# The HERPETOLOGICAL BULLETIN

Number 81 – Autumn 2002



PUBLISHED BY THE BRITISH HERPETOLOGICAL SOCIETY

# THE HERPETOLOGICAL BULLETIN

The **Herpetological Bulletin** is produced quarterly and publishes, in English, a range of articles concerned with herpetology. These include full-length papers of mostly a semi-technical nature, book reviews, letters from readers, society news, and other items of general herpetological interest. Emphasis is placed on natural history, conservation, captive breeding and husbandry, veterinary and behavioural aspects. Articles reporting the results of experimental research, descriptions of new taxa, or taxonomic revisions should be submitted to The Herpetological Journal (see inside back cover for Editor's address).

## ISSN 1473-0928

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Printed by Metloc Printers Limited, Old Station Road, Loughton, Essex.

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All submissions and correspondence arising from the Bulletin should be sent to the Editor, Peter Stafford, c/o Dept. of Botany, The Natural History Museum, Cromwell Road, London, SW7 5BD. *E-mail: pjs@nhm.ac.uk* 

#### **Front cover illustration**

African Pancake Tortoise, *Malacochersus tornieri* (top) and Leopard Tortoise, *Geochelone pardalis babcocki* (below). Photographs by Carl Ernst. See articles on pages 12 and 17.

## **EDITORIAL**

## Captive husbandry articles

I have been asked on a couple of occasions recently if the *Bulletin* could include an article on the captive husbandry and breeding of European tortoises. Given the large number of keepers in the UK, I would also be interested in articles that provide herpetocultural information on, among others, iguanas, *Uromastyx*, boas, pythons etc., particularly if based on original observations and accompanied by good photographs. If you have experience in keeping/breeding a particular species (or group of related species) and might thus be interested in writing such an article for inclusion in the *Bulletin*, please contact me directly to discuss.

Peter Stafford

## Meet the council....

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I have had a life-long interest in herpetology and conservation. I am told that at the age of one and a half years in Honk Kong, where I was born, I had my Chinese amah (nanny) collect geckos for me in containers so that I could watch these. Certainly, photographs exist of my avidly examining large tropical insects which amah had attached to my pram! When I was three in Western Australia I had a wonderful experience — a radiation of large, sluggish skinks which a three-year-old could easily capture - in the form of Sleepy Lizards (Trachydosaurus rugosus) and Blue-tongued Skinks (Tiliqua scincoides). I can still picture the huge — ginormous to a three-year-old — goannas (Varanus) which I saw searching the high tide mark at North Beach north of Perth in the early mornings at a time when few people were about.

As a boy in my early teens in Scotland I had some 500 animals in my private 'zoo' predominantly herpetological (especially tailed amphibians, constrictors and lizards) and at 15 I carried out my first public conservation exercise which resulted in saving the Aldabran Giant Tortoises from probable extinction as a result of proposed exploitation of their island home. This was my first experience of the levers of political power..... Since then my interest in conservation has been a major motivating force in my life. I also joined the BHS at 15 and over the years have contributed many scientific papers, articles and notes to the Society's publications. After my first degree in zoology and physiology at St. Andrews I returned to Australia to the Australian National Universty of Canberra where I was a Scholar, a Queen Elizabeth II Fellow, a Research Fellow and subsequently Head of the Applied Ecology Unit, which I had founded. These positions enabled me to carry out full-time scientific research for 11 years unencumbered by teaching or administrative responsibilities.

Although my work included a 10-year study of the population dynamics of the gecko Gehyra variegata, four other geckos in four genera and a predatory skink in northern New South Wales. together with work on many 'inland' species, I am probably best known for my extensive research and conservation work on sea turtles and crocodilians. In Australia my students and I carried out very extensive work on the ecology and population dynamics of both the Green and Loggerhead sea turtles. This work resulted in total protection being afforded to all species of sea turtles throughout Australia and its international waters (Australia is home to six of the world's seven species of sea turtles including the endemic Flatback which I rediscovered — Archie Carr had said it did not exist!).

People in Europe and the US have difficulty in grasping the sheer size of Australia. The State of Queensland in the northeast of the country alone has a coastline of some 2,500 miles, plus the 1,200 mile-long Great Barirer Reef with its numerous coral cays provides ideal safe nesting sites for sea turtles. IUCN (then known as the International Union for the Conservation of Nature and Natural Resources) realised the significance, however, writing that the 1968 legislation which I brought about in respect of Queensland was 'by far the most significant legislation in turtle conservation that has yet been enacted anywhere in the world'.



In the Sahara / South Tunisian desert

For crocodilians I likewise achieved Australiawide protection of both native crocodiles — the endemic freshwater Australian crocodile (Crocodylus johnsoni) and the world's largest species, the Saltwater or Estuarine Crocodile (C. porosus) (the world record for any species of crocodilian being an Indian individual reported by me at 24 feet nine inches). I carried out my first international consultancy in 1968 to Papua-New Guinea to advise on the crocodile skin industry and work out the continuation of an industry whilst maintaining viable populations of both crocodiles (C. porosus and C. novaeguinae). This provided excellent consultancy practical experience and I successfully got the House of Assembly to pass legislation restricting the lower size at which crocodiles could be taken.

I also served on a number of IUCN Specialist Groups, was a Founder Member of of the Marine Turtle Specialist Group and founded the Crocodile Specilaist Group which I led as Secretary for a number of years.

I was invited to India by the Prime Minister to advise the Government of India on the possible conservation of the critically endangered Gharial (*Gavialis gangeticus*). On reporting that the species could be saved, though it was down to some 60-70 surviving adults throughout its extensive north Indian range resulting in some animals never meeting individuals of the opposite sex, the Prime Minister said the Government would implement my report if I would return to

India to head up the project. This task developed into by far the world's largest crocodilian conservation project with multiple sites in 10 States of the Indian Union and an enormous network of sanctuaries and National Parks developed specifically for crocodilians, including some that covered many thousands of square kilometres. The work embraced the Saltwater Crocodile (endangered in India) which I already knew well from Australia and New Guinea and the greatly depleted Indian Mugger (C. palustris), as well as saving the Gharial. I spent a fascinating eight years in India working on these projects. A recent review volume of the Wild Life Institute of India devoted to India's crocodilians, after 25 years of the Crocodile Project, paid tribute to its great and enduring successes.

After 19 years abroad I am back in Scotland again but continuing my international conservation interests and encouraging the Society to embrace conservation worldwide. Throughout, I have kept — and bred — many species of lizards, snakes and amphibians. For instance, I first bred Bearded Dragons in the 1960s and the Society's journal from 1955 carried many of my breeding successes. I was for many years particularly fascinated by chameleons.

I have published numerous scientific papers (over 100) and articles for the 'intelligent layman' (at least in similar numbers) as well as the books *Australian Lizards, Sea Turtles: Their Natural History and Conservation*, and a more popular book *Kay's Turtles*. In the 1960s I was elected Fellow of the Herpetologists League (the Society which publishes *Herpetologica*) for my contributions to herpetology.

I currently keep and breed some European tortoises (I was given my first — *Timothy* — at the age of five) and am very active in promoting their conservation as well as keeping and breeding the magnificent *sulcata*. I have retained my love of the 'Sleepy Lizards' of my Western Australian childhood and am fascinated by the many naturallyoccurring, and very beautiful, colour forms.

## **ORIGINAL ARTICLES**

## Why do some chelonians seem so silly?

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ABSTRACT. — The behaviour of chelonians is based on instinct rather than on learning. Nevertheless, casual observations suggest that some species are quite capable of association learning if not of insight.

**TINNIE-THE-POOH** may have been a 'Bear of Very Little Brain', but he was a genius compared with many tortoises. Give them a lettuce leaf, and they almost never try to eat it from the edge in a sensible way. On the contrary, they keep on and on biting at the middle of the leaf until by pure chance, the side falls towards them so that they can get their mouths round it. They are nearly as silly as the goldfish in the pond. These quickly learn to come to the surface when they see me but, when I throw a pinch of food to them, all too often they start to bite at floating leaves or flower petals, which are obviously far too large to get into their mouths. Only later do they begin to eat the food. Moreover, they prefer to eat 'goldfish pellets, floating type', rather than enjoy a healthy varied diet of chopped up worms, breadcrumbs, insects and the like.

Frogs and salamanders are almost as silly. Offer them a beetle or a woodlouse, and they will wait until it has moved beyond reach before they begin to show any response. Nine times out of ten, the prey will have departed long before they begin to show any response at all! Toads need to be stung many times before they learn not to eat honeybees (Cott, 1936, 1940). Surely, one would think, natural selection should have instilled a modicum of learning and common sense over the aeons that have passed since the Testudines or Chelonia first appeared in the fossil record at the end of the Permian period, some 250 million years ago. The ancestry of the Amphibia reaches back to the Carboniferous, nearly 100 million years earlier. Moreover, unlike tortoises, adult Urodela and

Anura are carnivorous, and carnivores tend to be more intelligent than herbivores because they need to capture active prey. Perhaps the development of brain cells is more costly in terms of energy than one realises.

Amphibians such as frogs do not display any obvious evolutionary advance over fish, as far as the complexity of their fore-brains is concerned. A frog manages fairly well with its fore-brain removed though it is probably rather sluggish and unenterprising, according to Barnett (1967). Reptiles have substantially enlarged cerebral hemispheres relative to total size, but there is no cerebral cortex as there is in mammals. The cortex arises from the roof of the fore-brain, but it is the floor which is well-developed in reptiles. Thorpe (1956) reviewed learning and instinct in amphibians and reptiles. He cited Fischel (1934) who demonstrated trial-and-error learning in the Snapping Turtle (Chelvdra serpentina), and added 'The learning curves also show characteristics suggesting insight when the animal is required to learn a modification of the original way of getting at the food — for instance, over instead of under a wire'. Although instinctive behaviour has been studied in depth among Testudines, little attention seems to have been paid towards learning. Doubtless instinctive responses have always sufficed the needs of these armoured herbivores. Moreover, tortoises probably seldom come across cut vegetables or loose green leaves under natural conditions. Consequently they are ill-adapted to deal with them.

Much of my own interest in tortoises stems from the days when I was conducting research on the physiology of thermoregulation in *Geochelone* sulcata (Cloudsley-Thompson, 1970), *Terrapene* ornata (Riedesel et al., 1971) and *Testudo graeca* (Cloudsley-Thompson, 1974) (reviewed in Cloudsley-Thompson, 1974) (reviewed in Cloudsley-Thompson, 1999). Adult *G. sulcata* never struck me as being particularly silly, but very probably size had something to do with it. As Jennings (1906) postulated, if an amoeba were the size of a dog, no-one would hesitate to credit it with intelligence. (A common Tripos examination at Cambridge in the 1940s was to comment on this statement.)

In 1969, my colleague Sir Marriot Nicholls (Professor of Anatomy, University of Khartoum) and his wife Mary witnessed a curious event in the tortoise enclosure at Khartoum Zoological Gardens. A large *G. sulcata* fell accidentally onto its back and was unable to right itself. Two other giant tortoises, however, saw what had happened. They hurried over from the opposite side of the enclosure and, with their shells, tipped their unfortunate comrade back onto its feet. This apparently altruistic behaviour has, I believe, also been recorded in other species of Testudines. If it is instinctive, however, how did it evolve? Is it group selection or kin selection? Wynne-Edwards (1962) never mentioned it.

