

**Volume 6, Number 4**

**June 1981**

**BRITISH JOURNAL OF  
HERPETOLOGY**

**Published by  
The British Herpetological Society**

# BRITISH JOURNAL OF HERPETOLOGY

Volume 6, Number 4

June 1981

HONEGGER, R. E. Breeding endangered species of amphibians and reptiles: some critical remarks and suggestions	113
WISNIEWSKI, P. J., PAULL, L. M. and SLATER, F. M. The effects of temperature on the breeding migration and spawning of the common toad, <i>Bufo bufo</i> .	119
LOPEZ, A. and BONIS, J. Studies on a case of papillomatosis in the eyed lizard, <i>Lacerta lepida</i> .	123
MEBAN, C. Physical properties of surfactant from the lungs of the northern leopard frog, <i>Rana pipiens</i> .	127
HALLIDAY, T. R. and JOLY, P. The functional significance of foot-webbing in European newts ( <i>Triturus</i> ).	131
DUTTON, R. A. The herpetology of the Chagos archipelago.	133
KAR, S. K. and BUSTARD, H. R. Attacks on domestic livestock by the salt-water crocodile ( <i>Crocodylus porosus</i> ) in Orissa, India.	135
BUSTARD, H. R. and KAR, S. K. Crocodile kills taken as human food.	137
BUSTARD, H. R. and KAR, C. S. Annual nesting in the Pacific Ridley sea turtle ( <i>Lepidochelys olivacea</i> ) in Orissa, India.	139
ERNST, C. H. Courtship of the African helmeted turtle, <i>Pelomedusa subrufa</i> .	141
LETTERS TO THE EDITOR	143
BOOK REVIEWS	144

**BRITISH HERPETOLOGICAL SOCIETY**  
(Founded 1947)

\*\*\*\*\*

c/o The Zoological Society of London,  
Regent's Park, London NW1

\*\*\*

Correspondence, membership applications, subscription renewals, and purchase orders for the *British Journal of Herpetology* should be sent to the above address.

\*\*\*

EDITORIAL REPORT FOR 1980

<i>Papers published</i>	1980	1979	1978
Pages published		62 (A5)	110 (A5)
	77 (A4)	36 (A4)	
Number of papers	16	17	16
Time (months) between receipt and publication, median (range)	14 (8-45)	19 (5-30)	25.5 (7-36)

*Papers received* (final figures for 1979 in parentheses)

	From U.K.	From abroad	Total
Received	12 (9)	20 (14)	32 (23)
Accepted	6 (8)	11 (6)	17 (14)
Published as letter	0 (0)	0 (1)	0 (1)
Rejected or withdrawn	5 (1)	8 (7)	13 (8)
Awaiting decision	1	1	2
Received specifically on British species	3 (5)	0 (0)	3 (5)
Received on captive breeding	1 (0)	3 (0)	4 (0)

*Referees.* The Editor is most grateful to the following who refereed papers in 1980: E. N. Arnold, R. A. Avery, A. D. Bangham, T. J. C. Beebee, A. D'A. Bellairs, D. R. Blatchford, J. L. Cloudsley-Thompson, A. S. Cooke, J. R. Cooper, P. M. C. Davies, J. F. D. Frazer, I. W. Henderson, M. R. K. Lambert, G. Shelton, I. F. Spellerberg, S. Townson, G. Underwood.

*Papers awaiting publication* 14 (12 in 1979, 16 in 1978).

\*\*\*\*\*

PUBLICATIONS

*British Journal of Herpetology* and *BHS Bulletin* are published twice a year and are issued free to members.

*British Journal of Herpetology.* Instructions to authors are printed inside the back cover. Contributions should be addressed to the editor, Dr R. A. Avery, Department of Zoology, The University, Bristol BS8 1UG.

*BHS Bulletin.* Contributions should be addressed to the joint editor, Mr J. Pickett, 84 Pyrles Lane, Loughton, Essex.

\*\*\*\*\*

It is hoped to publish the index for volume 5 of the *Journal* in 1981.

Contact the editor for advertising in the *Journal*.

## BREEDING ENDANGERED SPECIES OF AMPHIBIANS AND REPTILES: SOME CRITICAL REMARKS AND SUGGESTIONS†

RENÉ E. HONEGGER

Zurich Zoological Garden, CH 8044 Zurich, Switzerland

Several zoological gardens and institutions seem to be making good progress in breeding amphibians and reptiles, but their reproduction over consecutive generations under captive conditions still remains a novelty. To illustrate this fact I quote from volumes 18 and 19 of *International Zoo Yearbook* (Olney,

1978

*Eublepharis macularius*  
*Gekko gekko*  
*Hemidactylus flaviviridis*  
*Phelsuma madagascariensis*  
*Boa constrictor*  
*Eunectes notaeus*  
*Python molurus bivittatus*  
*Elaphe guttata*  
*Elaphe subocularis*  
*Pituophis melanoleucus sayi*  
*Boiga blandingi*  
*Oxyuranus scutellatus*  
*Bitis lachesis (arientans)*  
*Vipera ammodytes*  
*Vipera berus*  
*Agkistrodon bilineatus*  
*Crotalus atrox*  
*Crotalus pusillus*  
\**Crotalus unicolor*  
*Trimeresurus purpureomaculatus*

1979

*Eublepharis macularius*  
*Phelsuma abbotti*  
*Boa constrictor*  
\**Python molurus pimbura* X *P.m. bivittatus*  
*Python reticulatus*  
*Elaphe guttata*  
*Elaphe g. emoryi*  
*Elaphe obsoleta quadrivittata*  
*Elaphe obsoleta williamsi*  
*Pituophis melanoleucus sayi*  
*Boiga blandingi*  
*Oxyuranus scutellatus*  
*Bitis lachesis*  
*Echis carinatus*  
*Echis coloratus*  
*Vipera kaznakovi*  
*Agkistrodon bilineatus*  
*Crotalus adamanteus*  
*Crotalus atrox*  
*Crotalus pusillus*  
*Trimeresurus purpureomaculatus*

† A talk given at the Annual General Meeting of the British Herpetological Society in March 1980.

1978, 1979) where only the following taxa are listed as having been bred over several generations by zoos:

Only those taxa marked with an asterisk are listed in the IUCN Red Data Book (Honegger, 1975b, 1979).

We can add, of course, more species which are bred by other institutions and individuals, and which consequently are not listed in the census of *International Zoo Yearbook*.

Apparently it is still cheaper to buy specimens caught in the wild than it is to breed them (Honegger, 1975b). This is especially true for taxa which are relatively unattractive, or which need considerable time and space to mature, e.g. *Macroclemmys teminckii* or *Paleosuchus*.

Those who have followed the discussion on breeding endangered species of wild animals in captivity know of the three international meetings which took place during the past years. The proceedings for the first meeting, held at the Jersey Wildlife Preservation Trust, were published in 1975 (Martin, 1975). The papers of the second meeting, held at the Zoological Society of London in 1976, appeared in Volume 17 (Olney, 1977) of *International Zoo Yearbook*. The papers delivered at the third World Conference at San Diego in November 1979 will again be published in *International Zoo Yearbook*.

All publications contain an enormous wealth of information which is also important to the field of applied herpetology, i.e. on the breeding and keeping of amphibians and reptiles.

With your permission I will repeat an important point made at the London Meeting by Paul Leyhausen: "At present, we are unable to breed any species in captivity indefinitely without seriously decreasing its viability under natural conditions. The first aim of a conservation programme for any species, therefore, must always be to preserve natural habitats of sufficient size and to protect the species there. Wherever captive breeding is thought necessary or desirable, parallel to remnant natural populations, exchange of individual animals between the captive and the free-living population should be a regular routine, provided that this can be done without adding to the peril of the free-living population. Of course, all this does not mean that there should not be captive breeding for other reasons, especially for the scientific studies, to complement those of free-living populations" (Leyhausen, 1977).

In his closing address at the third world conference in San Diego, Thomas Lovejoy of the World Wildlife Fund U.S.A., drew our attention to the fact that conservation should also take care of those endangered taxa which have no, or very little, aesthetic value, or

whose scientific appeal is momentarily almost nil. He also mentioned that probably one of the most critical phases in modern conservation will be the willingness of zoos and individuals to collaborate and overcome institutional jealousies and dandyism. "Ultimately, the extent of zoo co-operation will determine how full tomorrow's ark will be."

Now, let me select a number of species and discuss some aspects of problems which might be encountered while attempting to breed them under captive conditions with the aim of conservation. I shall not concentrate on endangered species, but shall discuss problems involved with so-called common taxa.

Since the first Japanese giant salamander, *Andrias japonicus* (syn. *Megalobatrachus japonicus*) arrived in Europe in 1829, little of our knowledge has changed. Most publications deal with the taxonomy of the genus. There are few ecological observations available. The observation by Kerbert (1905) on the reproduction of this giant amphibian is being quoted again and again in all biological literature throughout the world (for example, see Rimpp, 1978).

In 1978, the number of giant salamanders, *Andrias* (*Megalobatrachus*) *japonicus*, living in zoos around the world was indicated as follows: 3♂, 3♀ + 75 in 24 collections (including 12 Japanese zoos) (Olney, 1979).

The large number of unidentified giant salamanders is a clear indication that there are still great difficulties in determining the sex of living specimens. It would be of great benefit to find a suitable method to determine sex in living giant salamanders, perhaps using a similar sophisticated method recently discovered by Judd *et al.* (1977) and Ruedi *et al.* (1977) for living Squamata. Here I see a rewarding field of co-operation between a well-equipped, staffed laboratory and a zoological garden.

Nickerson's research (1978) on a close relative to *Megalobatrachus*, the hellbender, *Cryptobranchus alleganiensis* might also offer some indication as on how to sex *Megalobatrachus*. In *Cryptobranchus* the males may be distinguished from the females by the presence of enlarged cloacal glands just before, during and sometimes after the breeding season. Additionally, females have been shown to have a much higher serum calcium level than males (Nickerson & Mays, 1973).

Nickerson (1978) also suggests that *Cryptobranchus* should be exhibited under red light in highly oxygenated, alkaline, cool water.

*Andrias japonicus* is listed as a rare species in the Red Data Book (Honegger, 1975a). It occurs only in oxygen-rich, unpolluted mountain streams of Hondo Island, and in the upper parts of the Oria and the Yakkan rivers in Central Kyushu.

To advance our poor knowledge on the giant salamanders, some zoos and perhaps serious amateurs should start to concentrate on the breeding biology of this largest living amphibian. A giant salamander breeding facility could be built in a very pleasing manner, which the general public considers a real attraction, *i.e.* as a well-planted exhibit with fish, salamanders and birds, separated in a public and a special breeding facility.

A very positive prognosis can be given for the future of *Pipa carvalhoi*, a relatively small member of the

family Pipidae. *Pipa carvalhoi* was described in 1937 by Miranda Ribeiro. Its habitat in Brazil includes sunny ditches and ponds.

This small frog, which has some resemblance to the African clawed frog, *Xenopus*, can be easily bred in aquaria. A female may lay eggs every four to eight weeks. Development of the eggs takes from two to four weeks, depending on water temperature. The larvae filter their food from the water and metamorphose at 26°C in about 60 to 80 days. The young toads (35–45 mm long), feeding now on tubifex worms and daphnia, are sexually mature at five to seven months after metamorphosis. Weygolt (1976a, b), who studied the species intensively, concludes that *Pipa carvalhoi*, because of its great adaptability, is to become a new frog species for the laboratory.

Despite the fact that amphibians have been utilized in laboratories and classrooms for a long time, only two taxa have been maintained as laboratory animals: the axolotl, *Ambystoma mexicanum*, and the African clawed frog, *Xenopus laevis*. The *Guidelines for the breeding, care, and management of laboratory animals—Amphibians* (Nace *et al.*, 1974) can definitely stimulate a better understanding of amphibian reproduction. Concentrated efforts to start breeding additional taxa under artificial conditions are most needed, both in the U.S. and in Europe.

Some of the most beautiful creatures can be found in the family of the poison-arrow frogs (Dendrobatidae) which number about 100 species (Silverstone, 1975, 1976). Many species, especially those with contrasting colours, are widely kept by amateurs and public collections. Before World War II, the keeping of dendrobatid frogs in Europe was a rare event, and the breeding of *Dendrobates tinctorius* (Oeser, 1932) and *Dendrobates auratus* (Senfft, 1936) made headlines in the relevant journals.

The food spectrum of *Dendrobates* contains small terrestrial ants, followed by termites and spiders which play an important role in their diet (Silverstone, 1975, 1976). This fact may illustrate some of the difficulties in breeding them: the logistics in producing suitable food are sometimes enormous, for *Drosophila* and crickets are *no* substitutes for the wide variety of natural food.

Today, a relatively large number of *Dendrobates* species are now maintained by amateurs and zoos. Although few data exist on the mortality in shipping these creatures, it must be assumed that a large number die because of inadequate packing methods, crowding, and from self-poisoning. As most buyers of these multi-coloured frogs do not have the slightest knowledge of their biology and do not intend to breed them, reproduction of these taxa remains a rare event. At least for the moment, their status can be considered safe. Some species, especially those with a limited range, such as *Dendrobates azureus* or *Dendrobates lehmanni*, might become threatened species in the future. *Dendrobates azureus*, only known from a few forested islands surrounded by arid savannah in south-eastern Surinam, has aroused considerable interest in American and European herpetological communities. According to Hoogmoed (1969) and Polder (1973, 1974) who observed captive breeding, *Dendrobates*

*azureus* has a rather low reproductive rate; only two tadpoles are carried at a time, possibly several times a year.

The provisions provided by the Surinamese authorities to protect their fauna appear to be sufficiently enforced. Hopefully, only limited numbers of these brilliant blue frogs will be permitted to be exported and then for the sole purpose of breeding them. I consider it most important to stress that the major contributions to the breeding biology of the poison-arrow frogs have been made by some serious private amateurs in their home terraria (Mudrack, 1969; Oeser, 1932; Polder, 1973, 1974; Senfft, 1936).

