistosum* and not in *T. piscator*. It would appear that *P. atretiumi* maintains a high degree of specificity in its host selection. Williamse (1968) noted a high degree of host specificity for *Proteocephalus filicollis* and *P. ambiguus* in *Gasterosteus aculeatus* and *Pygosteus pungitius* respectively.

SUMMARY

Proteocephalus atretiumi n.sp. from the anterior part of the intestine of the water snake, *Atretium schistosum,* can be distinguished from *P. beddardi* and *P. woodlandi* in the number of testes, number of uterine diverticula, arrangement of vitellaria and the structure of the scolex. The worm shows a high degree of host specificity in the selection of its host.





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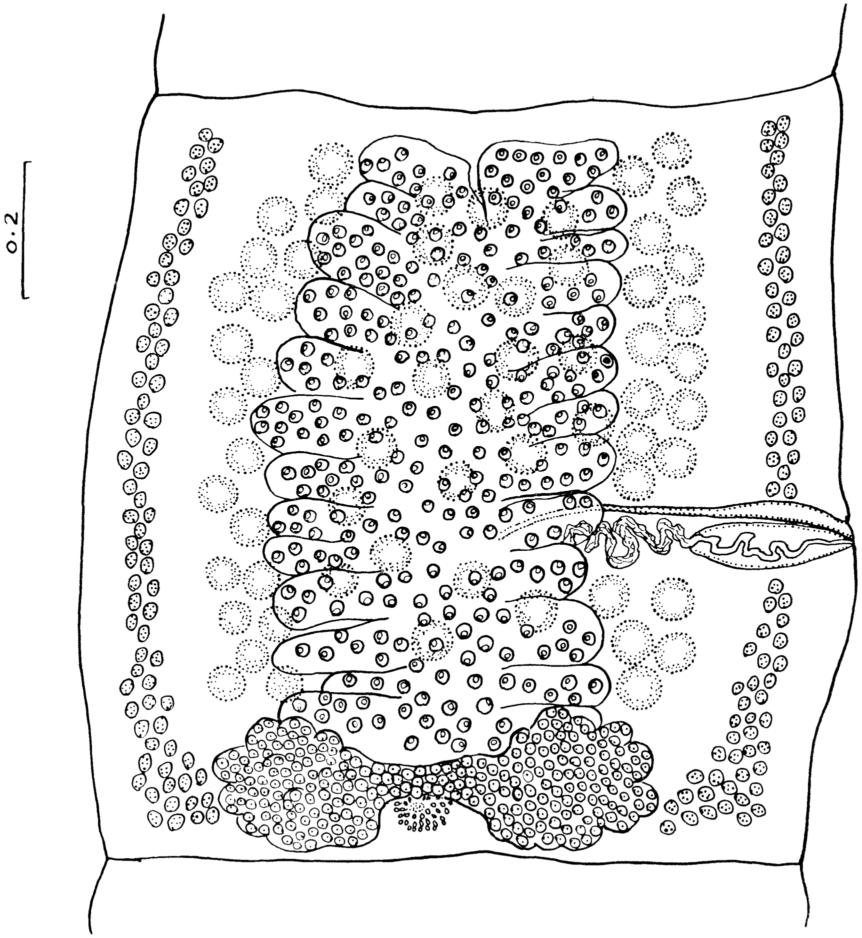
FIGURES 1-4:

Proteocephalus atretiumi. n.sp. 1. scolex, dorsal view. 2. mature proglottid, dorsal view. 3 and 4. gravid proglottids, ventral view. All illustrations were drawn with the aid of a camera lucida. Scale values in mm.



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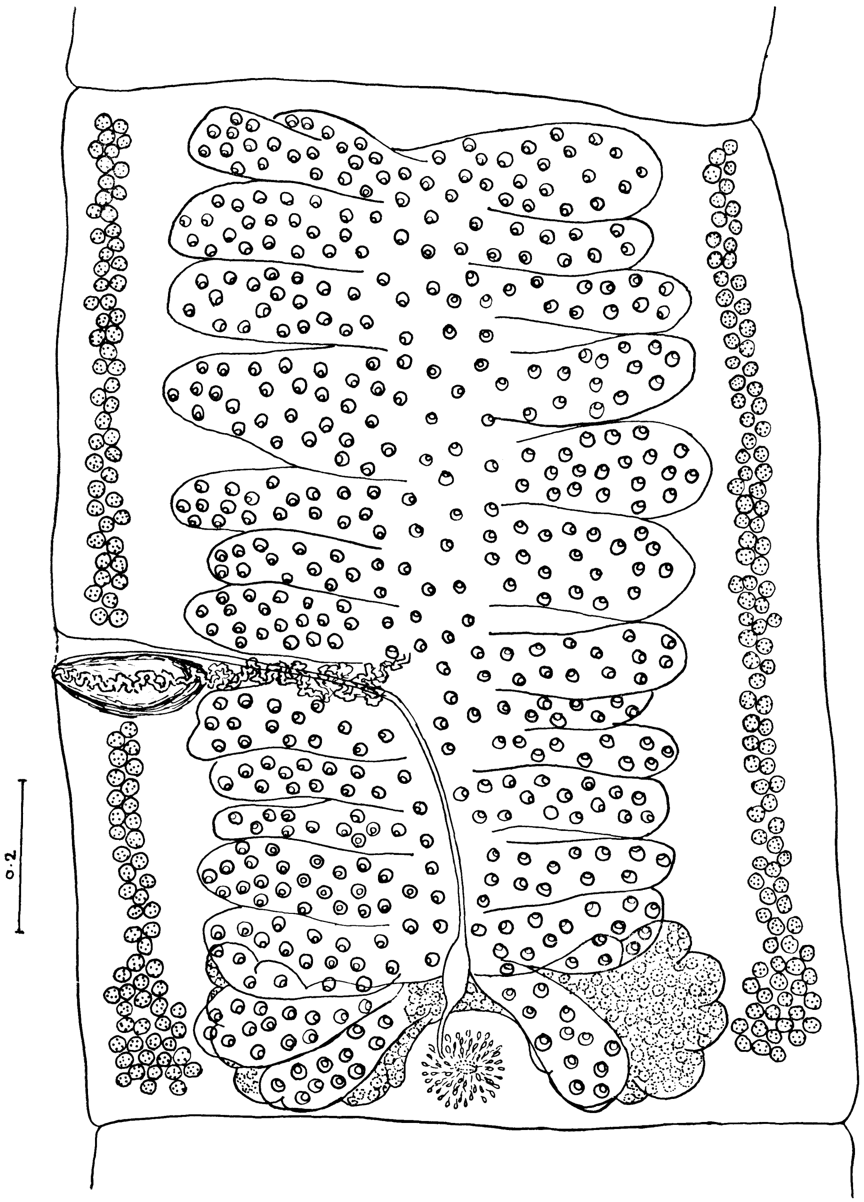

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ACARINE PARASITES ON THE LIZARD, *LACERTA VIVIPARA* JACQUIN

By
AVIS D. PEARSON AND D. L. TAMARIND
205 Camden Road, London NW1.
(*Received* 15/8/72)

Ticks are believed to be of very rare occurrence on British lizards in the wild. However, our preliminary observations suggest that the sheep tick (*Ixodes ricinus* L.) may, in certain regions, be a common parasite of the viviparous lizard.

OBSERVATIONS

In mid-April, 1972, a pair of viviparous lizards carrying ticks were captured in a New Forest inclosure. Both lizards had three to five small ticks (abdomen 2 to 4 mm long), about and behind the base of each forelimb (as in Fig. 1). None were seen near the hind limbs or elsewhere on the body. Attempts to remove the ticks by painting them with vegetable oil were unsuccessful and painting them with paraffin oil caused them to shrivel up without dropping off. Cetrimide cream ("Savlon") was applied and the remains of the ticks were cast with the next slough, leaving no signs of infection.

A third lizard (male) was captured one week later at a spot about three miles from the first. This lizard had four ticks near the base of the left forelimb, three of which were gently worked out by holding the abdomen with fine forceps, without apparently inconveniencing the host. However, the lizard jerked as the fourth was being removed, shredding the abdomen so that the head could not be worked out. Cetrimide was again applied and no evidence of infection was seen subsequently. Ticks which had been present by the right forelimb appeared to have dropped off of their own accord within a day or so of capture.

The removed ticks were identified at the British Museum as nymphs of the sheep tick, *Ixodes ricinus* L.

On a subsequent visit (24/6/72) to the second site, two gravid females were seen basking in weak sunlight. One of them (Fig. 1) had four ticks, similar to those seen on the captured lizards, about the base of the left fore-limb; the other side was clear. The second female had a solitary tick near the right forelimb. No other adults were seen sufficiently clearly for detection of ticks, but of four juveniles glimpsed, three appeared to be free of them. None of the four adults seen sufficiently clearly on each of two subsequent visits (29/7/72 and 12/8/72) carried ticks.

DISCUSSION

From our observations, admittedly on a small sample, it appears surprising that ticks have been reported so rarely on wild lizards in this country. The sheep tick normally ceases to feed during the summer (Arthur, 1963)—its occurrence on hosts as late as June in 1972 may be related to the cold spring—normally it feeds from March until May, when lizards may be more easily observed than later in the year. However, adult sheep ticks only rarely appear to parasitise mammals smaller than the stoat and they have not been reported on reptiles. Ticks at all stages in the life cycle require an extremely humid microclimate, and ticks do not appear to move very far from the place they land on dropping from their host (see Arthur, 1963). It may be that apart from the New Forest, in this country a habitat suitable for both ticks and lizards is rare.

It is curious that the ticks were confined to the region of the forelimbs. Conceivably, lizards could use their mouths to remove ticks from near the hind limbs yet they are also capable of scratching at the forequarters with the hind limbs.

SUMMARY

In parts of the New Forest adult *L. vivipara* Jacquin were seen to be host to one or several nymphs of the sheep tick (*I. ricinus* L.) in the months of May and June, 1972, though not at the end of July or in mid-August. Ticks appeared to be confined to the region of the forelimbs. Juvenile lizards may have been free of ticks at a time when adults were infested.

ACKNOWLEDGEMENT

The authors wish to thank Mr. K. Hyatt of the Department of Zoology, British Museum (Natural History) who identified the ticks.

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FIGURE 1:
Female *L. vivipara* Jacquin photographed in the wild, showing four ticks, nymphs of *Ixodes ricinus* L. about the base of the left forelimb.

REPRODUCTION TWICE IN ONE YEAR IN A CAPTIVE VIPER (*VIPERA ASPIS*)

By
G. NAULLEAU, C.N.R.S.
Centre d'Etudes Biologiques des Animaux Sauvages
Villiers-en-Bois—79360 Beauvoir (France)
(*Received* 11/10/72)

INTRODUCTION

According to numerous authors the female viper (*Vipera aspis*) reproduces annually in nature and under optimum conditions (Saint-Girons, 1952, 1957; Duguy, 1963).

Under generally stable artificial conditions however, the reproductive cycle may be reduced to 9 or 10 months spread over two years (Naulleau, 1970). In the case reported here a female reproduced twice in the same year

MATERIALS AND METHODS

Conditions for rearing vipers have been described in detail elsewhere and can be summarized (Naulleau, 1965, 1968). The female was kept in captivity in a small terrarium 0.25 metres square from July 1965 to February 1969, and thereafter in a large terrarium which had a sand and gravel substrate and drinking water. The small terrarium was lit by an incandescent lamp functioning from 8 a.m. to 8 p.m.; this gave a point of maximum warmth. In the large terrarium lit by a fluorescent tube the warmest point was esablished by an infra-red radiator. Tube and radiator functioned from 8.a.m. to 8 p.m. The surrounding temperature varied from 18°C to 25°C and the relative humidity from 35 to 75%. At the warmest point the temperature could reach 40°C. The vipers' food consisted of white mice from a colony, sometimes with field voles or chicks.

