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ANNOUNCEMENTS

Change of Editor

Dr Malcolm Peaker of the A.R.C. Institute of Animal Physiology, Babraham, Cambridge, has taken over as Editor of the Journal from Dr Harold Fox who has been Editor since 1966. All editorial matters concerning the Journal should now be addressed to Dr Peaker at the above address.

Faunistic lists

Minor faunistic lists will no longer be accepted for publication in the Journal. Such lists may however be submitted to the Editor for deposition in the Society's library; a notice to this effect will be published in the Journal.

Instructions to Authors

The attention of potential contributors is drawn to the new list of instructions to authors which appears on the back cover of the present issue.

An apology

Owing to production difficulties, the last issue of the Journal (Volume 5, Number 7) was produced in a different size to earlier issues in the volume. It is hoped to standardise the size, beginning with the present issue.

BRITISH JOURNAL OF HERPETOLOGY, Vol. 5, pp. 597–600

THE BRITISH HERPETOLOGICAL SOCIETY, 1947–1977

J. F. D. FRAZER

The inaugural meeting of the Society took place in the rooms of the Linnean Society on 11 July 1947. By then, some fifty people had already agreed to join, and twenty-one members attended the inaugural meeting. Captain J. D. Romer had been acting as secretary until then, but since he was about to take up a post overseas, Mr A. E. Leutscher was elected as Secretary/Treasurer of the new society, with Dr Malcolm Smith as President, Dr A. d'A. Bellairs as Editor and Dr Helen Spurway and Mr H. W. Parker as ordinary members of committee. At this time the subscription was ten shillings per annum, out of which it was possible to provide the Journal, as well as a bulletin which was produced every three or four months.

The objectives of the society were laid down as being to *encourage the study of herpetology, in particular of this country and of Europe; publish a Journal containing papers and reviews on all aspects of herpetology.*

The first general meeting of the society was held on 26 September 1947 when the President spoke to sixteen other members on some aspects of British herpetology which still required attention. These included: research on distribution of species in the wild; on changes in colour and growth, which could best be studied in captivity under conditions as near as possible natural; on movements in the wild (and the necessary methods of marking individuals); and on sexual cycles, which should be studied both in the wild and in the laboratory. Various interesting live and preserved specimens were exhibited, including metamorphosed hybrids between *Rana esculenta* and *R. ridibunda* (Dr Spurway) and a full-grown neotenic *Triturus vulgaris* from Enfield (Dr Smith).

By January 1948, at a time when it was very difficult to import anything, the Society was negotiating with the Board of Trade for a licence to import living reptiles and amphibians, in order to assist members' research and studies. By the beginning of its second year, the Bulletin was listing members who wished to exchange specimens. In 1948 the Society staged an exhibit at the National Aquarists' Society's exhibition.

At the first Annual General Meeting (October 1948), Dr Spurway resigned from the committee, which was now increased in size, and Maxwell Knight, Jack Lester and B. M. Smith were added to it. The next AGM was in April 1949, and at this time it was made clear that the Society's aim to promote the study of reptiles and amphibians, "could take the form of scientific research, field-study, or for that matter observations on animals in the vivarium". It was stressed that this referred especially to helping beginners. Field outings took place in May 1948 and 1949 and June 1950 to see *Rana esculenta* at the Ham Gravel Pits, Surrey, and in May 1949 to observe *R. ridibunda* in Romney Marsh. In May 1950 about thirty members and friends attended a field meeting in the New Forest, in dull weather.

By January 1950 there were over two hundred members and by the end of the year London and Northern branches had been formed, though the latter was soon disbanded for lack of support. The London Branch was set up especially for those particularly interested in keeping living specimens. On 3 October 1950 Major M. Knight gave a talk on the care and maintenance of reptiles and amphibians in captivity. He stressed the need for a correct environment, and for not handling specimens too frequently. There was a particular need for observations on their behaviour and habits. The regular society meetings were being held quarterly on Saturday afternoons, with London Branch meetings on weekday evenings 8 times yearly. Annual General Meetings were now starting to be held at the London Zoo, followed by a visit "behind the scenes" at the Reptile House, where the Curator of Reptiles (the late Jack Lester) showed us animals which were not on public view. In 1952 Mr Leutscher resigned as Secretary, and was succeeded by Mr J. I. Menzies. By this time a small library had been accumulated, and it was possible to produce the first library list.

In March 1955 Malcolm Smith retired from the presidency, having not only been the founding spirit of the society, but a strong guiding hand in its doings. By now, phenological reports on frog and toad breeding were being collected by me and published in the Journal. Volume 1 (part 2) of the Journal was devoted, through a Royal Society grant, to publishing H. J. Moore's paper on toad migration, based on work carried out by the boys at Clayesmore School, Dorset. During 1956 the Secretary took up an overseas appointment and Monica Green took over his duties, her appointment being confirmed at the AGM in 1957. Her recent retirement (April 1976) has been a sad loss to the Society. In 1955, Maxwell Savage succeeded Angus Bellairs as Editor, who followed him again in 1957. In 1966, Dr Harold Fox joined him and in 1967 became sole editor. From the start Mr B. M. Smith (no relation to the founder president), was the Society's librarian until 1961. Mr H. Munro then took over until 1969 when Mr J. Swindells succeeded him, retiring in 1974, when Dr D. Tamarind undertook this office. In tabulated form the list of officers reads:

	President	*Secretary*	*Editor*	*Librarian*
1947				
1950	Malcolm Smith	A. E. Leutscher	A. d'A. Bellairs	
1955		J. I. Menzies		B. M. Smith
			M. Savage	
1960				
			A. d'A. Bellairs	
1965				
	J. F. D. Frazer	Monica Green		H. Munro
1970				
			H. Fox	J. Swindells
1975				D. Tamarind
		M. R. K. Lambert		J. Pickett

It can be seen that during the thirty years' existence of the Society, there have been only two Presidents, while the other offices have been held for up to five terms. During this period, roughly thirty members served as ordinary members of committee. Only six honorary members have been elected—Dr Gerald Leighton (1952), A. E. Leutscher (1952), Malcolm Smith (1953), J. D. Romer (1957), B. M. Smith (1962) and Monica Green (1962). It is clear that even 15 years ago the Society was fully conscious of the great debt it owed to Mrs Green.

The London Branch has been mentioned above. This was founded in 1951, and for a number of years held eight evening meetings per annum. It was possible at an early stage to report that some fifty members belonged to it, and that attendances at these evening meetings averaged thirty people. This was in contrast to the Society's quarterly meetings, normally held on Saturday afternoons. By 1956 the Society's committee and the London Group's committee organising the evening meetings had agreed on the need to merge the two sets of meetings, and since then the Society's programme has consisted of eight evening meetings a year. It was agreed to maintain the character of the evening meetings, at which members were free to display and talk about living or dead specimens. Normally one or two meetings a year comprised set talks and one the display of slides or films. This pattern has been kept, in the main, though there have been occasional joint meetings or symposia with other societies.

In the early days, the Annual General Meeting was normally held at the Zoological Society's rooms, and the late J. W. Lester and his assistant Margaret Southwick would show members round the reptile house afterwards. This included seeing specimens which were receiving special care in the Curator's office. Unhappily, Jack Lester died prematurely in 1957; the Society, at the suggestion of the late Maxwell Knight, set up the Jack Lester Memorial Fund and arranged for a public show in support of this at the Royal Festival Hall. Max Knight took the chair, and the other members who took part were James Fisher, Peter Scott and David Attenborough. A total sum of £540 was raised for the fund: this was used in putting a memorial plaque, by agreement with the Zoological Society of London, in the entrance to the reptile house, and the remainder was handed to Jack's widow, Mary Lester.

In the past thirty years several of the members who helped to found the Society and set it on its feet have gone. In particular, Malcolm Smith died on 22 July 1958 and the succeeding Journal became a memorial number to our founder. One problem has been to make sure that members' knowledge did not die with them. Jack Lester, for example, had a vast fund but seldom found time to put it down on paper. Malcolm Smith told me once that when Jack told him something new, he used to write it down and send it to the Journal, signed "J. Lester".

From the beginning the Society had agreed that field observations needed to be combined with the results of keeping animals in captivity, and this had included full consideration of the problems of vivarium keeping. In early numbers of the Notices, names of members wishing to exchange live specimens were given. At the 1951 AGM, the Secretary drew attention to the fact that many tortoises were imported during the winter months, and a resolution was passed deploring winter sale, though the President pointed out that the Society *per se* could take little direct action, but that individual complaints could be made. A few years later, Mrs Green represented the Society on a joint working-party with the Fauna Preservation Society, the Universities Federation for Animal Welfare and the Royal Society for the Prevention of Cruelty to Animals, which examined thoroughly the conditions under which tortoises are imported. More recently, Dr Lambert went to North Africa as a consultant to the Fauna Preservation Society, and his report on the Moroccan tortoise trade was published in *Oryx*.

It became clear that British reptiles and amphibians were under increasing threats and that there was both a grave concern over these and desire within the Society to take action to counter them. The suggestion that a conservation committee be set up was pioneered by Mr K. P. Corbett in 1969. The first chairman of this was Mr J. W. Steward, who was succeeded at the end of the next year by Dr M. R. K. Lambert. Surveys of the declining status of sand lizard (*Lacerta agilis*), smooth snake (*Coronella austriaca*) and natterjack (*Bufo calamita*) have been followed by the adoption of active conservation measures in the field, in conjunction with landowners and through liaison with county nature conservation trusts and representatives of the Nature Conservancy Council and other official bodies; habitat management has been undertaken with the help of the British Trust for Conservation Volunteers. World Wildlife and Carnegie Trust Funds have given generous help in this work, and the threat of collection for the pet trade has been lessened by listing these species in Schedule 1 of the Conservation of Wild Creatures and Wild Plants Act, 1975.

What of the future? It is clear that we still have not got all the basic knowledge that we require in an overcrowded world if our reptiles and amphibians are to survive. We need even more accurate knowledge of their distribution and the factors influencing it, as well as the behaviour and ecology of the various species. There is still a case for carrying out research in the wild, complemented by work on captive creatures, just as Malcolm Smith stated. The Society remains as the forum where all true herpetologists can meet, discuss and argue.

We now need to look long and carefully at our own internal structure and our external relations, to see if we are still constituted in the best way to enable us both to survive and to carry out a useful function.

BRITISH JOURNAL OF HERPETOLOGY, Vol. 5, pp. 601–602

AMPHISBAENIA: DEFINITION AND PHYLOGENY

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The language of each country contains vernacular names for its common animals, particularly when these are easily recognised or of economic or folkloric importance. When travellers of the past encountered strange animals, they tended to name these in terms of the familiar. English explorers wrote about horned toads and sea cows, even though neither had any particular affinity to the more familiar animals after which they were named. The further an animal is from the public's normal experience, the more difficult the explanation of a new name by a zoologist. Thus the inappropriate term "worm lizards" for the Amphisbaenia.

All 130 species of the Amphisbaenia are elongate burrowers. Most of them lack any trace of external limbs and reduced pectoral and pelvic girdles have evolved to the point where it is difficult to homologise these remnants with the elements of limbed forms. Amphisbaenians differ from other reptiles by such characteristics as having the right, rather than the left, lung reduced in size or lost and their much enlarged and medial premaxillary tooth. They have a heavily ossified and extremely solid skull, a marked craniofacial angle and a uniquely enlarged stapes and other modifications of the middle ear. Other characteristics, almost unique among the Amphisbaenia, are a very heavy premaxilla with a prominent facial process, a relatively low number of very large teeth and a brain case completely surrounded by frontal bones, which in snakes form only the case's dorsal roof. Although Amphisbaenians thus differ from snakes and lizards, they also show affinities with one or the other of these groups in the arrangement of the endocrine glands, the architecture of the brain, and the path of some of the blood vessels. There is no indication that they share an unusual number of characteristics with any particular family of lizards or snakes.

The pattern of diffuse similarities in a variety of organs suggests that these three groups have had a long independent history, and the fossil record seems to confirm this. The earliest known Amphisbaenia date back to the Eocene (about 50 million years ago). Yet one has no trouble recognising that these specimens were true amphisbaenians. This suggests that the three groups separated much earlier, well before the Cretaceous (135 million years ago).

Unfortunately, we lack fossils intermediate between the Amphisbaenia and other groups and can only speculate what their ancestors looked like. Although the earliest fossils seems to be among the largest known Amphisbaenians, they were probably less than 3 cm in diameter—and the ancestral forms were unlikely to have been larger. The absence of ancestral forms from the fossil record seems to reflect their small size and perhaps their burrowing habits. After all, a burrower would be unlikely to be trapped and fossilised in a crevice or other cavity; if it did fall in, it could presumably dig its way out! If the transition from protoamphisbaenians to recognisable ones proceeded quickly, perhaps within a million years or so, there would be a very low chance of finding any fossils; in fact, we have fewer than fifty samples to document the history of the Amphisbaenia for the forty or fifty million years since the Eocene.