In 1960 and 1971, I had the opportunity to visit a turtle-breeding farm in Mississippi. I was fascinated by their success in hatching more than 150 000 *Chrysemys scripta elegans* annually for the pet-trade. Ten years later, the same turtle farm had an annual production of over 1.5 million pet turtles (Haga, 1970).

The rate with which the red-eared sliders were consumed by the pet-trade in the United States, before the hysteria of salmonellosis started some years ago, was enormous. Today, it appears as if the market has shifted to Europe, where baby terrapins are sold in almost every pet shop.

As most buyers become more and more familiar with the requirements of these creatures, specifically through zoo public-education programmes, the number reaching medium-size has correspondingly increased. Fortunately for our native Swiss fauna, turtles are rarely released into the wild because of our relatively cold climate. As a consequence, the number of sliders donated to zoos is considerable. During the last 5 years, Zurich Zoo received an average of about 150 terrapins a year. The maintenance and feeding of these creatures in large holding-tanks cost considerable man-hours and money. Sometimes an exchange with a foreign zoo or an amateur is possible.

Returning these *Chrysemys* to the U.S., where at least the females could be incorporated into captive breeding programmes of the farms, is nearly impossible, because of existing U.S. laws and regulations. Killing and using terrapins for feeding other reptiles is not advisable, as these turtles are often contaminated with parasites, etc.

I have elaborated on *Chrysemys scripta elegans*, a taxa which poses absolutely no difficulty in maintenance under captive conditions, to illustrate the reverse of the problem we face with other reptiles.

The survival rate of Mediterranean land tortoises under captive conditions in West Germany and Switzerland in the first year after importation is below 20% (Blatt & Müller, 1975).

The status of *Testudo hermanni* has not yet been decided (Honegger, 1978). However, all reports throughout its range indicate that it is decreasing in population and numbers. *Testudo hermanni hermanni* is legally protected only in Rumania and Bulgaria, and is listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. As long as it is still much cheaper to obtain Mediterranean tortoises caught in the wild for the pet-trade than to breed them, there will be no

serious efforts made to breed these creatures under captive conditions.

Kirsche (1979) suggested that tortoise farms in the countries of origin of the Mediterranean species should be established. The farmed animals then could satisfy the needs of those genuinely interested in maintaining and breeding tortoises under captive conditions.

I am in favour of such enterprises if they are worked out along sound biological and logistic lines. However, the first and most noble task for such enterprises would be the propagation of specimens to be released in suitable, protected habitats. If such areas are not yet available, specimens should be maintained in relatively close quarters until the time for release is ripe.

Kirsche who started his breeding projects with *Testudo hermanni hermanni* (1967) and *Testudo horsfieldii* (1971) has given proof that success is possible even in countries outside the natural range of the species.

The status of the subspecies *Testudo hermanni robertmertensi* is more precarious than that of the nominate form. It suffers not only under the heavy pressure of collectors—some of which finance their vacations to the Mediterranean Sea—but also from the annual bush-fires which destroy the habitat, and which lower the density necessary for a viable population. The creation of strict biological reserves in the Maures and Esterel mountains in France and on Corsica are indispensable. Only after reserves like these have been established, may we consider reintroducing specimens from the small captive stock held by amateurs and zoos in Europe (Honegger, 1978).

Exhibiting tortoises in a public terrarium can become an important tool in conservation. In a pleasant manner we have the ability to educate the general public that the large majority of tortoises imported into the country are being consumed by the pet-trade, *i.e.* by the numerous amateurs, who keep tortoises simply out of curiosity and not by the zoological gardens. In Switzerland we are, at present, under the impression that educational displays, together with repeated press releases, have decreased the number of imported tortoises.

One group of Squamata which is neglected by almost all zoos with respect to their breeding over multiple generations are the lizards of the family *Lacertidae*, especially those of the Mediterranean region. The potential threat to some of these forms, mainly the isolated subspecies, is the increasing pressure brought by collectors for the pet-trade. Although few exact figures are available concerning specimens collected on each island, we know that *Podarcis pityusensis formenterae*, *P. p. maluquerorum* and *P. p. kameriana* were offered in the late 1970s by several pet-dealers in West Germany. Other island forms appear regularly on dealers' price lists. Sometimes, they are offered by amateurs returning from a collecting trip. Apparently the mortality rate is high.

Another threat to isolated forms may be the purely scientific interest to study island forms, or to observe reactions of native populations after alien species have been released.

In addition, I consider the conservation status of some larger taxa, *i.e.* *Lacerta lepida* or *Lacerta pater* to be unsafe. Reasons for this might be change of micro-climate in the northern outmost parts of their range, predation by feral animals especially cats, wanton killing, destruction of habitat, suffering on inroads brought by misuse of herbicides and insecticides, and last but not least in some areas from over-collecting.

Under this aspect the success in breeding various species of the genus *Lacerta* by Langerwerf (1978) are commendable. His paper earns much attention from the herpetological community, especially in Europe. Among the taxa bred in 1977 and 1978, I pick out the 70 and 186 *Lacerta pater* which were raised.

Besides the detailed information on incubation and housing the lizards, an important part is the demonstration showing what a strictly controlled feeding and watering regime with respect to vitamins and calcium can do. Lagerwerf successfully used one teaspoon of calcium lactate and 10 000 IU/Vitamin E (water-soluble) in the drinking water and dusted the crickets prior to feeding them to the lizards. His data, I am sure, are also of great interest to the Conservation Committee of the British Herpetological Society and their efforts to save *Anguis fragilis*, *Lacerta agilis* and *Lacerta vivipara*.

*Boa constrictor* is also very common in private and public collections throughout Europe and the U.S. Under the provisions of the Washington Convention, the Swiss Government now keeps statistics on the importation of all species of wildlife.

Legal imports of *Boa constrictor*:

Year	Imports
1975	22
1976	356
1977	272
1978	188
1979	138

(Dollinger, 1976, 1977, 1978, 1979, 1980).

During the last 15 years, Zurich Zoo has bred and raised over 250 *Boa c. imperator*, which were supplied to zoos and amateurs throughout the world. During the same period, we received about 40 adult boas from amateurs. Almost all European zoos maintain their stock by accepting such "unwanted pets" from the private snake fanciers. So far we have been able to cope with the problem, especially since we consider the boas very useful specimens for demonstrating serpentine behaviour and for educational programmes for school groups in the zoo.

Earlier, we tabulated some of our data on mating time, birth and number of young, which indicated interesting regularities in reproductive behaviour within zoo collections (Honegger, 1970). The breeding success of our boas, some in their third zoo-generation, could well lead to the wrong conclusion that such a prolific species can be bred over multiple generations and thus is safe from extinction. We have observed that newly-introduced specimens into the boa group stimulate the mating behaviour of all animals, at least

seasonally. If such a stimulus is missed for various reasons, breeding results may become rare again. In the case of the boa, it is easy to rely, at least at the moment, on other specimens. The problem arises when dealing with threatened forms, where other stock is not readily available.

The Eastern Indigo snake *Drymarchon corais couperi* occurs in parts of Florida and the Georgia coastal plains. It is thought to be declining throughout its range. It is considered a threatened species in the U.S. and is protected by state and federal law.

The eastern subspecies of the indigo snake is a large and glossy animal, having a uniform black or purplish body with markings of red, coral or cream around the chin and the cheeks. The docile nature and handsome appearance of this non-venomous species give it a high value in the pet-trade. The demand for the indigo snake combined with habitat destruction, highway-fatalities, and possibly the influence of pesticides, led to a noticeable decline throughout its range. Pet-dealers were selling average-sized adults for up to \$250 per specimen in 1977.

Legal protection, propagation, establishment of sanctuaries, restocking and restrictions on gassing gopher tortoise burrows (to mainly collect rattlesnakes), have been called for as conservation measures (Speake *in litt.*, 1978).

A Florida amateur, Terrence Whitacer (pers. comm.) started propagating the nominate race *Drymarchon corais corais* from South America regularly in 1975. His experiences led him to believe that rapid fluctuating winter temperatures and controlled photo-periods were the most important factors that triggered reproduction in *Drymarchon*. His work proves that a serious amateur not only can achieve most remarkable results but also could assist local conservation projects, *i.e.* supplying captive-bred specimens with known locality records for sound restocking programmes.

The prospects of restocking *Drymarchon corais couperi* appears good in large areas of wild country if the snakes can be protected from collectors and from gassing of gopher tortoise burrows by rattlesnake-hunters. At the same time, conservationists are to make every effort to publicize the protection of the snake.

A special education programme within the zoo's terrarium, with the aid of the mass media, was initiated by the Atlanta Zoo, U.S.A., towards the protection, recovery and management of *Drymarchon corais couperi* (Lawler, 1978).

The Austrian herpetologist Werner described *Vipera lebetina schweizeri* from the Cyclades islands of Milos, Kimolos, Polinos, Siphos, and possibly Kythnos in 1935. The Lebetina viper, also called the blunt-nosed viper, lives in the so-called Potomos, dried out riverbeds and in the adjacent vegetation and rocky outgroups. The entire population is estimated at about 3000 to 5000 specimens (H. Kratzer, pers. comm.)

*Vipera lebetina schweizeri* has long been a snake which has great appeal to European amateurs. Today, it looks as if this taxa, of which there are two colour phases, a grey and a red one, is becoming somewhat of a status symbol. During recent years, the numbers of requests from the U.S. for this island form also have increased. Almost all these orders, placed

with amateur collectors, originate from laboratories and private buyers.

However, the major threat to the isolated populations does not originate from amateurs but from a scheme set up by the Greek Government to eradicate this snake.

According to reliable information, in 1971 and 1972 at least 1500 *V. l. schweizeri* were killed under a bounty system initiated by the Greek Department of Agriculture. A bounty is paid locally for every snake killed and delivered on Milos. The figures for 1976 shows over 1000 snakes killed in one year. This scheme apparently was initiated to destroy the venomous snakes which could be harmful to tourists visiting the islands.

The bounty system is not only detrimental to *V. l. schweizeri*, but also to other island endemics such as *Natrix natrix schweizeri* and *Lacerata trilineata hansschweizeri* which are killed by mistake.

*Vipera lebetina schweizeri* is being kept by a large number of European herpetologists. The first captive breeding was observed by Tierpark Dählhölzli in Berne in 1978. A female, captured in 1974, laid 11 eggs, from which one young hatched. In 1979 the same female laid 8 eggs, again from which one young hatched. Although the actual copulation was not observed, the animal was engaged in active courtship behaviour during both years (K. Robin & H. Triet, *in litt.*, 1980). All other reported egg-laying is from females gravid when captured. *V. lebetina schweizeri* is listed as a vulnerable species in the Red Data Book (Honegger, 1975a). At present there is no need for a revision of the data sheet. However, it must be stressed that serious efforts in captive-breeding of this unique island form would be most welcome, not only to increase our knowledge of this taxon, but also to make some captive individuals available to a larger herpetological community. Last but not least, to demonstrate to the Greek authorities the scientific value of this unique subspecies.

### CONCLUSION

Through specialization and concentrated effort, our knowledge of amphibian and reptile propagation has increased considerably during recent years. For some taxa, we now can rely, at least locally, on captive-bred stocks. However, a large number of species has still to be collected in the wild, where more and more species become threatened. To avoid duplication of trial and error due to lack of expertise and to exchange matching specimens, zoos and private amateurs have to co-operate more closely for the sake of conservation of rare and threatened species. Breeding relatively common taxa under artificial conditions offers a chance to study problems involved in captive breeding. Such well-planned studies could later be used as guidelines when dealing with threatened forms.

The breeding of threatened forms in their area of distribution must be encouraged. Specimens can either be loaned to enlarge small breeding stocks or for reintroduction in reserves. Any such project will stimulate local interest in rare species, and will eventually

aid in its conservation. Reintroduction, or restocking, in the wild needs careful planning, expert supervision and a long-term follow-up to assure that the measures taken are successful.

Whatever the justification for captive-breeding programme is, one must carefully avoid the impression that captive propagation of amphibians and reptiles can be conducted instead of sound conservation programmes in the wild.

### REFERENCES

- Blatt, G. & Muller, P. (1975). Die Mortalitätstrate importierter Schildkröten im Saarland. *Salamandra* **10**, 115–125.
- Dollinger, P. (1976). 1st Annual Report to IUCN on the Management of the Convention on International Trade in Endangered Species of Wild Fauna and Flora in Switzerland. *Swiss Federal Veterinary Office, Berne*.
- Dollinger, P. (1977). 2nd Annual Report to IUCN on the Management of the Convention in International Trade in Endangered Species of Wild Fauna and Flora in Switzerland. *Swiss Federal Veterinary Office, Berne*.
- Dollinger, P. (1978). 3rd Annual Report to IUCN on the Management of the Convention on International Trade in Endangered Species of Wild Fauna and Flora in Switzerland. *Swiss Federal Veterinary Office, Berne*.
- Dollinger, P. (1979). 4th Annual Report to IUCN on the Management of the Convention on International Trade in Endangered Species of Wild Fauna and Flora in Switzerland. *Swiss Federal Veterinary Office, Berne*.
- Dollinger, P. (1980). 5th Annual Report to IUCN on the Management of the Convention on International Trade in Endangered Species of Wild Fauna and Flora in Switzerland. *Swiss Federal Veterinary Office, Berne*.
- Haga, J. (1970). Turtle farming. *International Turtle and Tortoise Society Journal* **3**, 6–8.
- Honegger, R. E. (1970). Beitrag zur Fortpflanzungsbiologie von *Boa constrictor* und *Python reticulatus*. *Salamandra* **6**, 73–79.
- Honegger, R. E. (1975a). *Red Data Book. III. Amphibia/Reptilia*. IUCN, Morges, Switzerland.
- Honegger, R. E. (1975b). Breeding and maintaining reptiles in captivity. In *Breeding endangered species in captivity*. Martin, R. (Ed). London: Academic Press.
- Honegger, R. E. (1978). *Study on threatened amphibians and reptiles in Europe*. Strasbourg, Council of Europe.
- Honegger, R. E. (1979). *Red Data Book. III. Amphibia/Reptilia*. Revised edition. IUCN, Morges, Switzerland.
- Hoogmoed, M. S. (1969). Notes on the herpetofauna of Surinam. III. A new species of dendrobatids (*Amphibia Salientia, Dendrobatidae*) from Surinam. *Zoologische Mededelingen, Leiden* **44**, 133–141.
- Judd, H. L., Bacon, J. P., Ruedi, D., Girard, J. & Benirschke, K. (1977). Determination of sex in the Komodo dragon, *Varanus komodensis*. *International Zoo Yearbook* **17**, 208–209.
- Kerbert, C. (1905). Ueber die Eier und Larven von *Megalobatrachus maximus* Schl. *6ieme Congres Internationale de Zoologie, Berne*, 1904, 289–294.
- Kirsche, W. (1967). Zur Haltung, Zucht und Ethologie der griechischen Landschildkröte, *Testudo hermanni hermanni*. *Salamandra* **3**, 36–66.
- Kirsche, W. (1971). Zur Pflege und Zucht der steppenschildkröte, *Testudo horsfieldii* Gray. *Aquarien Terrarien* **18**, 84–86, 118–120, 158–160, 198–200.
- Kirsche, W. (1979). The housing and regular breeding of Mediterranean tortoises, *Testudo* spp., in captivity. *International Zoo Yearbook* **19**, 42–49.