Neither Testudo graeca nor T. hermanni, charming creatures through they are, ever struck me as being anything other than rather silly. Terrapene ornata, however, is another matter altogether. During the summer of 1969, in company with Bud Riedesel at the University of New Mexico, Albuquerque, my wife Anne and I carried out some experiments on thermoregulation in this species of box-turtle (Riedesel et al., 1971). The animals were by no means easy to handle. For no apparent reason they would close their shells with considerable force, pinching one's fingers quite painfully. To prevent this, it was necessary to wedge a cork at either end of the shell before insinuating thermistor probes into the mouth and cloaca. The terrapins evidently did not enjoy this and, surprisingly quickly, learned to close up as soon as the door of the laboratory opened. It soon became necessary to stalk them in their vivaria. catch them by surprise, and insert the corks before they realised what was happening! We were loath to anaesthetise them heavily because it took ages for chloroform or ether to take any effect, and we did not want to risk harming our involuntary guests before returning them to the wild.

These casual observations suggest that chelonians are quite capable of association learning, if not of insight, and by no means so silly as they may at first appear. Robert Bustard (2001) has revealed clear evidence that *Testudo hermanni* has a well-developed ability to learn and remember local topography, and his observations may suggest the possibility of insight!

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# A preliminary look at the spatial distribution of Treeboas at a site on Grenada

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FACTORS influencing the spatial distribution of snakes are poorly understood. Because of the heterogeneous nature of most (all?) snake environments, however, we can assume that they are not randomly distributed. Furthermore, as there is little indication of territorial defence of fixed areas, it is 'more appropriate to regard snakes as maintaining individual distances that vary with circumstances' (Gregory et al., 1987); i.e., the spatial distribution of snakes is dependent on the spatial and temporal distribution of resources.

The treeboa Corallus grenadensis (Figs. 1-2) occurs in a wide range of habitats on the Grenada Bank. Although it occasionally descends to ground level (e.g., to cross a road), virtually all of its activity (foraging, sleeping/resting. thermoregulation, etc.) is restricted to aboveground vegetation. At night, the nocturnally active Corallus grenadensis projects a brilliant eyeshine in a beam of light, allowing it to be seen from distances approaching 50 m. Because of the telltale eyeshine, and because C. grenadensis is common in some situations, it is often encountered in numbers not usually associated with snakes in the Neotropics. Although a foraging or resting treeboa can be overlooked if its eyes are covered by a sprig of vegetation, or if it is oriented in such a manner that the light beam misses the snake's eye, the eyeshine does facilitate a much higher encounter rate than if it was absent. Visual surveys of C. grenadensis have been conducted at a number of sites on Grenada for more than a decade (Henderson, 2002).

Here, based on the capture, measurement, and mapping of the distribution at a site on Grenada, a

preliminary analysis of spatial distribution in *Corallus grenadensis* is described and discussed.

#### **METHODS**

A 440 m transect was marked-off in 10-m sections at Pearls Estate (St. Andrew Parish), a heterogeneous patchwork of mixed agriculture (mango, breadfruit, citrus, coconut, cacao, papaya), native vegetation, and relatively open areas. The site is described in more detail in Henderson (2002). Treeboa locations were recorded by distance along the trail to the nearest metre. That is, a snake captured at 3 metres into section 5 was at metre 53 of the transect. The perpendicular distance from the trail was also determined to the nearest metre. Over 11 nights in February 2002, treeboas were collected, sexed, weighed, measured, PIT-tagged, and released at the site of capture 24 hrs later. Data used here are based only on the original capture site and not on subsequent observations of marked snakes.

Snakes were divided into three size classes that correspond to an ontogenetic shift in diet the snakes undergo: <600 mm SVL (exclusively anole predators), 600-1100 mm SVL (transitional from anoles to rodents), and >1100 mm SVL (primarily rodent predators) (Henderson, 2002). The location of each snake captured was plotted to scale on graph paper and the distance to the nearest snake of the same size class, or to its nearest neighbour regardless of size class, was determined. Distances are straight-line distances and do not take into account presence or absence of arboreal corridors that undoubtedly influence the distribution, movements, and spacing patterns of treeboas and their prey.

	<600 mm SVL	600-1100 mm SVL	>1100 mm SVL
SVL (mm)	513.1 ± 11.1	813.9 ± 3	1164.0
± 34.0	443-598 (15)	600-980 (14)	1130-1198 (2)
Mass (g)	21.3 ± 1.6	99.9 ± 12.2	377.0 ± 45.0
	9-31 (15)	28-171 (14)	332-422 (2)
Distance 1 (m)	18.1 ± 5.8	32.8 ± 6.6	158.5 ± 2.5
	2-71 (15)	4-78 (14)	156-161(2)
Distance 2 (m)	11.4 ± 2.5	21.1 ± 4.9	18.5 ± 2.5
	2-34(15)	3-59(14)	16-21(2)
Distance 3 (m)	26.1 ± 3.0	30.1 ± 3.8	14.7 ± 3.5
	7-46(15)	7-59(14)	8-20(3)

**Table 1.** Size class and spacing data for *Corallus* grenadensis at Pearls Estate. The mean  $\pm 1$  SE is followed by the range of values and sample sizes. Distance 1 is the minimum distance between snakes in the same size class; Distance 2 is the minimum distance to another snake regardless of size class; Distance 3 is the minimum distance to the nearest neighbour of a different size class.

## **RESULTS AND DISCUSSION**

Small, anole-eating Corallus grenadensis are, on average, spaced closer to one another than are those treeboas in a transitional size class or those that are exclusively rodent predators (Table 1). The mean minimum distances between treeboas of different size classes were statistically significant (ANOVA, F = 32.51, P = 0.0001). Significant differences occurred between the largest size class and the two smaller size classes, but not between the two smaller size classes (Tukey's Studentized Range Test, P < 0.05). Those results are tempered somewhat by the fact that the largest size class has only two values. While working at Pearls in February 2002, we were not able to capture every snake encountered because of the height at which they were foraging or resting in tree crowns. However, we could determine that most of those that were out-of-reach were of small to medium size (<1000 mm SVL). Only one large snake (>1100 mm SVL) was encountered that we could not capture and it was 156 m from the nearest point at which we captured another large (>1100 mm SVL) treeboa, and we included it in our distance analysis.

Within the smallest size class, the nearest neighbour was in the same size class 80.0% of the time, for the middle size class it was 57.1%, and 0.0% for the largest snakes. Mean distances between different size classes regardless of the size class of the nearest neighbour were not statistically significant (ANOVA, F = 1.73, P = 0.1951). Likewise, mean distance to the nearest

neighbour of a different size class was not significant between different size classes (ANOVA, F = 1.93, P = 0.1634) (Table 1). Perhaps most striking is the proximity of large snakes to smaller snakes compared to the distances between individual large snakes.

It is to be expected that over the 11 nights we conducted our work, some redistribution of the snakes would have occurred. However, based on past observations at other sites on Grenada, we know that treeboas will often stay in a localized area for several days to weeks. This is especially true of small *Corallus grenadensis* (Henderson, 2002).

Small snakes which prey on ecologically ubiquitous lizards (Anolis aeneus and A. richardi) that occur at very high population densities (e.g., Roughgarden et al., 1983) occur in closer proximity to one another than snakes in size classes that prey occasionally to almost exclusively on rodents. Data on rodent population densities are lacking, but they are certainly not as ubiquitous or numerous as the two species of Anolis. Although snakes in the smaller size classes are more numerous than those in the largest size class, their spatial pattern could be altered in such a way that they could be spaced farther apart. However, the fact that anoles are so plentiful probably precludes the need for that. Large Corallus grenadensis are not common, prey on a less plentiful trophic resource, and, seemingly, distribute themselves accordingly.



Fig. 1. Corallus grenadensis from Spring Gardens Estate, St. Andrew Parish. Photograph © R.A. Sajdak.

A foraging snake needs to avoid conspecifics when they negatively impact its foraging success (Gregory et al., 1987). If maintenance of individual distances is a factor in the foraging behavior of Corallus grenadensis, then a foraging treeboa should avoid an area currently in use, or recently used, by a conspecific because that conspecific has possibly caused a resource depression in the immediate vicinity (Charnov et al., 1976; Gregory et al., 1987). Gregory et al. (1987) suggested that solitary foraging would 'be achieved by mutual avoidance without the risk and expenditure of energy involved in territorial defense, provided that appropriate signals could be transmitted and received'. The 'appropriate' signals are currently unknown, but olfaction is a likely candidate.

## ACKNOWLEDGMENTS

Recent field work in Grenada has been funded by the J.C. Penny Golden Rule Foundation (through the kindness of Robert W. Bourgeois), the Milwaukee Public Museum, Paul Bourgeois, and the Windway Foundation. The Forestry Department on Grenada continues to be supportive of my research on *Corallus grenadensis*. Andrew Wootten was a competent and pleasant field companion on several nights of work. Bob Powell offered helpful criticism on an earlier version of the paper.



Fig. 2. Corallus grenadensis from Pearls, St. Andrew Parish, Grenada. Photograph © R.A. Sajdak.

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# The influence of breeding success on adult length in a population of Crested Newts

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ABSTRACT. — The level of breeding success of Crested Newts (*Triturus cristatus*) was recorded at Shillow Hill, Cambridgeshire, annually from 1986 to 2001. Breeding failure, 1990-1992, presented the opportunity to study how adult length was affected from 1993 onwards. As was anticipated, the population in 1993 seemed to be composed of large, old adults. Mean length decreased to a minimum in 1996 as small recruits joined the breeding population, following successful breeding starting in 1993. Suggestions are made on how measuring samples of adults may help understand significant past and contemporary events in the absence of detailed knowledge of breeding success.

CRESTED Newts (*Triturus cristatus*) are relatively widespread and abundant in lowland Britain, yet are fully protected by law. This fact results in much management of newt populations, for reasons of both conservation and development-related mitigation (English Nature, 2001; Langton et al., 2001). There is, therefore, always a need for new field techniques to support management decisions.

The species usually seems to require two or three years to reach sexual maturity, and most newts continue to grow for several years beyond this time (Glandt, 1981; Oldham & Nicholson, 1986; Oldham, 1994; Baker & Halliday, 2000; Cummins & Swan, 2000; Kupfer & Kneitz, 2000). It is possible that studying the size frequency distribution of adult Crested Newts could inform an observer about recent recruitment to a breeding population (Oldham & Nicholson, 1986), although length is not an accurate indicator of age, especially for older adults (Hagstrom, 1977; Glandt, 1981). Cooke (2001a) described a translocation exercise involving Crested Newts rescued from a very shaded pond. The newts were all large adults, the inference being that breeding had failed for a number of years. Further evidence supporting this suggestion was obtained when, after several years of successful breeding, newts in the subsequent colony were found to be significantly smaller than the translocated individuals.

Crested Newts have been studied at Shillow Hill in Cambridgeshire since the 1980s (Cooke, 1995; Cooke & Arnold, 2001). A severe drought in the early 1990s resulted in dry summer conditions and almost total breeding failure over a period of three years. This provided an opportunity to determine whether detectable changes in the mean size of adult newts occurred during subsequent years. Recording any such changes might prove of value in indicating breeding success in other situations where direct observations on metamorphic output had not been made.