All we may state with certainty is that the Amphisbaenia belong among the class Reptilia because they share the reptilian characteristics of ectothermy and an amniotic or layered egg. Within the Reptilia they should be placed in the super-order Squamata, which also includes snakes and lizards. They show the characteristically scaly skin but also have the double male generative organ or hemipenis, the transverse cloacal opening, and the true egg tooth on the premaxilla. (Hatchling squamates use the forward projecting egg tooth at birth to cut their way through the tough egg shell. The egg tooth is shed shortly thereafter. In the Amphisbaenia it is replaced by the large median premaxillary tooth.)

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THE AMPHISBAENA OF ANTIQUITY: THOUGHTS ABOUT THE ORIGIN OF THE NAME

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The word *amphisbaena* first makes its appearance in Greek literature in the *Agamemnon* of Aeschylus (458 BC), line 1233 (Aeschylus, *Agamemnon* 1233; Smyth, 1922: **2**: 106). When Cassandra, after the fall of Troy, has been brought as a captive to Argos by Agamemnon, she prophesies in a state of mantic possession. In cryptic and symbolic language, which is obscure to the chorus but obvious to the audience, she predicts that Clytaemnestra will murder the king. "What loathsome monster shall I rightly name her? An amphisbaena or a scylla who lurks in the rocks, a peril to sailors?" The image of the serpent is often applied to Clytaemnestra in this trilogy, and in the second play, the *Choephoroe*, the same sentiment is repeated when Orestes (Aeschylus, *Choephoroe* 994; Smyth, 1922: **2**: 256) refers to Clytaemnestra as a *muraena* or *echidna*, both generally assumed to be large and dangerous sea serpents, but probably moray eels, as the writers were unlikely to have occasion to encounter or hear about actual sea-snakes (the closest records pertain to the Persian Gulf). Compare Arisophanes' *Frogs* (Aristophanes, *Frogs* 475; Rogers, 1924: **2**: 338), where Aeacus spies Dionysus disguised as Hercules, and berates this Hercules with the hope that the monsters of hell, among whom are the *muraena* and *echidna*, would tear him apart. It is clear from the context that Aeschylus used the word *amphisbaena* to mean a monstrous and deadly, snake-like creature.

The etymology of the word and an explicit reference in a fragment of Aristophanes make it clear that the beast was early regarded as having a head at each end. *Amphis* is an adverb meaning "both ways", and the second member of the compound is a noun form related to the verb *baino*, "go, walk, proceed". Hence the compound, a feminine noun, means roughly "proceeding in both directions". A fragment of Aristophanes' play *Pelargoi* or *The Storks* indicates that the *amphisbaena* was a snake "having a head also on its tail" (Aristophanes, *Fragment* 439 A; Edmonds, 1957: **1**: 697).

The Hellenistic didactic poet, Nicander of Colophon (second century BC) in the *Theriaka*, a poem on poisonous beasts, describes the *amphisbaena* as follows:

> After him (the chersydrus) you shall learn of the amphisbaena, less in bulk and slow of gait, two-headed, ever dull of eye. From either end a blunt chin protrudes, the one far from the other. Its body is earth coloured and wears a skin ragged, speckled and sheeny. This snake, when it comes to full growth, do wood-cutters, as though they had cut for a walking stick a stem of twisted wild-olive, strip off its skin as soon as it appears, before the note of the cuckoo in spring. The amphisbaena benefits those with afflicted skin when crippling chillblains break out upon the hands of men overcome with cold when the bonds of their sinews slacken and weary. (Nicander, *Theriaca* 372 ff.; Gow and Scholfield, 1953.)

Later references to the *amphisbaena* occur in treatises on natural history, in the medical writing on poisons, or in lexicons. Pliny the Elder (first century AD) mentions the animal in passing with the reflection that, "the amphisbaena has a pair of heads, that is, one on the tail end also, as if it were not enough for the poison to pour forth from only one mouth" (Pliny, *Natural History* 8.85; Rackham, 1940: **3**: 63). The Latin poet Lucan (39–65 AD), in a famous catalogue of the serpents of the Libyan desert, lists "the dangerous amphisbaena terminating in a double head" (Lucan, *Pharsalia*, 9.719; Duff, 1928: 559).

There is some fluctuation of opinion among the ancients whether *amphisbaena* is a fabulous beast or a genuine flesh-and-blood zoological actuality. Aelian (ca. 170–230 AD) vigorously opposes the idea that it is a storybook monster like the hydra or the chimaera, and vouches for its reality. Aelian says:

> The amphisbaena, however, is a snake with two heads, one at the top and one in the direction of the tail. When it advances, as need for a forward movement impels it, it leaves one end behind to serve as a tail, while the other it uses as a head. Then again if it wants to move backwards it uses the two heads in exactly the opposite manner from what it did before. (Aelian, *On the Characteristics of Animals* 9.23; Scholfield, 1959: **2**: 243.)

The tendency to regard the animal as genuine leads to the kind of rationalisation we find represented in the *Lexicon* of Hesychius (sixth century AD). His information probably goes back to earlier writers of the fourth century BC. Hesychius and his sources clearly believe it to be a real animal:

> A kind of serpent with a long head, and with a cylindrical shape (that is the body is not tapered) and with a docked or truncated tail which often proceeds backwards so that some people dispute the notion that it has two heads. (Hesychius, *Lexicon, s. v. amphisbaena*; Latte, 1953: **1**: 143.)

It might be mentioned that Hesychius (or his sources) has indulged in a pretty little pun here, since the Greek word for *dispute* is *amphisbetein* to which the noun *amphisbaena* is transparently related.

The controversy whether the *amphisbaena* of antiquity is real or fabulous continues in modern works on the zoology of antiquity. Several authors, following Lenz (1856: 451), argue that it is idle to try identifying it with any real animal, and others such as Keller (1913: **2**: 293), Gossen (1937: **7**: 1927) and Leitner (1972: 17) argue that it should be identified with the blind snake *Typhlops vermicularis* Merr. We are told quite clearly by the medical writer Philumenus (ca. 180–250 AD), in a work called *On Poisonous Animals and the Treatment of their Bites* (*Corpus Medicorum Graecorum* 27.2; ed. Wellman, 1908), that the wound of one bitten by the *amphisbaena* looks like the bite of a horse-fly (*Tabanus*) in that a very light, harmless swelling takes place. While it may not be convincing to identify the *amphisbaena* as a *Typhlops*, still it is clear that Philumenus thought that the animal was real and that he had seen the bite of some snake-like animal which was called *amphisbaena*.

For the sake of completeness, we add the few remaining references. Nonnus (fifth century AD) in the *Dionysiaca* (5.146; Rouse, 1940: **1**: 179), describing a necklace, compares it to the *amphisbaena* because the two heads join at the clasp. Lucian (second century AD) in *De Dipsadibus* (3; Kilburn, 1959: 79) simply lists it among the serpents of the desert. Pliny the Elder (30.85; Rackham, 1940: **8**: 333) and Aelian (8.8; Scholfield, 1959: **2**: 187) repeat the information from Nicander *Theriaka* (372 ff.; Gow and Scholfield, 1953) with some misunderstanding. Pliny further claims (30: 128; Rackham, 1940: **8**: 361) that a pregnant woman who steps over a dead *amphisbaena* will suffer a miscarriage.

It seemed initially that it might be as reasonable to ask what species Cassandra's *amphisbaena* really was as it might be to ask for the specific identification of Siegfried's dragon. The attempt to synonymise *amphisbaena* with *Typhlops vermicularis* seemingly has to ignore the fact that in antiquity the *amphisbaena* was universally regarded as a venomous serpent, and that the small *Typhlops* does not bite.

However, the early reports on this animal are remarkably consistent and do permit conclusions regarding the nature of the name. We learn from Nicander that the animal is brownish or greyish coloured, lacks obvious (shiny) eyes, is relatively small and does not move rapidly. There are remarks that its skin may be ragged, suggesting occasional flaky ecdysis. There is the clear indication that the body is cylindrical and head and tail are blunt, and that there is at least some possibility for forward and backward movement. All of these characteristics would apply to any small amphisbaenian in the modern sense. The obvious species would be *Blanus strauchi*, a form widely distributed along the Turko–Syrian coast and its offshore islands.

This form is a relatively small animal of dark brownish violet pigmentation (Alexander, 1966) and is well known to local farmers. Its colour pattern and size match the description. It moves slowly when uncovered rather than slipping away quickly as do, for instance, species of *Typhlops*, which also differ by rolling their skin during ecdysis rather than shedding it in flaky patches.

An obvious question concerns the poison or generally noxious nature of the mythical creatures. Certainly, none of the recent amphisbaenians, particularly not *Blanus*, have any indication of venom glands or other noxious properties. However, this need not be a critical point, as local people traditionally consider such curious reptiles to be noxious, a point that can be documented by many reports from other regions as well. Note, for instance, the observations of Dampier (1703: 77) who states that in Brazil there "are several sorts of serpents, . . . most of them very venomous" when actually the percentage of venomous forms is perhaps less than 5%. The same author goes on to note that the local *Amphisbaena* has a bite that is reckoned to be incurable and, at the end of the discussion, repeats that it is a very venomous creature. Since the form in question (possibly *Amphisbaena fuliginosa*) is harmless, we have another documentation of the general fear of diverse reptiles, similar to that which refers to many lizards as "escorpiones", and considers them extremely dangerous.

All in all, then, one can argue that the animal, used as a model for the name *Amphisbaena*, is *Blanus strauchi*. Its occurrence some distance away from the site where many of the descriptions were written and the allusions were made must have made it even easier to accept the mistaken nature of this actually harmless reptile.

REFERENCES

Alexander, A. A. (1966). Taxonomy and variation of *Blanus strauchi*, with comments on the nature of its meristic variation. *Copeia*, 1966 (2), 205–224.

Dampier, William (1703). *A voyage to New Holland, &c. in the year 1699*. Vol. 3. London: J. Knapton.

Duff, J. D. (1928). *Lucan*. Loeb Classical Library. London: William Heinemann and Cambridge, Mass.: Harvard University Press.

Edmonds, J. M. (1957). *The fragments of Attic comedy*. 3 vols. Leiden: E. J. Brill.

Gossen, H. (1937). Die Zoologischen Glossen im Lexicon des Hesychius. *Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin*. **7** (1). Berlin: Julius Springer Verlag.

Gossen, H. and Steier, A. (1921). *Schlange*. In Pauly, A., Wissowa, G. and Kroll, W. eds. Real-Encyclopaedie der classischen Altertumswissenschaft. 2te Reihe, 3te Halbband, col. 523. Stuttgart: J. B. Mezlersche Verlagsbuchhandlung.

Gow, A. S. F. and Scholfield, A. F. (1953). *Nicander, the poems and fragments, edited with translation and notes.* Cambridge: Cambridge University Press.

Keller, O. (1909–1913). *Die antike Tierwelt.* Leipzig: W. Engelmann.

Kilburn, K. (1959). *Lucian.* Vol. 6 of Harmon, A. M. 1913. *Lucian.* 8 vols. Loeb Classical Library. London: William Heinemann and Cambridge, Mass.: Harvard University Press.

Latte, K. (1953). *Hesychii Alexandrini Lexicon.* 2 vols. Copenhagen: Einar Munksgaard.

Leitner, H. (1972). *Zoologische Terminologie beim aelteren Plinius.* Hildesheim: H. A. Gersternberg.

Lenz, H. O. (1856). *Zoologie der alten Griechen und Roemer.* Gotha: Becker'sche Buchhandlung.

Rackham, H. (1940). *Pliny. Natural history.* 10 vols. Loeb Classical Library. London: William Heinemann and Cambridge, Mass: Harvard University Press.

Rogers, B. B. (1924). *Aristophanes.* 3 vols. Loeb Classical Library, London: William Heinemann and Cambridge, Mass: Harvard University Press.

Rouse, W. H. D. (1940). *Nonnos. Dionysiaca.* Loeb Classical Library, 3 vols. London: William Heinemann and Cambridge, Mass: Harvard University Press.

Scholfield, A. F. (1959). *Aelian. On the characteristics of animals.* 3 vols. Loeb Classical Library. London: William Heinemann and Cambridge, Mass: Harvard University Press.

Smyth, H. W. (1922). *Aeschylus.* 2 vols. Loeb Classical Library, London: William Heinemann and Cambridge, Mass: Harvard University Press.