- Langerwerf, B. A. W. (1978). Die erfolgreiche Zucht nicht-tropischer Echsen. *Elaphe* **1**, 2-5; **2**, 15-17.
- Lawler, H. E. (1978). A zoological contribution to practical wildlife conservation. *AAZPA Regional Workshop Proceedings 1977-1978, Special Publication*, pp. 421-425.
- Leyhausen, P. (1977). Breeding endangered species. *Oryx* **13**, 427-428.
- Martin, R. D. (Ed) (1975). *Breeding endangered species in captivity*. London: Academic Press.
- Mudrack, W. (1969). Pflege und Zucht eines Blattsteigerfrosches der Gattung *Phyllobates* aus Ekuador. *Salamandra* **5**, 81-84.
- Nace, G. W., Culley, D. D., Emmons, M. B., Gibbs, E. L., Hutchinson, V. H. & McKinnell, R. G. (1974). *Amphibians. Guidelines for the breeding, care and management of laboratory animals*. Washington, D.C.: National Academy of Sciences.
- Nickerson, M. (1978). Maintaining hellbender salamanders in captivity. The evolution of our knowledge. *AAZPA Regional Workshop Proceedings 1977-1978*, 396-399.
- Nickerson, M. & Mays, C. E. (1973). The hellbenders. North America's giant salamanders. *Publications in Biology and Geology No 1 Milwaukee Public Museum* **1**, 1-106.
- Oeser, R. (1932). Die Zucht des Baumsteigers, *Dendrobates tinctorius*. *Blätter für Aquarien und Terrarienkunde* **43**, 196-200.
- Olney, P. J. S. (Ed) (1976). *International Zoo Yearbook*, vol. 16.
- Olney, P. J. S. (Ed) (1978). *International Zoo Yearbook*, vol. 17.
- Olney, P. J. S. (Ed) (1978). *International Zoo Yearbook*, vol. 18.
- Olney, P. J. S. (Ed) (1979). *International Zoo Yearbook*, vol. 19.
- Polder, W. N. (1973). Pflege und Fortpflanzung von *Dendrobates azureus* und andern Dendrobatiden. *Die Aquarien und Terrarien zeitschrift* **26**, 424-428.
- Polder, W. N. (1974). Pflege und Fortpflanzung von *Dendrobates azureus* und andern Dendrobatiden. *Die Aquarien und Terrarien Zeitschrift* **27**, 28-32.
- Rimpp, K. (1978). *Salamander und Molche*. Stuttgart: Ulmer.
- Ruedi, D., Girard, J. & Heldstab, R. (1977). Geschlechtsbestimmung bei Reptilien mit Hilfe des Testosterons. *Verh. XIX. International Symposium Erkrankungen Zootiere, Posnan*, 141-145.
- Senfft, W. (1936). Das Brutgeschäft des Baumsteigerfrosches, *Dendrobates auratus* Girard, in Gefangenschaft. *Der Zoologische Garten (N.F.)* **8**, 122-131.
- Silverstone, Ph. A. (1975). A revision of the poison-arrow frogs of the genus *Dendrobates* Wagler. *Natural History Museum of Los Angeles Science Bulletin*, **21**, 1-55.
- Silverstone, Ph. A. (1976). A revision of the poison-arrow frogs of the genus *Phyllobates* Bibron in Sagra (Family Dendrobatidae). *Natural History Museum of Los Angeles Science Bulletin* **27**, 1-53.
- Weygoldt, P. (1976a). Beobachtungen zur Biologie und Ethologie von *Pipa (Hemipipa) carvalhoi*. *Mir. Rib. 1937, Anura Pipidae. Zeitschrift für Tierpsychologie* **40**, 80-99.
- Weygoldt, P. (1976b). Beobachtungen zur Fortpflanzungsbiologie der Wabenkröte *Pipa carvalhoi*. *Mir. Rib. Zeitschrift des Kölner Zoo* **19**, 77-84.

## THE EFFECTS OF TEMPERATURE ON THE BREEDING MIGRATION AND SPAWNING OF THE COMMON TOAD (*BUFO BUFO*)

P. J. WISNIEWSKI, L. M. PAULL AND F. M. SLATER

*Department of Applied Biology, U.W.I.S.T., Llysdyrnau Field Centre, Newbridge-on-Wye, Llandrindod Wells, Powys, Wales*

(Received 25 September 1980)

### SUMMARY

The effects of temperature on the breeding migration of the Common Toad (*Bufo bufo* L.) are described. The number of toads captured on the perimeter of Llandrindod Lake was positively correlated with air and water temperature in the pre-spawning period. A threshold air temperature of 3.3°C was calculated for both sexes. Differences in water temperature at the breeding pond seemed to have no influence on the spawning date between three populations in the Llandrindod Wells area.

### INTRODUCTION

Temperature constraints on the breeding activity of bufonid toads have been documented by several authors (Bragg, 1940; Frazer, 1966; Heusser, 1968; Heusser & Ott, 1968; Gittins *et al.*, 1980) and each has attempted to fit threshold temperatures to the populations they studied. The influence of water temperature on the spawning date has also been discussed by Heusser & Ott (1968). In general such temperature thresholds have been found to be strongly population specific even between colonies separated by a very short distance (Frazer, 1966). The present study attempts to identify the threshold temperatures for a large population of Common Toads (*Bufo bufo* L.) visiting a breeding lake at Llandrindod Wells, Mid-Wales.

### METHODS

During three breeding seasons (1978-1980) toads were collected from the perimeter road and path of Llandrindod Lake and these were sexed, counted and marked for population estimate purposes, before being released at the end of the evening's work. Collections were made on hourly circuits each evening, from late February onwards. The number of collecting circuits was dependent upon toad activity which varied with air temperature. In 1978, collection continued throughout the night except when the temperature fell below 4°C when only two circuits were made. In the following years three circuits were made each evening and only one on cold nights.

In all three years the temperatures of the surface water of the lake and the air above the lake were measured at dusk each evening as was (except in 1980)

the temperature of the soil at a depth of 10 cm. In 1979 and 1980, readings were also taken hourly throughout the evening, before each circuit. Maximum and minimum temperatures for the preceding twenty-four hours were recorded at dusk for air and water, during the 1979 and 1980 seasons and also for soil, in 1979. To assess the effect of water temperature on spawning date, maximum and minimum values were also obtained, in 1979, for two other toad spawning sites, Pentrosfa Pond, 0.75 km south-west and Llanfawr Quarry, 1.0 km north-east of the Lake. From known behaviour patterns the spawning date at the Lake was taken to be that date on which spent females were observed migrating back across the road and path while at the other two ponds where visual assessment was easier, it was the date on which spawn was first recorded.

### RESULTS

#### EFFECT OF AMBIENT TEMPERATURE

Gittins *et al.* (1980) provided results for the 1978 breeding season at the Lake. They found a high correlation ( $P < 0.001$ ) between the number of male and female toads caught in the first two collecting rounds and the soil temperature at dusk. High correlations were also found between male numbers and both air and water temperatures at dusk.

During the following two seasons, data were obtained before each collecting round to enable a more accurate description of temperature effects. In 1979, the number of male toads collected showed a high correlation with air, soil and water temperature ( $P < 0.001$ ) while females showed the highest correlation with water temperature ( $P < 0.01$ ). These data are summarized in Table I. For both sexes, consistently better correlation was found before spawning had occurred. In 1980, fewer data were collected and, because of interference with toads by visitors, these data were less reliable. Both sexes showed higher correlation with water temperature than with air temperature in 1980 and once again pre-spawning data were more highly correlated than those for the post-spawning period (Table I).

An attempt at correlating the maximum and minimum temperatures of the air, soil and water, for the preceding 24 hr with the number of toads captured in the first two circuits of the Lake proved largely unsuccessful, and no significant relationship could be found except for female toads. In both years, the

TABLE I. Relationship between toad numbers per circuit and external temperature 1 = data for whole period; 2 = data for pre-spawning period; 3 = data for post-spawning period

			1979			1980		
			Corr Coeff	<i>n</i>	<i>P</i>	Corr Coeff	<i>n</i>	<i>P</i>
Male nos	v. air temp	1	0.62	57	<0.001	0.41	39	<0.01
		2	0.71	38	<0.001	0.80	26	<0.001
		3	0.53	19	<0.05	-0.11	11	N.S.
	v. soil temp	1	0.59	56	<0.001	—	—	—
		2	0.76	37	<0.001	—	—	—
		3	0.42	19	N.S.	—	—	—
	v. water temp	1	0.47	56	<0.001	—	—	—
		2	0.69	29	<0.001	0.80	22	<0.001
		3	0.24	19	N.S.	—	—	—
Female nos	v. air temp	1	0.36	43	<0.05	0.19	32	N.S.
		2	0.52	24	<0.01	0.58	21	<0.01
		3	0.09	19	N.S.	-0.14	11	N.S.
	v. soil temp	1	0.24	43	N.S.	—	—	—
		2	0.43	24	<0.05	—	—	—
		3	-0.03	19	N.S.	—	—	—
	v. water temp	1	0.48	43	<0.01	—	—	—
		2	0.65	24	<0.01	0.79	18	<0.001
		3	0.32	19	N.S.	—	—	—

TABLE II. Mean maximum and minimum water temperatures (°C) at three toad breeding sites in the Llandrindod Wells area

	Llandrindod		
	Lake	Pentrosfa	Llanfawr
Mean max. temp.	12.45	9.68	9.00
Mean min. temp.	3.08	4.61	3.50

number of females showed some correlation with the maximum air, water and in 1979, the soil temperatures ( $P < 0.05$ ), though this is not surprising considering the good correlation between these three temperature regimes.

#### THRESHOLD AIR TEMPERATURE

In 1979, the lowest air temperature at which male toads were still observed moving to or from the Lake was 2°C and for females 4°C. In 1980 the minimum temperatures were 2.5°C for males and 3.5°C for females. Only one or two individuals were concerned in all of these cases.

Gittins *et al.* (1980) calculated the threshold air temperature by regression, as 3.8°C for males and 4.1°C for females in 1978.

Since toad numbers were only highly correlated with air temperature before spawning, the threshold temperature for movement to the lake was calculated from 1979 and 1980 data. For 1979, the temperature was calculated as 3.1°C for males and 3.2°C for females while in 1980 it was found to be 3.6°C for males and 2.8°C for females. Combining the data for both sexes in both years gives a threshold temperature of 3.3°C.

#### EFFECT OF TEMPERATURE ON SPAWNING DATE

In addition to data from Llandrindod Lake, information was collected for Pentrosfa Pond and Llanfawr Quarry. These both contain smaller populations of toads, a maximum of 1350 having been counted at Pentrosfa Pond in 1979 and 1200 at Llanfawr Quarry

as opposed to an estimated 8000 toads at the Lake. All three breeding sites had different water temperature regimes (Table II) but spawning occurred on the same date (15th April) in 1979.

#### DISCUSSION

Several factors are undoubtedly involved in the initiation of the spawning migration of the Common Toad. Heusser (1968) and Heusser & Ott (1968) state that temperature and rainfall complement internal factors ensuring that migration does take place even under unfavourable conditions. They concluded that migration is controlled primarily by the time of the year and certainly this species is remarkably consistent in the timing of its breeding season (Boulenger, 1912; Cooke, 1977; Gittins *et al.*, 1980). This fact is borne out by observations at the Lake in February 1980 for, although the evening temperature was sufficiently high to allow movement on several consecutive nights, no toads were seen, suggesting that a day length factor may have been operating. Climatic thresholds probably act as checks, reducing the chance of spawn being produced during severe weather. The effect of rainfall is unclear. Gittins *et al.* (1980) found no significant difference between the median number of male toads collected, in the first two rounds, on wet and dry nights. Personal observation suggests, however, that the first major movement to the Lake coincides with a mild, wet evening although on subsequent evenings, rainfall is not essential to movement.

That evening temperature is important in governing the migration to the Lake is indicated by the data although these effects are sometimes reflected better by air, water or soil temperatures. The number of toads active at the Lake perimeter is, however, most consistently correlated with air and water temperature and this is especially true of the pre-spawning period. Once in the Lake toads are not directly influenced by ambient air temperatures and so probably do not respond to it. This may explain why, after spawning,

activity does not appear to be related to air temperature or alternatively it may be indicative of the change, noted by Heusser (1968) from a critical breeding temperature of activity to a higher critical summer temperature of activity. The water temperature might be expected to influence migration from the Lake but this is not implicit in the data for 1979. Gittins *et al.* (1980) did note some movement from the Lake when the air temperature was below 4°C and the water temperature was above this critical level (as calculated by regression analysis) and the movement of the animals became increasingly sluggish with distance from water. Threshold air temperatures calculated for the pre-spawning periods in 1979 and 1980 suggest, however, that their estimates may be a little high and that the critical temperature for pre-spawning activity is about 3.3°C, there being no real difference between the sexes. This critical temperature is probably population specific as Frazer (1966) mentions that toads at St Ives moved to the pond when the air temperature was about 7°C while an Exmouth population had a higher critical temperature, and Heusser (1968) states that the critical temperature for breeding activity was found to be 5–6°C for a Swiss population.