Under these conditions vipers do not hibernate and are active all the year. Female No. 2, to be described, was captured on July 13th, 1965 in the west of France south of the Loire—Atlantique (Legé). In this region female vipers have a sexual cycle which is biennial (Saint-Girons, 1957; Duguy, 1963, 1964). The viper measured 47 cm and weighed 55g at capture and was at once placed under the conditions just described.

RESULTS. Increase in weight and size after capture, mating, parturition, food and moults.

The weight record (Fig. 1) falls into two parts. During the first 2½ years there is a continuous rapid increase in weight from 55 to 265.5g by January 10th, 1968 (the maximum weight recorded while non-pregnant). Food was abundant and the viper consumed 61 mice, 1272.5g of food and moulted nine times.

The second part of the weight record (Fig. 1) shows a series of peaks corresponding to different phases of the reproduction cycle. The viper was not weighed in the period between the first mating and parturition (1968).

Maximum weight during pregnancy and weight after parturition are slightly different for each pregnancy (Fig. 1). The loss of weight at parturition does not depend on the number of young or their total weight. As already seen (Naulleau, 1970) the pregnant female loses about one third of her weight of which the weight of the young represents 54.8 to 67.5%. As shown in Fig. 1 the viper feeds freely after mating and there is a rapid and substantial increase in body weight. At the end of gestation she ceases to feed and this results in a slight loss of weight.

The viper at first grows rapidly but then stabilizes (Fig. 1). In 2½ years the length increased from 47 to 67 cm.

The two matings observed (Fig. 1) make it possible to calculate the duration of gestation, 88 and 90 days, very similar to the values obtained for a larger number of females: 88.4 days (Naulleau, 1970). If 90 days is taken as the average time between mating and parturition the dates of the two matings not observed can be calculated approximately. From this it can be observed that the four matings took place at different times of the year (end of December, February, April and August) (Naulleau, 1971).

If the litters from viper No. 2 are compared with those of 13 earlier females (Naulleau, 1970) (Table 1) it is noticeable that the average number in a litter is larger for the present female (7.7 compared with 5.4). The sex ratio for 16 litters is near unity but for female No. 2 there is excess percentage of young males, 67.7%. For both sexes the size of the young is similar in the two groups, but female No. 2 is larger than the previous females.

DISCUSSION

As already noted (Naulleau, 1970) the sexual cycle of the female is appreciably shortened under our artificial rearing conditions. For female No. 2 the cycle is the shortest yet observed. The lengths of three cycles estimated from consecutive parturitions were 10, 8 and 8 months respectively, two parturitions occurring in the same calendar year 1969 (Fig. 1), and not over two years as estimated previously for cycles of less than 12 months (Naulleau, 1970). It is interesting to note that the two reproductions in the same year did not cause any lengthening of the following cycle which also lasted eight months. After the third parturition in 16 months the weight of the female was quite high (167.5 g); she would feed abundantly after each parturition thus adding to her nutritional reserves (Fig. 1).

Temperature is the essential indirect cause of the shortened sexual cycle through its action on digestion and food intake and thence on vitellogenesis.

Under most favourable natural conditions (maximum active period, minimal inactive winter period) the viper has an annual cycle, and it might seems difficult for this to be reduced. However, artificial conditions in which hibernation is abolished, far from depressing reproduction, make it possible for the sexual cycle, biennial in the original locality of viper 2, to be greatly reduced.

Other climatic factors, light, humidity, atmospheric pressure do not appear to play an important rôle on the course of the sexual cycle.

According to Saint-Girons (1966) "dans les conditions naturelles les grandes lignes du cycle sexuel (spermatogénèse, périodes d'accouplement, date de l'ovulation) sont sans doute determinées par des facteurs endogènes innés et spécifiques" and "les facteurs cosmiques interviennent au moins pour assurer une "remise à jour" qui interdit les décalages progressifs". If these endogenous factors referred to by Saint-Girons exist, they must be relatively plastic since under our rearing conditions, almost identical throughout the year, and in the absence of significant variations in extrinsic factors, the sexual cycle undergoes a progressive displacement leading to a reduction in its length. The development of the endocrine glands must accordingly differ from that found under natural conditions (Saint-Girons and Duguy, 1962), since the sexual cycles are shortened and displaced in time.

Conclusion

In captivity, under hardly varying artificial conditions, there occurs a progressive displacement of the female sexual cycle leading to a progressive reduction in its length. The minimal duration was eight months within a single calendar year and not as we had previously observed spread over two years.

Summary

Under almost constant artificial conditions, the sexual cycle is greatly shortened compared with the cycle in nature. It had a minimal length of eight months and in the case described here parturition occurred twice in the same year.

Resume

Dans des conditions artificielles à peu près toujours identiques, le cycle sexuel est très raccourci par rapport à ce qui se passe dans la nature. La durée minimale obtenue est de huit mois et, dans le cas relaté ici, deux mises bas consécutives se sont produites au cours d'une même année.

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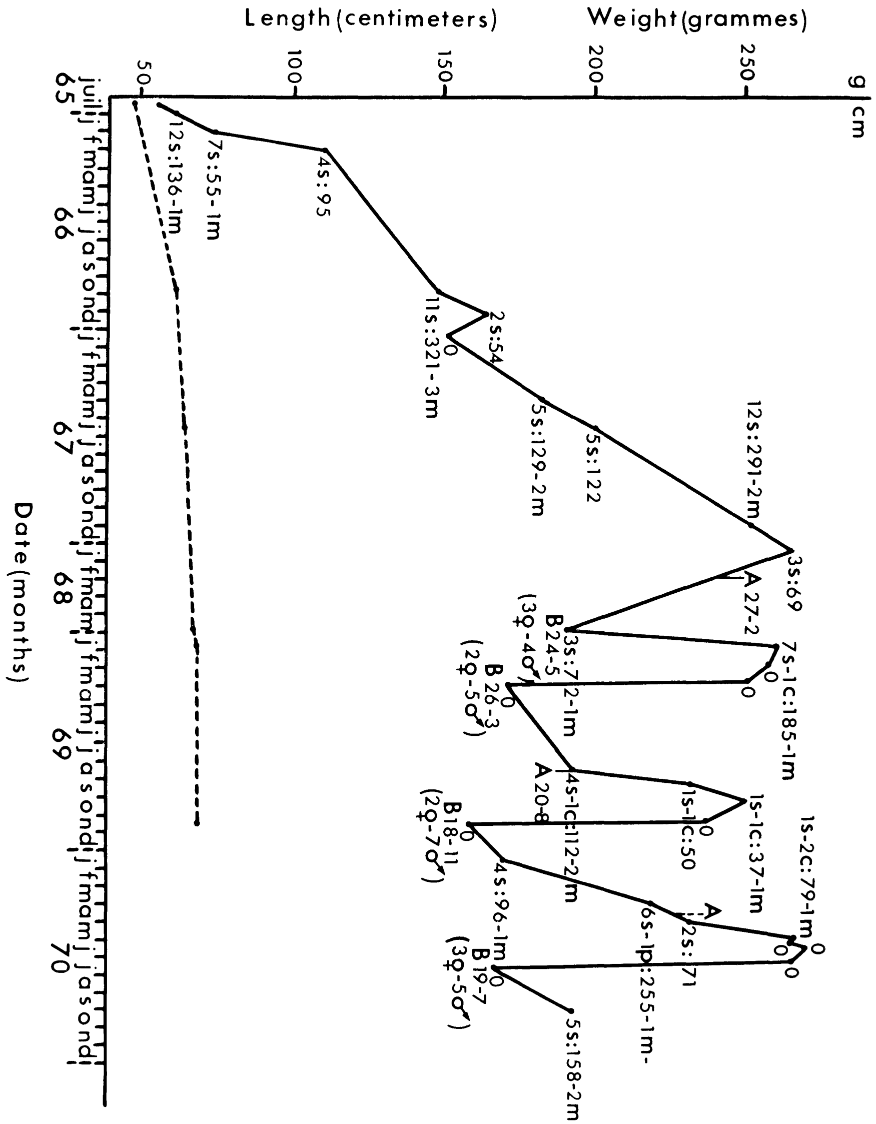

TABLE 1.

Results	Average number in a litter	Young Vipers Percentage of females	Young Vipers Percentage of males	Females Length in cm	Females Weight in g	Males Length in cm	Males Weight in g
From 13 females (16 litters)	5.4	51.8	48.2	20.5	6.7	21.6	7.1
From Female 2 (4 litters)	7.7	32.3	67.7	20.6	7.2	21.7	7.1

DESCRIPTION OF FIGURE 1.

Weight curves (continuous line) and Length curves (dashes) from female No. 2.

A. Mating followed by the date. If the letter A is not followed by a figure the date was calculated from the date of parturition.

B. Parturition followed by the date. In parentheses the numbers of male and female young.

With each weighing is given the amount of food taken and the number of moults since the previous weighing. The first figure indicates the number of animals ingested followed by a letter C=field vole, P=chick and S=mouse. The following figure shows the total weight of food ingested and the number of moults (m).

TABLE 1.

Comparison of the characteristics of the litters from female No 2 and from 13 other vipers.

REPORT ON A COLLECTION OF REPTILES FROM CYPRUS

By
R. J. CLARK
Potash Cottage, Hartest, Bury St. Edmunds, Suffolk.

(*Received* 23/3/72)

On a recent collecting trip to Cyprus (April 19th to May 12, 1971) my wife and I collected the following amphibians and reptiles. The total number of each species obtained is given in brackets and subspecific categories are included where these seem to be well-documented, but are omitted for those species that do not seem to be clearly resolved taxonomically.

Bufo v. viridis (5); *Gymnodactylus kotschyi* (30); *Hemidactylus t. turcicus* (3); *Ablepharus kitaibelli* (6); *Chalcides o. ocellatus* (11); *Mabuya vittata* (19); *Eumeces s. schneideri* (1); *Agama stellio* (19); *Acanthodactylus schreiberi* (88); *Lacerta laevis* (74); *Ophisops elegans schluteri* (38); *Typhlops vermicularis* (3); *Coluber jugularis jugularis* (12); *Coluber ravergieri* (1); *Malpolon monspessulanus insignitus* (1); *Telescopus fallax cyprianus* (2); *Vipera l. lebetina* (4).

In addition to these species *Eirenis modestus* was sight identified on one occasion and *Hyla arborea* was heard calling at one inland locality in the foothills of Troodos, north side, at 2000′. No ranids or chelonians were seen. The following other species appear in the literature on Cyprus: *Mabuya aurata, Chamaeleo chamaeleon, Coluber najadum, Natrix natrix* and *N.*

tessellata. (Boulenger, 1913; Werner, 1936; Bodenheimer, 1944; Leviton and Anderson, 1970; Steward, 1971.)

Only a few lizard species showed much habitat preference: *A. schreiberi* was numerous in certain sandy coastal areas near Kyrenia and Galanoupetra Point, and it was found less abundantly in all coastal sites at which collecting was done. It also occurred at a few inland localities (Komi Kebir, Lefkoniko and Morphou) below about 600′. The biotope was always well-drained and dry. From our experience on Cyprus it seemed improbable that this species ranged into the mountains. However Werner (1936) remarked that it was common near Platres on Troodos at 4000′. This discrepancy in observation is hard to explain except as a result of seasonal variation in activity. Werner visited Cyprus during the summer when the lowlands would have been very hot and lizards not much in evidence. I am convinced that *A. schreiberi* is principally an inhabitant of the sand dunes and dry plains at low altitudes as evidenced by its extensive distribution over all the lowland regions and, in our experience, its absence in the mountains.