#### SITE AND METHODS

Shillow Hill has about 2 ha of artificial and seminatural habitat and is situated at grid reference TL 28-82-. It is bordered on one side by the B 1040, but is otherwise surrounded by arable farmland. As far as is known there has never been any human translocation of newts into or out of the site. Throughout the 1990s, only the main pond at the site, Top Pond, has produced Crested Newt metamorphs. No other pond is shown closer than 500m on the 1:25000 Pathfinder map, with the nearest known Crested Newt site about 1 km away. Natural immigration can therefore be ruled out (eg see Baker & Halliday, 1999; Cooke, 2001a), and the maintenance of the population at Shillow Hill is dependent on its own progeny. Influence of breeding success on adult length in Crested Newts

Providing there w water in Top Pond, was netted for Crest Newt larvae on fo occasions duri July/August ea year, 1986-2001. F each metre of shore. 2 m sweep was ma with a pond n through the water an aquatic vegetati towards the edg After being counter larvae were return to the pond. T method was intended

Voor		Malas			Famalas		Decen
Icar	No in sample	Mean±SE (mm)	Range (mm)	No in sample	Mean±SE (mm)	Range (mm)	small newts in sample
1993	10	1 <sub>12±1</sub>	1 <b>07-<sup>1</sup></b> 17	5	<sup>1</sup> 26±3	121- <sup>1</sup> 35	0.00
1994	5	1 <sub>17±2</sub>	113- <sup>1</sup> 26	6	<sup>1</sup> 26±1	122-130	0.00
1995	13	1 <sub>12±3</sub>	95- <sup>1</sup> 26	8	<sup>1</sup> 27±2	113- <sup>1</sup> 33	0.29
1996	12	102±1*a	93- <sup>1</sup> 08	8	1 <sub>18±3*</sub>	107- <sup>1</sup> 30	0.65 <sup>bc</sup>
1997	17	1 <sub>08±2*</sub>	96- <sup>1</sup> 24	8	<sup>1</sup> 21±3	107- <sup>1</sup> 33	0.60
1998	8	115±3ª	104-129	9	<sup>1</sup> 21±2	113- <sup>1</sup> 33	0.35
1999	3	1 <sub>13±5</sub>	106-123	6	<sup>1</sup> 25±4	108-137	0.33
2000	18	<sup>1</sup> 14±2	103-127	12	1 <sub>22±2</sub>	108- <sup>1</sup> 35	0.30
2 <b>0</b> 01	6	$1_{17\pm1}$	113-123	7	<sup>1</sup> 22±2	117- <sup>1</sup> 29	0.23

to provide an indication of relative larval abundance at metamorphosis (Cooke & Arnold, 2001; Cooke 2001b).

To collect a sample of breeding adults from Top Pond for measurement, a pond net was used for about 30 minutes at night once each year between 14 April and 4 May, 1993-2001. Overall length of each newt, from tip of snout to end of tail, was measured to the nearest millimetre with a ruler. Newts were then returned to the pond. Two newts had appreciably shortened tails through injury, and were not measured. In 2001, the distance from tip of snout to the rear edge of the cloaca was also recorded to compare results with those of other authors for newts of known or suspected age.

## RESULTS

Netting of larvae in Top Pond showed that the drought experienced during 1990-1992 resulted in a long period of metamorphic failure not otherwise experienced during the study (Figure 1). The pond dried completely in the summers of 1990 and 1992, while its sump allowed limited metamorphosis in 1991. So the great majority of adults in 1993 must have been at least four years old; it is likely that many were five years of age, the last good year for metamorphosis being 1988.

Measurements of newts caught in 1993 and thereafter are given in Table 1. The shortest newts

Table 1. Total lengths of adult males and females in the yearly samples, 1993-2001. The proportion of small adults in each sample is also given (see text for method of calculation). \* significantly different from previous year by t test, P<0.05; <sup>a</sup> significantly different from two years before by t test, P<0.001; <sup>b</sup> significantly different from two years before by t test, P<0.001; <sup>c</sup> significantly different from two years before by chi-squared test, P<0.05; <sup>c</sup> significantly different from two years before by chi-squared test, P<0.001.

caught in 1993 were: male 107 mm, female 121 mm. In this paper, newts shorter than these thresholds are referred to as 'small', the proposition being that these will have tended to be individuals aged three years or younger.



Figure 1. Mean number of Crested Newt larvae netted each summer, 1986-2001.

In 1994, all newts in the sample were longer than these thresholds (Table 1) indicating that no individuals were returning to breed from the 1993 cohort of metamorphs (Figure 1). The increase in length between males caught in 1993 and 1994 reached statistical significance almost (0.05 < P < 0.1), suggesting growth was continuing. By 1995, 29% of the combined sample of males and females were classified as "small", these presumably being among the first of the 1993 cohort to mature (Table 1). In 1996, the proportion of small newts increased significantly to 65%, and mean lengths of both males and females were less than previously; this influx of smaller newts will have been due to three year olds from 1993 or two year olds from 1994. After 1996, mean length increased, with a significant change being recorded for males. From 1998 to 2001, mean length was stable for both sexes and some small newts were recorded in each annual sample. The breeding failure during the isolated drought year of 1997 (Figure 1) was not translated into any discernible effect on subsequent adult body length.

Mean snout-cloaca lengths  $\pm$ SE in 2001 were: large males 70.0 $\pm$ 1.0 mm (n = 6, range 67-73 mm); large females 72.0 $\pm$ 1.2 mm (4, 70-75 mm); small females 69.0 $\pm$ 1.2 mm (3, 67-71 mm). No small males were caught in 2001.

Immature Crested Newts, presumably aged 1-2 years, are recorded in Top Pond during most breeding seasons (e.g. see Cooke (1995) for night count data). They tend to be more abundant during late spring and summer. Samples of newts were caught in the present study relatively early in the breeding season, and no immatures were identified among the adults examined and measured.

## DISCUSSION

Despite an immense amount of recent conservation and rescue work on Crested Newt populations, there is relatively little published data from Britain on the length of newts of known age during the breeding season. Oldham & Nicholson (1986) described a cohort of adults breeding for the first time in their study population in 1984; they were at least two years of age, and many were

100-110 mm in total length. This is not dissimilar to the small adults of the current study which ranged between 93 and 120 mm. One would expect, though, that growth and body size might vary considerably between individuals in different populations or between years in the same population (e.g. see Hagstrom (1977) for Swedish populations). Baker & Halliday (2000), working on males of putative age, found their snout-cloaca lengths to be greater than those recorded in 2001 for larger males at Shillow Hill e.g. for males thought to be at least four years old, mean length was 84.5 mm (n = 9, range 75-90 mm). In contrast, Cummins & Swan (2000), working at a Cambridgeshire site only 11 km from Shillow Hill, recorded virtually identical sizes to the large newts at Shillow for individuals known to be four years old: mean snout-cloaca length for males 70.5 mm (n = 6, range 68-72 mm); females 72.7 mm (4, 69-76 mm).

In the study of Cummins & Swan (2000), there was no overlap in length for either sex between three year olds and four year olds. However, their sample sizes were small and they recorded growth of the same tagged individuals. In larger samples taken randomly from a population, the relationship between age and size may not be so clear cut (see Glandt, 1981; Oldham & Nicholson, 1986). While most 'small' newts at Shillow Hill may conceivably be less than four years of age, one might expect some older newts to occur in a sample of small individuals; and, conversely, some (two or) three year olds in a sample of larger newts.

While knowledge of age will aid prediction or interpretation of data, one aim of this exercise was to test a simple technique for use in the field. Unlike age determination, measurement of length is quick and easy. Data collected at Shillow Hill showed that, following three years of breeding failure during 1990-1992, length of adults was at least maintained for two years, then decreased to 1996 before increasing again. These observations are consistent with the appearance of recruits from the metamorphic cohort of 1993 initiating the reductions in mean length. Changes were more marked for males than for females.

Understanding events at Shillow Hill is facilitated by knowledge of past breeding success. At other sites without any direct observations on breeding success, one could deduce what might have happened from measuring annual samples of adults. If the observer has some knowledge of likely lengths for adults in a particular population, even a sample from a single year may provide clues, depending on the relative numbers of small and large adults (see Cooke, 2001a). Then samples collected in subsequent years can help to firm up on any tentative conclusion. It should be remembered that a high or increasing proportion of small newts may alternatively suggest an increasing population rather than one that is strictly recovering. Additional observations, such as monitoring adult numbers, will help to decide. On the other hand, if increases in length are noted from year to year this may indicate stabilisation of a population following a significant influx of recruits, or an ageing population in which there is little or no recruitment. Lack of recruitment may be due to poor survival of juveniles, as well as to low metamorphic success; and density dependent factors may operate. Again, monitoring numbers will help to inform the judgement, as will simple field observations on conditions in the breeding whether site water persists until e.g. metamorphosis. For the technique to detect an event such as breeding failure, it seems that event must be significant in its scale and/or persistence.

Had breeding success not been recorded at Shillow Hill until 1993, the changes in length, 1993-2001 (Table 1), could have been translated as suggesting little or no metamorphic success for several years up to and including 1992. The exact length of this period of failure would not have been known. It is hoped to produce another paper on the Shillow Hill data, focusing on population trends in relation to breeding success.

#### ACNOWLEDGEMENTS

It is a pleasure to acknowledge the help and support of Henry Arnold throughout this study. Dr. John Baker provided helpful comments on an earlier draft of the paper.

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# Keeping and breeding Leopard Tortoises (Geochelone pardalis). Part 2. Accommodation, diet and feeding

## **ROBERT BUSTARD**

Tobtained my first Leopard Tortoise when I was 15. Lit came — as did all tortoises in those days from the wild, but it was not a bulk import. It had been collected for me on a cousin's farm near Rongai in Kenya, which was then a British colony, in what was then called the 'White Highlands'. The day after its collection it was despatched to me by BOAC and the following day it was walking around our Scots garden. This was a very different situation from bulk imports where tortoises are collected and often held by dealers in their native country for extended periods with little or no food or water, let alone creature comforts. On arrival in Britain some dealers treat them abominably, providing them with none of the warmth that all tortoises - and especially non-hibernating subtropical/tropical tortoises - require.

This tortoise was an education. It was only the second type of true land tortoise which I had kept: the first one being a graeca, named Timothy after Gilbert White's famous tortoise, which had belonged to my nursery schoolteacher and which she gave to me when I was nearly five. I already had some very fine large Asian land/swamp chelonians, Melanochelys trijuga thermalis, which I found extremely interesting and also various American box tortoises (Terrapene). But I digress ... This Kenyan leopard did very well indeed, being outside during the warm summer months and indoors in roomy, warm, draught-free accommodation during the colder months of the year. It was beautifully marked with strongly contrasting black markings against a vellowish, straw-coloured ground colour. I had to find homes with friends for all my reptiles Timothy being an exception — when I went off to University. Thereafter I was abroad for some twenty years so my tortoise-keeping days were interrupted, there being no land tortoises in Australia where I spent the first 12 years.

It was not until after my return home in 1981 that

I could resume tortoise-keeping. All that follows is subsequent to that date. In the intervening years, however, I was fortunate to be able to see leopards in the wild in parts of their range. The Leopard Tortoise has an enormous distribution in Africa south of the Sahara from Sudan and Ethiopia in the north to Cape Province in the south and extending across much of Africa in an east-west direction. In this huge distributional range the species occurs over a wide altitudinal range. Not surprisingly there is very considerable geographical variation throughout this range and between more isolated populations. Our former Chairman, Mike Lambert (1995) reported on geographical size variations, growth and sexual dimorphism in Somaliland at the northeastern part of the range of babcocki. These variations are masked by only two geographical races being named; G. pardalis pardalis with a limited range in parts of the Republic of South Africa and G. pardalis babcocki covering the rest of the species' range. However, anyone who knows the species' zoogeography will tell you that among the various geographical differences a significant one is size. Some populations always consist of small tortoises, others of intermediate ones, and in some areas others of massive ones. Equally marked are differences in shell shape. In some populations the individual carapace scutes are more or less flat, whereas in others each scute is pyramidical in shape almost like a captive-reared tortoise which has not had a proper diet. That this is seen in wild tortoises, which have certainly not suffered from the problems which cause pyramiding in captivity, shows that it is a genetic feature.