The threshold water temperature for spawning has been shown, by Frazer (1966) and Heusser & Ott (1968), to influence spawning date directly, populations from colder ponds breeding later even where the spatial separation is small. However, no difference in spawning date could be detected between the three populations in the Llandrindod Wells area despite the fact that Llandrindod Lake had a much higher mean maximum water temperature (nearly three centigrade degrees higher than the other sites) while Pentrosfa Pond had a mean minimum temperature one degree higher than either the Lake or Llanfawr Quarry.

## ACKNOWLEDGEMENTS

We wish to thank the Department of Applied Biology, U.W.I.S.T., Cardiff and the Llysdynam Trust for facilities and assistance provided.

## REFERENCES

- Boulenger, G. A. (1912). Some remarks on the habits of British frogs and toads with reference to Mr. Cummings's recent communication on distant orientation in Amphibia. *Proceedings of the Zoological Society of London* 1912, 19–22.
- Bragg, A. N. (1940). Observations on the ecology and natural history of Anura. 1. Habits, habitat and breeding of *Bufo cognatus* Say. *The American Naturalist* 74, 424–438.
- Cooke, A. S. (1977). Spawning dates of the frog (*Rana temporaria*) and the toad (*Bufo bufo*) in Britain. *British Journal of Herpetology* 5, 585–589.
- Frazer, J. F. D. (1966). A breeding colony of toads (*Bufo bufo* L.) in Kent. *British Journal of Herpetology* 3, 236–252.
- Gittins, S. P., Parker, A. G. & Slater, F. M. (1980). Population characteristics of the Common Toad (*Bufo bufo*) visiting a breeding site in Mid-Wales. *Journal of Animal Ecology* 49, 161–173.
- Heusser, H. (1968). Die Lebensweise der Erdkröte, *Bufo bufo* (L.); Wanderungen und Sommerquartiere. *Revue Suisse de Zoologie* 75, 927–982.
- Heusser, H. & Ott, J. (1968). Wandertrieb und populations—spezifische Sollzeit de Laichwanderung bei der Erdkröte, *Bufo bufo* (L.). *Revue Suisse de Zoologie* 75, 1005–1022.

## STUDIES ON A CASE OF PAPILLOMATOSIS IN THE EYED LIZARD *LACERTA LEPIDA*

A. LOPEZ AND J. BONS

*Laboratoire de Pathologie comparée et Laboratoire de Biogéographie et Ecologie des Vertébrés E.P.H.E.,  
Place E. Bataillon 34060, Montpellier, France*

(Received 22 February 1980)

### SUMMARY

A striking case of cutaneous papillomatosis is reported in *Lacerta lepida*. The tumours, showing a similar basic histological pattern, involved eyelids on both sides, the whole margin of cloaca, femoral pores and part of one hind foot. They are, probably, a fungal disease.

### INTRODUCTION

Papillomas of the skin are the most frequent tumours of lizards. These fibroepithelial new growths, often multiple (Papillomatosis), display a characteristic papillary structure. Although histologically benign, they can lead to the animal's death by occluding natural orifices.

Papillomas have been described in *Lacerta muralis*, *Lacerta agilis* (Koch, 1904; Stolk, 1953) and, chiefly in *Lacerta viridis* (Blanchard, 1890; Plehn, 1911; Schnabel, 1954; Raynaud & Adrian, 1976, 1977; Harshbarger, 1965–1977). To our knowledge, a single case has hitherto been reported in *Lacerta lepida* (Reichenbach-Klinke, 1977: fig. 149a).

Causes of the lesions are still debated. Fungi (Blanchard, 1890), acarions and physical injuries have been successively suggested. The present-day trend is to ascribe the disease to a viral agent. Evidence for this is either indirect, such as nuclear inclusion bodies in tumour epithelial cells (Harshbarger, RTLA No. 1821) or direct, such as viral particles (Raynaud & Adrian, 1976, 1977).

We have recently observed an extensive tumoral process in *Lacerta lepida*, as remarkable as the first above-mentioned case but differing in its main pelvic localizations. This paper reports the morphological traits of the lesions and discusses their probable aetiology.

### METHODS

The diseased lizard, an immature male 100 + 115 mm long, was examined macroscopically just after its death then photographed in the laboratory.

Every tumour was totally excised with subcutaneous fat and muscles, fixed afterwards in Bouin's fluid and included finally in paraffin. The serial slides were stained with hematoxylin–eosin–orange G, Masson's

trichrome and Hotchkiss–McManus technique (PAS), the latter being of great value to demonstrate fungi (Kligman, Mescon & De Lamater, 1951).

### RESULTS

#### MACROSCOPY

Tumours injured the eyelids on both sides, the whole margin of cloaca and the hind-limbs. In every localization, tumours appeared as brown rough bark-like outgrowths, very protruding and more or less pedicellate. On the eyelids, they were low and gathered in little clusters overhanging directly the cornea. The cloaca was completely encircled by long slender projections forming a kind of collar (Fig. 1). Each hind limb bore a linear range of big excrescences situated along femoral pores and thus simulating long pendants hanging from the thighs (Fig. 1). Another new growth lay on the right hind-foot; it involved the skin of two toes and tarsus (Fig. 1).

#### HISTOLOGY

Histologically, the whole tumoral burden of *Lacerta lepida* originates from the integument superficial layers: epidermis and loose chorion (Fig. 2). These two layers, the former being lifted by connective tissue, builds up papillary eminences uniting to constitute new-growths like other papillomas (Klein, 1952). Epithelial component derives from the whole epidermis with which it becomes united in the periphery of the lesions. Maurer

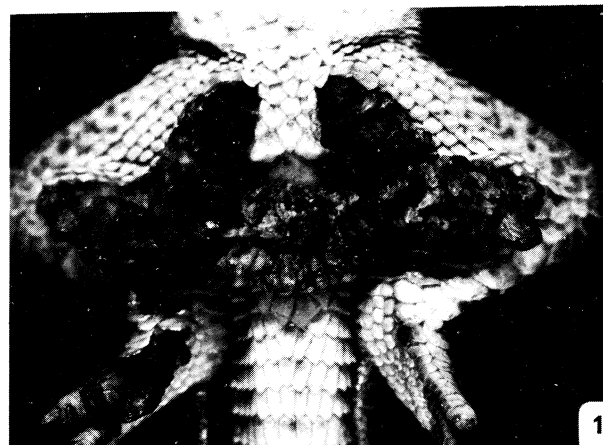


FIG. 1. Papillomatosis of cloaca, thighs and hind foot: a ventral view.

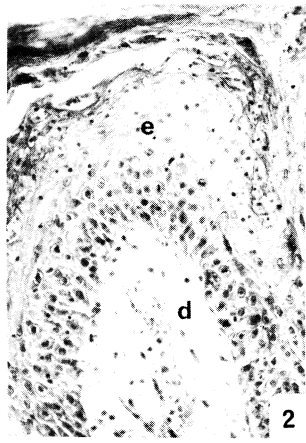


FIG. 2. Part of a femoral tumour: hyperplastic epidermis (e) and dermis (d). Hematoxylin–eosin–orange, G × 625.

strata can still be readily identified. However, the epidermicule has disappeared. The stratum corneum is greatly thickened. Its superposed lamellae keep, in some points, recognizable nuclei (parakeratosis). The stratum intermedium and stratum spinosum remain, as a whole, rather thin, but intercellular spaces are widened, here and there, by spongiosis making their bridges (desmosomes) more conspicuous. The cells do not show nuclear or cytoplasmic inclusion bodies. As for the stratum profundum, it is characterized by an important multiplication of its germinative or basal cells; they divide actively and accumulate in several layers producing a typical hyperplasia picture (Fig. 2). At every level a great number of migratory cells, heterophyl and macrophages, are seen coming from the underlying dermis (exocytosis). They insinuate into the intercellular spaces, then into the deep loose layer of the keratin coat; they tend to accumulate just under the keratin coat and there constitute microabscesses. The cornea, femoral glands and the cloaca interior are not involved. The dermis is slightly œdematous (Fig. 2) it contains dilated vessels and a chronic inflammatory infiltrate. Pigment cells, contrary to other lizard papillomas (Blanchard, 1980; Raynaud & Adrian, 1976) are always lacking. Among granuloma, numerous spongy macrophages are sometimes present; they slip through basal cells layers. They also form giant cells, either by uniting their cytoplasm or by

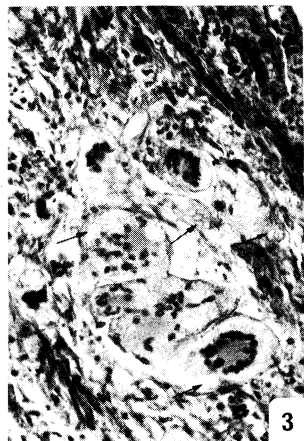


FIG. 3. Dermal foamy giant cells enclosing fungus particles (Arrows). Hematoxylin–eosin–orange, G × 625.

amitotic nucleus division. In these giant cells, which strongly resemble the Touton cells of xanthoma, the nuclei lie near the centre, gathered around a small chromophilous island and are surrounded by foamy cytoplasm (Fig. 3). Routine stainings suggest innumerable faintly-coloured particles lying in the whole papillary dermis, in the cytoplasm of macrophages, giant cells and, as far as the stratum corneum, between epidermal cells (stratum profundum, intermedium). A very conspicuous feature of the particles is their strongly positive reaction with PAS stain. Through this property they appear as round bodies, alone or in chains, or as discrete club-ending thread-like structures more or less segmented in appearance, lying free in the tissues or within the cytoplasm.

## DISCUSSION

Observation of papillomas in *Lacerta lepida* is of interest for tumour appearance and their aetiological factor. Important size is determined by developmental exuberancy, seldom encountered elsewhere (Reichenbach-Klinke, 1977). It does not imply, however, a locally expanding malignant process, because the tumoral epithelium is strictly devoid of neoplastic character: squamous cells are well differentiated and atypicalities, such as individual keratinization, nuclear hyperplasia and hyperchromasia, are absent; in addition, they do not invade the underlying chorion. Similarly, widespread growth in four different body parts does not indicate a metastatic diffusion because the tumoral tissue is genuinely benign from a cytological standpoint. It follows that papillomas are due to a living infectious agent. The latter does not appear like a virus, the usual inclusion bodies and cell modifications being lacking. Its morphological features and its bright red staining by periodic acid-Schiff reaction indicates fungal cells, hyphae and spores, the walls of which contain large amounts of polysaccharide. Moreover, giant cells participating in the histological picture of granuloma are frequently encountered in other cutaneous fungal diseases (blastomycosis, cryptococcosis); their cytoplasm encloses similar phagocytized parasitic organisms. It follows therefore that papillomas of the eyed lizard may be attributed, in the present case, to a fungal disease involving both the dermis, where a macrophagic afflux is triggered, and the epidermal covering. This epithelium reacts against infestation by a hyperplasia of its actively dividing basal cells and by consecutive hyperkeratosis.

A long time after Blanchard (1980) demonstrated *Selenosporium* in tail papillomas of *Lacerta viridis*, we prove again fungal interference in lacertid oncogenesis. However, in the absence of other laboratory and epidemiologic data, we are still ignorant of the systematic position and inoculation modalities of this pathogenic agent.

## REFERENCES

- Blanchard, R. (1890). Sur une remarquable dermatose causée chez le lézard vert par un champignon du genre *Selenosporium*. *Mémoires Société Zoologique de France* **3**, 241–255.

- Harshbarger, J. C. (1965–1977). No. 482, 1389, 1524, 1821 in Registry of Tumours in Lower Animals. Activities report registry: 1965–1977. Smithsonian Institution, Washington, D.C.
- Klein, B. M. (1952). Die Borkengeschwulst der Eidechsen. *Mikrokosmos* **42**, 49–52.
- Kligman, A. M., Mescon, H. & de Lamater, E. D. (1951). The Hotchkiss–McManus stain for the histopathologic diagnosis of fungus diseases. *American Journal of Clinical Pathology* **21**, 86.
- Koch, M. (1904). Demonstration einiger Geschwülste bei Tieren. *Verhandlungen der Deutschen Pathologischen Gesellschaft* **7**, 136–147.
- Plehn, M. (1911). Über Geschwülste bei niederen Wirbeltieren. *2e Conference Internationale Etude Cancer*, 221–242.
- Raynaud, A. & Adrian, M. (1976). Lésions cutanées à structure papillomateuse associées à des virus chez le lézard vert (*Lacerta viridis* Laur). *C. R. Acad. Sci. Paris* **283**, D: 845–847.
- Raynaud, A. & Adrian, M. (1977). Papillomes cutanés chez *Lacerta viridis*; étude histologique et mise en évidence de virus au moyen de la microscopie électronique. *Bulletin de Société Zoologique de France* **102**, 493–494.
- Reichenbach-Klinke, H. H. (1977). *Krankheiten der Reptilien*. Stuttgart & New York: Gustave Fischer Verlag.
- Schnabel, R. (1954). Papillome an einer Smaragdeidechse (*Lacerta viridis*). *Zoologische Garten* **20**, 270–278.
- Stolk, R. (1953). Hyperkeratosis and carcinoma planocellulare in the lizard, *Lacerta agilis*. *Koninklijke Nederlandse Akademie van Wetenschappen C*, **56**, 157–163.

## PHYSICAL PROPERTIES OF SURFACTANT FROM THE LUNGS OF THE NORTHERN LEOPARD FROG, *RANA PIPIENS*

C. MEBAN

*Medical Biology Centre, The Queen's University of Belfast, 97 Lisburn Road, Belfast BT9 7BL, Northern Ireland*

(Received 22 April 1980)

### SUMMARY

Surfactant was removed from the lungs of *Rana pipiens* by saline lavage and purified by centrifugation. It was found that interfacial films of surfactant generated high surface pressures and surface potentials under both static and dynamic conditions; the shear viscosity of the films was relatively low. The results suggest that the surface activity of frog lung surfactant is similar to that of mammalian lung surfactant.