Wellmann, M. (1908). *Philumeni De Venenatis Animalibus Eorumque Remediis. Corpus Medicorum Graecorum.* Vol. 10, No. 1. Leipzig and Berlin: B. G. Teubner.

BRITISH JOURNAL OF HERPETOLOGY, Vol. 5, pp. 607–610

AMPHISBAENIA: HEART AND ARTERIAL ARCHES

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In 1884 J. von Bedriaga gave the first illustrated account of the heart and blood vessels of an amphisbaenian. He saw a close similarity between the heart of *Amphisbaena cinerea* and that of a snake although he remarked that the apex of the heart and the liver are not in contact in *Amphisbaena.* His figures, from both dorsal and ventral aspects, are reasonably accurate but not detailed. In 1905 F. E. Beddard examined another species (*A. braziliana*) and noted differences. He was the first to note, "the left systemic arch in *A. braziliana* is considerably larger than the right", but he did not appear to regard this as of any special significance. He tended, throughout his account, to compare the heart and vascular system to that of a lizard rather than to that of a snake. Beddard differed from v. Bedriaga in the interpretation of the two arteries which arise from the right aortic arch to pass dorsally up the neck and which will be discussed more fully below. von Bedriaga called them vertebral arteries, and figured them as right and left branches of a single vessel emerging from the aortic arch, whereas Beddard called them subclavian arteries (although the pectoral girdle is absent) and represented them as separate vessels leaving the aortic arch one behind the other.

Beddard's nomenclature and description was confirmed by van der Merwe (1940), who was the most recent author to investigate the vascular and visceral systems of an amphisbaenian (*Monopeltis capensis*). He wrote in Afrikaans and in a journal which is not widely circulated. He did not add materially to the earlier accounts so far as the heart and arterial arches are concerned.

The present account is based on one specimen each of two species kindly put at my disposal by Professor Carl Gans. Both specimens were preserved in alcohol when received and although in very good condition, the tracing with certainty of any but the major vessels proved difficult. The account of the arteries is based on dissection of the specimen of *A. alba* supplemented by the much smaller specimen of *Agamodon anguliceps*. The heart was studied by means of dissection in the case of *A. alba* and by means of serial transverse sections in the case of *A. anguliceps*.

Figure 1a is a diagram of the arterial arches and their major branches with the position of the heart chambers shown in outline. The bases of the arterial arches are easily visible between the two atria, and the first thing that strikes one as unusual is that although the pulmonary arch quickly bends round dorsally to proceed caudally towards the left lung, the right and left aortae travel forwards a considerable distance before arching round the oesophagus. This is especially so in the case of the right arch, which makes the two arches very asymmetrical. Next, one is struck by the size of the left systemic arch, which is noticeably greater than that of the right and is seen to form the dorsal aorta with only a relatively small contribution from the right arch.

The right aortic arch at its origin lies dorsal to both pulmonary and left aortic

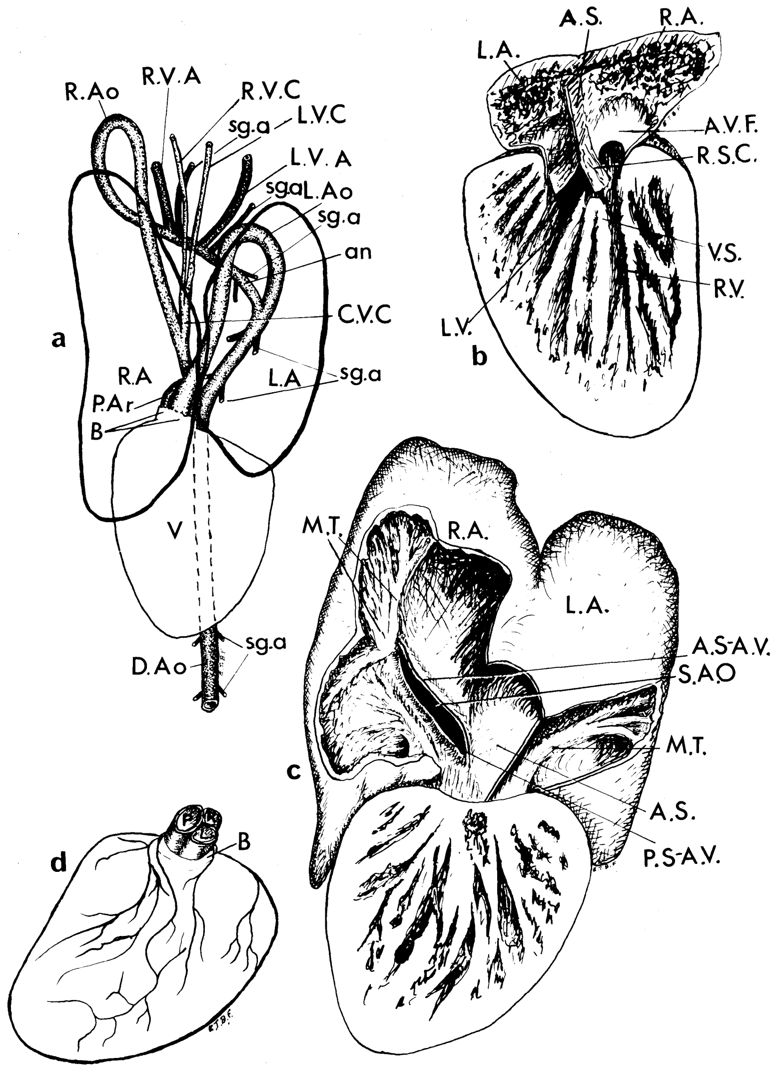

FIG. 1. Vascular system of *Amphisbaena alba.* (a) Aortic arches, ventral view with the position of the heart chambers shown in outline. (b) Ventral half of ventricle and bases of atria. (c) Dorsal half of ventricle with atria attached. (d) Ventral view of ventricle to show remnant of bulbus cordis, bases of arterial arches and the coronary vessels.

Key: **an**, anastomosis between right and left aortic arches; **AS**, atrial septum; **A.S.A.V.**, anterior (cranial) cusp of sinu-atrial valve; **A.V.F.**, atrioventricular funnel; **B**; vestige of bulbus cordis; **C.V.C.**, common ventral carotid artery; **D. Ao.**, dorsal aorta; **L.A.**, left atrium; **L. Ao.**, left aorta; **L.V.**, left ventricle; **L.V.A.**, left vertebral artery; **L.V.C.**, left ventral carotid artery; **M.T.**, muscular trabeculae; **P**, pulmonary arch; **P. Ar.**, pulmonary arch; **P.S.A.V.**, posterior (caudal) cusp of sinu-atrial valve; **R.A.**, right atrium; **R. Ao.**, right aorta; **R.S.C.**, right septal cusp of atrioventricular valve; **R.V.**, right ventricle; **R.V.A.**, right vertebral artery; **R.V.C.**, right ventral carotid artery; **S.A.O.**, sinu-atrial opening; **sg.a.**, segmental arteries; **V**, ventricle; **V.S.**, vertical septum.

arches. Very soon after it becomes visible to the right of the left arch it gives a substantial common ventral aorta which very soon bifurcates into right and left ventral carotid arteries; these pass up the neck to the throat and finally supply the face, lower jaw and throat as well as the thyroid glands and larynx. The right aortic arch continues forward to a point just anterior to the forward extremity of the right atrium and then turns dorsally round the oesophagus, gives off a series of branches (see below) and finally joins the left aortic arch to add its contribution to the blood flowing into the dorsal aorta. Paired segmental arteries are given off to the vertebral column by the right aortic arch, by that part of it labelled "an" and by the dorsal aorta.

The right arch also gives off a pair of substantial vessels which pass dorsally right up the neck to the throat giving segmental arteries to the vertebral column all the way up the neck. At the throat these vessels appear to continue into the head to supply its dorsal region, the skull and presumably the brain, but in an uninjected specimen one cannot be certain of these details. The true identity of these two vessels (the vertebral arteries of v. Bedriaga and the sub-clavian arteries of Beddard and van der Merwe) seems to me to depend on the identification of the carotid arch. Nobody has so far described this vessel and it has not been possible to identify it in the present investigation since all arteries in the throat region were completely empty and transparent. If, however, the condition is comparable to that in snakes the vertebral arteries of v. Bedriaga would morphologically represent the lateral aortae or *ducti carotici.* Even if the actual carotid arch is missing this would seem to me the most logical view of their homology since their anterior extremities certainly join the vessels supplying the dorsal regions of the head and this of course is the territory of the dorsal (or internal) carotid artery; certainly "subclavian arteries" in an animal completely devoid of fore-limbs or limb girdles must be a misnomer.

We thus have a group of animals which is unique amongst living reptiles in that the *left* is the dominant aortic arch, as it is in mammals, and one must assume it was in the synapsids from which mammals arose. One only has to look at the condition shown in Fig. 1a to see that few changes are needed to transform the vessels depicted into a "proto-mammalian" condition; if the vessel labelled "an" is obliterated one is nearly there.

The hearts of both specimens are typically reptilian, both in respect of their morphology and their histology. The atria are large and elongated, the right atrium being the larger of the two. The ventricle is triangular in outline and not so noticeably elongated as in many snakes in spite of the snake-like form of the body.

A distinct vestige of the *bulbus cordis* is present at the base of the pulmonary and aortic arches (Fig. 1a) and its musculature extends as far as the semi-lunar valves at the proximal ends of these vessels; the change to smooth, arterial muscle is abrupt at this point.

Paired external jugular veins, approximately equal in size, course down the neck and in doing so receive substantial veins from the body wall, as well as from the large, longitudinal sub-vertebral muscle of the neck, to form the precaval veins. The right precaval vein enters the *sinus venosus* directly, the left precaval turns to the right across the dorsal surface of the left atrium before doing so. The large postcaval vein also enters the *sinus venosus* which forms a substantial and nearly spherical chamber.

The sinu-atrial opening is a long, oblique slit in the dorsal wall of the right atrium and is guarded by a pair of membranous valves, the anterior (cranial) cusp of which overlaps the posterior (caudal) cusp. The closure of this orifice is also assisted by the contraction of muscle bands which radiate from each end of the opening (particularly from the right anterior end) within the atrial wall (Fig. 1c).

The exterior walls of both atria are spongy and trabeculate, except for the surfaces of the interatrial septum and atrio-ventricular funnel which are smooth (Fig. 1c). The musculature of the walls of the atrio-ventricular funnel is sparse so that the junction between this structure and the atrial walls is quite sharply marked; its muscle fibres run in a circular (spiral) direction.

The pulmonary vein enters the left atrium near the septum, at the level of the septal end of the sinu-atrial opening. It is guarded by a small reflexed flap arising from the endocardium of the interatrial septum.

The interatrial septum is thin and imperforate although its musculature is sparse and fenestrated; its plane is nearly vertical. From its free border arise the two large septal cusps of the atrio-ventricular valves (Fig. 1b). In the dissected heart of *Amphisbaena* they appear to reach as far as the free (cranial) edge of the ventricular septum but from a reading of the transverse sections of the heart of *Agamodon* they certainly do not extend so far. Membranous chordae tendinae anchor the free borders of the cusps in *Agamodon* and probably do so in *Amphisbaena* also.

The interior of the ventricle follows a typical reptilian pattern (Fig. 1b, c). Some seven vertical septa running from the apex towards the base of the heart are present and the plane of the principal septum—the vertical septum—coincides fairly exactly with the plane of the interaterial septum and extends relatively further forwards towards the base in *Amphisbaena* than it does in *Agamodon*. The common ventricular chamber is therefore relatively greater in the latter species; it is quite small in *Amphisbaena*.

The helicoid septum so characteristic of reptiles is present and crosses from the dorsal wall of the bulbus (i.e. base of pulmonary arch) to the ventral wall of the ventricle. It does not extend far caudally and has no direct relation with the vertical septum.

REFERENCES

Beddard, F. E. (1905). Some additions to the knowledge of the anatomy, principally of the vascular system of *Hatteria, Crocodilus* and certain *Lacertilia*. *Proceedings of the Zoological Society of London* 461–489.

Bedriaga, J. von. (1884). Erste Beitrag zur Kenntnis der Doppelschleichen. *Archiv für Naturgeschichte* **50,** 23–77.

Merwe, N. J. van der. (1940). Die Liggaamstuate van *Monopeltis capensis*, Smith. *Tydskrif vir Wetenskap enkums* **1,** 201–207.