For the remaining species, of which sufficient numbers were obtained to permit an evaluation of altitude range and habitat preference, all appeared evenly distributed up to 2000′. Only *O. elegans* was found on the higher parts of Troodos and there but a single specimen near a stream in open conifer forest at 5,300′. *L. laevis* was not found higher than 3,600′ (Handri, north side of Troodos). Werner caught it between Platres and 5,000′ and considered it restricted to the higher elevations. He did not find it at all in the north of the island. By contrast we found *L. laevis* widespread throughout the island up to 3,600′. In the summer this lizard would certainly become retiring at low elevations and would have to be sought with great persistence. Even in April and May we had to look for it carefully as it shunned bright sunlight. This lacertid, the only wall lizard representative known from Cyprus, occupied sheltered shady localities and was more common near streams and damp places where it lived on tree trunks and rocks, coming off these to forage on open ground or amongst piles of leaf debris. We also found it in drier situations where there were carob and olive plantations and a certain amount of dense bush cover. In these dry places it lived mostly in pairs, usually one or two pairs together, and did not form colonies.

Agama stellio we found commonly on rocks, walls, tree trunks and also bushes and shrubs in sandy regions. It appeared to tolerate a wider range of habitat than in Greece and Turkey where it lived almost exclusively in rocky areas. On Corfu, though, it is known to live in olive groves (Mertens, 1961).

Mabuya vittata occupied banks, bushes and fields where there was some undergrowth and it semed at home in both damp and dry places. This skink is certainly not a rock dweller. (See Clark and Clark, 1973, for an account of its activity in Turkey.) Our series of *M. vittata* shows the complete range of dorsal patterning from completely plain-backed individuals to heavily striated specimens.

All the snakes we encountered were seen below 2,000′. *C. jugularis* is known from above 4,000′ and it is likely that all species range into the mountains. *C. jugularis* was the most common species and at least another eight specimens were seen. Our material shows a good range of size and colour variation. The two smallest males have the juvenile colouration which is similar to the subspecies *caspius* above, but with black powderings on the ventral surface. The specimen of 882 mm. total length is intermediate between juvenile and adult livery. Each dorsal scale has a fawn central line, but the ground colour is black. In larger, hence older, snakes the dorsal scales lose the fawn central line and the animal becomes a uniform jet black above and below with a whitish throat perhaps tinged with pink or red. Melanism is unknown in females but we found only one of this sex, a juvenile, which was identically marked as the young males. We suspected an adult female from a sight identification—a long brownish snake which moved fast. This was seen in a region where male *C. jugularis* were common. Adult females are brownish or greyish-brown above and retain the dark powderings and markings ventrally. The high proportion of males to females in *C. jugularis* populations has been noted by Wettstein (1953) from Rhodos, and we observed this also in Turkey.

The subspecies "*asianus*" mentioned by Werner (1936) is nothing more than the juvenile stage of *C. j. jugularis* and as such has no relevance. This was satisfactorily clarified by Wettstein (1953). Another point to make is that the Cypriot specimens differed from those caught by us in southern Turkey and the islands of Leros, Tilos, Symi and Rhodes. Adult males from southern Turkey and Leros were black above and red below; those from Tilos, Symi and Rhodos black above and either red/black or green/black on the ventral surface. Cypriot examples are uniformly black except on the throat.

V. l. lebetina we found around fields and bush cover early or late in the day (three were caught at 0900 hrs and one at 1800 hrs). All were males. At Galanoupetra Point the biotope was sandy and numerous snake tracks were seen on the coastal dunes. These could have been made by this snake.

Our single *M. monspessulanus* was found dead on the road and we found another severely damaged specimen also dead on the road north of Famagusta. We did not see this snake alive and concluded it was rare. Werner (1936) considered it to be the most common species, next to *C. jugularis.*

Our few *T. vermicularis* we turned up under stones, and in view of the large number of stones turned over we assumed this species also to be uncommon. Likewise *C. ravergieri*; we only caught and saw one specimen and in this, at any rate, our conclusions agree with those of Werner.

ACKNOWLEDGEMENT

We are grateful to Mr. and Mrs. William Tribe, English School, Nicosia, whose generous hospitality made our stay on Cyprus more enjoyable. Mr. and Mrs Tribe also gave us helpful suggestions on where to travel.

The bulk of our collection has been deposited with the Senckenberg Museum in Frankfurt. We have retained some specimens for our own reference.

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TABLE

Measurements and counts for snakes collected in Cyprus

Species	A	B	C	D	E	F	G
Coluber jugularis	M	1635+	1300	206	73+	19	4/5
	M	1597+	1180	206	110+	19	4/5
	M	1595	1150	204	113	19	4/5
	M	1430	1020	205	115	19	4/5
	M	1293	918	206	112	19	4/5
	M	1232	887	195	100	19	4/5
	M	1170	883	206	114	19	4/5
	M	1128	810	202	117	19	4/5
	M	882	625	202	111	19	4/5
	M	770	547	200	118	19	4/5
	M	729	524	204	116	19	4/5
	F	685	503	208	106	19	4/5
Coluber ravergieri	M	948	741	206	84	23	5
M. monspessulanus	?	775	572	166	88	17	4/5
Telescopus fallax	M	485	397	203	67	21	3/4/5
	?	400	334	210	62	21	3/4/5
Vipera lebetina	M	1090	955	159	43	25	—
	M	948	820	154	46	25	—
	M	865	745	157	44	25	—
	M	773	665	158	45	25	—

A, Sex; B, Total length (mm.); C, Snout to vent length (mm.); D, Ventrals; E, Subcaudals (x2); F. Dorsals; G. Scales in the supralabial series bordering the eye; M, Male; F, Female.

A REVISED TERMINOLOGY FOR PLATES IN THE LOREAL REGION OF SNAKES

By

Jay M. Savage
Allan Hancock Foundation and Department of Biological Sciences,
University of Southern California, Los Angeles, California, 90007, U.S.A.

(*Received* 2/9/72)

In preparing keys for the identification of snakes in the fauna of lower Central America, it has become obvious that the current terminology for plates in the loreal region of the head is both confusing and morphologically unsound. Most of the difficulty arises in trying to designate one of several scales between the orbit and nostril as the *loreal* according to traditional practice. This name is usually applied by herpetologists to a plate(s) lying between the nasal(s) and preocular(s). In snakes there is usually one or rarely two or three loreals. In some snakes only a single plate lies between the eye and nasal and is called a preocular if it is higher than long and a loreal if it is longer than high (Peters, 1964). From a morphogenetic view the loreal region may be best thought of as a single unit capable of developing into a number of plates (as many as five or six, in a few genera). Apparently under the control of distinct genetic influences different genera or species have less than the maximum number of sutures developed so that as few as two plates may be present in the region. The basic pattern for most colubrid and elapid snakes involves a series of three plates between the eye and nostril, that to avoid confusion in terminology are designated by letters (Fig. 1). Since the key morphologic unit on the upper head involved in this problem is the prefrontal shield, it has also been included.

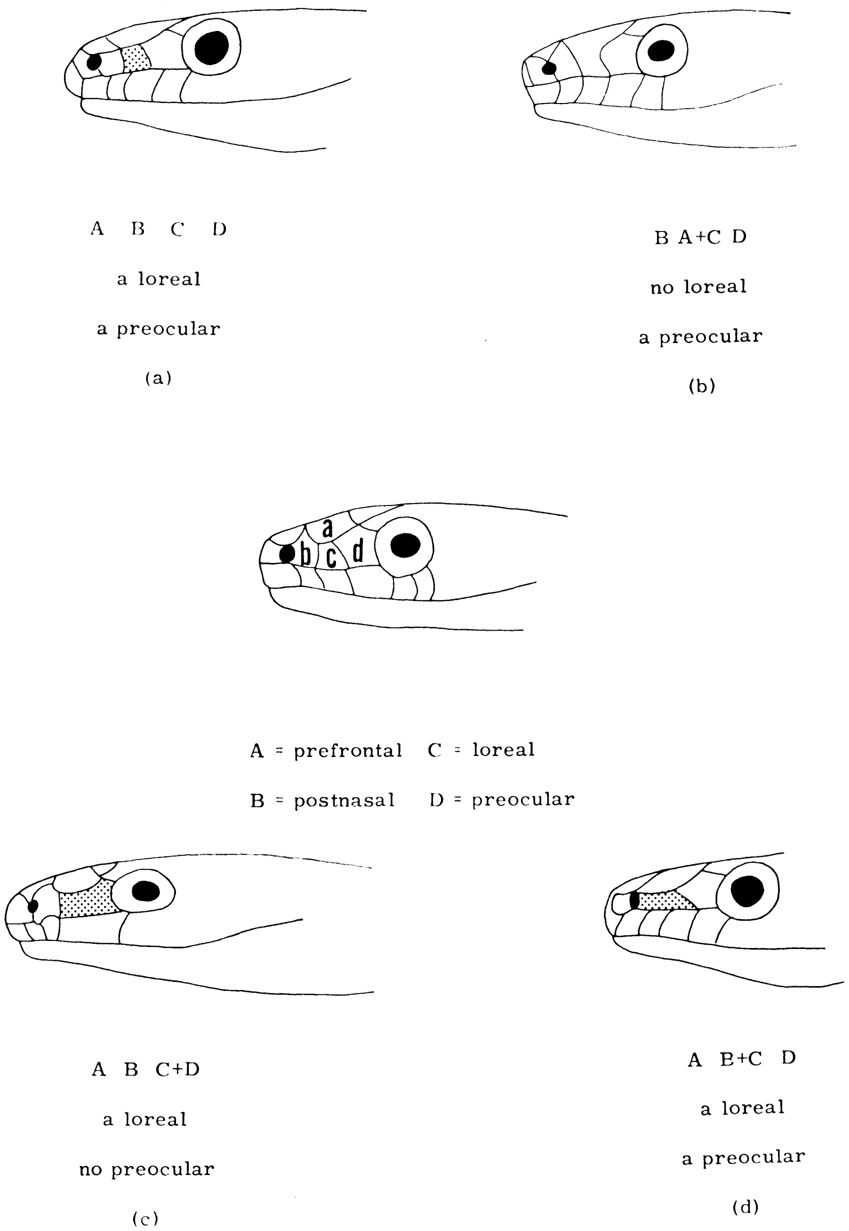

Fig. 1

The four major units are:
A — the prefrontal plate.

B — the plate on the side of the head just posterior to the nostril; this scale may be partially or completely separate from the plate just anterior to the nostril or fused with it.

C — the plate just posterior to B on the side of the head that separates B from D and keeps A from contacting the supralabials; this unit may be broken up into two or three plates by vertical sutures in a few genera.

D — the plate just anterior to the eye and separating C from the orbit; this unit may be broken up into two or three small plates by horizontal sutures in many genera.

The common variants for the loreal region are illustrated (Fig. 1) and described below:

a) A, B, C, D are each distinct.

b) A+C are fused (i.e. no suture develops between them) B and D are distinct.

c) A and B are distinct, C+D are fused.

d) A and D are distinct, B+C are fused.

According to traditional terminology B is a nasal or postnasal, C is a loreal and D is a preocular. This system works very well when applied to snakes having plates as in a), but what of the others? Is C+D a loreal or a prefrontal? Is B+C a nasal or loreal? Is D in condition b) a loreal if it is longer than high? Clearly to make sense of the situation, a terminology that more nearly reflects a consistent application of terms and a recognition of the morphogenetic situation is required.

It is apparent from the illustrations and the previous remarks that the key topographic relationship involved between the plates is whether or not the prefrontal is excluded from contact with the supralabials. If this key point is borne in mind a revised terminology may be developed that avoids much of the confusion and centres on the morphologic situation:

loreal—a plate or plates posterior to the nasal or postnasal and anterior to the orbit or preocular that separates the prefrontal from contact with the supralabials; when the loreal is absent (i.e. a suture fails to develop between the loreal and prefrontal, or they are "fused") the prefrontal contacts one or more supralabial.

preocular—a plate or plates anterior to and bordering the orbit, that separates the prefrontal and/or loreal from the orbit.