### INTRODUCTION

It is now widely accepted that the distal air spaces of mammalian lungs are lined by films of a highly surface-active lipoprotein ("pulmonary surfactant"). These films are located at the air–fluid interfaces and they are believed to contribute to the mechanical stability of the alveoli and respiratory bronchioles (for reviews, see Goerke, 1974; King, 1975). Interfacial films of mammalian lung surfactant have been studied *in vitro* and much is known about their surface properties (Watkins, 1968; Morley, Bangham, Johnson, Thorburn & Jenkin, 1978; Bangham, Morley & Phillips (1979). Pulmonary surfactant has also been detected in poikilotherms (Pattle & Hopkinson, 1963; Hitchcock & Parsons, 1977) but, as yet, the physical properties of this material have not been determined.

This paper presents the results of a study of the surface activity of surfactant from the lungs of the northern leopard frog, *Rana pipiens*.

### MATERIALS AND METHODS

Twenty mature frogs (*Rana pipiens*) were obtained from a commercial supplier and inspected to ensure that they were free from disease. The frogs were pithed and a needle was inserted into each lung. Four 3 ml aliquots of 0.145 M sodium chloride solution were instilled and withdrawn through each needle. The lavage fluid obtained was centrifuged at  $800 \times g$  for 5 min. The density of the supernatant was adjusted to 1.10 with sodium chloride and recentrifuged at  $100\,000 \times g$  for 1 hr. The surfactant was recovered from the centrifuge tubes as visible bands. The phospholipid content of a sample of each extract was determined by Bartlett's (1959) procedure of perchloric acid digestion.

Interfacial films were formed by adding measured quantities of surfactant extract to the surface of a subphase solution (Ringer) solution buffered with 0.01 M Tris-HCl, pH 7.35) using a microsyringe. A Wilhelmy expansion–compression balance was used to measure the surface pressure of the films. The platinum dipping-plate was suspended from a Cahn electro-balance (sensitivity 0.1 mN/m). Film pressure was measured under static conditions in a Dawson (1966) trough. The film potential was determined simultaneously using an air electrode (containing  $^{210}\text{Po}$  as an alpha particle emitter), an electrometer, and a saturated calomel electrode in the subphase. The film viscosity was measured using a rotary traction viscometer (sensitivity  $1 \times 10^{-4}$  g sec $^{-1}$ ) by the method described by Meban (1978a). The temperature of the subphase was controlled in each apparatus by placing the subphase container in a thermostated water bath.

In each experiment the film concentration was expressed as a *surface coverage* (i.e., the area of subphase surface available per mg of surfactant phospholipid). Measurements were made on eight films in each instance and the results are reported as mean values  $\pm$  S.E.M.

### RESULTS

Examples of the surface pressure-area isotherms obtained in the Wilhelmy balance with lung extract under dynamic conditions are illustrated in Fig. 1. The isotherms show considerable hysteresis, even after repeated cycling. Increasing the subphase temperature in steps over the range 10–25°C caused a modest decrease in the maximum pressure generated by the films (Table I). Prolonged cycling (e.g. for 10–20 cycles) caused no appreciable change in the maximum pressure of the films. The compressibility and the stability index of each film was computed using the formulae of Clements, Hustead, Johnson & Gribetz, 1961 and King & Clements, 1972. Concentrated films (i.e. those with low surface coverages) were found to be relatively incompressible and stable. For example, films with a coverage of 0.8 cm $^2$ /μg phospholipid had a compressibility of 0.035 m/mN and a stability index of 1.57.

In the static experiments using the Dawson trough, the surface pressure of the films increased progressively as their surface coverage was reduced. Again, the maximum film pressure was dependent on the subphase

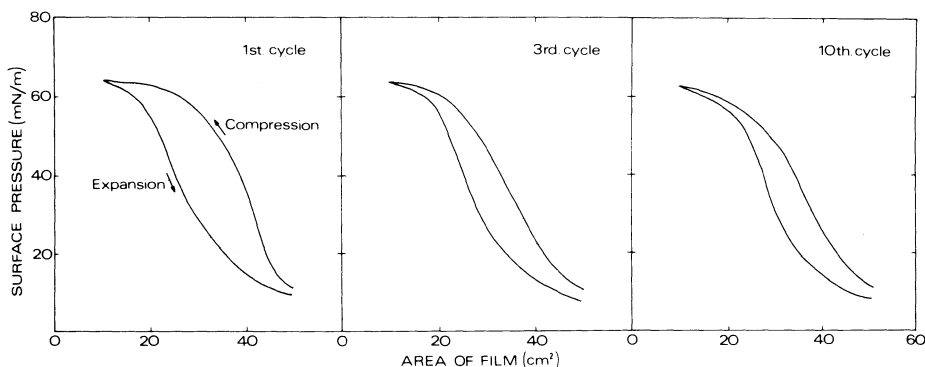


FIG 1. Compression-expansion isotherms of a surfactant film on different cycles of the Wilhelmy balance. Film surface coverage  $0.8 \text{ cm}^2/\mu\text{g}$  phospholipid; subphase temperature  $10^\circ\text{C}$ .

TABLE I. Relationship between temperature and the maximum surface pressure of surfactant films

Temperature of subphase ( $^\circ\text{C}$ )	Maximum surface pressure (mN/m)*
10	$69.4 \pm 5.9$
15	$67.8 \pm 5.9$
20	$64.5 \pm 5.2$
25	$60.7 \pm 5.3$

\* Mean  $\pm$  S.E.M. of measurement on 8 films in the Wilhelmy balance.

TABLE II. Influence of temperature on the surface viscosity of surfactant films

Temperature of subphase ( $^\circ\text{C}$ )	Surface viscosity ( $\text{g sec}^{-1} \times 10^3$ )*
10	$4.0 \pm 0.4$
15	$3.9 \pm 0.3$
20	$3.1 \pm 0.4$
25	$2.5 \pm 0.2$

\* Mean  $\pm$  S.E.M. of measurements on 8 films.

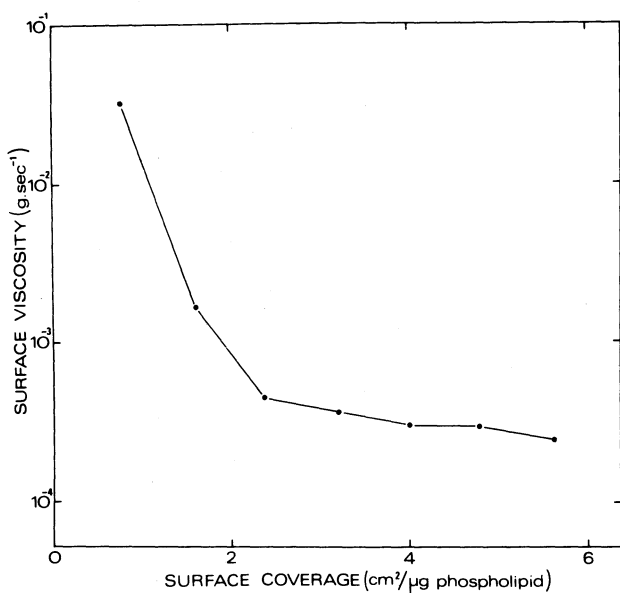


FIG. 2. Semilogarithmic plot of surfactant film viscosity against surface coverage. Subphase temperature  $20^\circ\text{C}$ ; viscometer rotation speed 2 revolutions/min; each point represents the mean of 8 measurements.

temperature, being  $48.4 \pm 3.6 \text{ mN/m}$  at  $10^\circ\text{C}$  and  $39.9 \pm 2.5 \text{ mN/m}$  at  $25^\circ\text{C}$ . The pressure of concentrated films remained constant for prolonged periods of time (maximum time tested 18 hr). In all experiments it was found that the films reached the maximum pressure within a few seconds of the addition of the extract to the subphase surface.

The surface potential of the films varied with the surface coverage under static conditions, decreasing progressively from  $222 \pm 25 \text{ mV}$  at low coverage ( $0.8 \text{ cm}^2/\mu\text{g}$  phospholipid) to  $180 \pm 22 \text{ mV}$  at high coverage ( $4.0 \text{ cm}^2/\mu\text{g}$  phospholipid). Slightly higher potentials were produced under dynamic conditions: for example, the maximum potential for films with a dynamic surface pressure of  $64.4 \text{ mN/m}$  at  $20^\circ\text{C}$  was  $302 \pm 33 \text{ mV}$ .

Films of high surface coverage had a relatively low shear viscosity. However, at coverages of less than  $2.4 \text{ cm}^2/\mu\text{g}$  phospholipid the viscosity increased significantly (Fig. 2). Increasing the subphase temperature caused a modest decrease in the film viscosity (Table II). There was a critical surface coverage above which the film viscosity was independent of the rate of revolution (*i.e.* the films displayed pure Newtonian viscous flow); this coverage was  $3.2 \text{ cm}^2/\mu\text{g}$  phospholipid at  $20^\circ\text{C}$ .

## DISCUSSION

The results of this study have shown that extracts from the lungs of *Rana pipiens* spread rapidly to form coherent films at air-fluid interfaces and that the resulting films exhibit strong surface activity. Concentrated films generate surface pressure in excess of  $60 \text{ mN/m}$  when compressed and expanded in a cyclic manner for prolonged periods of time. The compressibility of these films is low while their stability index is high. Furthermore, it is possible that concentrated surfactant films of this type could exist *in vivo*. The respiratory surface of the lungs of *Rana pipiens* is about  $28 \text{ cm}^2$  (calculated from the external dimensions of the lungs and the data of Czopek, 1965) and the mean yield of phospholipid was  $75 \mu\text{g}$  per animal in this study. The surfactant content of the lungs is therefore more than twice the amount required to form a film of coverage  $0.8 \text{ cm}^2/\mu\text{g}$  phospholipid over the entire respiratory surface. Interfacial films of frog

lung surfactant therefore satisfy the criteria established for mammalian surfactant (Goerke, 1974; King, 1975).

It is significant that the phospholipid-rich surfactant from the lungs of *Rana pipiens* displays much stronger surface activity than other body fluids when spread in interfacial films. For example, the maximum surface pressure produced by concentrated films of pulmonary surfactant in the Wilhelmy balance at 20°C was  $64.5 \pm 5.2$  mN/m; in contrast, concentrated films of cutaneous mucus, serum proteins and bile had pressures of  $11.4 \pm 1.5$  mN/m,  $13.3 \pm 1.6$  mN/m and  $19.0 \pm$  mN/m, respectively under the same conditions (C. Meban, unpublished observations).

Inspection of the data shows that the viscosity of frog surfactant films increases sharply when the film coverage is reduced below a certain level ( $2.4 \text{ cm}^2/\mu\text{g}$  phospholipid). In this respect frog surfactant resembles human lung surfactant (Meban, 1978a).

It is widely believed that the principle function of surfactant in the mammalian lung is to lower the surface tension at the air-fluid interfaces within the alveoli and respiratory bronchioles and hence protect these air spaces from collapse during expiration (Pattle, 1958; Scarpelli, Clutario & Taylor, 1967; King & Clements, 1972). In the amphibian lung the walls of the terminal air spaces are much less curved than those of mammals and consequently the need for pulmonary surfactant would appear to be less. However, it must be remembered that the stabilization of lung architecture is not the sole function of surfactant. The surface activity of its films greatly decreases the amount of energy required to inflate moist air sacs (Meban, 1978b). In addition, the films probably also regulate the fluid balance in the gas-exchange region of the lung (Pattle, 1965). Thus amphibians, even those with irregular lung breathing, may benefit from the possession of lung surfactant.

#### ACKNOWLEDGEMENTS

I am grateful to Mrs S. Higgins for technical assistance and to Miss A. Richardson for typing the manuscript.

#### REFERENCES

- Bangham, A. D., Morley, C. J. & Phillips, M. C. (1979). The physical properties of an effective lung surfactant. *Biochimica et Biophysica Acta* **573**, 552–556.
- Bartlett, G. R. (1959). Phosphorus assay in column chromatography. *Journal of Biological Chemistry* **234**, 466–468.
- Clements, J. A., Hustead, R. F., Johnson, R. P. & Gribetz, I. (1961). Pulmonary surface tension and alveolar stability. *Journal of Applied Physiology* **16**, 444–450.
- Czopek, J. (1965). Quantitative studies on the morphology of respiratory surfaces in amphibians. *Acta Anatomica* **62**, 296–323.
- Dawson, R. M. C. (1966). The hydrolysis of unimolecular films of  $^{32}\text{P}$ -labelled lecithin, phosphatidylethanolamine and phosphatidylinositol with phospholipase A (*Naja naja* venom). *Biochemical Journal* **98**, 35–37.
- Goerke, J. (1974). Lung surfactant. *Biochimica et Biophysica Acta* **344**, 241–261.
- Hitchcock, K. R. & Parsons, W. J. (1977). Separation and partial characterization of fractions derived from frog lung homogenates. A possible marker system for amphibian pulmonary surfactant. *Journal of Histochemistry and Cytochemistry* **25**, 1363–1367.
- King, R. J. (1975). The surfactant system of the lung. *Federation Proceedings* **33**, 2238–2247.
- King, R. J. & Clements, J. A. (1972). Surface active materials from dog lung. II. Composition and physiological correlations. *American Journal of Physiology* **223**, 715–726.
- Meban, C. (1978a). Surface viscosity of surfactant films from human lungs. *Respiration Physiology* **33**, 219–227.
- Meban, C. (1978b). Influence of pH and temperature on behaviour of surfactant from human neonatal lungs. *Biology of the Neonate* **33**, 106–111.
- Morley, C. J., Bangham, A. D., Johnson, P., Thorburn, G. D. & Jenkin, G. (1978). Physical and physiological properties of dry lung surfactant. *Nature, London* **271**, 162–163.
- Pattle, R. E. (1958). Properties, function and origin of the alveolar lining layer. *Proceedings of the Royal Society (Series B)* **148**, 217–240.
- Pattle, R. E. (1965). Surface lining of lung alveoli. *Physiological Reviews* **45**, 48–79.
- Pattle, R. E. & Hopkinson, D. A. W. (1963). Lung lining in bird, reptile and amphibian. *Nature, London* **200**, 894.
- Scarpelli, E. M., Clutario, B. C. & Taylor, F. A. (1967). Preliminary identification of the lung surfactant system. *Journal of Applied Physiology* **23**, 880–885.
- Watkins, J. C. (1968). The surface properties of pure phospholipids in relation to those of lung extracts. *Biochimica et Biophysica Acta* **152**, 293–306.