The Leopard Tortoise is the second largest tortoise on the African continent, only *G. sulcata* growing larger. Both subspecies include large races/individuals. Branch et al. (1990) list record sizes as 656mm (26") in males and 705mm (28") in females with corresponding weights of 43 and 48.6kg respectively. These are exceptional although

I have seen individuals of about 550mm (22") in the UK. In view of currently held opinions regarding sulcata I would stress that even the largest leopards are not at all destructive, can be easily contained, and will not attempt to dig out of their pen. In recent years most of the Leopard Tortoises imported into this country have come from Zambia in Southern Africa. The most positive point about leopards is that they are now being regularly bred in captivity with the result that captive-bred youngsters are fairly often available. If you wish to have a leopard tortoise you should try to obtain one of these rather than an imported tortoise. Leopard tortoises grow very rapidly with proper care, so you can have a sizeable tortoise - say 20-25cm (8-10") only about five years from hatching (see also below).

Like all tortoises, leopards like space — as much room as possible — and preferably 'interesting' space. By interesting space I mean some of the following: a raised area of ground angled towards the south which will be used for basking; some larger easily climbable rocks scattered around the enclosure; or even a small scree-slope; one or two larger logs so arranged to provide temporary hiding places and shade during the heat of the day; one or two substantial low-growing leafy plants which will also provide natural shade and cover. These can be sunk into the ground in their pots and lifted each autumn if not reliably frost hardy.

There is no substitute in my opinion for an outdoor enclosure — as large as possible — for them to use whenever the weather is suitable. It is important to point out than once they have attained large size, when their compact shape has warmed up, they can come out to graze for quite extended periods, even on quite cool days, returning back inside before they lose too much heat. Many individuals will quickly learn to carry out this shuttling behaviour exactly as they would do in the wild — with the change that here they are avoiding over-cooling, whereas in nature they would be avoiding over-heating. I found that when my juveniles, at a size of about 12-15cm (5-6"), joined the adult group, they very quickly learned to shuttle in and out with the differences that a) they were more active than large individuals and b) their small mass necessitated much more frequent return to the

warm indoor accommodation during cold/cool weather. Leopard tortoises must have indoor heated accommodation for the colder months of the year. This often used to be achieved by giving them a room within the house. The system described above where they have access to an outdoor area at will (except for very cold periods when they may be shut in) is much to be preferred.

I am a great believer in under-floor heating for tortoises as they lie flat on the ground for very extended periods. Heat lamps are much less effective if the tortoise is lying on a cold substrate. One has also to consider their environment when the heat lamps are turned off, as at night. Under-floor heating can be achieved in any one of a number of ways. In a custom-built, concrete-floored shed it is fairly straightforward to install a grid-system of piping at the time of construction through which hot water from a boiler circulates to maintain the desired substrate temperature. With my own tortoises I prefer to use raised, custom-built, high quality, tongue and grooved, wooden sheds. The whole shed - walls, ceiling and floor - is insulated with sheets of 5cm (2") thick polystyrene and custom-built heat mats cover the entire floor area. These heat mats are of an output (150 watts/M<sup>2</sup>) that I have found ideal for tortoises. This is lower than normal reptile heat mats because the tortoises are lying directly on the floor unlike many other reptiles.

To protect the heat mats from damage from large tortoises — which includes urination as well as physical abrasion - I cover the entire floor area with large aluminium trays. Aluminium has a high heat conductivity, which is obviously important, but has the added advantage that is light, so the travs can be easily removed for cleaning. Stainless steel is very much heavier. Each tray has a 2.5cm (1") lip all round and the trays fit closely together to cover the entire floor area. On the advice of my heat-mat specialist I run sheets of silica, placed at right angles to the mats, across the entire floor area to prevent any possible electrical discharge from the mats through the aluminium trays to the tortoises. So, to summarise: the heat mats are placed on top of 5cm (2") thick polystyrene, covered by sheets of silica run at right angles to the length of the mats, and then the whole is covered by aluminium trays, the latter of suitable gauge to the size/weight of the tortoises being kept, as well as being suitable for the owner to walk on. My leopards had a floor area of approx 4.3x53 m (14 feet by 18 feet) and this area was covered by 6 trays. It is important that wiring from the heat-mat(s) is protected by a conduit securely fixed down so that tortoises cannot become entangled in the wiring. The normal tortoise response to becoming entangled in anything is to push/pull, with — in this instance — unfortunate consequences such as ripping out the wiring and so cutting off the heat source!

An under-floor heat mat set-up such as described above can, of course, be kept at a desired temperature by including a thermostat in the circuit. In the winter in Scotland the heat mat under-floor heating is kept on without thermostat twenty-four hours a day. The heat is reduced/increased in spring/autumn. In 'summer' it is time-clock controlled so that it goes off in the morning after the tortoises have emerged into their pen and comes on again between three and four in the afternoon so that they return to a warm floor environment to sleep. In hot summer weather it is switched off completely. This period can, of course, also be thermostatically controlled. I cannot over-emphasise the advantages for subtropical/tropical tortoises of under-floor heating.

Bright sunlight is also important in the lives of all but deep forest tortoises. For much of the year in the UK the intensity of the light — even if the sun shines — is poor. My large tortoise shed — where my leopards lived — is lit using 4 foot 'daylight' spectrum fluorescents (Thorn/EMI) to provide a bright, natural light environment. These, like the additional heating provided by two heat lamps, are time-clock controlled which results in bright light and a temperature lift from morning to evening together with darkness and a gradual fall off in temperature at night. I alter day-length to match the seasons.

Although leopards should be allowed into their outside area whenever possible, including warmer periods during the winter months, it is important to ensure that all have returned to their heated accommodation before temperatures fall in the late afternoon. Different species of tortoises — as well as individuals within a species - vary greatly in their daily 'homing' ability, the species' differences presumably depending on their habits in nature. Tortoises (Bustard, 2001) have the ability to very quickly learn the geography of their pen and shed so that they can return 'home' from day one. However, not all species, nor all individuals of a species, will regularly do so. I found that most of my leopards would home of their own accord; but some would often either move into a corner in the late afternoon or push into a tussock of tall grass. Even in a modestly-sized pen, any but large tortoises were extremely hard to see under such conditions and one quickly comes to appreciate the camouflage effect of their striking colouration - just like that of their namesake the feline leopard. In the right environment both provide excellent examples of the camouflaging effect of disruptive colouration.

The initial pen measured 8m (26') square and early in the season the grass growth exceeded the leopards grazing ability so that it grew long. The area was also left natural so that dead grass was also present in the tufts giving the leopards a lot of cover. A second pen measuring  $14 \times 10m (46' \times 33')$  was added later because I had expanded the collection to include *sulcata* and by changing one set of boards the tortoises could be directed to either pen. This allowed one pen to recover while the other was being grazed.

Cover of the above kind may be valuable in 'breaking up' the outdoor enclosure so that tortoises cannot see the entire area of the pen from any one point. It is certainly much less 'boring' than an area of mown lawn where they can see the entire enclosure (and all the other tortoises) at any one time - a most unnatural situation. Furthermore, 'lawn' will provide a much poorer foraging area than is ideal. My pens are seeded with a good agricultural mix of grasses including additional items such as Clover. Not only does this provide an excellent range of 'graze' but adds to the 'tuftiness' of the grass and consequently the cover provided. This gives individual tortoises privacy, which is very important when mating is occurring as the 'lack of view' ensures females are not constantly harassed by courting males.

Access to and from the shed is through a small

opening cut at floor level in one side just wide and high enough to allow the larger tortoises to pass through. Thus, when the tortoises are outside all/most of the day, the shed becomes a secluded sleeping area. Individual sleeping quarters can be provided within the shed using either strong cardboard boxes (of short lifespan!), or better wooden boxes minus a floor area as this would reduce heat gain for the sleeping tortoise insulating it from the tray-covered heat mat. Alternatively, one can construct a series of stalls of varying breadths to suit different size categories of tortoises. A removable sheet of plywood is put across the top of these to provide an added feeling of security. The boxes or stalls can be partly filled with dry leaves. I avoid hay or straw for my tortoises, as these can result in sharp ends which could cause eye injury.

I consider it important that the tortoises are able to go out whenever the weather is suitable. No artificial lighting set-up is nearly as beneficial as the heat and the light intensity of natural sunlight. This applies equally to baby leopards. These will require baby pens which need to be covered with chicken wire when the tortoises are very small lest they be eaten by birds. It is, of course, possible, and very desirable, to incorporate small water-proof sleeping quarters with heat mats into these baby or small juvenile pens even although the tortoises are taken indoors each evening. This is doubly important, due to the vagaries of our climate, if someone is not on hand throughout the day.

In many urban areas foxes are now common and are sometimes out foraging even during the day. In such localities it is essential to have fox-proof enclosures for all small tortoises. Adults should, however, be safe from even the most determined fox unless the tortoises are used to domestic dogs and have become overly tame.

Food - Leopards are vegetarian grazing animals and will consume large amounts of mixed grasses (the European tortoises *T. graeca* [*ibera*] and *hermanni* prefer to eat the weeds — such as Dandelions and Clover — amongst the grass, rather than eating the grass itself). The normal high fibre diet recommended for all grazing tortoises is very important. As well as mixed grasses they also like all 'weeds' which you would feed to rabbits including Dandelions, Sowthistle, Groundsel, Clover, plaintains, Cowparsley, etc). It is important to try to keep up this graze as much as possible during the winter months when the tortoises are mostly indoors. This is also a reason to allow outdoor grazing whenever the weather is sufficiently mild. During the winter it will be necessary to supplement what graze is available with greens such as cabbage, cauliflower leaves and brussel sprout leaves. These all have different tastes so can be used in turn, or mixed together to provide variety and all are coarse leaves containing a lot of fibre so essential to their diet. Some other vegetable matter can be provided such as small quantities of tomatoes and cucumbers, both of which my leopards always liked.

I do not include fruit in the diet as unless provided in very small amounts it is likely to cause diarrohea in this species. They, like almost all tortoises, should NOT be given meat or meat products such as cat or dog food, as such high protein foods can have deleterious effects including shell 'pyramiding' and can place an unnecessary strain on the liver and kidneys during their breakdown (deamination). Nor should they be fed on dry products such as 'tortoise chow' which again can cause kidney problems unless the tortoises drink copiously, since tortoises are used to vegetable food which is predominantly (up to 90%+) water.

There are tremendous advantages in allowing them to graze naturally on vegetation based on a good agricultural meadow seed mix which you can obtain from your local Farmer's Cooperative. Under this regime the food is always fresh and vitamin rich at the time of consumption, whereas a lettuce, for instance, loses 30% of its vitamin C content within six hours of harvesting.

Leopard Tortoises grow quickly and the calcium requirements of both this rapid growth and egg production by breeding females are considerable, so it is important to provide dietary supplements. I recommend Nutrobal which I use for all my tortoises. In addition it is a good idea to provide pieces of cuttlefish bone which the larger tortoises will regularly nibble. Field observers have noted this

species eating bones in the wild presumably for their calcium content. I do not recommend the feeding of bones (which may break into splinters and cause problems in the alimentary canal) but cuttlefish bone is perfectly safe. Field observers have also noted leopards eating hyaena droppings in the wild. Again, because of the hyaenas' habit of crunching up bones, these are a very rich calcium source. For baby/small juveniles, additional calcium can be provided by scraping cuttlefish to provide a fine powder which can be sprinkled onto the food once or twice a week in addition to regular provision of Nutrobal. Fresh water should always be available. I have noted my leopards of all sizes to be regular drinkers. Regular water is particularly important for baby tortoises which in warm conditions, due to their large surface area and small volume, dehydrate rapidly.