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THE BIOLOGICAL ROLES OF TAXONOMIC CHARACTERISTICS UTILIZED IN AMPHISBAENIAN CLASSIFICATION

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Among the folklore that persists in biology, one of the more curious tales separates the characteristics of animals into taxonomic and functional ones. The former are supposed to be the stable character states, presumably those that are not exposed to the immediate effects of current selection. Such stable systems should presumably be used to classify animals; in contrast more variable aspects, as for instance, those associated with the feeding or motor apparatus, must not be used in taxonomy. The assumption is wrong, but it is also pernicious. It is wrong because all aspects of an organism will be "seen" by natural selection, and stability of a particular set of characteristics is likely to reflect strong rather than absence of current selection. It is pernicious because it suggests implicitly that taxonomy proceeds outside of the adaptive framework and may be down-graded because "museum types" spend their time at nitpicking quibbles about insignificant aspects of the organism.

The last few decades have seen ever more new techniques become available for taxonomists. Electrophoretic and chromatographic separation of compounds from blood and other tissues, karyotypes, scanning electron micrographs of the surface and stereo X-rays of the interior may be available in special studies. Yet such tools are useful primarily in those groups that lack simple, quantifiable, and preferably external characteristics, and these should be the basis of the first level analysis. When standard techniques disclose problems such as high variability, numerous intergrades, and unisexual populations, or again provide us with equivocal answers, it becomes useful to bring out the technique book and increase the number of characters being analysed.

The characteristics of an animal's surface are clearly those most easy to measure, count, or otherwise quantify; for reasons of parsimony they are characters of choice for first level analysis. There are two other reasons why they are most appropriate. The first is that on an *a priori* basis any characteristic is as good as any other. Without knowing something about the animals, i.e. using the final results as part of the input to the study, we cannot predict which characters will be stable within any genus and which may vary within particular species. The several characteristics of any phenotype, furthermore, each result from the expression of multiple pleiotropic genes. Each of these genes acts on multiple pathways and produces multiple effects. A change of an internal characteristic is highly likely to be reflected in a parallel shift of an external character state. The second reason is that the external characteristics are almost certain to have functions very significant to the fitness of the organism; their analysis may offer suggestions about the mode of life history of the several species. The assumption that details of integumentary architecture and proportion are functionless often reflects ignorance of the animal's biology.

A recent taxonomic study of a major portion of the spade-snouted amphisbaenids of Africa (Gans and Lehman, 1973; Broadley, Gans, and Visser, 1976) utilized a number of external characteristics of these animals. I here speculate on the functional reasons for the observed character states, more to pose questions for future functional analysis than to provide definite decisions.

The head shape of the spade-snouted species may be the first character. Some of the smaller species, for instance *Monopeltis zambezensis* and *M. capensis*, tend to have a relatively blunt head as well as a symmetrical, rounded keratinization on the top of the head. In other species the keratinization is elongate and oval, and the snout pointed. This pattern is most obvious in *Dalophia ellenbergeri*. In yet other species, for instance in *Dalophia gigantea*, the head seems relatively blunt and the keratinized area is asymmetrical with the posterior edge sharply transverse. Presumably all of these relations reflect the penetrating forces required to drive wedges of diverse sizes into soils of various consistencies and the relative balance of the effort required for this with that for vertical displacement to widen the tunnel thus formed.

In the larger species, as well as those that have either partially or completely transverse sutures, there is a general tendency for the anterior half of the keratinized region to show a concave and the posterior a convex curvature of the mid-dorsal line. This keratinization and curvature is most sharply expressed along the sagittal line. The transverse curvatures are quite different so that parasagittal sections differ in profile. The preocular region is generally slightly convex and the eye, which is almost always covered with a spherically convex *brille* or spectacle, retains an anterior field of "vision". The convexity of the preocular region may, in some cases, have facilitated the retention of pre-ocular segments (as well as open unkeratinized areas such as those seen in *Monopeltis vanderysti*). These zones may also produce a wear shadow, reducing abrasion on the *brille*.

The third infralabials are extremely large in all species of the two genera. The stability of shape and size of these segments clearly reflects the underlying extracolumellar structures (Kritzinger, 1946; Gans and Wever, 1972) which are associated with sound detection.

The gular region may be subdivided into organized sets of widened annuli composed of enlarged segments; these annuli alternate with fields of irregular imbricate segments, that seem randomly divided and not organised into rows. The fields represent folding zones; as they become wider and can fold deeper it becomes easier to lift the head without forcing the pectoral shields to slide anteriorly over the body and simultaneously to wear against the soil. We need comparative data on the forces different species exert against the tunnel walls to correlate these with gular and pectoral patterns.

The modified pectoral region is extremely smooth and its skin tends to be thickened regardless of the pattern of its geometrical subdivision. The variability of segment shape increases outward from the medial line, suggesting that selection is greatest for a particular shape, but that the degrees of freedom increase laterally. This again is easily related to the observation that the reaction forces due to vertical rotation of the head will impinge most strongly on to the medial surface, so that this zone will transmit most of the force and also encounter potentially the greatest sliding wear. As deeper gular folds reduce antero-posterior slippage of the pectoral region as the head is raised, the absolute length of the pectoral shield can probably be increased. The involvement of one or more "pre-pectoral" annuli would, furthermore, result in a bending plane that combines smoothness with transverse flexibility needed during lifting of the head as the nuchal folds expand. *Dalophia ellenbergeri* has the longest and most regularly arranged pectoral region with integral anterior pre-pectoral annuli and a deep gular fold; this condition would seem to represent an adaptive peak for the pectoral system.

The issues of absolute diameter and body proportions have been discussed earlier (Gans, 1968, 1974). The greatest portion of the southern range is occupied by members of medium to small-sized species of fairly stout diameter. Superimposed upon this range is a lower density of records (presumably reflecting a sparser distribution) for much more slender species of roughly equivalent absolute diameter. Further north one obtains a fair number of records for elongate but slightly more slender forms. We have one excellent set of samples from the Caprivi Strip of South West Africa, that documents that the general sympatry must be real. Four species of *Monopeltis* and *Dalophia* plus one of *Zygaspis* were taken in a single area not more than 8 km long. Each species differs in relative body diameter and cephalic modifications. Combined with more incidental ecological observations, these differences suggest that vertical stratification of niches is real and that reduction of relative body diameter (coupled perhaps with improved digging specialisations) permits species to invade and maintain themselves in deeper levels and in harder substrates. The number of records for Zaire, Angola and Zambia, as well as more northern areas, is less adequate; we only know that these regions show the two longest and stoutest species of the genera but exhibit fewer smaller ones. Regions north of the Zaire (and perhaps some zones of the Zaire Basin), furthermore, show no evidence of sympatry of multiple spade-snouted species, so that such sympatry is again restricted to the centre of the generic range (cf. Gans, 1968).

The absolute number of dorsal segments clearly reflects the need to transmit forces across portions of the skin and alternatively to fold those portions of the integument anterior and posterior to the fixed site, so that the trunk can travel in rectilinear movement. This capacity is a function of the number of annuli, and the number of segments per annulus in the contact region.

The annular number relates to the number of vertebrae in a two-to-one ratio. The character shows infraspecific differences, but some species have up to 30 supernumerary dorsal half-annuli, generally concentrated among the first fifty body annuli. Such increase in dorsal number only occurs in relatively short species with the lowest vertebral ($N \leqslant 100$) and ventral annular number ($N \leqslant 200$); none of the longer species, with vertebral numbers above 130, shows it. This suggests that the supplementation serves mainly to increase the flexibility of the skin and is associated with contraction of the multisegmented muscles attaching to the nuchal tendons that rotate the head on the neck joint. Integumentary flexibility is not required along the posterior portions of the body. It is perhaps also significant that there is no such intercalation of annuli in any round-headed or keel-snouted amphisbaenians, which do not rotate the head dorso-ventrally. There is, however, an even more spectacular situation in the South American (spade-snouted) genus *Leposternon*; in many species of this genus, the segmentation of body annuli (dorsal as well as ventral) became independent of the vertebral number (Gans, 1971).

A recent paper (Vanzolini, 1968) provided some correlation between absolute minimum environmental temperature and mean yearly temperature range, and the number of vertebrae across a transect of 25° latitude. While the numbers may vary roughly in parallel and may even be associated, the correlation is not a functional one, and unpublished studies show that incremental steps in temperature do not directly cause increments in vertebral number (during development). Consequently the observations can only be interpreted as suggesting that vertebral number is in this case established by an adaptive compromise with other aspects of the organism.

While the interannular raphes facilitate folding, the segment arrangement presumably facilitates contact of skin to tunnel wall. Absolute segmental size generally remains constant or decreases with adult size of species. Many of the elongate species show some herringboning of the nuchal region. This may well reflect an increase in the skin's frictional capacity and avoid slippage between body and tunnel wall.

Another set of specialisations relates to the distribution of the longitudinal sulci. These generally start after the first fifth to one-quarter of the body. Lateral sulci are fairly well developed in all the species under discussion. In contrast, all but the most elongate forms lack dorsal and ventral sulci or have them expressed only by alignment of intersegmental sutures. It is, however, interesting that more than half of those species lacking a dorsal sulcus show numerous and deep diagonal folding lines crossing the dorsum. This suggests that the dorsal sulcus not only provides the possibility of expanding the girth, but also acts to shift the zone of expansion laterally, away from the weight-bearing area of the skin.

Finally there is the caudal region. The least modified species have a short tail with a rounded, stiffened caudal boss and do not show autotomy. Another group shows slightly longer tails with marked autotomy annuli at which breakage, but no regeneration, takes place. The third group has significantly longer tails with stiff and transverse caudal bosses, as if the tail has been truncated. Autotomy occurs in some of these species but not in others. The function of the terminal reinforcement is suggested by a specimen preserved with the chelicerae of an ant deeply embedded in its distal pad, suggesting that ant attack drove the animal to the surface and brought it to the collector's attention.

This brief review then offers explanatory functional hypotheses for all of the major characteristics used in the systematic review of a major group of amphisbaenians. For each system we have seen different levels of modification and presumably of adaptation. A particular character state will rarely represent a perfect match to local function. It must be remembered that one always will see different equilibria of the adaptive compromise. To paraphrase Alexander (1974), "what stops the evolutionary process at any particular point is [not the difficulty of perfecting any one functional process but] the difficulty in building a better organism." The biological roles suggested appear vital to the survival of these animals and the analysis forced some major changes in the classification; this again supports the contention that the characteristics utilised as well as the results obtained by taxonomists inevitably have significance for those engaged in more obviously "functional" studies.

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REFERENCES

Alexander, R. D. (1974). The evolution of social behavior. *Annual Review of Ecology and Systematics* **5,** 325–383.

Broadley, D. G., Gans, C. and Visser, J. (1976). Studies on amphisbaenians (Amphisbaenia, Reptilia). 6. The genera *Monopeltis* and *Dalophia* in southern Africa. *Bulletin of the American Museum of National History* **157,** 311–486.

Gans, C. (1968). Relative success of divergent pathways in amphisbaenian specialization. *American Naturalist* **102,** 345–362.

Gans, C. (1971). Studies on amphisbaenians (Amphisbaenia: Reptilia). 4. A review of the amphisbaenid genus *Leposternon. Bulletin of the American Museum of Natural History* **144,** 379–464.

Gans, C. (1974). *Biomechanics: Approach to vertebrate biology.* Philadelphia: J. P. Lippincott.

Gans, C. and Lehman, G. C. (1973). Studies on amphisbaenians (Amphisbaenia; Reptilia), 5. The species of *Monopeltis* from north of the river Zaire. *Occasional Papers of the Museum of Zoology, University of Michigan* (669), 1–34.

Gans, C. and Wever, E. G. (1972). The ear and hearing in Amphisbaenia (Reptilia). *Journal of Experimental Zoology* **179,** 17–34.

Kritzinger, C. C. (1946). The cranial anatomy and kinesis of the South African amphisbaenid *Monopeltis capensis* Smith. *South African Journal of Science* **42,** 175–204.

Vanzolini, P. E. (1968). Environmental temperature and number of body annuli in *Amphisbaena alba:* notes on a cline (Sauria, Amphisbaenidae). *Papeis Avulsos do Departamento de Zoologia* **21,** 231–241.

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SOME ASPECTS OF THE BIOLOGY OF *AMPHISBAENA ALBA* L.

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INTRODUCTION

Amphisbaenians are a group of slender, elongate, limbless squamates, sometimes classified with the lizards, at other times accorded status as a separate suborder or order. All known species are entirely subterranean, living in tunnels of their own construction (Gans, 1968). Their burrowing has been described in detail by Gans (1960, 1968); movement down the tunnels is by undulation, concertinering or, as in *Amphisbaena alba*, by rectilinear locomotion. Not surprisingly, thereafter, the animals resemble enormous earthworms. Most other aspects of their mode of life are relatively little known.