When these definitions are applied, the following terminology can be applied to the figured cases:

a) a loreal and preocular present
b) no loreal, a preocular present
c) a loreal present, no preocular
d) a loreal (or nasoloreal), a preocular present

The use of these revised definitions will require a shift in usual herpetological practice and care in utilizing older works. My experience indicates that the revised terminology makes usage of the terms loreal and preocular unambiguous and more properly reflects the potentialities for variation in the loreal morphogenetic field. These advantages outweigh the inconvenience of change and I urge adoption of this usage by other herpetologists.

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Figure 1.

Variation in head plates of the loreal region of snakes. The centre figure shows the usual situation in most snakes and the current terminology used for them.

THE MORNING EMERGENCE OF THE COMMON LIZARD *LACERTA VIVIPARA* JACQUIN

By
R. A. Avery
Department of Zoology, University of Bristol
and
B. H. McArdle
Department of Biology, University of York.
(*Received* 10/8/72)

Viviparous lizards spend the night in holes in the ground, in crevices in rocks, or under logs or stones, and are active by day. Many field herpetologists will have noticed that the time at which they first emerge in the morning can be predicted—it depends on the warmth of the sun. During the course of several years of study in the West of England, we have made a careful note of the times at which lizards were first seen, and find that on fine sunny mornings (which are relatively uncommon!) the emergence time varies seasonally in a regular way; it is more than one hour earlier in midsummer than in spring or autumn. During cloudy or dull weather the time of appearance is not so regular, but nevertheless with experience it can often be predicted.

A lizard's first activity on emerging is to bask in the sun. This is part of a complex series of behavioural adjustments by which it maintains its body temperatures at a fairly constant, and surprisingly high level. This level was called the "preferred body temperature" (PBT) by Bogert (1949), and it is now known that regulation of this kind is characteristic of many diurnal lizards (see Cloudsley-Thompson, 1971). The PBT of viviparous lizards in the West of England is about 30°C, and on sunny days in summer it is achieved very rapidly (Avery, 1971). Most important activities, such as feeding, only take place when the body temperature is at or near the preferred level.

It therefore seems reasonable as an hypothesis to suggest that the actual time of emergence is related to the speed at which a lizard can reach its preferred temperature; it would be disadvantageous for an individual to emerge very early, at a time when it would need to bask for excessively long periods before warming up, because this would prolong a period during which it is particularly at risk from predators (we have no direct observations on this point, but know from our own experience that this is the time when we can catch lizards most easily). Conversely, it would be wasteful for an individual to delay its emergence after such time as the PBT could be rapidly achieved, because the time available for feeding would be reduced, and there is evidence that viviparous lizards in Britain are frequently unable to obtain a complete meal because there is insufficient time during which the sun is warm enough to enable them to do so (Avery, 1971).

The experiments reported here were designed to test this hypothesis. We have measured the rates at which viviparous lizards will warm up when they are exposed to different levels of incident thermal radiation, have calculated the radiation which is available to a basking lizard at different times during a morning, and so have determined the periods of basking needed to achieve the PBT. These have then been compared with the actual times of emergence observed in the field.

METHODS AND RESULTS

1. Heating Curves

It was originally planned to measure the rise in temperature of lizards exposed out of doors to solar radiation at different times during the

morning, and several preliminary experiments of this kind were performed. Mornings with uninterrupted sunshine and little wind were so infrequent and unpredictable, however, that the work was abandoned and we used an artificial source of radiant heat in the laboratory instead.

This was a 250W incubator lamp, which was connected across a rheostat. It was calibrated using a thermopile, which in turn was calibrated from a 275W photographic photoflood bulb, which for simplicity was assumed to be 100% efficient and to provide even distribution of radiation. Hence the radiation (R, measured in joules [J]) received by the thermopile when placed r cm from the photoflood, was given by:

$$R = \frac{275}{4\pi r^2} \text{ J cm}^{-2} \text{ sec}^{-1}$$

(1 J = 0.238 calories).

The thermopile was then placed 50 cm from the incubator lamp, and in order to prevent the formation of a "heat shell", a gentle current of air was blown across it. A calibration graph relating the incident radiation to the voltage across the lamp was determined.

Lizard temperatures were measured with a copper-constantan thermocouple which was inserted into the cloaca. The working junction was encased in a thin polythene tube, the tip of which was rounded off with a smooth cap of araldite to avoid damage to the lizard. The reference terminal was immersed in an insulated jar of iced water. The lizard was strapped to a wooden block using two thin strips of masking tape, in such a way that the cloaca just overhung the end of the block. The thermocouple was held in a universal joint, which was clamped once the working junction had been inserted. The preparation was then placed in a cardboard box, the inside of which was painted matt black to reduce reflected radiation, and the front of which was an aluminium panel painted gloss white to reduce absorption. The panel contained a slit measuring 15 × 5 cm, and the lizard was placed behind the slit so that its dorsal surface was normal to the radiation from the lamp. The ambient temperature was 15°C throughout.

In order to determine heating rates, a lizard was placed in the refrigerator at 5°C for half an hour. It was then strapped to the block, which had also been cooled, and the thermocouple was inserted into the cloaca. The preparation was then clamped in position, and the lamp switched on. Readings of the lizard temperatures were taken at half-minute intervals until the animal reached 30°C, when the lamp was switched off and the lizard released. A typical heating curve for an adult male lizard weighing 2.9 g is shown in Fig. 1; in this experiment the animal was receiving 3.36 J cm^{-2} min^{-1}. The overall relation between radiation and rate of heating at 15°C for this lizard is shown in Fig. 2.

2. Calculation of heating rates in the field

We calculated the rates at which the lizards would warm up if they emerged on the morning of June 15th at Bristol (latitude 52°N, longitude 2°W). The Local Hour Angle and Declination of sun were calculated for different times during this morning, and the corresponding Altitudes and Azimuths determined (*Nautical Almanac,* 1970; Admiralty Hydrographic Department, 1951). Radiant energy was then calculated from data in Trewartha (1954) and Geiger (1965). The times which it would take for the temperature of each of the experimental lizards to rise from 15°C to 25°C were thence calculated, using data from the previous experiments.

We chose these temperatures because 15°C is the ambient temperature at which we worked, and seems reasonable for a June morning, and 25°C is the lower limit for activity. The heating times for five adult lizards are shown in Fig. 3. A lizard is first able to warm itself to 25°C at about 0530 hours, when it takes nearly 15 minutes. The curve falls steeply in the early morning and begins to level off at about 0800 hours (all times are GMT). A lizard emerging before 0700 hours will take significantly longer to warm up than one emerging later. There will be little advantage, however, in emerging after 0900, when it takes an animal less than six minutes to reach 25°C, because even at midday it still takes 5½ minutes.

3. Emergence in the field

Earliest times at which adult lizards were observed in the field on fine sunny mornings are shown in Fig. 4; they ranged from 0915 hours during March to 0754 hours during June. Fig. 4 also shows the amounts of incident solar radiation at these times, calculated from Geiger (1965). Note that the levels of radiation at the times of emergence in the spring and autumn are about 15% lower than those at the time of emergence in the summer.

DISCUSSION

The results presented here provide a quantitative confirmation of our hypothesis: the time at which the warming-up period begins to level off (Fig. 3) corresponds fairly well to the actual time of emergence on June 15th (Fig. 4). In fact, the predicted time is a little early. Two obvious explanations for this discrepancy are first, that solar radiation is calculated for a clear atmosphere and second, that the time at which a lizard was first seen in the field may have been a little later than the time of emergence. In addition, our model rests on a number of untested assumptions, for example that the thermal radiation from the sun and from an incubator lamp are equivalent, and that the ambient temperature is 15°C.

We have made no effort to assess the relative importance of different substrates upon which a lizard may bask. Nor have we further investigated the interesting observation that lizards emerge at lower thermal radiation levels during the spring and autumn than they do in the summer (Fig. 4). This may well be a consequence of seasonal changes in the environmental factor or factors which act as the stimulus to emergence, but our experiments and observations shed no light on this difficult problem (Kayser and Marx, 1951; Hoffman, 1968 and many others). It does, of course, increase the discrepancy between the observed and calculated times of emergence referred to in the last paragraph.

There is clearly a need for further research in this area. We would like to draw attention to a pioneering paper by H. Knötig (1964) which seems to us to have been neglected in much of the recent literature on thermoregulation in reptiles, and to note that the time at which a lizard retreats after the day's activity is not determined by a simple reversal of the processes we have described above.

It is a pleasure to thank our colleague Dr G. M. Jarman for many discussions on the physical principles involved in this work.

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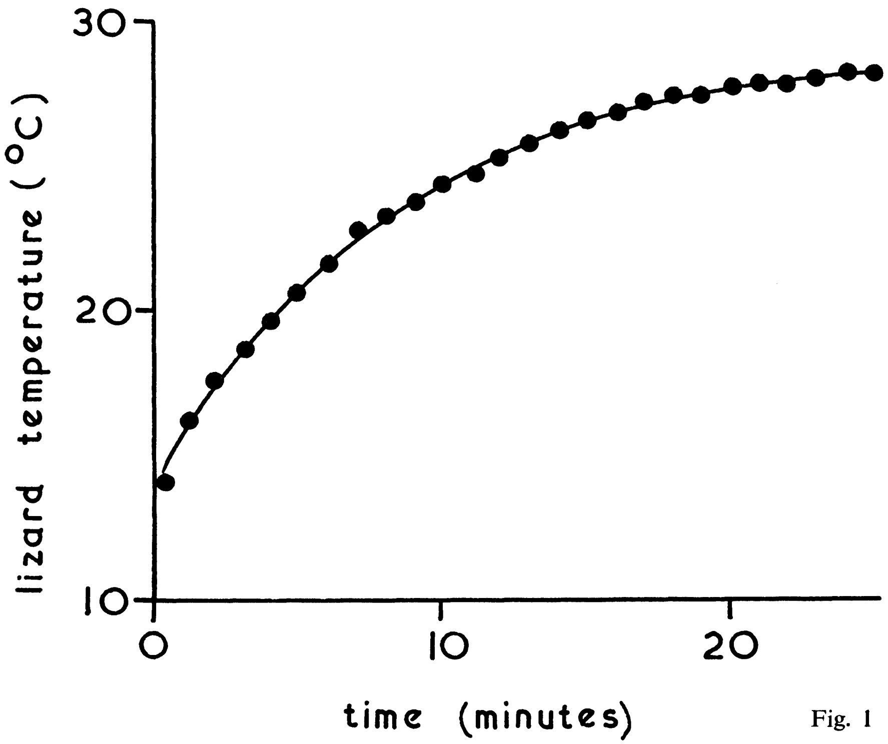

Fig. 1

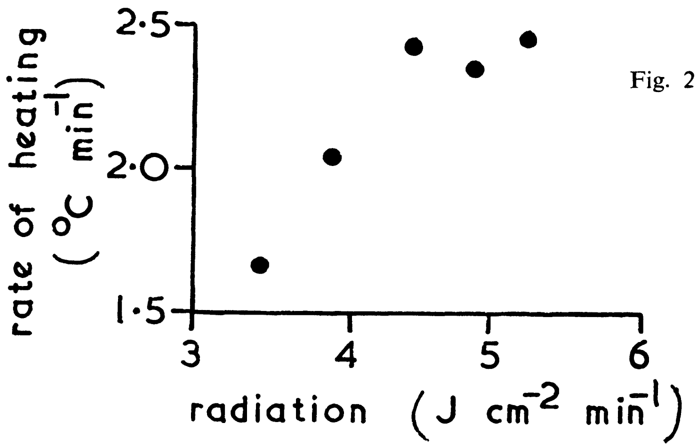

Fig. 2

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FIGURE 1.
Typical heating curve for an adult male lizard.

FIGURE 2.
Relation between radiation and rate of heating of an adult male lizard at 15°C.

FIGURE 3.
Calculated heating rates of five basking lizards.

FIGURE 4.
Earliest sightings of adult lizards on fine sunny mornings, together with the calculated solar radiation at the time.