## THE FUNCTIONAL SIGNIFICANCE OF FOOT-WEBBING IN EUROPEAN NEWTS (*TRITURUS*)

T. R. HALLIDAY<sup>1</sup> AND PIERRE JOLY<sup>2</sup>

<sup>1</sup>Department of Biology, The Open University, Milton Keynes MK7 6AA, and <sup>2</sup>Laboratoire des Rythmes et Comportement, Department de Biologie Animale, Université Claude Bernard, 43 Bd du 11 novembre 1918, 69621 Villeurbanne, France

(Received 14 July 1980)

Males of the Smooth Newt (*Triturus vulgaris*) and of the Palmate Newt (*T. helveticus*) differ from the female in many physical characteristics, among them in having webbed hindfeet. In the Smooth Newt this webbing takes the form of lateral fringes of skin along the toes. In the Palmate Newt there is complete webbing between the toes. The fact that these characters are present only in males, together with the fact that they develop only during the breeding season, suggests that they are related in some way to sexual behaviour.

Halliday (1975) reiterated the suggestion of Darwin (1871) that foot-webbing enables males to swim faster than females and thus overtake them in the important early phases of courtship in which the male pursues the unresponsive female (Halliday, 1974). Beebee (1980) has rejected this idea, pointing out that when newts swim they hold their legs flat against their bodies and do not use them for propulsion. We accept this point of view, with the reservation that the feet do seem to be used to give initial impetus when a newt first starts swimming.

Beebee suggests that webbed hind feet are used by the male to stabilize the body when he descends from the water surface to the substrate after breathing. He pointed out that, compared to the males of two other species, *T. cristatus* and *T. alpestris*, and to the females of all four species, male Smooth and Palmate newts have much larger tails relative to the body weight. Thus, as they sink their tails would tend to tilt them backwards, were it not for the "parachute" effect provided by outspread webbed hind-feet. We accept this suggestion as highly plausible but suggest that the hind-feet may be used as stabilizers in a much wider range of contexts than suggested by Beebee.

Analysis of newt courtship behaviour indicates that the length of time that a male can devote to courtship is limited by his ability to remain submerged without taking in air from the water surface (Halliday & Sweatman, 1976; Halliday, 1977a). Thus, in order to maximize their reproductive success, male newts have to maintain air-filled lungs, thereby tending to make themselves buoyant. This problem will be especially acute for the males of Smooth and Palmate newts, for whom courtship is more active and vigorous, and therefore more consuming of oxygen, than it is in other *Triturus* species (Halliday, 1977b). Thus we suggest that natural selection will have favoured the ability in male newts to hold gaseous oxygen in the lungs as near as possible to the point at which they become neutrally buoyant. Under such conditions they will experience a

secondary problem, that of maintaining their stability during vigorous movements associated with feeding and courtship.

When they feed newts snap at their prey and, having grasped it, make violent movements of the body and head to centre the prey in the mouth before swallowing it. These movements are especially vigorous when the prey is large, such as a chironomid larva. During these actions one of us (P.J.) has observed that the hindlimbs of male Palmate newts are held so that the toes are spread vertically. This means that the foot-webbing acts as a brake, opposing any tendency of the animal to move backwards as a result of its violent movements.

Female newts, though they feed in a similar way, do not have a comparable problem. They are always likely to be heavier than males because of being full of eggs. Furthermore, they have probably not been subject to such intense selection pressure as have males to carry large volumes of air, since they are very much less active during courtship (Halliday, 1974).

The male Alpine newt *T. alpestris* lacks any webbing on his hind feet. His courtship display is less vigorous than that of the male smooth and palmate newts and thus may be sustained more by cutaneous than by pulmonary respiration. During food ingestion alpine newts adopt a distinctive posture (Fig. 1) in which the hindfeet and part of the tail are applied to the substrate to provide a firm tripod-like base that maintains stability.

During courtship male smooth and palmate newts make a variety of vigorous movements (Halliday, 1974). In the Whip display the tail is suddenly and violently beaten against the body, creating a powerful disturbance in the water that tends to push the male backwards. In the Fan display the tail is rapidly vibrated against the body in a gentler but more sustained movement, again with the effect of producing

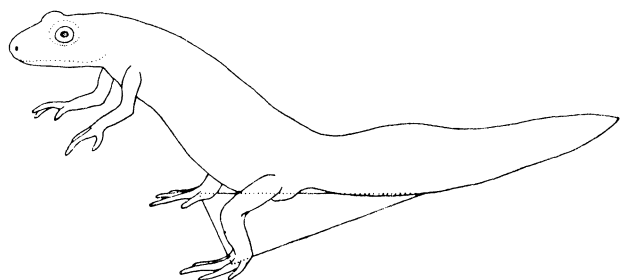


FIG. 1. Posture adopted by Alpine newts *Triturus alpestris* while ingesting prey. The feet and the tail form the three points of a triangle on the substrate.

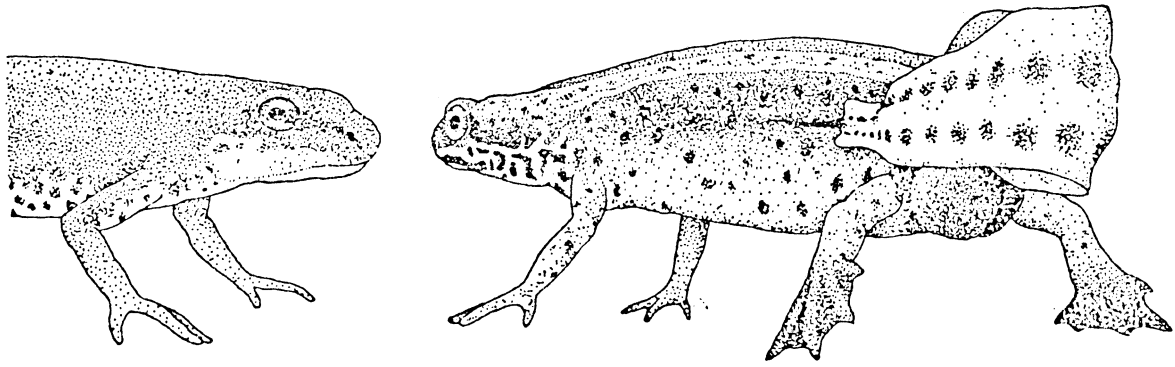


FIG. 2. A male Palmate Newt *Triturus helveticus* (right) fanning to a female.

a backwards movement. During these displays males tend, as during feeding, to hold their feet in such a way that the webbing opposes this backwards movement (Fig. 2).

During the initial phases of courtship in Smooth and Palmate newts, males vigorously pursue females who tend to be unresponsive and to move away from them. The male repeatedly swims rapidly past the female from behind, coming suddenly to a halt in front of her in a movement called Move-to-the-front (Halliday, 1974). He brakes his movement largely by performing a whip movement with his tail but also by spreading his hindfeet.

Our hypothesis is that webbing of the hindfeet has evolved in male Smooth and Palmate newts as a stabilizer during sudden movements. Males of these species are especially likely to be unstable because they are small and because they have probably been selected to carry large amounts of air while under water and are thus intrinsically close to neutral buoyancy and therefore unstable. While this hypothesis is highly speculative, it is consistent, as any hypothesis about foot-webbing in *Triturus* must be, with the fact that foot-webbing occurs only in males and only in these two species.

#### REFERENCES

- Beebee, T. J. C. (1980). Belly colour and foot-webbing in newts of the genus *Triturus*. *British Journal of Herpetology* **6**, 59–61.
- Darwin, C. (1871). *The Descent of Man*. London: Murray.
- Halliday, T. R. (1974). Sexual behaviour of the Smooth Newt, *Triturus vulgaris* (Urodela: Salamandridae). *Journal of Herpetology* **8**, 277–292.
- Halliday, T. R. (1975). On the biological significance of certain morphological characters in males of the Smooth Newt *Triturus vulgaris* and of the Palmate Newt *Triturus helveticus* (Urodela: Salamandridae). *Zoological Journal of the Linnean Society* **56**, 291–300.
- Halliday, T. R. & Sweatman, H. P. A. (1976). To breathe or not to breathe: the newt's problem. *Animal Behaviour* **24**, 551–561.
- Halliday, T. R. (1977a). The effect of experimental manipulation of breathing behaviour on the sexual behaviour of the Smooth Newt, *Triturus vulgaris*. *Animal Behaviour* **25**, 39–45.
- Halliday, T. R. (1977b). The courtship of European newts: an evolutionary perspective. In *Reproductive Biology of Amphibians*, 185–232. Taylor, D. H. and Guttman, S. I. (Eds). New York: Plenum Press.

## THE HERPETOLOGY OF THE CHAGOS ARCHIPELAGO

RICHMOND A. DUTTON

*Department of Botany, University of Liverpool*

(Received 17 March 1980)

### SUMMARY

The 1978/79 Chagos Research Expedition located only two species of reptiles, *Eretmochelys imbricata* and *Hemidactylus frenatus*. Other species mentioned by earlier expeditions may well be extinct or at least very scarce. For security reasons, the visiting of this archipelago will continue to be restricted and settlement limited to parts of Diego Garcia. Thus a ready made reserve has been made possible for the endangered Hawksbill Turtle.

### INTRODUCTION

The Chagos Archipelago (5°S, 71°E) in the Indian Ocean, consists of some 55 coral islands grouped in 6 atolls (Fig. 1). It is about 2000 miles east of Africa and 1000 miles south of India. Despite its remoteness, it has been inhabited for two hundred years by communities engaged in copra production, until in 1974 the last islanders departed. Now only Diego Garcia is inhabited, by members of the armed services of Britain and the United States. The archipelago has been infrequently visited by scientific expeditions and many islands had not been surveyed herpetologically. An opportunity arose in 1978/79 when the Joint Services Chagos Research Expedition made a detailed survey of the archipelago over an eight-month period. The reptile survey of Chagos encompassed the atolls of Diego Garcia, Peros Banhos and Saloman, and the island of Middle Brother. Only one species of gecko (*Hemidactylus frenatus*) and the hawksbill turtle (*Eretmochelys imbricata*) were located, although other species have been discovered by earlier expeditions.

### SAURIA

Apart from the *Hemidactylus*, one other species of gecko is known in Chagos, *Lepidodactylus lugubris*. Boulenger (1909) records J. Stanley Gardiner's collection of this species in 1905 from Diego Garcia and Saloman. Gardiner also collected the *Hemidactylus* in Diego Garcia, Saloman and Peros Banhos (Gardiner & Cooper, 1907). All 91 specimens collected by Fehlmann in 1967 in Diego Garcia proved to be the *Hemidactylus* (Stoddart, 1971). *Hemidactylus frenatus* was recorded on this expedition on Middle Brother, Iles Anglais and Boddam, (Saloman), Ile du Coin and Petite Soeur, (Peros Banhos) and Diego Garcia.

Specimens were identified by Mr Colin McCarthy of the British Museum (Natural History). The habitat of these lizards varied from coconut palm trunks to under rotting logs, to buildings and amongst dense, low ground-cover such as *Ipomea* and *Canavalia*. Specimens were active both by day and night and were loudly vocal. Their prey consisted of small insects, chiefly moths, mosquitoes and spiders. They were seen to take large ants and one individual managed a small scorpion (*Isometrus maculatus*). Natural predators included the large hunting spiders which abound in the herbage.

### CHELONIA

A determined but unsuccessful search was made for the two species of terrapin formerly known in Diego Garcia. The side-necked terrapin (*Pelusios subniger*) was collected by Gardiner in 1905 in a swamp near East Point (Gardiner & Cooper, 1907), and Bourne (1886a) found *Geomyda trijuga thermalis* to be abundant in marshy pools. Neither species were located in 1967 in Diego Garcia by Fehlmann (Stoddart, 1971) but Stoddart mentions that J. Frazier was informed by the Staff of the Meteorological Station in 1970 that terrapins were still present.

Previously recorded marine turtles in Diego Garcia are the green (*Chelonia mydas*) and the hawksbill (*Eretmochelys imbricata*) (Bourne, 1886b). The 1967 Diego Garcia expedition identified hawksbills in the lagoon (Stoddart, 1971). The turtle survey undertaken by the Joint Services Expedition took place between 15 November 1978 and 24 January 1979 and took the form of walking around the perimeter of each island, counting completed nests and their location. Turtle nests were located on 11 islands of 17 visited in the Peros Banhos atoll. Of 88 nests found nearly a third were on one island, Ye Ye. The islands of the eastern rim had most signs of turtle activity and this is consistent with the lack of human interference there in contrast with the islands in the south and west. In Saloman only 11 nests were found on all 11 islands of the atoll. More than half were on one island, Anglais. All sightings were of hawksbills.

### ACKNOWLEDGEMENTS

I am indebted to all members of the Joint Services Chagos Research Team who made this survey possible, and to Mr. Colin McCarthy for identifying specimens.