The observations in this article were made on two living specimens of *A. alba* collected from El Manteco, 500 km south of Caracas, Venezuela, and kindly given to me in December 1974 by Dr S. Gorzula; their initial weights were 195 and 130 g.

HABITAT

Amphisbaenians are limited to tropical and sub-tropical regions. Some species occur in semi-desert where they live deep in the ground and among the roots of plants where interstitial moisture keeps the air saturated. They tend to congregate in the vicinity of seasonal water courses. According to Gans (1968) moist soils are necessary for the construction of semi-permanent tunnels.

The skins of many species are highly permeable to water (Krakauer, Gans and Paganelli, 1968). The contrast between the plump appearance of well-watered amphisbaenians and the shrivelled aspect of dry animals becomes particularly obvious when several examples of a species that exhibits territorial behaviour are placed in a cage having only a single moist area; the individual occupying the moist zone always appears to be in better "condition" than the others. When kept in a container 60 × 40 cm, filled with earth to a depth of 15 cm and watered at one end, my two specimens were always to be found in the dampest region. In general, however, the animals were maintained in a vivarium containing damp earth to a depth too shallow to permit them to bury themselves. Therefore their behaviour could be observed at all times. It was noticed that the skin was shed every few weeks as in *Baikia africana* (Dunger, 1964).

AGGREGATION

My two specimens showed no apparent territorial behaviour, mentioned by Gans (1968) as occurring in some species. On the other hand, it was frequently observed that they would be resting in partial contact with one another. In order to estimate the frequency of contact the positions of the two animals were noted when I entered the laboratory each day. Over a period of four months, the animals were not in contact on 20% of occasions, less than 50% of the body was in contact on 45% of occasions, and more than 50% of the body was in contact on 35% of occasions. In view of the relatively large size of the container and the fact that the animals were by no means always in contact with its sides, the extent of mutual contact seems significant.

DEFENSIVE BEHAVIOUR

According to Ditmars (1910), *A. alba* shows a marked aversion to light and is very sensitive to vibration. My specimens reacted to vibrations but soon lost their sensitivity to light. When annoyed, as described by Ditmars, the stumpy tail would be elevated like a head in threat unless the body were pinched. "Then the head swung about for the offender, while a tiny pink mouth gaped as widely as possible in a display of harmless bluff". This behaviour has also been reported by Bateman (1897), Gans (1968) and Thomas (1965). However, the statement seems incorrect as regards bluff. On one occasion, the smaller of the two specimens fastened its teeth into the skin of my hand with a vicious sideways twist of the body, like a crocodile feeding under water. I was unable to lever the jaws apart but eventually persuaded the animal to let go by pouring alcohol into the wound. It nearly succeeded in removing a small but very thick circle of skin; the bite healed slowly.

Whether the function of raising the tail is to attract the attention of potential predators away from the head seems by no means certain. Wickler (1968) cited several examples of "head mimicry" by "dummy heads" in reptiles, and concluded that it may simply represent a means to confuse possible enemies over which is the anterior end. It could also be a mechanism to give the impression that double the number of animals are actually present or, in the case of *A. alba*, that raising the tail gives the appearance of a rattlesnake.

FEEDING

Amphisbaenians are formidable predators. Their short, heavy jaws and interlocking teeth enable them to crush small arthropods and to bite chunks out of larger animals. According to Gans (1968) sensory and behavioural specialisations permit them to locate and catch their prey within the soil. The prey is recognised by acoustic signals which can apparently be perceived for a limited distance beyond the tunnel walls (Gans and Wever, 1972). Some species emerge at night to feed on the surface of the soil. Thomas (1965) found that although *A. gonavensis leberi* feeds naturally on termites, it will also eat raw meat. Pieces too large to be swallowed are worked into the mouth by the action of the scaly tongue, which forms a ratchet and draws out the meat into morsels of consumable size. Similar feeding was observed in captive specimens of *A. caeca*. My specimens of *A. alba* did not do this but simply bit off chunks of meat. Thomas concluded that amphisbaenians may at times eat carrion in the wild.

Ditmars (1910) fed captive *A. alba* on earthworms and strips of raw beef. He found that they became tame enough to take food from his fingers. My specimens fed readily on raw beef, lamb and chicken, disabled cockroaches, mealworm larvae and other insects. They seemed to prefer minced meat and they were offered food at approximately weekly intervals. An estimate of food intake was obtained by weighing the animals before and after they had eaten; these results are shown in Table I.

TABLE I. Records of food ingested by two specimens of *A. alba*

Date	Food intake (g) Specimen 1 (195 g)	Specimen 2 (130 g)
21 Jan. 1975	6.9	11.6
30 Jan.	9.7	—
7 Feb.	5.4	4.2
4 Mar.	3.0	2.6
10 Mar.	—	10.5
23 Mar.	—	11.5

DRINKING

My specimens were not observed to drink when kept in damp soil and fed regularly but they would sometimes do so when desiccated. They were very slow drinkers, licking water with the aid of the tongue. After one experiment, during which the larger specimen had lost 21 g (11% body-weight) over a period of one week, it drank 9.8 g in 20 min and then ate 5.4 g of chicken liver. The smaller specimen refused water on this occasion even though it had lost 14 g (10% body-weight) over the same period, but it ate 4.2 g of liver shortly afterwards. These and other results are shown in Table II.

TABLE II. Water consumption in two specimens of *A. alba* following desiccation. The figure for the larger specimen is shown on the left of each column, that for the smaller on the right

Date	Weight loss (% body-weight)		Amount drunk (g)		Weight recovered by drinking as % of weight loss	
7 Feb. 1975	11	10	9.8	0	43	—
14 Feb.	9	6	5.6	8.7	33	109
21 Feb.	4	4	4.5	1.8	58	32
28 Feb.	3	3	3.0	2.6	55	65
7 Mar.	4	4	2.5	6.5	36	144
14 Mar.	3	7	1.4	3.2	23	32

WATER RELATIONS

When loss of water to dry, moving air was measured from various burrowing snakes and amphisbaenians by Krakauer, Gans and Paganelli (1968), it was found to be greater in species from humid regions. Although the rate for *A. alba* at 27°C in dry air moving at 320 ml/min was only 2.7 ml/g hr, that for *A. caeca* was up to thirty times greater, overlapping with the rates of water loss found in amphibians.

Rates of water loss in still air from my two specimens under various conditions are shown in Table III. They show a correlation between mean water loss, ambient temperature and humidity. The rate was lowest when the animals were in damp soil. The larger specimen showed a rate of loss greater than that of the smaller at 20°C, and the smaller specimen showed a significant increase in water loss during the five days after casting its skin. These observations suggest that the major avenue of water loss is cutaneous rather than respiratory, although respiratory frequency and water loss would presumably have increased at higher temperatures as the metabolic rate increased.

TABLE III. Effect of different temperatures and humidities on water loss of two specimens of *A. alba* in still air. Mean ± S.E.M.

Temperature (°C)	Relative humidity (%)	Water lost per day (g) Specimen 1 (195 g)	Water lost per day (g) Specimen 2 (130 g)	N*
20	50	1.7 ± 0.09	1.3 ± 0.09	15
			3.8 ± 0.10†	5†
25	50	3.4 ± 0.04	2.0 ± 0.73	10
25	in damp soil	1.1 ± 0.45	0.9 ± 0.25	20

* Number of observations.
† During five days after sloughing.

A loss of 3.4 g/day at 25°C (0.725 mg/g hr) from the larger specimen and 2.0 g/day (0.64 mg/g hr) at 25°C from the smaller, are considerably lower than the figure obtained by Krakauer, Gans and Paganelli (1968) in moving air. Since air movement would be unlikely greatly to enhance respiratory water loss, these results tend to confirm that most water is lost by evaporation from the skin. Furthermore, most of the weight loss of animals in damp soil will be due to respiratory loss and if these figures are compared with those for water loss at the same temperature but at 50% relative humidity, it appears that only about one-third of the total water loss could have been due to evaporation from the respiratory tract. After the death of the largest specimen the rates of water loss at 50% relative humidity were 2.3 g/day at 20°C, 2.8 g/day at 22.5°C and 4.5 g/day at 25°C. Since these values were considerably in excess of the rates of loss measured in the live animal, it is clear that a considerable degree of physiological control must exist to control cutaneous water loss.

From measurements of length (500 and 550 cm) and diameter (6·0 and 7·5 cm), the surface area of the two specimens was calculated to be 3000 cm^2 and 4100 cm^2. If respiratory loss is ignored, the larger would have lost water at a rate of 3·5 μg/cm^2 hr and the smaller at 2·8 μg/cm^2 hr.

Even when desiccated the animals were unable to take up water through the skin, either when placed on damp blotting paper for various periods of time or when left in damp soil overnight. They would, however, drink water as noted above, and also obtained water from their food.

REFERENCES

Bateman, G. C. (1897). *The vivarium.* London: Gill.
Ditmars, R. L. (1910). *Reptiles of the world.* London: Pitman.
Dunger, G. T. (1964). *Baikia africana* (family Amphisbaenidae): ecology and individual variation. *Annals and Magazine of Natural History* (13)**7,** 217–221.
Gans, C. (1960). Studies on amphisbaenids (Amphisbaenia: Reptilia) 1. A taxonomic revision of the Trogophinae and a functional interpretation of the amphisbaenid adaptive pattern. *Bulletin of the American Museum of Natural History* **119,** 129–204.

Gans, C. (1968). Relative success of divergent pathways in amphisbaenian specialization. *American Naturalist* **102,** 345–362.
Gans, C., Krakauer, T. and Paganelli, C. V. (1968). Water loss in snakes: interspecific and intraspecific variability. *Comparative Biochemistry and Physiology* **27,** 747–761.
Gans, C. and Wever, E. G. (1972). The ear and hearing in Amphisbaenia (Reptilia). *Journal of Experimental Zoology* **179,** 17–34.
Krakauer, T., Gans, C. and Paganelli, C. V. (1968). Ecological correlation of water loss in burrowing reptiles. *Nature, London* **218,** 659–660.
Thomas, R. (1965). The feeding habits of captive amphisbaenids. *Herpetologica* **21,** 238.
Wickler, W. (1968). *Mimicry in plants and animals.* London: Weidenfeld & Nicolson.

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ASPECTS OF THE ECOLOGY OF *AMPHISBAENA ALBA* LINNAEUS IN THE VENEZUELAN GUAYANA

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The Amphisbaenia are a little-known order of the Squamata; there are about 17 genera and 125 known species. The genus *Amphisbaena* contains 45 species, and all but *A. violacea* are from the New World (Gans, 1967). The largest species is *A. alba* Linnaeus, which ranges from Colombia, Venezuela and the Guianas through Peru and Bolivia east of the Andes to Northern Paraguay and Brazil in the south. Amphisbaenids are highly specialised burrowing forms, and *A. alba* is reported to live in ant and termite nests, where it is said to feed upon the hosts (Terent'ev, 1961).

This paper reports data gathered on *A. alba* captured in El Manteco, Bolivar State, Venezuela.

INCIDENCE OF CAPTURE

Fourteen *A. alba* were brought in by local inhabitants between 27 July 1974 and 22 November 1974. All were captured between 05.00 and 08.00 local time in the vicinity of the village square. The local people claim that *A. alba* lives in the nests of leaf-cutter ants, from which it may be excavated. Such nests are very common in the square. Figure 1 shows the monthly rate of capture over a twelve-month period. The period of their capture corresponds with the rainy season, but only 4 were captured when there had been rain in the previous 24 hours. Table I shows the size, weight and sex of the 14 specimens; although the sample is small, there is no indication that males and females differ in size.

BEHAVIOUR

The defensive posture of *A. alba* is shown in Fig. 2. The characteristic horse-shoe posture, with both head and tail pointing upwards, is often accompanied by a thrashing movement of the body and an open mouth. The vernacular name, *culebra de dos cabezas* (snake with two heads) is apt. This posture may be held for several minutes before the animal slowly moves off.

If handled, *A. alba* can inflict a bite which is very painful for the size of the animal. It holds on with extremely powerful jaws and turns in a similar manner to that of the hagfish, tearing away a piece of flesh. A tame jacana (*Belonopterus cayannensis*) which was bitten by *A. alba* lost a foot.