To sum up: if you would like to keep a subtropical/tropical non-hibernating species of tortoise and feel that you can provide the facilities required — especially as they grow — then the Leopard Tortoise is an excellent choice. I rate them an easy tortoise provided they are given the facilities/care described in this article.

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# Reproduction in four species of turtles at the National Zoological Park, Washington D.C., U.S.A.

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CINCE 1986, data have been recorded for Dreptiles and amphibians reproducing in the Reptile House at the National Zoological Park (NZP), Smithsonian Institution, Washington, DC, USA. These records represent an almost untapped wealth of information, and an opportunity to examine the reproductive biology of four species of turtles that have produced a sufficient number of clutches to provide significant data - the aquatic Australian Common Snake-necked Turtle, Chelodina longicollis, the aquatic South American Matamata, Chelus fimbriatus, the terrestrial African Pancake Tortoise, Malacochersus tornieri, and the terrestrial African Leopard Tortoise, Geochelone pardalis. Data concerning these clutches, eggs, and hatchlings are presented below.

#### **METHODS AND MATERIALS**

Husbandry conditions in the Reptile House for all specimens included a 12:12 hour artificial light regime, but overhead windows allow more or less light to enter depending on the season. The heating unit was set at 27°C (80°F); however, the air temperature was usually lowered to 25°C (78°F) because of frequent opening and closing of the outer doors by visiters. Water temperature in aquatic displays was also set at 27°C, but, like the air temperature, was actually about 25°C. The indoor enclosure housing *Geochelone pardalis* was opened, weather permitting, to an outside yard from mid-April through September so the tortoises could move there to obtain natural sunlight.

Geochelone pardalis and Malacochersus tornieri were fed a diet of mixed greens, carrots, and sweet potatoes once a day for six days each week. The aquatic turtles, Chelodina longicollis and *Chelus fimbriatus*, were fed different diets: *C. longicollis* was presented chopped earthworms and crickets, ad libitum at least once, but sometimes twice, daily; *C. fimbriatus* had goldfish added to its tank at least once weekly for feeding ad libitum (if all the initial goldfish were consumed, more were added).

The masses of female C. longicollis, C. fimbriatus, and M. tornieri, and all eggs and hatchlings were measured with a triple-beam balance accurate to 0.1 g; those of the larger female G. pardalis were determined with a calibrated bathroom scale. In addition, the length and width of eggs, and hatchling carapace length were measured with dial calipers accurate to 0.1 mm. Straight-line carapace lengths of female turtles were measured with either the dial calipers, or by placing the larger individuals on a meter stick. When possible, other data recorded were oviposition and hatching dates, condition of (fertile/infertile), individual female eggs identification number, and male identification number. Eggs were collected, marked for identification, and arranged in ventilated plastic shoe boxes or Rubber Maid sweater boxes on a 1:1 vermiculate/water media, and were incubated at 27.5-28.5°C (82-84°F) in a Parcifol Incubator. Both temperature and length of incubation were recorded. An attempt was made to determine reproductive effort by calculation of the relative clutch mass (RCM), total clutch mass divided by the postparturient mass of the female turtle (Hirshfield & Tinkle, 1975; Vitt & Congdon, 1978; Shine, 1980; Cuellar, 1984; Seigel & Fitch, 1984; Barron, 1997).

Statistical procedures were all done using the SAS system (v. 8.12). Analyses done included standard t-tests, linear regression, spearman rank correlation, and rank regression (Birkes & Dodge, 1993).

### **RESULTS AND DISCUSSION**

#### Geochelone pardalis

Thirty-three clutches containing 299 eggs were produced between 1984 and 1997; however, only females responsible for 17 clutches could accurately be determined--301248 (7), 302454 (5), 304001 (3), 303475 (1), and 301677 (1). Masses recorded for these females averaged 1.82 (1.13-2.40) kg. Clutch size averaged 9.6 (1-26) eggs. The single egg clutch is a new record, as this tortoise was previously known to lay 5-30 eggs per clutch, and 5-7 clutches per nesting season (Ernst & Barbour, 1989). No correlation between female mass and clutch size was evident. Two of the females that produced more than one clutch laid large clutches alternating with very small clutches: 301248--17 (1990), 24 (1991), 2 (February, 1992), 22 (August, 1992), 2 (November, 1992), 26 (August, 1997), and 20 (September, 1997) eggs in seven clutches, respectively; 302454--16 (1984), 2 (1989), 16 (1992), 11 1993), and 17 (1993) eggs in five clutches, respectively. However, female 304001 did not follow this pattern, producing three clutches of 13 (1990), 9 (1991), and 9 (1992) eggs, respectively. Since several months to years passed between normal clutches and those containing few eggs, no cycle is apparent. Perhaps the eggs in clutches of two were infertile, and merely passed instead of being absorbed. Overall, six (18.8%) clutches contained 1-4 eggs, including the single clutch of four eggs attributed the to largest female (303475, 3.41 kg).

Masses of clutches with no damaged eggs averaged 471 (83.1-1,165.8) g. RCM for the 17 clutches identified with females for whom body masses at the time of oviposition were known averaged 0.285 (0.098-0.333); clutch masses averaged 37.3 (10.9-54.0)% of postpurient female body mass.

Data concerning the eggs are presented in Table 1. No significant differences were found between

the dimensions or masses of fertile versus infertile eggs. Regressing average egg and clutch masses on female mass also yielded no significant results.

Eggs were produced in all months, but June and July; 82% were laid from August-January, with most in August (18%) and November-January (45%). Clutch intervals for those laid by the three females mentioned above were: 302454 laid three clutches between 1st September 1992 and 29th October 1993 at a mean interval of 212 (80-344) days; 304001 produced three clutches between 6th August 1990 and 8th February 1992 at intervals of 180-359 (mean, 270) days; and 301248 laid five clutches between 4 November 1990 and 4 November 1992 at intervals averaging 175 (89-334) days, and also laid two clutches of 26 and 20 eggs, respectively, in 35 days in 1997 (16th August-20th September). Incubation averaged 141 (123-176) days.

The fertility rate was 58.1 (10-100)% for clutches with no damaged eggs. The hatching rate was relatively low--28.3 (0-100)% for all clutches; 53.8 (10-100)% in 100% fertile clutches. Seventy-five percent of neonates hatched in December and January (single clutches hatched in February, May and August). Thirteen hatchlings had 43.0-50.2 (mean, 46.0) mm carapace lengths, 39.1-41.4 (mean, 40.2) mm carapace widths, and masses of 22.4-33.7 (mean, 30.1) g. Four had 10-16 (mean, 13.8) mm x 7-17 (mean, 13.3) mm yolk sacs. The ratio of hatchling mass to fertile egg mass averaged 60.6%, and hatchling mass to female body mass averaged 1.6%.

#### Malacochersus tornieri

Twenty-five clutches containing 29 eggs were produced between 1986 and 1998; 13 were laid by three females--30272 (6), 304281 (4), and 304728 (3). Masses recorded for females which produced 15 clutches averaged 385.8 (310.6-558.0) g. Clutch size averaged 1.16 (1-3) eggs. Usually only a single egg is laid during an oviposition (Ernst & Barbour, 1989).

The largest female, 30272, laid a clutch of two eggs in 1995, and another of three eggs in 1998; each of her previous four clutches in 1992-1993

contained a single egg. She was heavier in 1995 (545 g) and 1998 (558 g) than in 1992 and 1993 (433-525 g), possibly indicating a direct relationship between clutch size and female body mass. Mass of the clutch containing two eggs was 50 g, compared to 17-26 g for her single egg clutches (the clutch of three eggs had one crushed and could not be compared). Female 304728 produced three single egg clutches at body masses of 366-

Species	combined	fertile	infertile
Geochelone pardalis			
egg mass (gm)	47.4 (30.1-70.0)	50.2 (39.0-70.0)	46.0 (30.1-60.0)
egg length (mm)	45.4 (38.0-56.8)	45.6 (40.9-52.6)	45.3 (38.0-56.8)
egg width (mm)	41.9 (32.0-48.0)	42.7 (38.5-46.1)	41.6 (32.0-48.0)
Malacochersus tornei			
egg mass (gm)	22.3 (16.1-29.4)	20.8 (16.1-26.0)	23.9 (20.0-29.4)
egg length (mm)	43.0 (18.8-55.0)	43.4 (38.2-48.5)	42.7 (18.8-55.0)
egg width (mm)	19.2 (14.0-37.0)	28.0 (24.6-31.4)	27.5 (14.0-37.0)
Chelodina longicollis			
egg mass (gm)	6.0 (0.6-8.4)	6.5 (4.7-8.4)	5.2 (0.6-8.0)
egg length (mm)	29.6 (14.0-39.9)	30.2 (20.7-39.9)	28.5 (14.0-34.0)
egg width (mm)	18.5 (7.5-29.0)	18.9 (12.9-22.4)	17.8 (7.5-29.0)
Chelus fimbriatus			
egg mass (gm)	35.1 (15.3-46.2)	37.7 (31.3-46.2)	34.9 (15.3-41.0)
egg length (mm)	39.3 (36.3-47.0)	39.7 (36.3-42.7)	39.3 (37.0-47.0)
egg width (mm)	38.6 (36.5-40.4)	37.4 (36.5-38.5)	38.7 (37.0-40.4)

394 g, and female 304281 laid four single egg clutches when 424-499 g.

RCM of nine clutches for which female masses were available and no eggs damaged were 0.030-0.102 (mean, 0.054). Clutch masses averaged 5.80 (3.05-11.54)% of postpurient female body mass. Individual egg masses averaged 59% of female body mass (fertile eggs, 5.5%; infertile eggs, 6.4%). Regression of both average egg mass and clutch mass on female mass yielded no significant results.

Data on the elongated eggs is presented in Table 1. No significant differences were found when comparing the dimensions and masses of fertile and infertile eggs. The fertility rate was 60.9% for clutches with no damaged eggs.

Oviposition occurred in every month, except August; 87% of the clutches were laid between September and April, with most (40%) in January and February. Female 30272 laid three clutches in 1992 (15<sup>th</sup> January, 15<sup>th</sup> September, 28<sup>th</sup> December) at intervals of 243, 104, and 88 days, respectively; female 304281 laid two clutches in 1994 (12 January, 4 May) 112 days apart, and female 304728 laid clutches on 27<sup>th</sup> November 1993 and 4<sup>th</sup> May 1994, 158 days apart. Incubation periods ranged from 154-175 days at 28.5<sup>o</sup>C to 
 Table 1. Mean egg size measurements for all four species discussed. Figures in parentheses are ranges.

122-149 days at 29.5-31.0°C. Hatching dates were clustered in January-March (42.8%), but also occurred in June (28.6%) and September (28.6%).

Hatchlings had carapace lengths of 35.9-39.5 (mean, 37.5) mm and masses of 12.0-13.0 (mean, 12.4) g. The ratio of hatchling mass to fertile egg mass averaged 58.5%, and hatchling mass to female body mass averaged 3.2%.