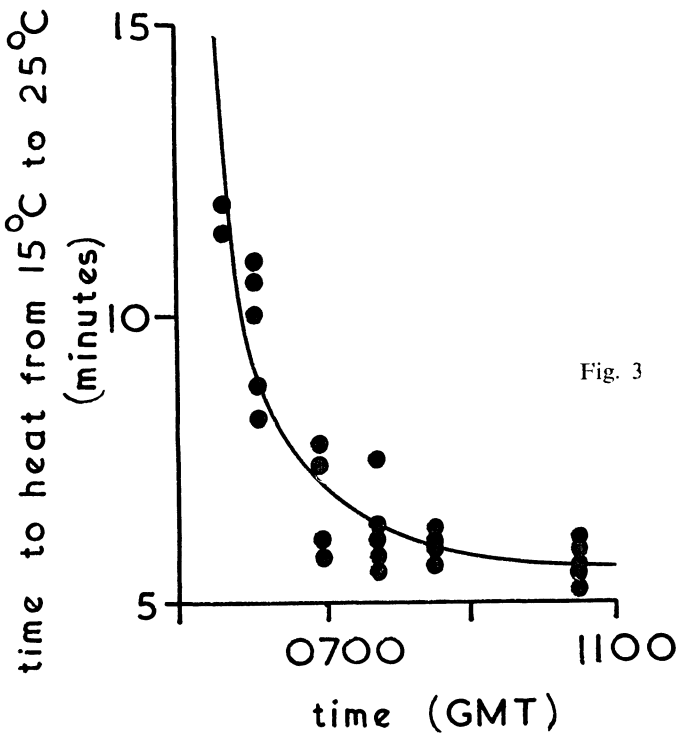

Fig. 3

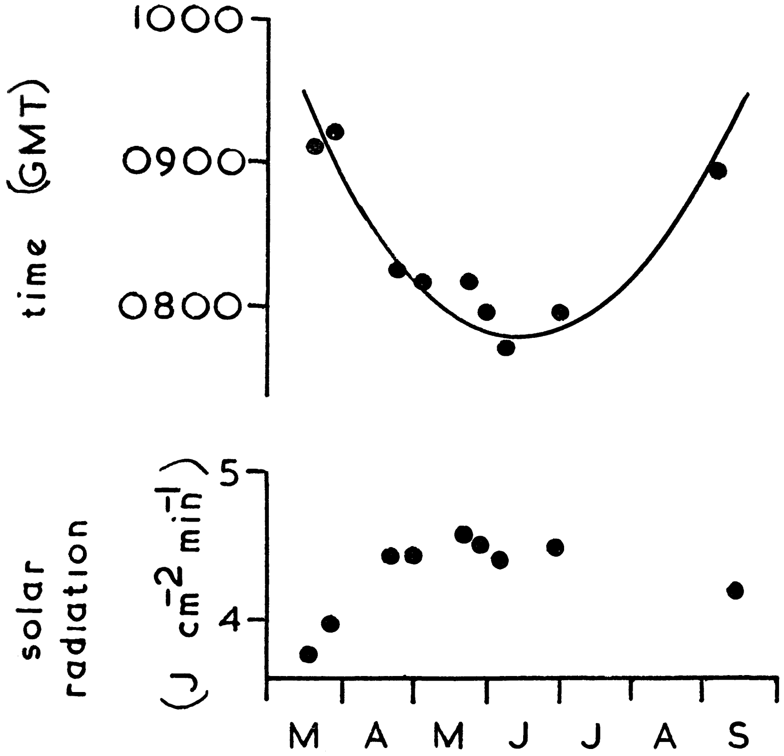

Fig. 4

VETERINARY ASPECTS OF RECENTLY CAPTURED SNAKES

J. E. COOPER*
Veterinary Services Division
P. O. KABETE
Kenya.

(*Received* 13/8/72)

INTRODUCTION

Snakes are kept in many parts of the world for scientific research and for educational and display purposes. The use of snakes for venom production is of particular importance in the Tropics where human deaths from snakebite may reach 30,000 a year (Swaroop & Grab, 1954). Snakes are maintained on "farms" and milked regularly; their poison is used to produce antivenom by injection into horses. There are institutes and laboratories for the production of such antivenom in many countries of the world (Reid, 1968). In addition to its value in antivenom production venom may be used itself for medical purposes—in the case of the Malayan pit viper (*Agkistrodon rhodostoma*), for example, the venom is a potent defibrinating agent (Reid, 1967) and can be used to treat thrombosis.

*Present address:—
Clinical Research Centre, Harrow, Middlesex, England.

Veterinary treatment of snakes is not widespread but can be of considerable economic importance, especially where large numbers of them are maintained for venom production. Careful examination and management of recently captured snakes can significantly reduce disease and mortality and in this paper attention is drawn to some of the conditions encountered by the author with snakes in East Africa.

MATERIALS AND METHODS

The data herein are based on work carried out at the Nairobi Snake Park and at a private "snake farm" in Kenya. The Nairobi Snake Park is a part of the National Museum, Nairobi and as such its primary role is the education of local people and visitors (Nares & Cooper, 1971). The private snake farm is a commercial concern which exports venom and deals with large numbers of venomous African snakes.

Investigation of disease at these two establishments has been based on clinical examination and therapy of sick snakes and the *post-mortem* examination of those which die. The techniques of examination have been described elsewhere (Cooper & Nares, 1971).

CONDITIONS ENCOUNTERED

Trauma

The capture of wild snakes can be an arduous task and the specimen may easily become damaged. This is especially so in the case of venomous species where restraint must be by metal grab sticks. In the case of the arboreal mambas (*Dendroaspis spp.*) the snake must also be extricated from the branches in which it lives; such a snake may often suffer damage from thorns as well as from the direct action of the grab stick. Stick wounds are, however, of particular importance (Fig. 1) since the snake is usually gripped in several places before it can be placed in a collecting bag. Such wounds vary in severity from small superficial scale lesions to extensive stripping of the skin which often extends for several inches. Deeper wounds may also be inflicted and the author has examined snakes which have died of haemorrhage due to traumatic liver damage during handling. In other cases healed fractures of ribs and other chronic lesions have been attributed to earlier grab stick damage.

Skin wounds are not only unsightly but also permit entry of bacteria (e.g. *Aeromonas*) and possibly, of larval Nematodes (e.g. *Kalicephalus*). Good handling techniques go a long way towards reducing the incidence of such wounds and similar care in handling must be maintained during the snake's time in captivity. The skin is particularly liable to be damaged when the snake is sloughing and handling at this time should be minimal. Thorough disinfection of wounds following infliction will also help reduce the risks of infection.

Other relatively common causes of trauma in recently captured snakes are wounds inflicted by man and by the snake's prey. Snakes also have a number of "enemies" in the form of predatory mammals and birds, and grass fires; such factors are described in some detail by Pitman (1938). Wounds inflicted by man are especially common in East Africa where the natural reaction of most people to a snake is to attempt to kill it. In one such case a valuable gaboon viper (*Bitis gabonica*) was involved and amputation of the tail was necessary (Cooper, 1971a). Other cases have consisted of severe slash wounds and treatment has been carried out by suturing these wounds. The volatile anaesthetics are usually used for such cases and where haemorrhage is severe, glucose saline (5% glucose, 0.85% saline) is administered intra-peritoneally or sub-cutaneously.

Damage by prey can be surprisingly extensive. Large constricting snakes may be bruised while capturing their prey or be damaged by horns or teeth. In one case, an African python (*Python sebae*) was captured at Naivasha, Kenya, shortly after swallowing a dog and several of the snake's teeth were missing or damaged; this is thought to have predisposed to severe necrotic stomatitis ("mouth-rot") which quickly supervened. Small mammals supplied to newly-captured snakes for food may also inflict damage; mice may gnaw the snake's skin for example, and for this reason live food should be removed if not eaten within a few hours.

It is of interest that C. J. P. Ionides in his personal notebooks (now in the care of Mr. J. H. E. Leakey) recorded a number of wild snakes as having "truncated tails", presumably as a result of mechanical damage. One particularly severe case was a black mamba (*Dendroaspis polylepis*) which he caught on 8/9/64 and recorded "fair sized female, had tail truncated about one inch from vent." Similar cases of truncated tails are recorded as "common" by Leakey (Pers. Comm.) who also reports finding fractured ribs, flesh wounds and scars in newly caught snakes of several species. Ionides also recorded a green mamba (*D. angusticeps*) caught on 26/12/61 which had its "right eye opaque and white and obviously blind in it." Conjunctivitis and traumatic damage to the spectacle are common in captive snakes but Ionides' observation is the only one that has been traced to ocular disease in a wild snake. A number of snakes have a translucent appearance to the eyes at capture but this is a prelude to sloughing and is perfectly normal: it disappears when the skin is shed.

Newly captured snakes may also suffer injury, or death, if not stored and transported correctly. In East Africa snakes are usually carried in individual canvas bags. These are suspended in a box or on a rail so that the snakes inside cannot be inadvertently trodden on: this serves to protect the handler as well as the snakes. If bags are left in the sun snakes may become overheated and die, since it has been shown (Moseuer, 1936) that even deserticolous snakes will die quickly if their body temperature exceeds 44.2-53.0°C. If the bags are packed too tightly there is some slight risk of a snake biting another through the bag. One rhinoceros-horned viper (*Bitis nasicornis*) was found dead in its canvas bag and on examination proved to have a grossly swollen area in the "cervical" region. Fang marks could not be detected but from the oedematous and haemorrhagic appearance of underlying tissues it was concluded that the snake while in the bag had been bitten by another, probably viperine, species.

Recently captured snakes can be kept in canvas bags for periods of up to two weeks without food or water and without obvious ill effects but observations at the Nairobi Snake Park suggest that such prolonged confinement may render the snake more susceptible to disease when it is placed in a cage. If canvas bags are not cleaned between batches of snakes bacteria will build up and infection may be a sequel. Snakes frequently regurgitate food after capture; this is a perfectly normal procedure but it too may contribute to bacterial contamination of the bag.

Traumatic injuries are common when snakes are first placed in a cage since they often damage their muzzles on the glass in an attempt to escape. This can be reduced by providing adequate cover in which the reptile can hide. Care should also be taken if the cage is artificially heated since severe burns can result if a reptile comes into close contact with the heater (Cooper, 1971b).

Parasites

A number of snakes carry a parasite burden when first captured. These may be ecto-parasites (ticks and mites) or endo-parasites (helminths, protozoa and pentastomes). Of these the ticks and mites are easiest to diagnose and treat. They warrant control since they suck blood, may transmit bacterial disease (Camin, 1948) and, if introduced into a collection, may establish themselves. At the Nairobi Snake Park all new reptiles are sprayed on arrival with a 1% trichlorphon ("Neguvon": Bayer) solution and this is repeated every 4-6 weeks. As a result ecto-parasite problems are few.

In Kenya the author has experienced no trouble with protozoal parasites despite the reported pathogenicity of entamoebiasis (due to *Entamoeba invadens*) in other parts of the world. Haemogregarine parasites have been found in blood smears but appear not to be associated with disease.

Nematodes have posed problems and some recently arrived snakes have been found to carry large burdens. In particular disease has been associated with *Kalicephalus* worms (Cooper, 1971c), the adults of which attach to the upper intestinal tract and can cause erosive lesions with haemorrhage and a build-up of cellular debris. Several other genera have also been identified (e.g. *Ophidascaris* and *Abbreviata* spp.) but the pathogenicity of these is less certain. All new arrivals at the Nairobi Snake Park are dosed orally with thiabendazole ("Thibenzole": Merck, Sharp & Dohme) at a dosage of 50 mg per lb body weight and this is repeated every 6 weeks. Disease and death due to nematode parasites are now very infrequent.