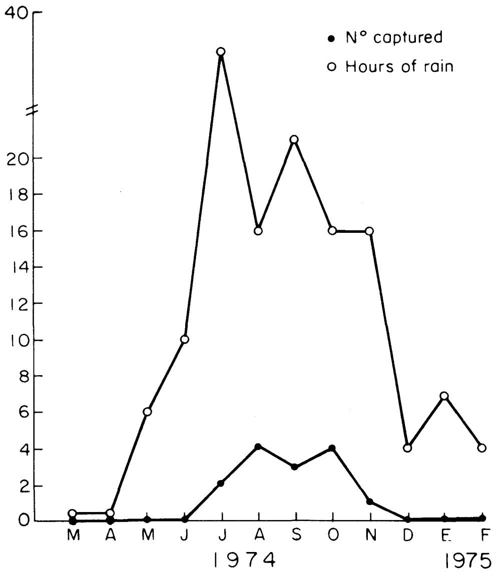

Fig. 1. Monthly rate of capture over 12 months

TABLE I. Data on captured *Amphisbaena alba*

Specimen No.	Date	Length: snout to anal pores (cm)	Length of tail (cm)	Total length (cm)	Wt. (g)	Sex	Identifiable remains in gut contents
1	23.7.74	59.6	5.8	65.4	240	F	4 beetles, sand many cockroaches
2	27.7.74	30.0	3.0	33.0	28	?	No record
3	23.8.74	50.0	5.3	55.3	133	M	5 squamate eggs, 3 beetles
4	24.8.74	51.5	4.7	56.2	152	F	2 beetle larvae, 3 beetles, sand
5	26.8.74	31.8	3.2	35.0	45	?	No record
6	27.8.74	53.5	4.5	58.0	160	F	Empty
7	13.9.74	57.5	5.0	62.5	205	M	Many cockroaches, 1 beetle
8	16.9.74	35.8	4.2	39.0	39	—	—
9	16.9.74	54.0	4.6	58.6	187	F	Few cockroaches
10	3.10.74	35.5	3.8	39.3	56	F	Clay particles and digested arthropod remains
11	5.10.74	43.5	4.0	47.5	74	M	Sand grains
12	17.10.74	54.3	5.6	59.9	172	—	—
13	21.10.74	49.8	4.7	54.5	158	—	—
14	12.11.74	59.5	5.6	65.1	202	—	—

Fig. 2. Defensive posture of *Amphisbaena alba*

DISSECTION

Ten specimens of *A. alba* were dissected between July 1974 and 12 October 1974. They were killed between one and eight days after capture. All had very extensive fat bodies in the visceral cavity. The gonads were inconspicuous in specimens 2 and 5 and these therefore could not be sexed. The mean testis length of specimens 3, 7 and 11 were 7.5 mm, 28 mm and 20 mm respectively, showing a proportional increase from August to September. Table I also summarises the gut contents of eight specimens. In specimens 3, 4 and 10 the volume of the gut contents was 4–5 ml. Seven guts contained many nematodes and four contained between one and three cestodes.

PREDATION

A significant predator of the village population of *A. alba* is man. The rural Venezuelans believe that the reptile is venomous. It is also one of the most ubiquitous folkloric cures among the people of the Venezuelan Guayana. Live *A. alba* are induced to enter an empty bottle, which is then filled with rum. The resulting extract is drunk as a tonic, or used as an embrocation for varicose veins and rheumatism. Consequently any specimen that falls into human hands is either killed or pickled in alcohol.

DISCUSSION

Since *A. alba* may be found on mornings when there is no rain, it can be cautiously assumed that those captured during the rainy season are actively foraging during this season above ground. Hoogmoed (1973) caught *A. alba* on two occasions at 08.30 hours. Observations on captive specimens show their activity to be nocturnal.

The defensive posture may serve as a warning to predators, for there is a 50% chance that the tail may be mistaken for the head, and the predator will then be bitten. Such a high probability of damage should deter many predators.

The examination of gut contents does not support Terent'ev's statement that *A. alba* feeds on ants and termites. In the case of specimen 10 the clay particles were from the cage in which the amphisbaenian had been kept for a week before being killed, indicating that some earth is ingested while the animal is burrowing. Hoogmoed (1973), summarising the literature as regards diet, lists food as including a snake, *Anilius scytale* (Linneaus), a mole cricket, a grasshopper, termites, annelids, reptiles and rodents. According to Stahel and Geijskes (1939 and 1940, quoted in Hoogmoed 1973) this amphisbaenian does not occur in the living-nest of leaf-cutter ants, but in the refuse pits where the larvae of the beetle *Coelosis biloba* occur and which form an important part of the diet of *A. alba*. Furthermore *A. alba* is restricted to nests of *Atta cephalotes*, and is not found in nests of *Atta sexdens* because the refuse pits of *A. cephalotes* are large and wide whereas those of *A. sexdens* are small and narrow.

It would thus appear that the varied diets reported for *A. alba* indicate opportunistic foraging, and that this foraging period is restricted to the rainy season. It is surprising that this slow-moving reptile can catch an insect as fast-moving as a cockroach, which is most active at night.

The small size of the testes in August implies that their reproductive period was before the rainy season, possibly at the beginning of the year.

In view of the fact that man has been collecting *Amphisbaena* from the village square for nearly a century, the population must be quite large, to sustain such a predation rate.

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REFERENCES

Gans, C. (1967). A check list of Amphisbaenians. *Bulletin of the American Museum of Natural History* **135,** 68–76.
Hoogmoed, M. S. (1973). Notes on the Herpetofauna of Surinam IV, *Biogeographica* **4,** 1–419.
Terent'ev, P. V. (1965). *Herpetology*, Jerusalem: Israel Program for Scientific Translations Ltd.

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HAEMATOLOGY OF *AMPHISBAENA ALBA* LINNAEUS

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Few haematological studies have been made on neotropical reptiles. Scorza (1971) published data on the haematology of the iguanid lizard *Tropidurus torquatus* in north-western Venezuela, and Acuña (1974) studied the iguana in the north-east of the country. The Amphisbaenids, however, have received little attention either in the New World or the Old.

Seven adult specimens of *Amphisbaena alba* were captured at El Manteco, Bolivar State, Venezuela, during the rainy season of 1974. The animals were anaesthetised using chloroform and ether, and blood was removed by cardiac puncture. In order to prevent coagulation the cardiac area was irrigated with heparin. Erythrocyte counts (RBC), expressed as number of red blood cells per ml of blood, and white cell counts (WBC) were determined with a haematocytometer, using Shaw's avian solution (Otis, 1974). Thrombocyte counts were made using a Thomas pipette and a Neubauer chamber. Haemoglobin content (Hb) was determined by Sahli's colorimetric method, and the pH was read using a Corning Scientific Instrument Model 12 pH meter with a micro-sample attachment. The packed cell volume was determined by centrifugation at 3000 r.p.m. for 30 min. Smears were made on cover-slips and stained with Wright's stain.

The erythrocytes were elongated and contained laxe nuclei; the mean cell length was 12 μm. The WBCs were not identical to those found in man; their nuclei were larger, more laxed and sometimes lobulated, and the granulations of the polymorphonuclei were larger and more pronounced. With the Wright stain the thrombocytes appeared more spherical, darker and larger than in man. The results of the haematological values are summarised in Table I.

The differential white cell counts are summarised in Table II.

It has been shown for certain snakes and lizards that there is seasonal variation in

Table I. Haematological values from specimens of *Amphisbaena alba*

Specimen No.	PCV (%)	Hb (g/100 ml)	RBC $\times 10^6/\text{mm}^3$	WBC $\times 10^4/\text{mm}^3$	Thrombocytes $\times 10^3/\text{mm}^3$	pH
1	44	13	1.11	1500	—	7.287
2	55	13	2.35	3190	81	7.309
3	42	11	2.38	3520	132	7.054
4	39	11	1.82	19800	102	—
5	57	13.5	2.78	4400	103	—
6	47	14	2.40	2200	169	7.135
7	44	10	2.42	3300	98	—
Means	44.9	12.2	2.18	5420	114	7.196

Table II. Percentage of white cell types in blood from *A. alba*

	Number of specimen						
	1	2	3	4	5	6	Mean
Polymorphonuclear neutrophils	10	0	4	9	10	0	6
Metamyelocytes	6	17	1	0	0	0	4
Myelocytes	4	2	5	4	2	0	3
Eosinophils	75	45	56	71	61	65	62
Lymphocytes	4	17	21	13	26	25	18
Monocytes	1	19	13	3	1	10	8

the white cell population (Duguy, 1970). Therefore the results will probably be influenced by seasonal variation. The value of the pH is somewhat low, but it was noted by Dessauer (1970) that the pH of reptilian blood may drop drastically under stress and under anaesthesia. The size of the red blood cells is at the low end of the ranges for the 75 species of reptiles summarised by Saint Girons (1970). The values for haematocrit and haemoglobin are higher than any reported for 71 species of testudines, saurians, ophidians and crocodilians by Dessauer (1970). In fact, the values for haematocrit and haemoglobin for *A. alba* are within the normal range for those of mammals. It has been shown by De Graaf (1975) that the haemoglobin content of the blood of amphibians is related to oxygen demand. It may well be that the high haematocrit and haemoglobin values of *Amphisbaena alba*, coupled with the size of the red cells, is an adaptation to their environment. *A. alba* lives in burrows, a mode of life in which a shortage of oxygen could easily occur, especially when the water content of the soil is high.

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REFERENCES

Acuna, M. L. (1964). The haematology of the tropical lizard *Iguana iguana* Linnaeus: II Seasonal variations, *Herpetologica* **30,** 299–303.

de Graaf, A. R. (1957). A note on the oxygen requirements of *Xenopus laevis, Journal of Experimental Biology* **34,** 173–176.

Dessauer, H. C. (1970). Blood chemistry of reptiles: physiological and evolutionary aspects. In *Biology of the Reptilia*, 1–72. Gans, C. (Ed.). London: Academic Press.

Duguy, R. (1970). Numbers of blood cells and their variation. In *Biology of Reptilia*, 93–109. Gans, C. (Ed.). London: Academic Press.

Otis, V. S. (1974). Leucocyte and erythrocyte diluent for reptilian blood cell counts. *Copeia* (1), 254–262.

Saint Girons, M. (1970). Morphology of circulating blood cells. In *Biology of the Reptilia* 91–93. Gans, C. (Ed.). London: Academic Press.

Scorza, J. V. (1971). Some haematological observations on *Tropidurus torquatus* (Sauria, Iguanidae) from Venezuela. *Journal of Zoology, London* **165,** 557–561.

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A COAGULATION STUDY OF *AMPHISBAENA ALBA* LINNAEUS

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INTRODUCTION

During the course of haematological studies on *Amphisbaena alba* it was found that when the heart was exposed by dissection and subsequently cut to release free-flowing blood into a collecting vessel, there was rapid coagulation of whole blood around the heart. Later a more efficient way of bleeding *A. alba* was developed and gave the opportunity to investigate some aspects of the blood coagulation system.

MATERIALS AND METHODS

Two adult *A. alba* (male and female) that had been in captivity for one to three months were used. Neither had been fed regularly but had during this time partially consumed a dead snake.

Blood sampling. Both specimens were anaesthetised with chloroform for 15 min. The heart was located by running the thumb along the ventral surface, and exposed by making an incision of about 2 cm. The pericardium was cut and the heart squeezed out so that it lay outside of the body cavity. This caused the heart to distend greatly and blood was then taken by cardiac puncture using a 22 gauge needle. Five ml of blood were drawn from each specimen. The blood was mixed in the proportion of 9 : 1 with 3.2% trisodium citrate. Platelet-poor plasma was prepared by centrifuging the blood samples at 3000 r.p.m. for 20 min.

Thromboplastins. Lung thromboplastin was prepared by a modification of the method for saline extract of human brain (Hardisty and Ingram, 1965). Freshly removed lung was washed in running tap water, then macerated at room temperature for about 1 min in a blender with 0.05 M tris-saline buffer at pH 7.4. For each gram of tissue 5 ml of tris-saline heated to 40°C were used. The homogenate was allowed to stand for 1 hr at room temperature, then centrifuged and the supernatant stored in aliquots of 2 ml at –20°C until required. In addition to thromboplastin from *A. alba*, thromboplastins were also prepared from lungs of a snake (*Mastigodryas bifossatus striatus*) iguana (*Iguana i. iguana*), caiman (*Caiman crocodylus*), domestic chicken, deer (*Odocoileus sp.*), domestic cow and man.

Clotting tests. All clotting tests were performed in a water-bath, the temperature of which was thermostatically controlled.

Recalcification time. 0.1 ml of plasma was recalcified with 0.1 ml 0.025 M calcium chloride and the clotting time recorded (Owen, Mann, Hurn and Stickney, 1955).

Prothrombin time (*PT*) was measured by incubating 0.1 ml plasma with 0.1 ml of lung thromboplastin from the various species. After 1 min 0.1 ml 0.025 M calcium chloride was blown into the mixture and the clotting time measured using a stop-watch

(Quick, 1942). The effect of the temperature on the PT using homologous thromboplastin was studied in plasma from Specimen 1.