## Chelodina longicolis

Thirty-two clutches containing 255 eggs were produced in 1988-1998. Unfortunately, only two of the females that oviposited were identified. Most of the clutches were laid in the water-filled pool of the enclosure housing several females, making it impossible to determine which female was responsible for the clutch. Average mass and carapace length of the six females that probably produced clutches were 722.3 (578-951) g and 19.5 (17.5-24.0) cm, respectively. Female 305339 (650 g) produced a clutch of four eggs (cluth mass 23.6 g) on 23<sup>rd</sup> March 1992 (RCM, 0.035), and female 305145 (908 g) laid 10 eggs (six broken) in



Turtle species bred at the National Zoological Park, Washington. *Chelodina longicolis* (above) and *Chelus fimbriatus* (below). See also front cover.

a nest excavated to 10.0 cm deep in a flower planter on  $8^{\text{th}}$  March 1994.

Mean clutch size for the 32 clutches (255 eggs) was 8.0 (2-18) eggs; normally 6-24 eggs compose a clutch (Ernst & Barbour, 1989). Masses of 27 complete clutches (no eggs destroyed or damaged) averaged 41.9 (8.0-72.9) g. Measurement and weight data of the elongated eggs are presented in Table 1. Although suspect due to lack of independence, t-tests do indicate that egg length and egg mass differ between fertile and infertile eggs. This was confirmed visually by examination of box-and-whisker plots. Regressions of both average egg mass and clutch mass on female mass yielded no significant results. The mean fertility rate for the 255 eggs was 35.7 (0-100)%, and for clutches containing fertile eggs 54.7 (11.8-100)%. Eight clutches were infertile. One egg (24.9 mm X

19.4 mm x 6.7 g) in a clutch of 18 eggs laid 1<sup>st</sup> January 1995 contained two embryos.

Oviposition occurred from November to June. and in September. Most clutches 22, 68.8%) were laid between 1st January and 24th May, one clutch was laid on 30th June, another on 19th September, and five (15.6%) produced clutches were in November-December. Incubation periods ranged from 40-87 (mean, 59) days, depending on the incubation temperature (27.5 -28.5°C). Hatching occurred between 30 January and 26 May, with peaks in March (n=21 days, 39.6%), May (n=9 days, 17.0%) and June (n=13)days, 24.5%). Eggs hatched on three days (5.7%) in January, four days (7.5%) in February, and three days (5.7%) in April.

Hatchlings had carapace lengths of 21.0-28.1 (mean, 25.5) mm and masses of 2.5-5.6 (mean, 4.5) g. The mean ratio of hatchling mass to fertile egg mass was 55.7%.

## Chelus fimbriatus

Nineteen clutches were produced between 1990 and 1999. Only two females were identified as the parent of clutches (12)--30647 (six clutches between 14th August 1990 and 19th August 1996) and 304318 (five clutches between 9th December 1993 and 4 September 1997). These two females were also responsible for two other clutches laid on 18 January 1995 and 29 January 1999, but which female laid which clutch could not be determined. Female body mass at the time of ovipositing these clutches averaged 7.35 (5.40-11.62) kg. The larger female (30647) produced the following clutches: August 1990 (2 eggs), September 1990 (13 eggs), June 1991 (2 eggs), December-January 1992/1993 (12 eggs), August 1995 (7 eggs), and August 1996 (11 eggs). The

shorter female (304318) produced clutches in December 1993 (10 eggs), October 1995 (7 eggs), October 1996 (15 eggs), and September 1997 (8 eggs). The two clutches that could not be assigned to a specific female were laid 18<sup>th</sup> January 1995 (12 eggs) and 29<sup>th</sup> January 1999 (20 eggs). RCM of clutches produced by female 30647 averaged 0.050 (0.031-0.063), and the average percentage of clutch mass to female to female postparturient mass was 5.32 (3.25-6.78). Mean relative clutch mass for clutches produced by female 304318 was 0.065 (0.053-0.086), and the mean clutch mass to female postparturient mass was 6.93 (4.39-9.38). The combined average of these calculations for both females were 0.066 and 7.03%, respectively.

The 19 clutches of *Chelus fimbriatus* contained 149 eggs which averaged 7.84 (1-20) eggs. Ernst & Barbour (1989) reported a range of eggs per clutch of 12-28. Clutch masses averaged 299.35 (32.5-690.8) g.

Measurements and weights of 148 eggs (one was broken) are presented in Table 1. No significant differences in the dimensions and masses of fertile versus infertile eggs were found, and regressions of average egg mass and clutch mass on female mass also produced no significant results. Mean hatching percentage of fertile eggs was only 6.9%.

Spearman rank correlation indicated a possible significant association between hatching percentage and female mass (p = .0002). Further investigations using rank regression also showed significance (P = .01923) when hatching percentage was regressed on female mass. If true, it is interesting that the hatching percentage decreases with female mass; however, we suspect there may be some problems with data integrity. The other turtle species did not show any significant results when examining Spearman correlations or rank regressions involving hatching percentage and female mass.

Eighteen clutches (95%) totalling 147 eggs were laid between 5 August and 18 February, one clutch (5%) of two eggs was laid in July. Forty-two eggs (28.1%) (3 clutches) were laid in September, 23 eggs (15.4%) each in October (3 clutches) and December (4 clutches), and 22 eggs (14.8%) eggs were oviposited in August (4 clutches). Female 30647 laid two clutches in 1990 43 days apart. The mean interval between clutches for all clutches which could be accurately assigned to her was 437 (43-946) days; if the two unverified clutches are included, the average interval between clutches was 440.8 (43-893) days. The interval between the known clutches laid by female 304318 averaged 454.7 (315-678) days, if the two unverified clutches are included, the average interval between her clutches was 393.4 (315-512) days. The combined clutch interval average for the two females was 385.6 (43-747) days.

Incubation at 28.5-29.5°C averaged 303 (283-314) days. At hatchling, neonates had 42.9-47.8 mm carapaces (mean, 45.04 mm), and weighed 16.7-22.3 (mean, 18.8) g.

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## Preliminary results of herpetofaunal survey work in the Rus Rus Region, Honduras: A proposed biological reserve

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THE existing system of biotic reserves in Honduras was established without survey work to determine the composition of flora and fauna for these reserves. Reserve designs should take biotic survey work into account to maximize biological diversity intended to be protected with the effort and cost involved in maintaining the reserve. During 2000 and 2001, we had the opportunity to conduct a preliminary survey of the amphibians and reptiles in the Rus Rus region, Departamento de Gracias a Dios, in the mosquitia of northeastern Honduras. The Honduran Mosquitia comprises one of the last great wilderness regions of Central America. It contains both terrestrial and marine ecosystems that are of regional, national, and global importance. It is part of a forest corridor which extends southward into Nicaragua, forming the largest tract of tropical forest remaining in Central America.

The Rus Rus region is a proposed biotic reserve that is expected to be officially established by Honduran law during the present year. At this time, we have no data on the size of this future reserve, but the Honduran government is taking into consideration the research that has been done, not only on the herpetofauna, but also that on the birds, mammals, and plants to determine the size, limits, category, and other aspects of the future reserve. Our preliminary survey work has established the presence of 71 species (69 documented by preserved specimens) of amphibians and reptiles in the proposed reserve.

The Rus Rus proposed biotic reserve lies entirely within the Lowland Moist Forest formation of Holdridge (1967). However, two

distinct types of forest occur in this region. Broadleaf forest occurs as gallery forest along the Río Rus Rus and its larger tributaries in the vicinity of the village of Rus Rus. The width of this gallery forest gradually increases as one proceeds northwest of the village towards the Rio Tapalwás. At about the confluence of the Río Tapalwas with the Río Rus Rus (about 16 airline km NW of the village of Rus Rus), this broadleaf forest completely covers the landscape to the east, west, and north of that confluence. Thus, broadleaf forest entirely covers the northwestern portion of this projected reserve. Almost all of this broadleaf forest in the northwestern portion is in a pristine condition, transversed only by several foot trails used by game hunters from the village, and occasionally dotted with small areas of secondary forest. These patches of secondary forest are the result of the establishment of Nicaraguan refugee camps in the area during the 1980s. About 4,000 refugees lived for almost eight years near the confluence of the ríos Rus Rus and Tapalwás.

The other forest type in the projected reserve is open pine savanna. This pine savanna occurs on either side of the gallery forest along the Río Rus Rus southward of its confluence with the Río Tapalwás. Nearly treeless swamps also occur to the east, southeast, and southwest of the village of Rus Rus. These pine savannas are frequently burned during the dry season, although apparently not intentionally. People living in the village of Rus Rus claim that these fires are caused by lightning and lit cigarettes tossed from vehicles traveling the road connecting the village with Puerto Lempira to the northeast and Awasbila to the west. The abundant grasses and sedges that prevail in the pine savannas provide ample fuel for these fires. Thus, all of the pine trees and logs lying on the ground in the pine savanna are fire scarred.

McCranie and Nicholson spent 10 days (8-17 October 2001) surveying the Rus Rus region. Castañeda also accompanied McCranie and Nicholson during 8-11 October. In addition, Castañeda has made three other trips totaling 30 days in the proposed reserve (21 November-5 December 2000; 26 June-1 July 2001; 2-7 October 2001). Also, Tomás Manzaneres, a resident of Rus Rus, collected several specimens of reptiles from August to October 2001. Specimens collected for this survey will be deposited in the reference collection of the Protected Areas and Wildlife Department of AFE-COHDEFOR, Tegucigalpa, and The National Museum of Natural History, Washington, D. C. We collected specimens very selectively (i.e., to document their presence), and most individuals seen of many species were left undisturbed.

Our collecting sites are outlined below:

1. Rus Rus village ( $14^{\circ}43'N$ ,  $84^{\circ}27'W$ ) and vicinity; elevation 50-60 m.

2. Crique Curamaira (14°39'N, 84°26'W), a tributary of the Río Coco about 8 airline km SSE of Rus Rus village; elevation 50 m.

3. Crique Ibantara (14°47'N, 84°27'W), a tributary of the Río Rus Rus about 8 airline km N of Rus Rus village; elevation 70 m.

4. Bodega de Río Tapalwás (14°56'N, 84°32'W) and vicinity; about 20 airline km NW of Rus Rus village; elevation 140-200 m.

5. Crique Yulpruan (14°54'N, 84°31'W), a tributary of the Río Tapalwás about 2 airline km S of Bodega de Río Tapalwás; elevation 140 m.

6. Loma Pinto Quiath (14°57'N, 84°32'W) in foothills of Montañas de Colón about 3 airline km N of Bodega de Río Tapalwás; elevation 200 m.

A total of 69 species of amphibians and reptiles were collected during this survey work. A list of these species is provided below. Terms defining habitat, diel activity, and abundance included in this list are: semifossorial (generally active under surface debris); terrestrial (active on the ground); arboreal (active on low vegetation); aquatic (active and feeding in water); diurnal (active during the day); nocturnal (active at night); common (found on a regular basis, many individuals can be seen); infrequent (unpredictable, few individuals seen); rare (rarely seen). These defining terms apply only to our experience in the Rus Rus region. See the Discussion for comments on two other species that we were unable to collect.

#### **CLASS AMPHIBIA**

ORDER GYMNOPHIONA FAMILY CAECILIIDAE

Gymnopis multiplicata Peters

Remarks: semifossorial; nocturnal; rare; found under logs in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

#### ORDER CAUDATA FAMILY PLETHODONTIDAE

FAMILY PLETHODONTIDAE

Bolitoglossa striatula (Noble) Remarks: arboreal: nocturnal: comm

Remarks: arboreal; nocturnal; common; numerous individuals seen in primary and lightly disturbed broadleaf forest.

Localities: Bodega de Río Tapalwás; Rus Rus.

## ORDER ANURA

FAMILY BUFONIDAE

## Bufo coccifer Cope

Remarks: terrestrial; nocturnal; rare; found in pine savanna.

Localities: Rus Rus.