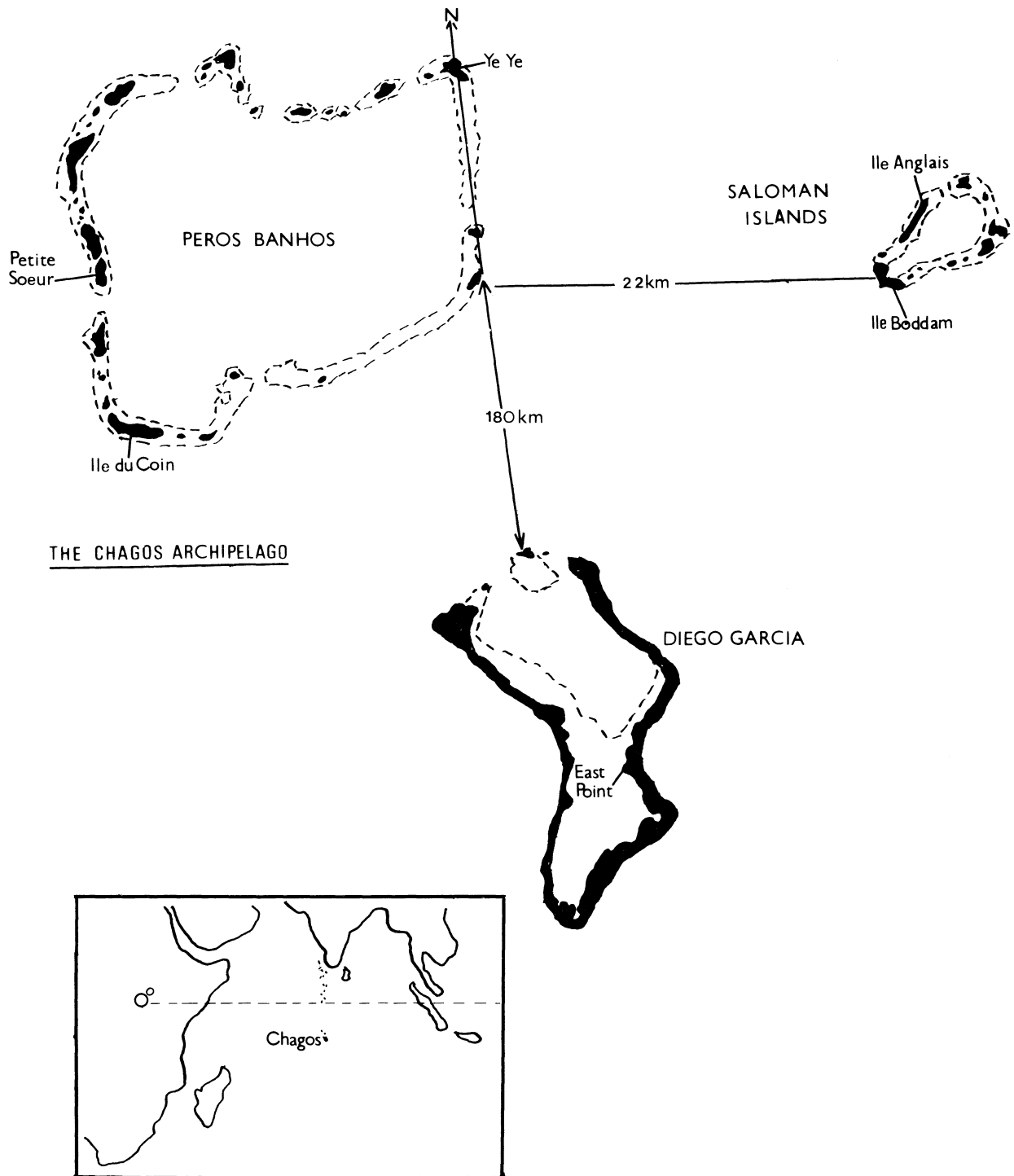


FIG. 1. The principal atolls of the Chagos Archipelago. Inset shows location of the islands in the Indian Ocean. Key: Shaded areas = land above sea level at low tide; ----- = coral reef.

REFERENCES

Boulenger, G. A. (1909). A List of the freshwater fishes, batrachians, and reptiles obtained by Mr. J. Stanley Gardiner's expedition to the Indian Ocean. *Transactions of the Linnean Society of London* II, **12**, (Percy Sladen Expedition Reports, 1) 296-297.

Bourne, G. C. (1886a). General observations on the fauna of Diego Garcia, Chagos group. *Proceedings of the Zoological Society of London* 333.

Bourne, G. C. (1886b). On the Island of Diego Garcia of the Chagos group. *Proceedings of the Royal Geographical Society* n.s. **8**, 392.

Gardiner, J. S. & Cooper, C. F. (1907). Description of the Expedition. *Transactions of the Linnean Society of London* II, **12**, (Percy Sladen Expedition Reports, 1) 48.

Stoddart, D. R. (1971). *Atoll Research Bulletin* Nos. 149, 168 and 169. Stoddart, D. R. and Taylor, J. D. (Eds). Washington D.C: Smithsonian Institution.

## ATTACKS ON DOMESTIC LIVESTOCK BY THE SALTWATER CROCODILE (*CROCODYLUS POROSUS*) IN ORISSA, INDIA

S. K. KAR<sup>1</sup> AND H. R. BUSTARD<sup>2</sup>

<sup>1</sup>*Saltwater Crocodile Research & Conservation Centre, Dangmal-754220, Orissa, and* <sup>2</sup>*Central Crocodile Breeding & Management Training Institute, Hyderabad*

(Received 14 February 1980)

### INTRODUCTION

It is known that large saltwater crocodiles can pull down and drown very large animals, such as full-grown beef cattle which are taken in north Queensland, Australia (Bustard, unpubl.). The Bhitarkanika Wild Life Sanctuary, Orissa, India, was gazetted in April 1975, for the critically-endangered saltwater crocodile. Instances of attack on domestic livestock by saltwater crocodiles have been recorded from August 1975 to October 1979 inclusive. A total of 11 such attacks involving five water buffaloes, five cattle (three bullocks and two cows) and a goat were recorded. In all instances here reported the animal attacked was killed (drowned) by the crocodile which fed upon the carcass.

For each attack the following information was collected: date, place and time of attack, state of the tide, size of the attacking crocodile, details of the livestock attacked, including their (likely) position at the time of the attack.

### OBSERVATIONS AND DISCUSSION

The seasonality of such attacks, given in Table I, indicates that these occurred in five months of the year from April-June (the hot season until the monsoon breaks in the second half of June) and August-September (Monsoon). Time of day at which the attacks took place is given in Table II which again shows two groupings. Six of the eleven attacks occurred in the morning between 10 and 12 noon, and the remaining five between 2 and 4 in the afternoon. There was a marked correlation between attacks and state of the tide. Eight of the attacks occurred at high tide, and a ninth when the tide was just starting to ebb.

TABLE I. Seasonality of attack

Month of year	J F M A M J J A S O N D
Number of attacks	— — — 1 2 3 — 3 2 — — —

TABLE II. Time of attacks. The divisions between the hours indicate half-hours

Time of day	6 a.m.   7   8   9   10   11   12   1   2   3   4   5   6 p.m.
Number of attacks	— — — 1 1 2 1 1 — 2 1 1 — —

The other two instances occurred when the tide level was increasing, and at mid-stage of the tide respectively.

Size of the attacking crocodile was estimated for seven of the attacks and varied between 5.5 and 6.4 m. All such large individuals are males.

Table I indicates marked seasonality of attack. This may reflect agricultural practices. The rice crop is cleared by the end of February or early March so the cattle are allowed to wander. They are restrained again from the end of September or early October with the second transplant of the rice seedlings.

Table II shows grouping of attack during the day. Most of the cattle are herded into sheds in the late afternoon (4-5 p.m.) and let out at 7 a.m. which explains absence of attacks in the early morning and late afternoon. Crocodiles, although most active in the period immediately following nightfall, are clearly opportunistic feeders taking food at any time of day (Cott, 1961; Kar, 1981).

All attacks here reported were by very large males. It is thought that only four individuals were responsible for the 11 attacks, taking four, three, two and two animals respectively. A year or more often separated consecutive attacks by the same crocodile which suggests that the crocodiles involved did not tend to become "cattle lifters" following a successful kill. However, one individual killed twice, only four days apart in August 1978, and made a third kill in September only twelve days after the second kill.

High tide is usually essential to bring the crocodiles lying in wait in the water within striking distance of the animals grazing on the river bank.

The occurrence of only a single goat among the animals taken is due to there not being many goats within the sanctuary and that goats rarely come near the river bank.

The attacks all occurred at (four) locations where the natural mangrove cover had been destroyed. Unless this is the case domestic livestock cannot come to the river bank. Cattle attacks increase the unpopularity of the saltwater crocodile and increase the pressures working against its conservation. Ideally crocodiles and cattle should be separated—there should be no grazing in sanctuaries. This ideal, however, is difficult to achieve in much of the developing world inhabited by crocodiles. The solution lies in maintaining a strip of undisturbed mangrove forest, at least 50 m wide along all creeks adjacent to cultivated land. Since this fringing

forest cover is important for the crocodiles themselves this should form a key aspect of management.

Kanungo (1976) estimated the cattle population of the sanctuary as 120,000. The evidence of attack, therefore, is very low in relation to the availability of domestic stock as food. Perhaps even large crocodiles hesitate to attack such large prey.

#### REFERENCES

- Cott, H. B. (1961). Scientific results of an enquiry into the ecology and economic status of the Nile Crocodile (*Crocodilus niloticus*) in Uganda and Northern Rhodesia. *Transactions of the Zoological Society of London* **29**, 211–356.
- Kanungo, B. C. (1976). *An Integrated Scheme for Conservation of Crocodiles in Orissa with Management Plans for Satkosia Gorge and Bhitarkanika Sanctuaries*. Cuttack: Orissa Forest Department.
- Kar, S. K. (1981). The ecology of the saltwater crocodile (*Crocodylus porosus* Schneider) in Bhitarkanika Wild Life Sanctuary, Orissa. Unpubl. Ph.D. thesis. Utkal University, Bhubaneswar, Orissa.

## CROCODILE KILLS TAKEN AS HUMAN FOOD

H. R. BUSTARD<sup>1</sup> AND S. K. KAR<sup>2</sup><sup>1</sup>Central Crocodile Breeding & Management Training Institute, Rajendranagar, Hyderabad (India), and <sup>2</sup>Saltwater Crocodile Research & Conservation Centre, Dangmal-754220, Dist. Cuttack, Orissa (India)

(Received 18 August 1980)

## INTRODUCTION

Cott (1961) illustrated a shift in the diet of the Nile Crocodile (*Crocodylus niloticus*) with increase in size. Mammals are taken in greater proportion with increasing size; the hatching year class take none at all. Fishes, however, are an important component of the diet throughout life. In the saltwater crocodile (*Crocodylus porosus*), large individuals are capable of pulling down and drowning cattle or buffalo (Kar & Bustard, in press). The crocodiles then feed upon the carcass over a period of several days, it is physically impossible for them to consume large prey items at one sitting. Natural mammalian prey of large saltwater crocodiles in India includes deer of various species, including cheetal (*Axis axis*) and sambar (*Cervus unicolor*), and wild boar (*Sus scrofa*).

## OBSERVATIONS AND DISCUSSION

In the Bhitarkanika Wildlife Sanctuary of Orissa, declared for the saltwater crocodile in 1975, records are kept on all large mammalian kills that are noticed by reliable people. Such kills are frequently taken by local villagers for their own food, decorative use of antlers in the case of male deer and for the hide if the kill is fresh. Records for the period July 1975 to September 1979 are summarized in Table I, and indicate that *all* crocodile kills located in a fresh condition, were taken by local villagers.

The removal of crocodile kills by people is paralleled by human stealing of tiger kills in India (G. S. Khedkhar, pers. comm.; S. R. Choudhury, pers. comm.). Such conduct should not be permitted in gazetted sanctuaries as it has the adverse effect of forcing the predators to either make more kills—which they may also lose—or go without food. In areas where opportunities to make kills are restricted, loss of kills may be a serious limiting factor for the population. Furthermore, large predators which lose their natural kills must pose a more serious threat to man or his domestic animals.

TABLE I. Large wild mammalian prey killed by crocodiles and used as human food

Prey	Number killed by crocodiles		Carcasses taken as food by people
	Seen by one of us personally	Reported by reliable persons	
Cheetal ( <i>Axis axis</i> )	2	5	5*
Sambar ( <i>Cervus unicolor</i> )	—	1	1
Wild boar ( <i>Sus scrofa</i> )	1	2	1*

\* In each case the two carcasses not taken for human consumption were rotten when located by people.

The adverse effect of “kill robbing” is likely to be more serious for tigers than crocodiles, however, as tigers have to feed the cubs which will perish in the absence of sufficient food. Juvenile saltwater crocodiles do not depend on their parents for food nor do they feed on mammalian carcasses.

The implication of kill stealing for the management of crocodile (and tiger) sanctuaries is clear. There is a need to separate crocodiles from local villagers. The *sanctum sanctorum* or core area of such sanctuaries must be free from human habitation or intrusions. In sanctuaries the animals must have “right of way” at all times, otherwise the sanctuaries will ultimately prove of little value in conservation of their endangered species.

## REFERENCES

- Cott, H. B. (1961). Scientific results of an enquiry into the ecology and economic status of the Nile Crocodile (*Crocodylus niloticus*) in Uganda and Northern Rhodesia. *Transactions Zoological Society of London* **29**, 211–358.
- Kar, S. K. & Bustard, H. R. (1981). Attacks on domestic livestock by the Saltwater Crocodile (*Crocodylus porosus* Schneider) in Orissa, India. *British Journal of Herpetology* **6**, 135–136.

## ANNUAL NESTING OF THE PACIFIC RIDLEY SEA TURTLE (*LEPIDOCHELYS OLIVACEA*) IN ORISSA, INDIA

H. R. BUSTARD<sup>1</sup> AND C. S. KAR<sup>2</sup>

<sup>1</sup>Central Crocodile Breeding and Management Training Institute, Rajendranagar Road, Hyderabad, and

<sup>2</sup>Gahirmatha Sea Turtle Project, District Cuttack, Orissa, India

(Received 28 July 1980)

Precise biological data are lacking concerning many facets of the life history of the Pacific ridley (*Lepidochelys olivacea*), despite its wide geographic range (Bustard, 1972). Bustard (1976) noted the very large rookery at Gahirmatha, Cuttack District, Orissa, where more than 100,000 turtles of this species nest annually, and this was included in the sanctuary known as Bhitarkanika Wild Life Sanctuary, being gazetted in 1975 for the saltwater crocodile (*C. porosus*). The junior author started detailed research on this rookery in October 1977.