Partial thromboplastin time (PTT) with kaolin. 0.1 ml plasma was mixed with 0.1 ml of kaolin suspension (5 mg/ml) in tris buffer for 5 min. 0.1 ml of Thrombofax (Ortho Diagnostic) was then added, followed by 0.1 ml of 0.1025 M calcium chloride, and the clotting time recorded (Matchett and Ingram, 1965).

Partial thromboplastin time (PTT) with activated Thrombofax. This was measured by incubating 0.1 ml of plasma with 0.1 ml of activated Thrombofax (Ortho Diagnostic) for 3 min, recalcifying with 0.1 ml 0.025 M calcium chloride and recording the clotting time (Ortho Diagnostics, leaflet with reagent, 1975). Partial thromboplastin time without activation was also measured by mixing 0.1 ml of plasma with 0.1 ml of Thrombofax and 0.1 ml 0.025 M calcium chloride and recording the clotting time.

RESULTS

Details of the animals are shown in Table I. Specimen 1 had a haematocrit at the bottom of the normal range (Ramirez *et al.*, 1977). Specimen 2 was under-weight and slightly anaemic. Recalcified plasma from both specimens did not clot after one hour incubation at 37°C.

TABLE I. Details of specimens used

	Sex	Length (cm)	Weight (g)	Visceral Fat reserves (g)	Haematocrit (%)
Specimen 1	Female	60	190	17.5	39
Specimen 2	Male	64.5	185	7.0	34

The effect of temperature on the PT of plasma from Specimen 1 is shown in Fig. 1. The shortest clotting times were obtained over the range of 35°C to 45°C. All subsequent clotting tests were performed at 37°C. The effect of various thromboplastins on the PT is shown in Table II. The shortest PT was from *A. alba* plasma with *A. alba* lung thromboplastin. Short times were also obtained with snake, iguana, and chicken thromboplastins. Cow and human thromboplastins gave long PTs of almost 5 min, and caiman and deer thromboplastins resulted in almost no activation of the clotting system of *A. alba* plasma.

TABLE II. Prothrombin time with different thromboplastins

Source of thromboplastin	*Amphisbaena alba* plasma prothrombin time (sec): Specimen 1	Specimen 2	Mean
A. alba	9.2–8.8	12.2–11.6	10.5
Snake	26.2–22.8	27.8–26.8	25.9
Iguana	32.0–30.2	38.6–39.0	35.0
Caiman	+1200.0	1710.0	1455.0
Chicken	40.0–33.6	34.2–34.8	37.5
Deer	1980.0	1680.0	1830.0
Cow	351.0	206.5	278.8
Human	327.6	208.0	267.8

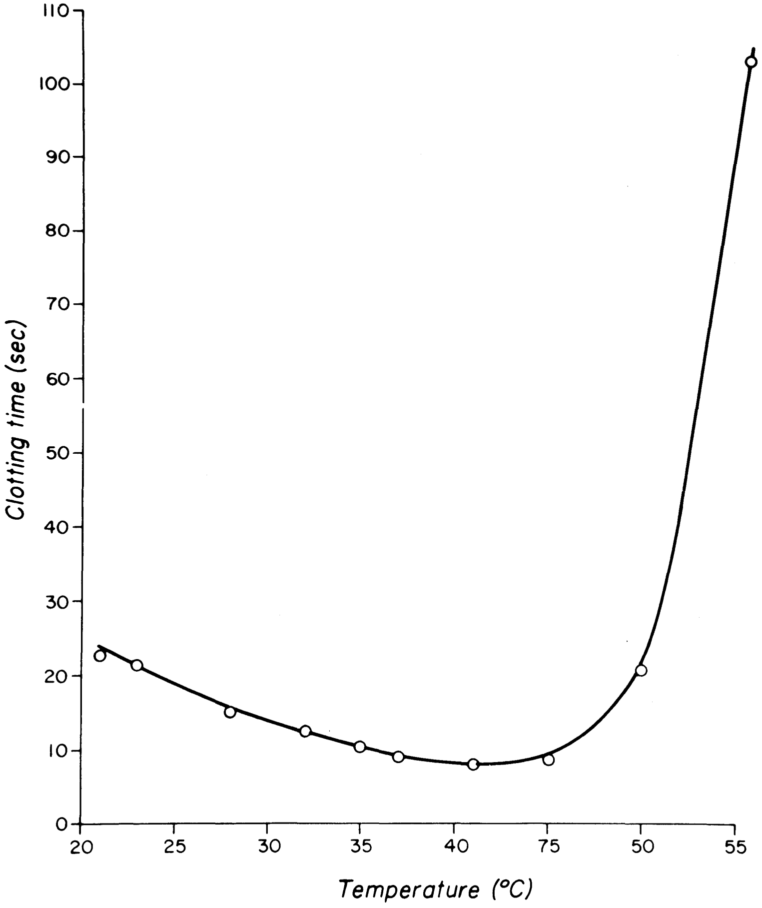

FIG. 1

PTT's using kaolin were recorded as 192.2 sec and 192.4 sec (mean 192.3 sec) for specimen 1 and 264.0 and 290.6 sec (mean 277.3 sec) for specimen 2. PTT's using activated Thrombofax were 214.8 sec and 222.6 sec (mean 218.7 sec) for specimen 1. PTT without activation did not clot after 30 min.

Figure 2 shows the effect of diluting *A. alba* plasma in tris-buffer on the PTT using activated Thrombofax. It can be seen that the PTT shortens until a dilution of 25% is reached and thereafter lengthens.

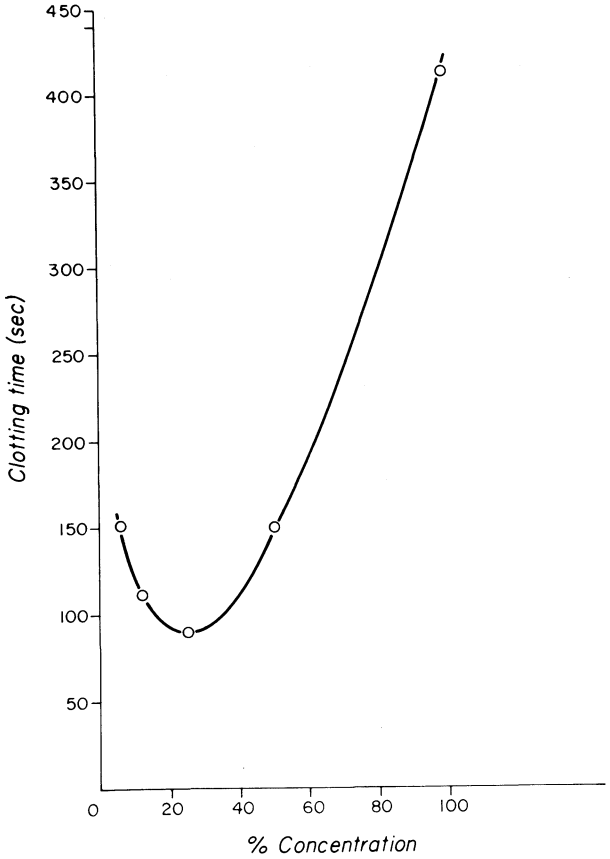

FIG. 2

DISCUSSION

From the above results it is apparent that *Amphisbaena alba* possesses both an extrinsic and an intrinsic pathway for producing a fibrin clot. Both systems require free calcium ions.

The extrinsic system requires tissue thromboplastin. The thromboplastin is species specific for *A. alba*, but iguana, snake, and chicken thromboplastins also produced fairly rapid coagulation, suggesting that reptile and bird thromboplastins are more closely related to each other than to mammalian thromboplastins.

Two exceedingly long PT's resulted with caiman and deer thromboplastin. The caiman appears to be unique among the reptiles studied in that both the brain and the lung are poor sources of thromboplastin, and that its own clotting factors do not respond to thromboplastins of other reptiles (unpublished observations).

The response of *A. alba* plasma to deer thromboplastin is more difficult to interpret. The deer thromboplastin gave short PT's with human and cow plasma but in general gave long PT's with reptile plasma (unpublished observations).

The optimum temperature for blood coagulation was between 35°C and 45°C. Hackett and Le Page (1961) have shown that the optimum temperature for the coagulation of leucocyte free plasma of *Bufo marinus* also lies between 35°C and 40°C. It would appear that blood coagulation is one of the many biochemical processes in lower vertebrates with an optimum temperature of about 37°C.

The intrinsic system as shown by the PTT is activated by both surface contact (with kaolin particles) and by ellagic acid. *A. alba* plasma can be concluded to contain factors with a similar mode of action to factors XI and XII in mammals. The absence of clotting in recalcified plasma with or without phospholipid suggest that the formation of blood thromboplastin by *A. alba* requires a higher level of activation than in mammals or the presence of an inhibitor. An inhibitor has been demonstrated in the blood of a wide variety of reptiles, and it has been shown by Jacques and Musacchia (1961) that a metachromatic-staining anticoagulant in the plasma of *Pseudemys scripta elegans* was recovered in far greater quantities from hibernating animals than from warm ones. They concluded that the anticoagulant assists haemofluidity during hibernation. Hackett and Hann (1967) described an inhibitor in variety of Australian squamate reptiles and concluded this inhibitor to be antithrombinic; Arocha-Piñango and Gorzula (1975) demonstrated that an inhibitor in the plasma of the caiman acts against the intrinsic system of human plasma. The dilution curve of *A. alba* is very similar to that shown by the caiman and probably indicates the presence of a similar circulating inhibitor.

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REFERENCES

Arocha-Piñango, C. L. and Gorzula, S. A. (1975). Naturally occurring inhibitor in the blood-clotting mechanism of *Caiman crocodylus*. *Herpetologica* **31**, 419.

Hackett, E. and Hann, C. (1967). Slow clotting of reptile bloods. *Journal of Comparative Pathology and Therapeutics* **77**, 175.

Hackett, E. and Le Page, R. (1961). The clotting of the blood of an amphibian, *Bufo marinus* Linn. 1. Prothrombin-thrombin and "fibrinogen-fibrin" stages. *Australian Journal of experimental Biology* **39**, 57.

Hardisty, R. M. and Ingram, G. I. C. (1965). *Bleeding disorders. Investigation and management*. Oxford: Blackwell Scientific Publications.

Jacques, F. A. and Musacchia, X. J. (1961). Variations in concentrations of a metachromatic staining anticoagulant in plasma of the turtle, *Pseudemys scripta elegans*. *Copeia* (2), 222.

Matchett, M. O. and Ingram, G. I. C. (1965). Partial thromboplastin time test with kaolin-normal range and modification for the haemophilia and Christmas disease. *Journal of Clinical Pathology* **18**, 465.

Owen, C. A., Mann, F. D., Hurn, M. M. and Stickney, J. M. (1955). Evaluation of disorders of blood coagulation in the clinical laboratory. *American Journal of Clinical Pathology* **25**, 1417.

Quick, A. J. (1942). *The haemorrhagic disease and the physiology of hemostasis*. Springfield, Illinois: Thomas.

Ramirez, F. J., Arocha-Piñango, C. L., Gorzula, S. and Salazar, C. (1977). Haematology of *Amphisbaena alba*, Linnaeus, *British Journal of Herpetology* **5**, 627–628.

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LETTERS TO THE EDITOR

MORE MARSH FROG COLONIES

In these days, in the decline in numbers of reptiles and amphibians, it is worth noting that the spread of our most successful introduced species, the marsh frog *Rana ribibunda*, continues unabated. Apart from the original stronghold in the Romney–Welland marshes, it was reported in the *British Herpetological Society's Newsletter* for 1971 to be present in north Kent. I found them in plenty in the dykes north of Sittingbourne and Sheppey in that year, and I also saw a few specimens at the eastern end of the Pevensey Levels in Sussex. Returning to Sussex this year, I find that the marsh frog has appeared on the Lewes Levels around the River Ouse. I saw ten adult and immature frogs there, spread over several dykes, in mid-September. I only examined a fairly small part of the grazing marshes for a short time, so it may be fairly widespread around Lewes. Therefore, it now appears that the marsh frog has become established in at least four of the major marsh systems in south-eastern England.

I lived in this same area between 1969 and 1972 and never saw marsh frogs near Lewes, despite frequent wanderings in the marshes. I believe it has become established there since that time, and the numbers I saw with such little effort in 1976 indicate the fecundity of the species. Netting the dykes did not produce tadpoles but I may not have been netting breeding dykes; alternatively, the hot summer may have accelerated metamorphosis. Netting at the same time (mid-September) in north Kent in 1971 produced very many tadpoles.