#### Bufo haematiticus Cope

Remarks: terrestrial; nocturnal; rare; found underneath overhanging leaves of a small plant in primary broadleaf forest.

Localities: Bodega de Río Tapalwás.

#### Bufo marinus (Linnaeus)

Remarks: terrestrial; nocturnal/diurnal; common; found in pine savanna. Localities: Rus Rus.

#### Bufo valliceps Wiegmann

Remarks: terrestrial; nocturnal/diurnal; common; found in primary broadleaf forest.

Localities: Bodega de Río Tapalwás; Loma Pinto Quiath.

## FAMILY CENTROLENIDAE

## Cochranella granulosa (Taylor)

Remarks: arboreal; nocturnal; rare; found along a slow-flowing stream in lightly disturbed broadleaf forest.

Localities: Rus Rus.

## Cochranella spinosa (Taylor)

Remarks: arboreal; nocturnal; rare; found along a small river in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

## Hyalinobatrachium fleischmanni (Boettger)

Remarks: arboreal; nocturnal; infrequent; found along a slow-flowing stream in lightly disturbed broadleaf forest.

Localities: Rus Rus.

## FAMILY HYLIDAE

## Agalychnis callidryas (Cope)

Remarks: arboreal; nocturnal; common; found in both primary and lightly disturbed broadleaf forest, a breeding congregation located in primary broadleaf forest in a swampy area in October.

Localities: Bodega de Río Tapalwás; Crique Yulpruan; Rus Rus.

## Hyla ebraccata Cope

Remarks: arboreal; nocturnal; infrequent; found breeding in swampy area in primary broadleaf forest in October.

Localities: Crique Yulpruan.

## Hyla microcephala Cope

Remarks: arboreal; nocturnal; infrequent; found breeding in October in highly disturbed swampy area in transition zone between pine savanna and broadleaf forest.

Localities: Rus Rus.

## Scinax boulengeri (Cope)

Remarks: arboreal; nocturnal; infrequent; found breeding in October in highly disturbed swampy area in transition zone between pine savanna and broadleaf forest. Localities: Rus Rus.

Scinax staufferi (Cope)

Remarks: arboreal; nocturnal; common; found breeding in October in disturbed swampy areas in pine savanna.

Localities: Rus Rus.

Smilisca baudinii (Duméril and Bibron) Remarks: arboreal; nocturnal; rare; found along road through lightly disturbed broadleaf forest. Localities: Rus Rus.

## Smilisca phaeota (Cope)

Remarks: arboreal; nocturnal; infrequent; found breeding in October in highly disturbed swampy area in transition zone between pine savanna and broadleaf forest.

Localities: Rus Rus.

## FAMILY LEPTODACTYLIDAE

## Eleutherodactylus fitzingeri (Schmidt)

Remarks: terrestrial (or perched on vegetation less than 0.5 m above ground); nocturnal; common; found in primary and secondary broadleaf forest. Localities: Bodega de Río Tapalwás; Crique Curamaira; Crique Yulpruan; Rus Rus.

*Eleutherodactylus lauraster* Savage, McCranie, and Espinal

Remarks: terrestrial; diurnal; infrequent; found in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

*Eleutherodactylus noblei* Barbour and Dunn Remarks: terrestrial/arboreal; nocturnal/diurnal; infrequent; found in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

## Eleutherodactylus ridens (Cope)

Remarks: arboreal; nocturnal; rare; found in lightly disturbed broadleaf forest. Localities: Rus Rus.

## Eleutherodactylus sp. 1

Remarks: arboreal; nocturnal; common; found in primary broadleaf forest; the identity of these specimens is under study.

Localities: Bodega de Río Tapalwás.

## Eleutherodactylus sp. 2

Remarks: arboreal; nocturnal; common; found in primary broadleaf forest; the identity of these specimens is under study.

Localities: Bodega de Río Tapalwás; Crique Yulpruan.

#### Leptodactylus labialis (Cope)

Remarks: terrestrial; nocturnal/diurnal; common; found in and around swampy areas in pine savanna.

Localities: Rus Rus.

### Leptodactylus pentadactylus (Laurenti)

Remarks: terrestrial; nocturnal; infrequent; found in lightly disturbed broadleaf forest. Localities: Rus Rus.

#### FAMILY RANIDAE

#### Rana berlandieri Baird

Remarks: terrestrial; nocturnal; rare; found near highly disturbed swampy area in transition zone between pine savanna and broadleaf forest. Localities: Rus Rus.

#### Rana vaillanti Brocchi

Remarks: terrestrial; nocturnal; common; found near streams in primary and lightly disturbed broadleaf forest and in swampy areas in pine savanna.

Localities: Crique Curamaira; Rus Rus.

#### **CLASS REPTILIA**

ORDER CROCODYLIA FAMILY ALLIGATORIDAE

#### Caiman crocodilus (Linnaeus)

Remarks: aquatic; nocturnal; rare; found in river through lightly disturbed broadleaf forest. Localities: Rus Rus.

#### ORDER TESTUDINES FAMILY EMYDIDAE

1

## Rhinoclemmys annulata Gray Remarks: terrestrial; diurnal; rare; found in

primary broadleaf forest. Localities: Rus Rus.

## FAMILY KINOSTERNIDAE

Kinosternon leucostomum (Duméril and Bibron)

Remarks: terrestrial/aquatic; nocturnal/diurnal; infrequent; found in a slow-flowing stream in lightly disturbed broadleaf forest and on forest floor in primary broadleaf forest.

Localities: Bodega de Río Tapalwás; Rus Rus.

## Kinosternon scorpioides (Linnaeus)

Remarks: terrestrial/aquatic; nocturnal/diurnal; infrequent; found in and around large road puddles in pine savanna.

Localities: Rus Rus.

## ORDER SQUAMATA

## FAMILY GEKKONIDAE

Gonatodes albogularis (Duméril and Bibron) Remarks: terrestrial/arboreal; diurnal; common; found around human dwellings in pine savanna. Localities: Rus Rus.

Sphaerodactylus millepunctatus (Hallowell) Remarks: arboreal; diurnal; rare; found around human dwellings in pine savanna. Localities: Rus Rus.

#### FAMILY CORYTOPHANIDAE

#### Basiliscus vittatus Wiegmann

Remarks: terrestrial/arboreal; diurnal; common; occurs near streams and swampy areas in primary and secondary broadleaf forest and in pine savanna.

Localities: Crique Curamaira; Rus Rus.

#### Corytophanes cristatus (Merrem)

Remarks: arboreal; diurnal; common; found in primary and lightly disturbed broadleaf forest. Localities: Bodega de Río Tapalwás; near confluence of Ríos Rus Rus and Tapalwás.

#### FAMILY PHRYNOSOMATIDAE

Sceloporus variabilis Wiegmann Remarks: terrestrial/arboreal; diurnal; common; found in pine savanna. Localities: Rus Rus.

## FAMILY POLYCHROTIDAE

Norops biporcatus (Wiegmann) Remarks: arboreal; diurnal; infrequent; found in primary and lightly disturbed broadleaf forest.

## Herpetofauna of the Rus Rus region, Honduras



Bufo valliceps. All photographs © J.R. McCranie.



Scinax boulengeri



Norops biporcatus



Mabuwa unimarginata



Dryadophis melanolomus



Xenodon rabdocephalus

Herpetofauna of the Rus Rus region, Honduras

Localities: Bodega de Río Tapalwás; Rus Rus. Norops capito (Peters) Remarks: arboreal; diurnal; common; found in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

Norops cupreus (Hallowell) Remarks: arboreal; diurnal; common; found in primary and lightly disturbed broadleaf forest. Localities: Bodega de Río Tapalwás; Rus Rus.

Norops humilis (Peters) Remarks: terrestrial; diurnal; infrequent; found in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

Norops limifrons (Cope) Remarks: arboreal; diurnal; common; found in primary and secondary broadleaf forest. Localities: Bodega de Río Tapalwás; Crique Curamaira; Rus Rus.

Norops sericeus (Hallowell) Remarks: arboreal; diurnal; common; found in pine savanna. Localities: Rus Rus.

#### FAMILY SCINCIDAE

Mabuya unimarginata (Cope) Remarks: terrestrial; diurnal; rare; found in pine savanna. Localities: Rus Rus.

Sphenomorphus cherriei (Cope) Remarks: terrestrial; diurnal; common; found in

primary and secondary broadleaf forest and in pine savanna.

Localities: Bodega de Río Tapalwás; Rus Rus.

## FAMILY TEIIDAE

Ameiva festiva (Lichtenstein) Remarks: terrestrial; diurnal; infrequent; found in primary and lightly disturbed broadleaf forest. Localities: Rus Rus.

Ameiva undulata (Wiegmann) Remarks: terrestrial; diurnal; infrequent; found in pine savanna. Localities: Rus Rus. FAMILY BOIDAE

Boa constrictor Linnaeus Remarks: terrestrial; nocturnal; rare; found in pine savanna. Localities: Rus Rus.

Corallus annulatus (Cope) Remarks: arboreal; nocturnal; rare; found in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

## FAMILY COLUBRIDAE

Chironius grandisquamis (Peters) Remarks: arboreal; diurnal; rare; found in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

Dendrophidion percarinatum (Cope) Remarks: terrestrial; diurnal; rare; found in primary broadleaf forest. Localities: Rus Rus.

Dryadophis melanolomus (Cope) Remarks: terrestrial; diurnal; infrequent; found in lightly disturbed broadleaf forest. Localities: Rus Rus.

Drymobius margaritiferus (Schlegel)

Remarks: terrestrial; diurnal; infrequent; found in lightly disturbed broadleaf forest and in pine savanna.

Localities: Rus Rus.

*Erythrolamprus mimus* (Cope) Remarks: terrestrial; diurnal; rare; found in primary broadleaf forest. Localities: Crique Ibantara.

Geophis hoffmanni (Peters) Remarks: semifossorial; diurnal; rare; found under a log in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

Imantodes cenchoa (Linnaeus) Remarks: arboreal; nocturnal; rare; found in lightly disturbed broadleaf forest. Localities: near Crique Curamaira.

Leptodeira annulata (Linnaeus) Remarks: arboreal/terrestrial; nocturnal; infrequent; found in pine savanna. Localities: Rus Rus. Leptophis mexicanus Duméril, Bibron, and Duméril Remarks: arboreal; diurnal; infrequent; found in pine savanna. Localities: Rus Rus.

Ninia sebae (Duméril, Bibron, and Duméril) Remarks: semifossorial; diurnal; rare; found in pine savanna. Localities: Rus Rus.

#### Oxybelis fulgidus (Daudin)

Remarks: arboreal; diurnal; rare; found along a stream in very narrow stretch of broadleaf forest. Localities: near Rus Rus.

#### Pseustes poecilonotus (Günther)

Remarks: arboreal; diurnal; rare; found in primary broadleaf forest. Localities: Rus Rus.

#### Spilotes pullatus (Linnaeus)

Remarks: terrestrial; diurnal; rare; found along a small stream in primary broadleaf forest. Localities: near Crique Yulpruan.

#### Tantilla taeniata (Bocourt)

Remarks: semifossorial; diurnal; rare; found in pine savanna. Localities: Rus Rus.

#### Tantillita lintoni (Smith)

Remarks: semifossorial; diurnal; rare; found under a log in primary broadleaf forest. Localities: Loma Pinto Quiath.

Thamnophis proximus (Say) Remarks: terrestrial; diurnal; rare; found in waterfilled ditch in pine savanna. Localities: Rus Rus.

Urotheca guentheri (Dunn) Remarks: semifossorial; diurnal; rare; found under a log in primary broadleaf forest. Localities: Loma Pinto Quiath.