A particularly interesting finding has been that of large numbers of trematodes (*Ochetosoma* and *Mesocoelium* spp.) in the buccal cavities of newly caught bush vipers (*Atheris* spp.) (Fig. 2). These flukes are unsightly but do not appear to be pathogenic; no treatment is carried out other than manual removal with a dampened swab. Proglottides of cestodes are also commonly passed *per cloacam* by a number of freshly-caught snakes but these parasites appear not to be pathogenic unless their numbers build up in captivity.

Pentastome parasites warrant mention as the eggs of some can be pathogenic to humans if ingested and one host of these parasites, the rhinoceros-horned viper (*B. nasicornis*), is eaten by man in certain parts of Africa (Pitman, 1938). The parasites are primitive arachnids, segmented in appearance and usually occupy the respiratory tract of snakes. The species found at Nairobi have been of the genera *Armillifer* and *Raillietiella*. Persons working with newly captured snakes should ensure that they follow basic hygienic precautions, especially if pentastomes are seen to be coughed up by snakes.

Infectious Diseases

A number of recently captured snakes have been found to be suffering from necrotic dermatitis ("scale-rot") or necrotic stomatitis ("mouth-rot"). The former is characterised by necrotic scale lesions but the lesions vary greatly in appearance and severity. In some cases the condition is associated with the retention of a piece of skin after a slough. Such cases usually heal when the retained skin is removed, and a warm bath will often facilitate this. In other cases the lesions may be extensive and not associated with slough. At the Nairobi Snake Park a swab is usually taken and culture for bacteria and fungi is carried out, together with an antibiotic sensitivity test. Mild cases are treated by daily bathing in a warm solution of a quaternary ammonium disinfectant, more severe cases by topical application of an antibiotic/gentian violet spray. In all cases parenteral vitamins are administered and the snake is encouraged to feed.

Necrotic stomatitis also varies greatly in severity, ranging from slight inflammation to extensive erosion and build-up of necrotic debris. The condition is particularly common in captive snakes but both the author and Leakey (Pers. Comm.) have also found it in freshly-caught African pythons (*P. sebae*) and house snakes (*Boaedon fuliginosus*). In the author's view the condition can be either a straightforward infection of the buccal cavity by various bacteria or a "secondary" condition following periods of "stress" such as starvation, disease or surgical interference.

The former type of condition should be treated as early as possible. A large number of bacteria may be isolated from the necrotic debris and such cases are usually treated, with good results, with topical streptomycin for 5-7 days. It is important to remove any gross debris beforehand and if the streptomycin is applied using a syringe, this will itself dislodge any loose pieces of tissue.

In the case of "secondary" necrotic stomatitis, bacteria also invade and a similar clinical picture is seen, but in the author's experience the condition cannot be resolved solely by killing the bacteria. Attention must be paid to improving the condition of the animal by the provision of food and by multi-vitamin injections before antibiotics are given.

A large number of bacteria are pathogenic to reptiles and many of these may be introduced with new arrivals. The author has isolated *Salmonellae* from captive East African snakes but the source of a number of these is believed to have been animals (especially frogs) supplied as food for snakes. Nevertheless, basic hygienic precautions are always recommended when handling snakes in view of the possible danger of infection to man.

In a few cases a localised bacterial infection has been diagnosed in snakes at capture or shortly after arrival. The infections have included a staphylococcal cloacal infection in a Jameson's mamba (*Dendroaspis jamesoni kaimosae*) and an *Aeromonas* conjunctivitis in a house snake (*B. fuliginosus*). One gray-beaked snake (*Scaphiophis albopunctatus*) drank excessively when captured and died 3½ weeks later. At *post-mortem* examination it was found to have a chronic cloacitis associated with nephritis.

The Gram-negative bacteria *Aeromonas* and *Pseudomonas* are a particular problem in reptile collections and several authors have discussed their rôle in snake diseases (Page, 1966: Wallach, 1969). The organisms have proved to be a particular problem in Kenya and in some instances have been responsible for epizootics, valuable snakes dying from a septicaemia within a few weeks of

Fig. 1. Head and neck of mamba (*Dendroaspis* sp.) showing extensive skin loss on neck due to grab stick damage.

arrival. Examinations have shown that a percentage of snakes harbour *Aeromonas* and *Pseudomonas* in their intestines though these cannot always be detected in cloacal swabs. The cause of pathogenicity is not clear although it appears that disease in the holding pits is coupled with an increased suscepti-

Fig. 2. Head of bush viper (*Atheris* sp.) showing numerous trematodes within the buccal cavity.

bility to infection due to physical damage and " stress " during handling and milking.

Septicaemia due to *Aeromonas* and *Pseudomonas* is basically a disease of snakes in captivity and its control will not therefore be discussed here but the condition is mentioned since recent accessions almost certainly contribute to build-up of infection by introducing the bacteria as part of their gut flora. The control of ecto-parasites and the improvement of hygiene will contribute to a reduction in the spread of such infections.

SUMMARY

Diseases of recently captured East African snakes are described. Traumatic damage is particularly important but helminth parasites and bacteria are also encountered and may cause disease especially in the intensive environment of captivity. Certain bacterial infections are encountered at capture, in particular, necrotic stomatitis and necrotic dermatitis. The treatment of these and other conditions is described. Such conditions reduce the lifespan and value of snakes for venom production and for educational and research purposes. As such they warrant prevention and treatment and here the veterinary surgeon can offer useful advice. Whilst some of the conditions described need medical or surgical treatment the majority can be prevented or controlled by improved handling techniques, by rejection of injured or sick specimens, and by subsequent good management.

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CHANGES IN THE CHLORIDE CONTENT IN THE BLOOD OF THE GROUND DWELLING AGAMID LIZARD, *SITANA PONTICERIANA* ON THERMAL ACCLIMATION

By

M. V. Subba Rao*, B. S. Rajabai and K. Pampapathi Rao**
Department of Zoology, Sri Venkateswara University,
Tirupati (A.P), India.

(*Received 30/12/71*)

* present address: Post Graduate Department of Zoology,
Utkal University,
Bhubaneswar (Orissa), India.
** present address: Department of Zoology,
Bangalore University,
Bangalore 1, India.

INTRODUCTION

Extensive literature is available on the ionic composition of the body fluids of poikilotherms (Florkin, 1960; Maluf, 1939; Pampapathi Rao & Madanmohan Rao, 1963; Prosser, 1958; Prosser & Brown, 1961; Prosser, Mackay & Kato, 1970) but very little work has been carried out in its relation to sex, size and temperature. Pampapathi Rao (1961) while dealing with metabolism of tropical poikilotherms with special reference to temperature acclimation reported that metabolic compensation to temperature change take place in tropical poikilotherms also; changes in ionic concentration could play a part in affecting metabolic compensation. Padmanabhanaidu and Ramamurthy (1961) reported that the blood chloride in the crab, *Paratelphusa* sp. increased with weight in both sexes and then steadily decreased as the weight increased, whereas in the fresh water mussel, *Lamellidens marginalis,* the chloride content of the blood showed a small but steady increase with increasing weight. The effect of high temperature in *Paratelphusa* sp. resulted in a decrease in the chloride content, but on warm acclimation, *L. marginalis* unlike *Paratelphusa* sp. showed considerable increase in the blood chloride (Pampapathi Rao & Ramachandra, 1961); the chloride content in the blood of the tropical fishes, *Etroplus maculatus* and *Cirrihina reba* decreased on cold and warm acclimation (Parvatheswara Rao, 1962) and similar results were reported by Saroja (1963) and Saroja and Pampapathi Rao (1965) in the case of the body fluids of the earthworm, *Lampito mauritii.* In the normal and acclimated scorpion, *Heterometrus fulvipes,* the chloride content in males and females increased up to approximately 8 gm weight of the animal and then decreased with further increase in size; the chloride content of females was slightly greater than in males (Padmanabhanaidu, 1966). Such studies are lacking in lizards, hence the present report.

MATERIALS AND METHODS

The ground dwelling agamid lizards, *Sitana ponticeriana* Cuvier were always collected from the same locality to eliminate possible variations in metabolism due to differences in habitat. They were collected in January and early February (winter populations) and late May and June, 1965 and 1966 (summer populations) designated as " cold " and " warm " forms respectively. Studies in between seasons were made on lizards collected late in July to November and late in February to mid April (" normal " or " control " forms).

Systemic Studies

Methods of acclimation were the same as in a previous account (Subba Rao & Rajabai, 1971). The blood was extracted from cold and warm acclimated and normal lizards, to estimate chloride content. Estimations of blood constituents were made on animals which showed no signs of moulting. With *S. ponticeriana,* in winter, because of the non-availability of larger animals (the life span is one year — Subba Rao, 1970; Subba Rao & Rajabai, 1972) animals were taken only for cold acclimation. Therefore these lizards were not compared with warm acclimation forms. Animals were weighed in a Sartorius monopan balance and the size and sex were noted since these parameters were found to influence the ionic composition of the blood.

Method of Collection of the Blood

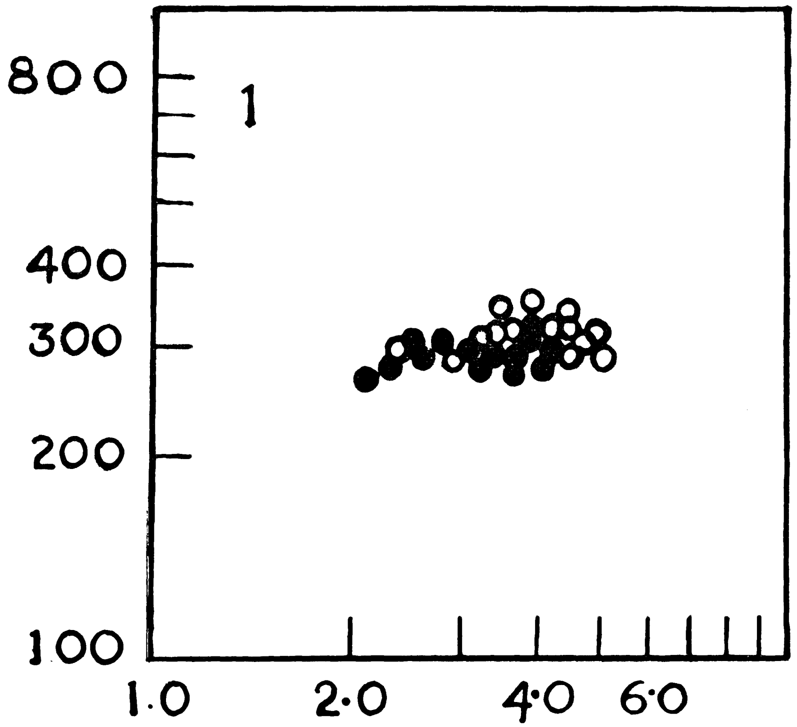
The living animal was fixed to a board by rubber bands while drawing the blood. Samples were collected by heart puncture with heparinised syringes into the embryo cups (see Bentley, 1959). The amount of blood drawn per animal was diluted to the required quantities for chloride ion estimation as follows: —0.1 ml heparinised heart blood, 4.9 ml 0.2 N of nitric acid (50 times dilution).

The blood chloride content was determined by a potentiometric method using a Gallenkamp electrometric micro-titration apparatus. 0.1 ml of blood was added to 5 ml of 0.2 N of nitric acid and the mixture titrated with 0.01 N silver nitrate solution. From the titre values, the chloride content was calculated and expressed in mM/l (milli Mols/litre).

RESULTS

Chloride content estimations were made on the blood of normal (28°C), cold (20°C) and warm (35°C) acclimated *Sitana ponticeriana* (Tables 1, 2; Figs. 1-5). 1. There was a significant difference ($P<0.01$) in the chloride content of blood of both sexes maintained at different temperatures (Table 2). 2. Chloride content in the blood of females was found to be significantly higher than in males (Table 2). 3. However these differences might be due to weight differences among the three groups of the animals tested at different temperatures (i.e., 20°C, 28°C and 35°C). 4. The pattern of size dependence in *S. ponticeriana* (Figs. 1-5) showed the chloride content in the blood to increase up to a weight of 4 gm and then it gradually decreased.