My earlier observations of 1969–1972 permit me to argue that in the case of the Lewes Levels at least, the marsh frog has not ousted *Rana temporaria*. The latter was always very rare there, and I only saw one in the entire three years—and that near the edge of the system. This agrees with the correspondent in the 1971 *Newsletter* who reported that common frogs were rare on the north Kent marshes. In my view the low-lying grazing fields and dykes are unsuitable for all British amphibians. I have only found common toad tadpoles in a dyke once—again peripheral to the system—and newts are singularly uncommon. I suspect that the terrestrial habitat is too open and hot for species other than virtually entirely aquatic ones, and I do not share the fears of some that *R. ribibunda* is a threat to the native amphibian fauna, at least in south-east England. However, this may not be true for similar marsh systems in slightly cooler parts of England, such as those in East Anglia, for here I have seen common frog and toad tadpoles in many dykes. The introduction of marsh frogs to these areas may pose more of a threat.

My own hope is that the trend towards arable farming does not destroy dyke habitats and that in south-east England the marsh frog will continue to enrich our fauna but not spead much further. I would be interested to know the views of other observers and particularly whether their observations of native amphibians in the marsh dykes are similar to my own.

TREVOR J. C. BEEBEE
School of Biology
University of Sussex
11 October 1976

BOOK REVIEWS

BIOLOGY OF THE REPTILIA, Volume 5, *Physiology* A. Edited by C. Gans and W. R. Dawson, London and New York: Academic Press, 1976.

Compared with other aspects of reptilian biology, searching and marshalling factual data on reptilian physiology is daunting and can be a test of one's patience and application to the subject. The relevant literature is widely scattered in a mass of scientific papers written by research workers for research workers, often in obscure or not readily available books and journals, or even more elusive by being tucked away with analyses of the functions of other classes of vertebrates. Worse still, in most physiology textbooks references to the processes in reptiles are invariably secondhand and sketchy with no clues to the sources of the statements made.

Following the tradition of scholarly appraisals set by the earlier volumes in the series that have a sustained reputation for excellence, the first volume on physiology has now been published. All the contributors assume that the reader has a specialised knowledge of the biological sciences and many demand a fair grounding in physiology. The specialist will undoubtedly be rewarded by finding in this volume a wealth of clearly understood accounts of the deeper problems in reptilian physiology, but the non-specialist may find himself stifled by the jargon and formulae, for much of the text is intellectually and scientifically rigorous and reading demands close concentration.

This volume contains an excellent acount of physiological adaptations and a long chapter on techniques, followed by chapters on metabolism, respiration, circulation, acid–base balance, osmoregulation, salt glands and renal function. I particularly commend Dr Bentley's and Dr Dunson's contributions on osmoregulation and salt glands which are the epitome of detailed practical investigation and experimentation served up in highly readable form and which writers of pop books would do well to digest, if only to grasp the debunking of oft repeated myths. A high standard of editing is achieved throughout, the illustrations are well produced and the blemishes are few. Nobody can deny that it has been well worth waiting for the first volume on physiology in this series.

A. G. C. GRANDISON

FROGS. By Michael J. Tyler (1976). 256 pp. Sydney and London: Collins, The Australian Naturalist Library.

In the Preface Dr Tyler states, "absolutely nothing at all [has been published] upon the vast number of interesting frog species in New Guinea". However, although this is not now true (see *Handbook of Common New Guinea Frogs* by J. I. Menzies, published by the Wau Institute in 1976), nevertheless this book is welcome and of value.

After a general introduction to frogs, and in particular to Australian and New Guinean species, there are succeeding chapters on hylids, leptodactylids (rather a dustbin group according to the author), microhylids (some species, barely 1 cm long, are able to sit on the end of a pencil), ranids and *Bufo marinus*, reproduction, diet and feeding, habits and various other topics, obtaining water and avoiding heat, breathing, sound communication, defence, dispersal, geographical distribution, collection and study of frogs, for example. Species are listed according to distribution in a check list and there is a useful collection of references; all but four of the twenty plates are in colour.

The author writes with a fresh, enthusiastic style. I enjoyed the book very much and am glad to recommend it.

H. FOX

HANDBUCH DER PALAOHERPETOLOGIE, Part 7 *Testudines*. By Marion Mlynarski (1976). Edited by O. Kuhn. Stuttgart and New York: Gustav Fischer Verlag.

This paperback volume is very much for the specialist and will be of value to those researching in this field. Only a few are likely to be able to afford DM 116 for this work, which is a pity because Professor Mlynarski of Krakow has produced a most learned volume.

H. FOX

REPRODUCTIVE CYCLES IN LIZARDS AND SNAKES. By Henry S. Fitch (1970). Lawrence, Kansas: University of Kansas Museum of Natural History.

After completing a review which included aspects of the reproductive cycles of reptiles, I was horrified and dismayed to learn of the existence of this work which is an important account of reproduction in amphisbaenids, lizards and snakes. Although it was published in 1970 and is probably not generally known, it is still available from the Publications Secretary, 602 Dyche Hall, University of Kansas, Lawrence, Kansas, U.S.A. for $2.50 plus 50c postage.

There is a great deal of information on reproductive seasons, number of eggs, gestation, hatching times and the size of breeding adults. Factors affecting reproductive cycles, brood size, breeding seasons, and viviparity and oviparity are discussed at the end of the book. There are twenty-seven pages of references. The book is cheap at the price, especially as it is produced in the U.S.A.—a real bargain for those interested in this subject. Libraries should have a copy.

H. FOX

ZOOTIER KRANKHEITEN. By H.-G. Klös and E. M. Lang (1976). 365 pp. Berlin: Paul Parey.

The book is the result of the co-operation of twenty-four German veterinarians attached to zoos with each one writing about his speciality. To encompass the large amount of experience accumulated on all the topics the book is necessarily written a little like a dictionary. The illustrations are all in black and white. The chapter on amphibians and reptiles is by Professor W. Frank, one of the leading German experts on the pathology of lower vertebrates. The only disagreement I have with this competent and important book concerns the title; the word *Zootier* (zoo animal) could not occur in any German dictionary.

E. ELKAN

MORPHOLOGY AND BIOLOGY OF REPTILES. Edited by A. d'A. Bellairs, and C. B. Cox (1976). Linnean Society Symposium Series 3. London: Academic Press.

The book comprises a collection of papers on living and fossil reptiles given at a symposium of the Linnean Society in September 1975. The theme is indeed a wide one, so wide in fact that it enables each author to "do his own thing". The book on the whole is a hotch-potch of a variety of topics among which a connecting theme is difficult to distinguish because fields covered range from morphology, evolution, taxonomy and functional anatomy to physiology. Only an expert on all these fields could comment adequately on the contents. In any case the authors are the experts and what they say must be treated as the latest reliable word. The editing seems to be first-class but I wish I could say the same about the miserable half-tones. I doubt whether any student or even professional zoologist will be able to afford a copy at £14.50 but all libraries should have one. The handsome volume is a valuable addition to our literature on the Reptilia.

H. Fox

PHYSIOLOGY OF THE AMPHIBIA, Volume 3. Edited by B. Lofts (1977). New York: Academic Press.

This is the third volume of a series which began in 1964. It includes a mixed bag of ten subjects of the usual high standard expected in this series.

Bagnara's contributions to our knowledge of the ultrastructure and function of melanophores and melanin movement are well known. It is a pleasure to read a general review of the subject, including much of his own work. Likewise, there is a valuable review of amphibian moulting by Lis Olesen Larsen. The article on the pathology of amphibians by Elkan isn't really fitted to a volume of this kind; it seems some way from being physiological. Yet as most zoologists who deal with amphibians are unlikely to have read anything of significance on amphibian diseases, perhaps such an article will provide a basis for those wishing to know more about the subject. Cooper's contribution on the immunology of amphibians is splendid; we are fortunate to have this comprehensive review by such an authoritative worker.

To conclude the volume there is an extensive, superb review by Dodd and Dodd on amphibian metamorphosis. I was thrilled to read it and clarify so many obscure and vague theories on the complex endocrinology of amphibian metamorphosis. The long-standing differences, between Etkin's hypothesis on the one hand and the results of Just and Frieden on the other, are analysed critically. A comprehensive explanation is offered which could indeed be the basis of a new understanding of the subject.

This is a well-produced and valuable book. The editor has done a fine job in seeing the work through and Academic Press do produce beautiful books, but at a price (£19.80).

H. Fox

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

The required six months' notice is given of the possible use of plenary powers in connection with the following names listed by case number (see *Bulletin of Zoological Nomenclature* **33**, parts 3 and 4, 31 March 1977).

Z.N. (S.) 2141 *Rana sphenocephala* Cope, 1886, request for conservation of; *Rana utricularius* Harlan, 1826 and *Rana virescens* Cope, 1889, request for suppression of (Amphibia Salientia).

Z.N. (S.) 2155 *Leptotyphlops* and *Ramphotyphlops* Fitzinger, 1843 (Reptilia: Serpentes): proposed conservation.

Z.N. (S.) 2165 *Psammophis moniliger* var. *bilineatus* Peters, 1867: proposed suppression in favour of *P. sibilans subtaeniata* Peters, 1882 (Reptilia, COLUBRIDAE).

Z.N. (S.) 2166 *Philodryas nattereri* Steindachner, 1870 (Reptilia, Serpentes): proposed conservation.

Z.N. (S.) 2174 *Chlorophis carinatus* Andersson, 1901: proposed nomenclatural precedence over *Philothamnus nigrofasciatus* Bucholz and Peters, 1875 (Reptilia: COLUBRIDAE).

Comments should be sent in duplicate (if possible within six months of the date of publication of this notice), citing case number to R. V. Melville, The Secretary, International Commission on Zoological Nomenclature, c/o British Museum (Natural History), Cromwell Road, London SW7 5BD, England. Those received early enough will be published in the *Bulletin of Zoological Nomenclature*.

The following Opinions have been published recently:

Opinion No. 1071 (*Bulletin of Zoological Nomenclature* **33** (3 and 4) p. 167) LIOPELMATINA, Mivart, 1869, under plenary powers emended to LEIOPELMATIDEA (Amphibia Salientia).

Opinion No. 1072 (*Bulletin of Zoological Nomenclature* **33** (3 and 4) p. 170) suppression under plenary powers for purposes of the Law of Priority but not those of the Law of Homonymy of *Hyla crucialis* Harlan, 1826 (Amphibia) refused: and *Hyla crucialis* Harlan, 1826 placed on Official List of Specific Names in Zoology.

BRITISH JOURNAL OF HERPETOLOGY

INSTRUCTIONS TO AUTHORS

1. The *British Journal of Herpetology* publishes original articles, reviews and notes on all aspects of herpetology; minor faunistic lists and bibliographies will no longer be published (see 12 below).
2. *Two* copies of papers and illustrations should be sent to the Editor. The submission of a manuscript will be taken to imply that no similar paper is being, or will be, submitted for publication elsewhere. When accepted the entire copyright of a paper passes to the *British Herpetological Society;* permission to reproduce material must be obtained from the Editor.
3. Papers should be concise with the minimum number of tables and illustrations. They should be written in English and spelling should be that of the *Oxford English Dictionary.* Papers should be typed double-spaced with wide margins all round; good quality paper is essential for the top copy. Except for short notes, papers should be divided into sections. The first sub-head will be centered in capitals, the second shouldered in lower case, and the third run on in italics. Footnotes are not permitted.
4. For all papers the title should be followed by the name(s) of the author(s) and the address or name of the Institution in which the work was done. For major papers a short summary is required before the body of the paper. Acknowledgements should be included before the list of references.
5. The usual rules of zoological nomenclature apply.
6. Tables are numbered in roman numerals, e.g. Table I; they should be typed on separate sheets and must not be divided by vertical or horizontal lines.
7. Line drawings and half-tones are numbered in sequence in arabic numerals, e.g. Fig. 1. If an illustration has more than one part each should be identified as (a), (b), etc. The orientation and the name of the first author should be indicated on the back. They should be supplied for uniform reduction by one-half on A4 size paper to fully occupy the width of the paper. Drawings should be in Indian ink on good quality tracing material, Bristol board or faintly *blue*-lined graph paper; photographic prints may be submitted. For half-tones high quality glossy prints are required. All labelling should be applied to illustrations using stencils or transfers. A metric scale must be inserted in micrographs, etc.; a figure for magnification in the legend is not acceptable. Legends for illustrations should be typed on separate sheets, one sheet for each illustration.
8. References in the text should be given as in the following examples: Smith (1964) stated . . ., observed by Smith (1964a, b), (Smith and Jones, 1963). For three or more authors, the complete reference should be given at the first mention, e.g. (Smith, Jones and Brown, 1972), and *et al.* used thereafter (Smith *et al.*, 1972). For the list of references *the full title of the journal must be given.* The following examples will serve to illustrate the style and presentation used by the Journal:

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

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