Tagging at this rookery commenced in the 1977/78 nesting season on a 10 km stretch of mainland beach using monometal cow ear tags, pioneered by Harrison (1956) and now widely used, applied to the trailing edge of the left front flipper as described by Bustard (1972). In the 1977/78 nesting season 337 turtles were tagged out of a total nesting population estimated at 230,000 female turtles. The following year (1978/79) over 130,000 turtles nested on this beach, of which 14,029 were individually inspected and five were found to bear the previous year's tags.

The proportion of the 1977/78 population tagged is  $337/230,000 = 0.00146$ . There is no reason to doubt the random dispersal of the tagged turtles in the population. If all the previous year's population returned to nest the following year and no tags were lost in the intervening year the number of tagged individuals which should theoretically be present in the sample would be  $0.00146 \times 14,029$ , the latter figure being the number examined, which equals 20.5. This figure compares with the observed recapture of five tags which indicate a return of about 24%.

This population, although fully protected ashore, is still subject to heavy poaching offshore, but since there is no reason to believe that the chance of tagged turtles being poached differs from untagged turtles it should not affect the *proportion* of tagged turtles in the population. Furthermore, since turtles may disperse to other breeding colonies or even nest just outside the limits of the present study area, this sort of level of return might be anticipated for a population tending to nest each year (making some allowance for mortality). For instance, Bustard (1974) recorded return levels of only 1–2% in the green turtle (*Chelonia mydas*) at successive nesting seasons but found that the loggerhead turtle (*Caretta caretta*) showed a return level of about 15%.

While it is too early to state that *Lepidochelys olivacea* is an annual nester in the Bay of Bengal a large proportion of the 1977/78 nesting turtles—24%—appear to have re-nested the following year.

### REFERENCES

- Bustard, H. R. (1972). *Sea turtles: natural history and conservation*. London & Sydney: Collins.
- Bustard, H. R. (1974). Barrier reef sea turtle populations. In *Proceedings of the Second International Coral Reef Symposium*, 1, 227–234. Brisbane: Great Barrier Reef Committee.
- Bustard, H. R. (1976). World's largest sea turtle rookery? *Tigerpaper* 3, 25.
- Harrison, T. (1956). Tagging green turtles, 1952–56. *Nature* 178, 1429.

## COURTSHIP OF THE AFRICAN HELMETED TURTLE (*PELOMEDUSA SUBRUF*A)

CARL H. ERNST

*Department of Biology, George Mason University, Fairfax, Virginia, U.S.A. 22030*

(Received 15 September 1980)

Few observations have been published on the reproductive biology of the African helmeted turtle *Pelomedusa subrufa* (Pleurodira, Pelomedusidae). The nesting behaviour, eggs, and hatchlings have been adequately described by Hewitt (1937), Loveridge (1941), Villiers (1958), Jaques (1966), and Ewert (1979), but the male courtship behaviour is practically unknown. The only previous report of *Pelomedusa* courtship is by Cloudsley-Thompson (1971). He describes the process in *P. galeata* (= *P. subrufa*) as follows: "the male and female face one another underwater which, in nature, may well be muddy (thereby prohibiting the use of visual signs). Then they touch noses and sides of their faces, as though kissing. These actions may be repeated for some minutes before mating takes place, also under water." In view of the paucity of information on the precopulatory behaviour of male *Pelomedusa subrufa* and differences noted from those actions reported by Cloudsley-Thompson (1971), some personal observations are here presented.

A male *P. subrufa* (carapace length 144.2 mm) and two females (carapace lengths of 130.0 and 106.1 mm, respectively) were kept in a 567 l aquarium filled to a depth of 60 cm. Water temperature was maintained at 25°C with aquarium heaters and a 75 watt incandescent bulb provided more heat and constant illumination over a basking platform. Also in the aquarium were several individuals each of the species *Chelydra serpentina*, *Sternotherus odoratus*, *Chinemys reevesii*, *Chrysemys picta*, and *Graptemys pseudogeographica*.

Beginning on 25 April 1980 the male *P. subrufa* began to court the 130 mm female of his species (he showed no interest in the other turtles in the aquarium). He pursued her with his head and neck fully extended as she swam about the aquarium or crawled on the bottom. When close enough he would touch his snout against her vent and hind quarters, sometimes pushing or biting her. The female was nonreceptive and fled from his advances, whereupon he would chase her again, snapping at her tail and hind limbs. This behaviour continued for several days until 7 May 1980 when the male was found mounted on the female's carapace at the bottom of the aquarium. He maintained his position by hooking all four of his feet beneath the marginal scutes on her carapace. His head and neck were fully extended and bent forward and downward in front of her withdrawn head and neck, at which he frequently bit. The male then began to sway his head back and forth like a pendulum in front of the female's face and to expel a stream of water through his nostrils

over her face. This continued for about 35 min, but coitus was not accomplished and the turtles separated. Similar activity was observed on 12 May 1980, and this time copulation was successful, lasting about 15 min, although it appeared the male forced his penis into the still-reluctant female's vent (she was more of a victim than a willing partner). At no time was the face to face anterior presentation described by Cloudsley-Thompson (1971) observed.

The full head and neck extended pursuits are similar to the single and double straight olfactory movements of *Clemmys insculpta* and *Terrapene carolina* as described by Eglis (1962) that are also known from many aquatic turtles. The swaying of the head back and forth in front of the female's face is also similar to the double or triple swinging sideways olfactory motion of *Homopus* (Eglis, 1962). These actions may indicate that the male was responding to pheromones released by the female.

The courtship patterns of pleurodiran turtles are poorly known; that of no other member of the Pelomedusidae has been described, and that of only a few of the Chelidae has been reported. The male *Pelomedusa* courtship behaviour is most similar to that described by Murphy & Lamoreaux (1978) for the Australian chelid sidenecks *Elseya latisternum* and *Emydura macquarii*. It differs, however, in that biting does not occur in those species, but stroking with the foreclaws does. Also in the two chelids there is a barbel aligning sequence in which the male and female face each other and the male expels water through his nostrils over the nasal and maxillary area of the female's face. It is possible that the face to face posture of *Pelomedusa* described by Cloudsley-Thompson (1971) was a barbel alignment sequence, lacking the water expulsion act. The unresponsiveness of the female *Pelomedusa* during the current observations may have prevented the face to face (barbel aligning?) behaviour. Bubble blowing or water expulsion through the nostrils is rare in turtle courtship, but also occurs in the chelydrid *Chelydra serpentina*; the emydids *Clemmys insculpta*, *C. muhlenbergii*, *Pseudemys scripta grayi*, *P. s. ornata*, *Terrapene carolina*, and *T. ornata*, and the kinosternid *Kinosternon flavescens* (see the review by Carpenter & Ferguson, 1977).

### REFERENCES

- Carpenter, C. C. & Ferguson, G. W. (1977). Variation and evolution of stereotyped behaviour in reptiles, In

- Biology of the Reptilia*. vol. 7, 335–554. Gans, C. & Tinkle, D. W. (Eds). London: Academic Press.
- Cloudsley-Thompson, J. L. (1971). Courtship of *Pelomedusa galeata*. *British Journal of Herpetology* **4**, 237.
- Eglis, A. (1962). Tortoise behaviour: a taxonomic adjunct. *Herpetologica* **18**, 1–8.
- Ewert, M. A. (1979). The embryo and its egg: development and natural history, In *Turtles: perspectives and research*. 333–413. Harless, M. & Morlock, H. (Eds). New York: John Wiley.
- Hewitt, J. (1937). *A guide to the vertebrate fauna of the eastern Cape Province, South Africa. Part II. Reptiles, amphibians and freshwater fishes*. Grahamstown.
- Jaques, J. (1966). Some observations on the cape terrapin. *African Wild Life* **20**, 137–150.
- Loveridge, A. (1941). Revision of the African terrapin of the family Pelomedusidae. *Bulletin of the Museum of Comparative Zoology, Harvard* **88**, 467–524.
- Murphy, J. B. & Lamoreaux, W. E. (1978). Mating behaviour in three Australian chelid turtles (Testudines: Pleurodira: Chelidae). *Herpetologica* **34**, 398–405.
- Villiers, A. (1958). Tortues et crocodiles de l'Afrique Noire Francaise. *Institut Francais d'Afrique Noire Initiations Africaines* **15**, 1–354.

## LETTERS TO THE EDITOR

### NEST DEFENCE AGAINST MAN BY THE SALTWATER CROCODILE (*CROCODYLUS POROSUS*)

A saltwater crocodile of approximately 3 m in total length repeatedly defended its nest against a party of four people including the junior author. This occurred on 31 May 1976 in the Bhitarkanika Wildlife Sanctuary of Orissa in Eastern India, when the party went to collect the eggs under a conservation project (F.A.O. India: Gharial and Crocodile Conservation Management in Orissa, 1975 (based on the work of H. R. Bustard) F.A.O. Rome (FO: IND/71/033). The crocodile, present in one of the wallows, charged at an assistant as the party approached the nest. The assistant and other members of the party escaped by climbing trees. The crocodile then lay atop the nest. Attempts to chase it away resulted in it coming right to the nearest tree and looking upwards with open jaws. The crocodile continued to guard the nest against the party for about half an hour before retreating to a wallow. Undoubtedly the crocodile would have physically attacked the staff had they not been able to ascend trees.

This observation is reported as we are unlikely to collect further data on the topic since we aim to collect eggs in the absence of the nest guarding crocodile and hence reduce disturbance to a minimum. The instance here reported resulted from failure to carry out this procedure. The observation is of interest in view of recent findings (Webb, G. J. W., Messel, H. and Magnusson, W. 1977. *Copeia*, 1977, 238–250) which

left the authors in doubt as to whether *C. porosus* defends the nest against *any* predators. We believe that behaviour similar to that recounted above was commonplace prior to recent massive crocodile hunting.

H. R. Bustard  
Central Crocodile Breeding  
and Management Training Institute,  
Hyderabad  
S. K. KAR  
Saltwater Crocodile Research  
and Conservation Centre, Dangmal,  
Dist. Cuttack, Orissa, India

### *EMYS ORBICULARIS* IN MENORCA

*E. orbicularis* has not previously been recorded in Menorca, Balearic Islands, but specimens were observed between 16–30 June 1978 in the marshy area of Cala'n'porter on a number of occasions. Three specimens were collected 40 m from the high water mark, in a stream which runs into the sea. They were most frequently observed in the morning with neck protruding and the dome of the shell visible. The neck was dark and spotted yellow, and the carapace was marked with radiating striations. Two more specimens were collected in the marsh near Son Bou beach in June 1980 by Mr T. Greer of London Zoo.

R. A. DUTTON  
Department of Botany,  
University of Liverpool

## BOOK REVIEWS

### THE REPTILES OF NORTHERN AND CENTRAL EUROPE.

By Donald Street (1979). 272 pp. London: Batsford. £10.

The author states in his preface that this book is intended for the field herpetologist and the general naturalist seeking to expand his or her knowledge of this much neglected group of animals. In fact, the most outstanding aspect of this book is that it is indeed written by a very competent field naturalist, and whose methods in the field over many years has left room for little speculation in his presentation.

As the title suggests, the book deals with the twenty-five species of snakes, lizards, and chelonians, to be found in Northern and Central Europe. However, the text information is highly relevant to Europe as a whole and the author admits that much of the research was undertaken in southern and eastern Europe.

Each species is dealt with in some detail and in addition to the expected description of colour, size, scalation, etc., valuable notes on habits and habitat are prominent throughout the text.

The illustrations are excellent, some of which were taken by the author, others by Eric Hosking and Sdeuard Bisserot, and eight of these are in colour. In fact, all the species mentioned in the book are complemented by a photograph.

For all of us who have enjoyed happy hours in the field, searching, and studying reptiles, this book is a welcome addition to one's library. It is also a book to be taken in the field, although its largish format denies the average pocket; it is a must for the rucksack or car glove compartment.

T. E. PHELPS

### REPRODUCTIVE BIOLOGY AND DISEASES OF CAPTIVE REPTILES. Edited by T. B. Murphy and J. T. Collins (1980). Society for the Study of Amphibians and Reptiles. \$20 (paper), \$24 (cloth).

This volume is the proceedings of a symposium held in 1978 under the sponsorship of the Society for the Study of Amphibians and Reptiles, and contains twenty-eight papers plus two which were invited in addition.

The book is divided into three parts. The first deals with the history of the subject and modern management of reptile collections; the second with reproduction in captive reptiles; the third with diseases.

The papers are very wide ranging and illustrate the dramatic advances made in reptilian husbandry and breeding during the last ten years. But they illustrate more than that; by the choice of contributors it is made clear these practical advances have been made as a result of progress made in reptilian reproductive physiology over the same period particularly in the U.S.A., which has a rich fauna ideal for field and laboratory work. The organizers are to be congratulated on the approach they have taken—papers on general aspects (e.g. methods of inducing reproduction in captive reptiles, temperature and light requirements of captive reptiles) to specific species or groups (e.g. geckos, *Epicrates*). Inevitably, the quality of the papers is variable, varying from the anecdotal to the well-argued review. But nearly all the contributors, at their particular level, have made a great effort and if there are deficiencies, then these serve to illustrate where more basic or applied work is needed.

While most of the papers are appropriate to the title, one is included which is not: that by Ehrenfeld on the commercial breeding of marine turtles. This was not the place for a one-sided polemic.

A particular delight is the presentation of historical photographs to accompany Conant's historical introduction.

The SSAR are to be congratulated on producing this volume. It is excellent value and all involved in keeping and breeding reptiles must buy a copy. It can be ordered from Dr H. C. Seibert, Department of Zoology, Ohio University, Athens, Ohio 45701, U.S.A.

M. PEAKER

### SUN, SAND AND SNAKES. By Stephen Sprawls (1980). London: Collins. £6.95.

The author is now aged 27 and for more than half his life has been catching snakes in Kenya. He brought his first cobra in to the Nairobi Snake Park when he was aged 13, and since then has collected snakes, lizards and amphibians for zoos and museums in all parts of the world. This book described a variety of species of snakes, their habits and capture, interwoven with anecdotes of other animals ranging from a "tame" giraffe to scorpions and spiders.

J. F. D. FRAZER