Fig. 1. Comparison between normal males (●) and females (O) at 28°C.



DISCUSSION

Considerable information is available on the ionic composition of the blood of marine and fresh water animals (see Prosser & co-workers, 1958, 1961, 1970). In the normal (28°C), cold (20°C) and warm (35°C) acclimated *Sitana ponticeriana* significantly there was some slight sex and size dependence. In the earthworm, *Lampito mauritii* (Saroja, 1963 and Saroja & Pampapathi Rao, 1965), the concentration of body ions is not related to body size whereas the chloride content of the body fluids of the crab, *Paratelphusa* sp. and the fresh water mussel, *Lamellidens marginalis*, are size and sex dependent in normal and warm acclimated animals (Padmanabhanaidu & Ramamurthy, 1961; Pampapathi Rao & Ramachandra, 1961). In the scorpion, *Heterometrus fulvipes* the chloride content of the female is higher than in the male (Padmanabhanaidu, 1963). Similar observations were made by Gilbert (1959) on the common shore crab, *Carcinus maenas* and by Padmanabhanaidu and Ramamurthy (1961) on *Paratelphusa* sp.

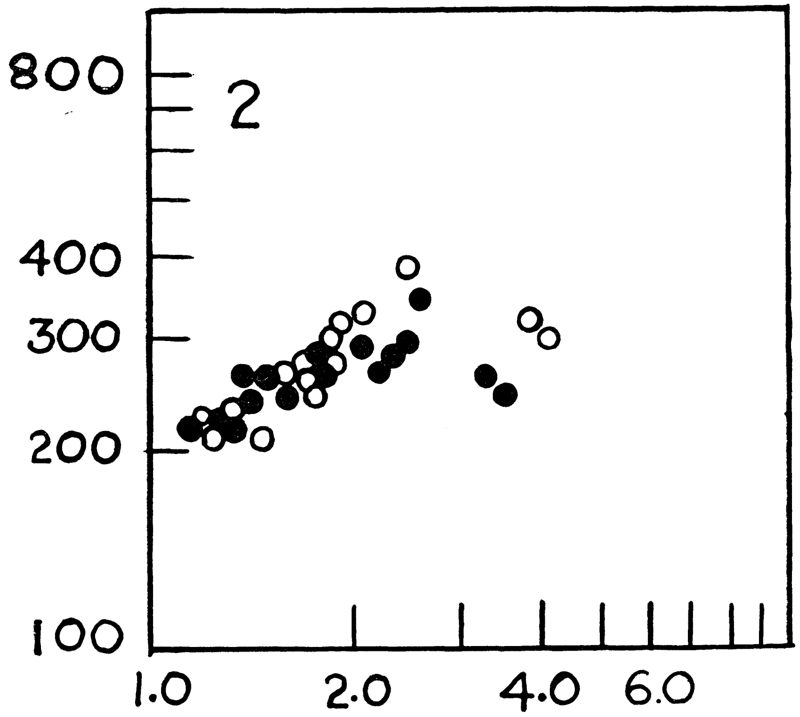


Fig. 2. Comparison between the cold males (●) and females (O) at 20°C.

Earlier publications from this laboratory have demonstrated that the chloride of the body fluids of *Paratelphusa* sp. and *L. marginalis* were size and sex dependent in normal and warm acclimated animals (Padmanabhanaidu & Ramamurthy, 1961; Pampapathi Rao & Ramachandra, 1961). The present results show that *S. ponticeriana* is also significantly size and sex dependent in this feature. There is metabolic compensation and activity to temperature change (Bullock, 1955). The degree of compensation differs in different groups of animals (Bullock, 1955; Precht, 1958), and possibly in different sexes too

but the mechanisms underlying compensation are not fully understood. Changes in ionic concentration could play a rôle in affecting metabolic compensation, though systematic changes are probably effected via the endocrine system, whose hormones when released might be triggered off by temperature changes (Pampapathi Rao, 1961).

The chloride content in *L. mauritii* decreased on cold and warm acclimation (Saroja & Pampapathi Rao, 1965). In *Paratelphusa* sp. it decreased on warm acclimation only but the opposite was observed in *L. marginalis* (Pampapathi Rao & Ramachandra, 1961). The present results show significant changes in blood chloride on cold and warm acclimation, in both the sexes of lizards, though weight differences among the three groups (normal, cold and warm) of animals may have influenced such differences.

In *S. ponticeriana*, the blood chloride gradually increases with increasing weight up to 4 gm and thereafter probably decreases with increasing weight. In *L. marginalis* (Padmanabhanaidu & Ramamurthy, 1961), the blood chloride showed a small steady increase with increasing weight. In *Paratelphusa* sp. it also increased with weight to a maximum at about 40 gm (males) and 35 gm (females) and then steadily decreased with further weight increase.

In *S. ponticeriana* the blood chloride showed no maximal value in the middle of the size range.

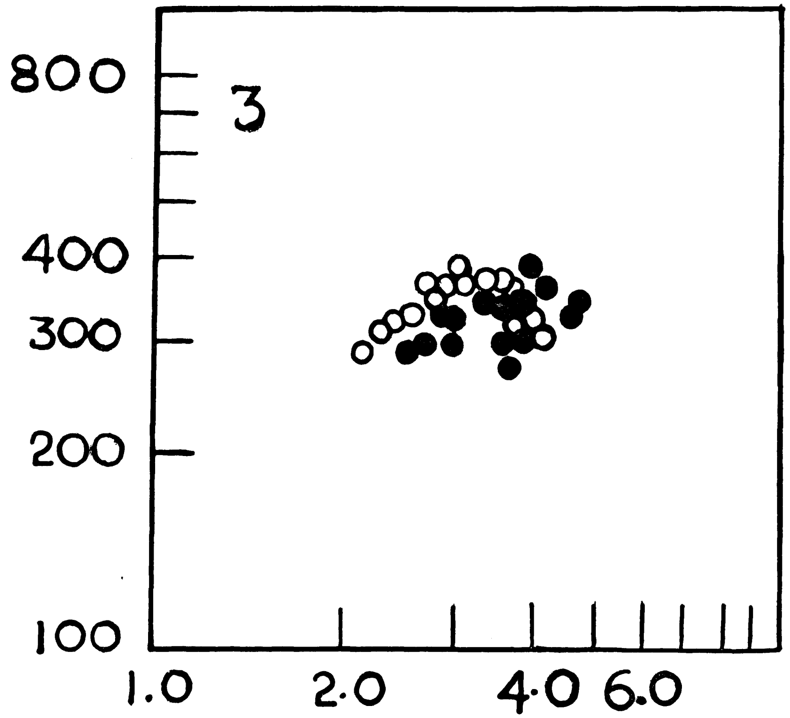


Fig. 3. Comparison between the warm males (●) and females (O) at 35°C.

SUMMARY

1. The blood chloride of normal, cold and warm acclimated *Sitana ponticeriana* was studied.

2. The blood chloride shows significant correlation to sex and size. It increases with body weight up to 4 gm and then thereafter probably decreases.

3. Changes in ionic concentration may be involved in metabolic compensation and activity during temperature change. Such compensation possibly differs in the two sexes.

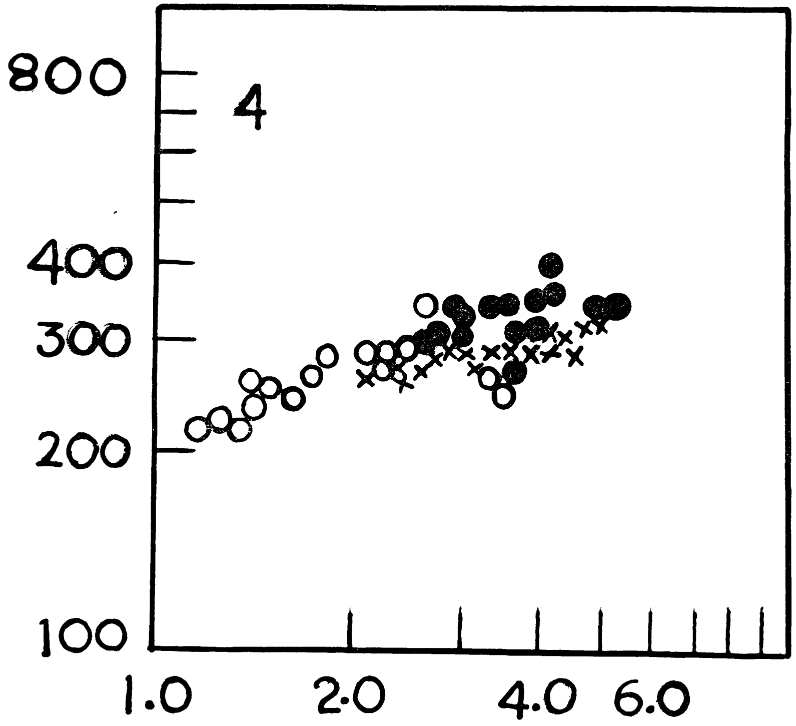


Fig. 4. Comparison between normal (X), cold (O) and warm (●) males.

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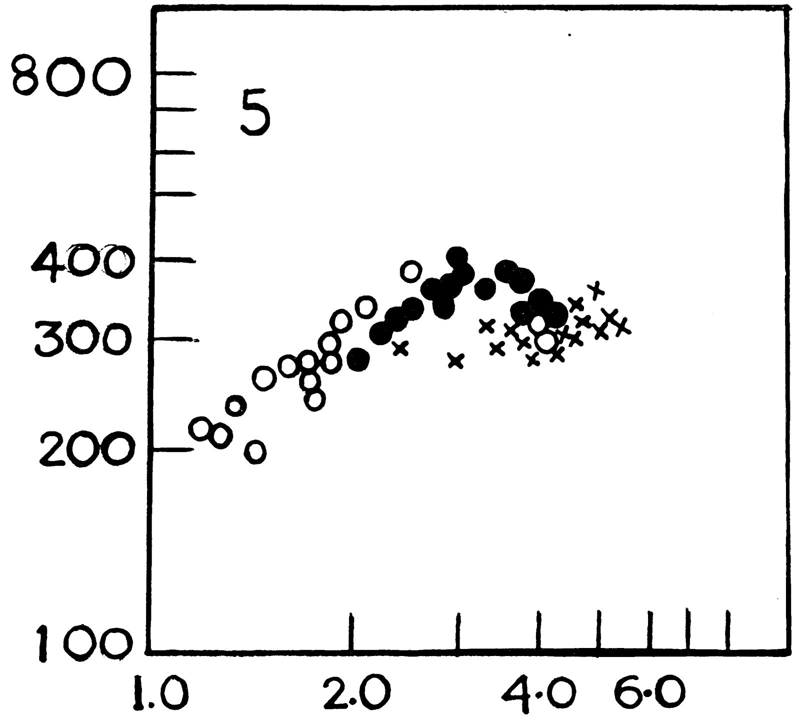

Figs. 1-5. Double logarithmic grid — X-Axis represents weight in grams; Y Axis represents mM/l.

Fig. 5. Comparison between normal (X), cold (O) and warm (●) females.

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LEGEND FOR FIGURES 1-5

Chloride content in the blood of normal, cold and warm acclimated lizards, *Sitana pontceriana*. Chloride content in the blood represented in terms of mM/l (Milli Mols per litre).

Table 1. Blood chloride of normal (28°C), cold (20°C) and warm (35°C) acclimated *Sitana ponticeriana* (No. of observations in each sex: 16).