Xenodon rabdocephalus (Wied-Neuwied) Remarks: terrestrial; diurnal; rare; found in pine savanna.

## Localities: Rus Rus. FAMILY ELAPIDAE

## Micrurus nigrocinctus (Girard)

Remarks: semifossorial; diurnal; rare; found in primary broadleaf forest and in pine savanna. Localities: Rus Rus.

## FAMILY VIPERIDAE

Bothriechis schlegelii (Berthold) Remarks: arboreal; nocturnal; rare; found in primary broadleaf forest. Localities: Bodega de Río Tapalwás.

## Bothrops asper (Garman)

Remarks: terrestrial; nocturnal/diurnal; common; found in primary and secondary broadleaf forest and in pine savanna along edge of broadleaf forest. Localities: Bodega de Río Tapalwás; Crique Curamaira; Rus Rus.

## Porthidium ophryomegas (Bocourt)

Remarks: terrestrial; nocturnal/diurnal; common; found in pine savanna, including swamps. Localities: Rus Rus.

## DISCUSSION

We collected 26 species of amphibians and 43 species of reptiles from the Rus Rus proposed biotic reserve. In addition we saw, but could not collect, a specimen of Oxybelis aeneus (Wagler) in lightly disturbed broadleaf forest near Rus Rus village, and residents of that village are familiar with Iguana iguana (Linnaeus). The latter species is used as a food source by the people of the village (as was the case with the Nicaraguan refugees), and as a result is said to be rare in the area. McCranie & Wilson (2002) recorded 61 species of amphibians from the Lowland Moist Forest formation, thus the 26 species collected from the Rus Rus region represent 42.6% of that total (but see below). There are presently 133 species of reptiles known from this forest formation in Honduras (McCranie, unpubl. data), thus 33.8% of that total is known from the Rus Rus region. Castañeda (1998) reported 40 species of amphibians and reptiles from several areas near the community of Mocorón, about 30 airline km NE of Rus Rus. Four of these species

(Thecadactylus rapicauda [Houttuyn], Cnemidophorus deppii Wiegmann [as Cnemidophorus sp.], Drymarchon corais [Boie], and Masticophis mentovarius /Duméril, Bibron, & Duméril]) were not found in the Rus Rus region, but are likely to occur there. The Mocorón region also supports broadleaf forest and pine savanna like the Rus Rus region. Nicholson et al. (2000) stated that about 105 species of amphibians and reptiles were expected to occur in the nearby Parque Nacional Patuca. The total herpetofauna of the projected biotic reserve of Rus Rus should contain a similar number of species.

The identity of two species of *Eleutherodactylus* collected in this survey are still under study. At least one of these species has not previously been recorded in Honduras. In addition, the specimen of *Corallus annulatus* represents the first from the country with unequivocal locality data. This species was known previously from the country based on an adult female (and her captive born 14 offspring) that was shipped to the USA by a Honduran animal dealer.

#### ACKNOWLEDGEMENTS

Victor Leonel Archaga, Protected Areas and Wildlife Department, DAPVS, AFE-COHDEFOR, Tegucigalpa, supported our research in the Rus Rus region. Arnulfo Messen and Carlos Cortés, AFE-COHDEFOR, Puerto Lempira, and Celso Pavon, AFE-COHDEFOR, Rus Rus, provided valuable logistical support and transportation. Financial support was provided by the personnel of PAAR, PROBAP, and Ecoservisa-Coheco. Marco Tulio López also provided support for our research. Tomás and Luis Manzaneres provided very valuable field assistance and were excellent guides; Tomás also collected specimens for us in our absence. Alicia Manzaneres and Ingri Miranda provided hospitality and cooked our meals while we were in Rus Rus village.

K.E.N. thanks the support of Drs. J. Losos and A. Larson (Washington University) and NSF funding (DEB 998276) during work on this project.

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## A terrestrial viviparous salamander into water: notes on the unusual larval aquatic development in Salamandra lanzai

## PAOLO BERGÒ and FRANCO ANDREONE

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Salamandridae) Sw Cottian Alps, in Italian and French territories (Andreone et al. 1999; Andreone & Sindaco, 1999; Miaud et al., 2001). This salamander lives at comparatively high altitudes (from 1200 to about 2800 m), and shows several adaptive characters to the montane environment. Among these adaptations are the black colouration and aplacentar viviparity (Wake, 1993; Blackburn, 1994): after a long pregnancy period (at least three years according to our unpublished data) the



Figure 1. Aquatic larva of *Salamandra lanzai* born in captivity and reared in water until metamorphosis.

females give birth to a few fully developed salamanders already adapted to the terrestrial life. In this aspect S. lanzai is similar to S. atra and to Mertensiella luschani (Özeti, 1979; Griffiths, 1996). Other species belonging to the genus Salamandra (e.g., S. salamandra, S. corsica, S. algira) give usually birth to aquatic larvae, although in some high altitude populations (e.g. those belonging to the subspecies S. s. bernardezi, and possibly to S. corsica) it is not uncommon that there is a tendency towards 'terrestrial viviparity' with the parturition of terrestrial juveniles. On the other hand, according to current knowledge, free aquatic larvae of S. lanzai and S. atra (as well as Mertensiella luschani) have never been observed in nature, and thus we argue that the parturition of terrestrial salamanders is the 'norm' for these species.

We here report the case of an induced aquatic larval development in captivity: during a study of the species' fecundity we kept for some days in a terrarium some pregnant females captured in Germanasca Valley (NW Italy, Turin Province, altitude 1550 m; co-ordinates not given for conservation reasons). One of the females (captured on 3<sup>rd</sup> June 2001) gave birth prematurely to two young on 8<sup>th</sup> June. They still had very developed external gills: in the attempt to save them from death they were put into water (in a small aquarium). They immediately turned out to swim and carried out an aquatic life, being in this very similar to larvae of *S. salamandra*. Besides the external developed gills (which were anyhow laminar), they also showed several other larval characters, such a laterally flattened tail, labial lobes, and thintranslucent skin (Fig. 1). The two larvae were fed with *Chironomus* larvae and small earthworms, and metamorphosed on 25<sup>th</sup> June, becoming terrestrial after an

aquatic permanence of 17 days. Two more salamanders were deposited by the same female on 12th June, but they died just after parturition, due to the fact that they were not immediately detected in the terrarium. This is the first report of aquatic development of S. lanzai larvae, and stresses therefore the evolutionary and adaptive meaning of terrestrial viviparity. This is confirmed by a similar case of 'captive-induced' aquatic larvae for another viviparous and montane Salamandra species (S. atra) (Sauer, 2001) In both these cases we interpret the aquatic life and larval development as a consequence of premature birth due to captivity, and we argue that this phenomenon is unusual and unlikely to occur in the natural environment.

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# NATURAL HISTORY NOTES

*Natural History Notes* features short articles documenting original observations made of amphibians and reptiles mostly in the field. With few exceptions, an individual 'Note' should concern only one species, and authors are requested to choose a keyword or short phrase which best describes the nature of their observation (e.g. Diet, Reproduction). Format details and other guidelines are available in *Herpetological Bulletin* No. 78, Winter 2001.

## RANA TEMPORARIA (Common Frog): TADPOLES OF THE COMMON FROG EATING THE SHELLS OF POND SNAILS

I was very surprised to see tadpoles of the Common Frog *Rana temporaria* eating the shells of water snails *Limnaea stagnalis* in my pond during 2001. The pond (at TQ 5122 5520), which has an area of 6 m<sup>2</sup> and mean depth of about 50 cm, had a large population of Common Frog tadpoles, from five large clumps of spawn, and at least 100-200 pond snails/m<sup>2</sup>. I noticed that the Common Frog tadpoles were congregating in masses over the shells of the pond snails. They were rasping at these shells and so eroding the outer layers that the shells became chequered with large white/silvery patches (Fig. 1).

On inspection, all shells had been attacked at the apex while the more basal areas showed more or less damage (Fig. 1). The reason for the universal attack at the apex is not clear; either this zone is easier for the tadpoles to attack or, as this is the oldest part of the shell, would have been subject to attack longer than other places. I had not seen this behaviour previously even though I had been observing the pond for ten years. The tadpoles in question came from spawn deposited on 10<sup>th</sup> March 2001. The first time that I noticed the tadpoles on the shells was in May when they were already well grown but with no evident limbs. Two ponds close by, with tadpoles and pond snails, did not show the same phenomenon although the density of tadpoles and snails in both was much lower.

Typical attack by the tadpoles is shown in the scanning electron micrograph (Fig. 2). Two circular lesions are indicated at a) and b); these penetrate all but the deepest layer(s) of the snail's shell. Many such lesions together lead to extensive erosion shown at the top left of the micrograph (Fig. 2, c). The greatest depth of penetration in the lesions is at the centre with progressively more shallow penetration towards the edges. This is consistent with the shape of the mandibles of the Common Frog tadople. These are like a pair of shears with the outer edge of the upper mandible convex in shape. When such a mandible cuts, its central portion will dig deepest, accounting for the difference in depth across the cut in the shell. More unusual is the fact that the cut created is circular. This appears to result because tadpoles hold themselves more or less at right angles to the shell, flexing their tail to remain in place. In so doing, they rotate on their long axis rasping as they go and so eroding at the surface like a drill. The

Wake, M.H. (1993). Evolution of oviductal gestation in amphibians. J. Exper. Zool. 266, 394-413.



Figure 1. Shells of the pond snail (*Limnaea stagnalis*) with, left to right, successive stages of erosion by Common Frog tadpoles (*Rana temporaria*).

two circular lesions in Figure 2 (a and b) were presumably made by tadpoles of different sizes. It is noticeable that none of the lesions actually penetrates the shell completely although occasionally they are associated with cracks due to other mechanical damage. The deepest layer(s) of shell, probably the nacreous layer, is either of no interest, unpalatable or too tough to attack.

My pond is mostly rainfed and in dry years requires topping up with tap water, but the year 2001 was wet enough that no topping up was required until July/August. It seems possible that the concentrations of one or more essential minerals/elements in the pond are particularly low, exacerbated by the high density of tadpoles and



Figure 2. Scanning electron micrograph showing details of damage to a snail's shell caused by tadpole feeding, a) and b) are circular lesions and c) an area of extensive erosion (1 mm = 4 mm).

addition to the pond of only soft rain water instead of our hard tap water. In March 2002, a check of the snails showed all but the very smallest to have eroded shells, presumably from the previous year. Where shells were intact, these appeared to be particularly fragile, suggesting that indeed there was some degree of mineral shortage. Testing the pond water at this time with universal indicator and a water hardness kit, showed that it was near neutral at pH 6.5, and hard.

Competition between tadpoles and snails is well known. Egg production and growth of L. stagnalis are reduced in the presence of high densities of R. temporaria tadpoles whereas increasing snail density has a positive effect on tadpole weight and growth rate. This has been attributed to nutrient cycling by snails from algae less favourable for tadpoles, such as Cladophora sp, which in turn increases the growth of micro-algae. Micro-algae are a preferred food source for tadpoles for which they are competitively dominant over snails (Brönmark et al., 1991). However, Brönmark et al. make no mention of any feeding direct from snails' shells and I have not been able to find any reports of similar behaviour by tadpoles. I can only conclude that this is a rare occurrence dependent on specific conditions of mineral/food scarcity and perhaps triggered by particularly high population densities of snails and tadpoles.

If anyone one would like to examine eroded snail shells I would be happy to supply them on request.

#### ACKOWLEDGEMENT

Thanks are due to Dr Ian Slipper for help with scanning electron microscopy.

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