No.	Mean or Standard error	Sex	Range Normal (28°) Weight gms	Normal (28°) mM/l	Cold (20°) Weight gms	Cold (20°) mM/l	Warm (35°) Weight gms	Warm (35°) mM/l
1.		Male	2.144 to 4.456	268 to 312	1.162 to 3.568	214 to 344	2.577 to 4.833	292 to 392
	Mean			293.56		262.25		329.89
	S.E.			3.02		8.17		7.88
2.		Female	2.424 to 4.822	290 to 340	1.198 to 4.124	218 to 384	2.120 to 4.116	282 to 383
	Mean			306.20		274.25		344.33
	S.E.			3.70		12.25		8.30

Table 2. Data analysis of variance of blood chloride of *Sitana ponticeriana* at different temperatures (see original data in Table 1).

	Degree of freedom	Sum of the squares	Mean squares	F-test
Both sexes	1	3,971	3,971	4.109*
Treatment	2	73,458	36,729	38.009**
Interaction	2	26	13	N.S.
Error	88	85,038	966.3	——
Total	93	162,493	——	——

* Significant at 5% level
** Significant at 1% level
N.S. Not significant

BOOK REVIEWS

AMPHIBIANS. By J. F. D. Frazer. Wykeham Science Series, 1973. XII, Pp. 122, 20 B/W illustrations. Paper back £2.00.

Chapters 1 and 2 consist of an elementary account of the classification, evolution, zoogeography and speciation of amphibians. Chapters 3 and 4 lightly sketch their anatomy, physiology, ecology and behaviour and Chapter 5 deals with the tadpoles. Chapters 6-10 are generally concerned with the adaptations of amphibians in different environments; Chapter 11 with their relationships to man and Chapter 12 discusses some problems which could well be investigated by serious naturalists outside the laboratory. A list of relevant suggested reading and a useful modern classification of living forms are appended.

The approach is very much a naturalistic one about amphibians in their typical habitats and emphasises the variety of morphological, physiological and behavioural modifications which they undergo to live in a varied set of ecological niches.

It seems that amphibians are found in most regions of the globe from the equator to the arctic circle and south to Australia and New Zealand. Some have a wide temperature tolerance; for example *Bufo americanus* can exist at temperatures between 10°C and 31°C, and eggs of the leopard frog of South Florida can endure a temperature of 35°C (p. 33). *Phrynobatrachus ukingensis mebaliensis* of S. Africa can jump into warm springs, often too hot for the human hand, when disturbed (p. 81). Amphibians can live wholly (neotinic species of Caudata) or partly in water, often in swift flowing streams (some newts, salamanders and the hairy frog *Astylosternus robustus*, for example, p. 78), or beneath ice (*Rana vertebralis* in the Drakensburg mountains of S. Africa) and *Rana sibiricus* of the Siberian mountains is active at temperatures from 6°C to 24°C (p. 79). They occur in brackish water and *Rana cancriva* of the mangrove swamps of S.E. Asia swims in the sea at high tide, its tadpoles living in water with 2.6% salt (p. 84). They can live below or on moist earth, in bracken, below logs, in caves, on mountains and up trees (*Hyla*). The mountain-living Alpine salamander never enters water at all but mates on the snow surface.

There are exceptions to the rule that amphibians always have an aquatic larval stage in their life history. The anuran *Eleutherodactylus* and *Liopelma* develop directly within the egg and omit a free swimming larval stage to hatch as little froglets. One may add here that we have learned a good deal about these genera from the work of H. Gardner Lynn of Washington and the Stephensons in Australia, among others. Again *Cornufer guentheri* from the Philippines undergoes direct development; the embryos have no tail and the head and fore-limbs of the adult kind form some days before hatching, though only a rounded tadpole body is present at this time (p. 59). There are even some viviparous species for *Salamandra salamandra* and *Hydromantes genei* extrude fully developed young from their cloacas, at birth; in the latter the tadpole gills subserve the functions of a placenta absorbing nourishment and oxygen from the circulatory system in the walls of the oviduct.

Only a brief mention is made of the Coecilia, which are less well known than are the urodeles and anurans. Perhaps here the work of Taylor on their classification and that by Lawson at Salford and Marvalee Wake at Berkeley on their anatomy could have been alluded to. *Hypogeophis* also has its entire larval life completed within the egg and an aquatic stage has been discarded in its life cycle.

I wish the author had remarked on the great service performed by *Xenopus laevis*, the South African clawed toad, for contemporary developmental biological research, a feature probably due to the ease with which fertile eggs may be obtained from gonadotropin-injected adults. Probably a good number of embryologists would be unemployed if *Xenopus* had not existed.

However Frazer has produced a competent, nicely written little book with much to interest the reader. It seems dear at the price (everything is these days), but if it is ever reprinted doubtless it will cost more. But that, as Congreve wrote, is the way of the world and not the fault of the author or for that matter the amphibians.

H. Fox

THE COMPARATIVE PHYSIOLOGY OF DESERT ANIMALS. Symposia of the Zoological Society of London, no. 31. By G. M. O. Maloiy (ed.). 1972. Academic Press Inc. (London) Ltd.

This symposium which was dedicated to a great inspirer of investigations into the adaptive physiology of desert animals, Prof. Knut Schmidt-Nielsen (a spontaneous decision on the part of the contributors), covers many aspects of studies in this field to date. Its scope ranges from desert snails and arthropods to African ruminants, and it constitutes one of a high-quality series of symposia produced over the years by the Zoological Society of London. There are three topics, besides many others, specifically on xeric amphibians and reptiles from the continents of Africa, Asia, America and Australia. Two other general accounts incorporate amphibians and reptiles, either in terms of habitat or in terms of general advance into the knowledge of desert physiological adaptation.

An attractive résumé at the observational and behavioural level (with some detail) is given by Prof. J. L. Cloudsley-Thompson on thermoregulation in desert reptiles. The treatment is comprehensive and I found the description of thermoregulatory frothing at the mouth as part of adaptive cooling in *Testudo sulcata* very interesting (the subjection of the tortoises to high temperatures was not continued experimentally up to the lethal point, once the process was adequately observed and described). Next an academic account is given of salt and water balance in desert lizards on a physiological and biochemical level by J. R. Templeton of the U.S.A. including much quantitative data. Finally, of the specific treatments, Dr. M. R. Warburg, in a detailed and learned way, describes at some length water economy and thermal balance of Israeli and Australian amphibia from dry habitats. Valuable quantitative estimations carried out mainly on numbers of European/Asiatic species substantiate his argument and he has elaborated on his own studies on the Australian burrowing frogs, toadlets and semi-arboreal hylids. A general account of behavioural adaptations of animals, including reptiles, to advective fog in the Namib Desert of South West Africa is given by Prof. G. N. Louw and Prof. Schmidt-Nielsen concludes with a comment on the recent advances in his field. He considers that there were few conceptually new findings on the success of reptiles to adapt to deserts, but considers the report of the use of uric acid as a means of nitrogen excretion by amphibians, otherwise characteristic of birds and reptiles, as sensational. Prof. E. J. W. Barrington wrote a pleasant, light foreword for the Symposium, which was an undoubted success.

However, this book of 413 pages with no colour plates (although an ample collection in black and white as well as line drawings) at £7.20 is for the desert enthusiast and specialist. It is only for the generalist if he includes an interest in the other groups, as well as in amphibians and reptiles, for which the latter although important concern a rather small proportion of the work.

M. R. K. LAMBERT

TURTLES OF THE UNITED STATES. By Carl H. Ernst and Roger W. Barbour. 1973. Pp. 347. University Press of Kentucky. $22.50.

This book deals with the life histories of 49 species of turtles native to the U.S.A. and Canada. Each species is described including its habitat, life history and reproductive processes and behaviour etc. There are more than 500 illustrations, 67 of them in colour

Initially there is an 8 page " Introduction to the Chelonia " and this is followed by an " Identification Key ". Thereafter there are descriptions of the *Chelydridae* (Snapping turtles); *Kinosternidae* (Musk and Mud turtles); *Emydidae* (Semi-aquatic Pond and Marsh turtles); *Testudinidae* (Tortoises); *Cheloniidae* (Marine turtles); *Dermochelyidae* (Leatherbacks); the single living species *Dermochelys coriacea* is the largest living turtle; *Trionychidae* (Soft-shelled turtles) and the book finishes with sections on turtle origin and evolution; care in captivity and their parasites, commensals and symbionts. A " Glossary " of scientific names and a 50 page " Bibliography " conclude the volume. The latter comprises more than 1,000 references which aims to include all the papers published between July 1st, 1950, and December 31st, 1970, on ecology, ethology and systematics of the American turtles. However, important earlier papers are referenced, especially those which contain the original descriptions of the species or subspecies.

This is indeed a very well produced handsome book with fine colour illustrations of these bizarre, fascinating and delightful animals. Like the giraffes and elephants they are one of nature's exquisite jokes for only the processes of natural selection and evolution could have resulted in a beast like a tortoise. I feel sure that those people interested in herpetology, especially the chelonians, would be pleased to have this book as a source of reference and to meander through it to sample the varied and wide range of information therein. Unhappily it is expensive though this is understandable in its lavish production. No serious biological library should be without this work and those Institutions with a bias towards herpetology should put it high on their shopping list.

H. Fox

LETTERS TO THE EDITOR

Reptiles of Birtain have unfortunately not been examined in great detail. Of the six species, the Smooth Snake (*Coronella austriaca*) has received least attention and is relatively unknown to many naturalists. The Slow Worm (*Anguis fragilis*) and the Sand Lizard (*Lacerta agilis*) are currently being examined by biologists and the Common Lizard (*Lacerta vivipara*) has been the subject of some scientific research. An extensive report on the Adder (*Vipera berus*) was published in 1971. Although the Grass Snake (*Natrix natrix*) is common and although we know much about its habits, further studies are required.

As we know little about the Smooth Snake in Britain I have commenced a detailed ecological and ethological study of this rare species. Populations of animals at the limit of their distribution range are particularly interesting because of possible alterations in their physiology and behaviour. The Smooth Snake of Britain has been isolated from European populations for thousands of years and so may have very interesting adaptations to Britain's climate.

Recent and reliable distribution records are required and they will be useful as a comparison with Taylor's records published in the *British Journal of Herpetology* in 1963. The animals should not be disturbed but photographs or accurate records would be most valuable.

The Smooth Snake may prove to be an "endangered species" in this country and so specimens cannot be sacrificed. There are, however, many preserved snakes in private collections and I should welcome the opportunity to examine these in the hope of gaining further information about this harmless and delightful animal.

DR. IAN F. SPELLERBERG,
Biology Department,
The University,
Southampton,
England SO9 5NH.
(*Received* 17/7/73)

AN ADDITIONAL REPORT OF UNUSUAL BEHAVIOUR IN JUVENILE TOADS

Huheey (1965) reported precocious sexual behaviour in immature *Bufo a. americanus* Holbrook. During the winter months of 1967-68, I also observed similar clasping several times beween immature *Bufo*. The toads, *B. w. woodhousei* Girard, were collected shortly after metamorphosis along the Missouri River in a sand-dune area near Elk Point, Union County, South Dakota, on 28 July, 1967. The six smallest were kept in a small aquarium containing sand and a water container.

On 18 April, 1968, the six ranged in snout-vent length (SV) from 33 to 41 mm. Of over 750 *B. w. woodhousei* from the same population handled during the summer of 1968, the smallest male with a black throat measured (SV) 57 mm (unpublished data). Underhill (1960) took no toads smaller than 50 mm during the 1959 breeding season. He stated that toads in South Dakota do not reach maturity until the beginning of the third year of life. The clasped toad did not resist. None of the six had developed nuptial thumb pads, a dark throat, or the male warning "chirp" or vibration by the death of the last one a year later. The pair would remain clasped, sometimes despite handling, for several hours. Because the six were not marked, I do not know for certain whether the same toads were involved each time.

At least one of my toads had developed a vocalization quite unlike the mating call of the species. It resembled a loud "chirp" but was not a warning chirp. I usually heard this note in the early morning hours after the lights were out before going to sleep. It was sufficiently loud to awaken me on several occasions. These observations were made at the University of South Dakota, Vermillion.

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JOE IDEKER,
Department of Zoology,
University of Texas,
Austin, Texas 78712.
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