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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).

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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: P.Stafford@nhm.ac.uk*

Front cover illustration. Left and top: *Physignathus* (*Lophognathus*) *longirostris*; right: *Amphibolurus* (*Ctenophorus*) *pictus*, male; centre bottom: *Abelpharus lineo-occellatus* var. *ruficaudus* (= *Morethia ruficauda*). From an original plate in *Report of the work of the Horn Scientific Expedition to Central Australia, Part II, Zoology*. Reproduction courtesy of The Natural History Museum.

EDITORIAL

New Managing Editor required for HJ

After some twelve years of forefronting the *Herpetological Journal*, Dr Richard Griffiths will be standing down as its Managing Editor. The Society will therefore be seeking to elect a replacement at the AGM in March 2004.

The role of the Managing Editor is to oversee the production and publication of the journal, from receipt of accepted manuscripts from the Scientific Editor (Dr Wolfgang Wüster) to the production of final copy. This involves checking and editing of articles to ensure that they conform to the journal's house style; co-ordination of the layout of the journal articles (currently done using Adobe PageMaker); production of author's proofs; and liaison with authors and the commercial print bureau. The Managing Editor should therefore be someone with a scientific background and familiar with the publishing process of scientific articles. For further information about the job please contact Richard Griffiths (01227 823434; R.A.Griffiths@kent.ac.uk).

Guidelines for contributing authors

As well as those printed on the inside front cover, a more detailed set of instructions are available to authors of articles published in *Herpetological Bulletin*. These will be posted shortly on the BHS website (currently being redeveloped), and a printed copy can also be obtained by sending a stamped addressed envelope to myself. When submitting the final version of a manuscript to *HB* can I remind prospective authors of the need to make sure that house style is adhered to as closely as possible – not to do so causes delays in the editorial process and can result in an article missing the sheduled publication date. The listing of references often causes particular problems; the best way of checking how these sould be formatted is by consulting articles printed in recent issues. *Ed*.

Meet the Council....

Russell Greenacre. Editor, *The Natter Jack*

I was originally born in Great Yarmouth, Norfolk and moved to Liverpool about three years ago, to settle down with my fiancé, Jayne. I am currently the editor of the *Natter Jack* newsletter, aside from which, in my spare time I work in the Civil Service! I do not have any professional involvement with any herpetological issues; I am more of a 'hands on' serious hobbyist. My main interest lies in the study and captive husbandry of snakes, but reptiles have fascinated me all my life.

I have only been keeping snakes for about four years. I would have liked to have started in this wonderful hobby a lot sooner, but unfortunately, living with my parents prohibited this. Largely due to the fact that my mother was terrified by them! Before moving to Liverpool and joining the Civil Service, I worked for a company that operated a holiday park in Great Yarmouth and found myself living in accommodation provided by my employer. It was at this point that I started to investigate the possibility of taking up my newfound hobby. I bought as many books as I could find, and sought advice from other hobbyists until I felt that I had enough knowledge on the subject of reptile husbandry before purchasing my female Corn Snake.

I currently have three snakes. A breeding pair of Corn Snakes (*Elaphe guttata guttata*), of which the male is a very dark colour phase, and the female is amelanistic. I have also recently purchased a hatchling Royal (or Ball) Python (*Python regius*). Hopefully, in the future (and with my fiancé's agreement), I will be able to establish a breeding pair of Royal Pythons as well.

Competition winner

Congratulations to Matthew Harris of Newport, South Wales, whose correct identification of the photograph in *Herpetological Bulletin* 83 – a Red-legged Frog, *Rana aurora*, from the Pacific northwestern states of the USA – was the first to be drawn from a hat (not at the Autumn Council meeting as originally stated – this having taken place on 20th September before the deadline date). Matthew will receive a book token to the value of £25.00. Altogether there were eight entries, all of them correct.

Natural history of the Queen Snake, *Regina septemvittata*, in southeastern Pennsylvania, U.S.A.

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ABSTRACT — The behaviour and ecology of the North American Queen Snake, *Regina septemvittata*, was studied in Lancaster County, Pennsylvania, from May 1965 through July 1967. Data were gathered on the snake's habitat, population dynamics, annual and daily activity cycles, hibernacula, thermal ecology, reproduction, diet and foraging behaviour, and predation, parasites and injuries.

THE Queen Snake, *Regina septemvittata*, ranges in North America from southeastern Pennsylvania, western New York, and southwestern Ontario west to southeastern Wisconsin and adjacent northeastern Illinois, and south to northern Georgia, Alabama, and eastern Mississippi (Ernst, 2002). A disjunct population occurred in the Ozark Mountains of northern Arkansas and southern Missouri, but Johnson (2000) reported that the Missouri population has been extirpated. Although widespread this snake is restricted in habitat to clean waters, usually shallow streams or brooks, where its crayfish prey are plentiful, and abundant hiding places are present along the banks (Ernst & Ernst, 2003). It has been mostly ignored, and knowledge of its life history parameters and population dynamics are generally lacking or anecdotal in nature. The only comprehensive study was in Kentucky by Branson & Baker (1973, 1974). Other reported studies were on growth (Raney & Roecker, 1974), aggregation and hibernation (Wood, 1944, 1949), various aspects of reproduction (Dunn, 1915; Tripplehorn, 1949; Dyrkacz, 1975; Ford, 1982; Minesky & Aldridge, 1982; Brown, 1992; Fontenot & Platt; 1996), and diet and feeding behaviour (Surface 1906; Uhler et al., 1939; Raney & Roecker, 1947; Judd 1955; Adler & Tilley, 1960; Burghardt, 1968; Brown 1979, 1992; Godley et al., 1984; Pinder, 1996).

Regina septemvittata was studied in Lancaster County, Pennsylvania from May 1965 through July 1967. Data gathered during that period are reported below.

METHODS

Study Site

Regina septemvittata were studied at the former White Oak Bird Sanctuary, approximately 1.6 km north of Manheim, Lancaster County, Pennsylvania. The site was privately owned and covered approximately 10 ha of woodland and marsh surrounding a 2.4 ha pond. The pond and marsh were originally formed by the damming of Big Chickies Creek, a tributary of the Susquehanna River, for a milling operation, which was still active at the time of the study. The original mill dam was supplemented by a paved stone road which crossed its top. The land surrounding the sanctuary included several boggy pastures crossed by clear, shallow brooks which were also examined during the study. The pond was shallow and slowly filling with silt. Its depth graded from 10 cm at the northern end to slightly less than 2 m at the dam at the southern end of the sanctuary. Beyond the northern shore of the pond was a > 5 ha marsh transversed by the creek and several 1-2 m wide tributary brooks, and including several shallow vernal pools. The more solid

portions of the marsh were filled either with peat of sand-loam soil. On the eastern and western shores of the pond were more than 2 ha of mixed woodlands, predominately of White Oak (*Quercus alba*), maples (*Acer ruber*, *A. saccharinum*, *A. saccarum*, *A. negundo*), and Hickory (*Carya cordiformis*), but also including Ash (*Fraxinus nigra*), American Elm (*Ulmus americanus*), Beech (*Fagus grandifolia*), Sassafras (*Sassafras albidum*), Gum (*Nyassa sylvatica*), Hackberry (*Celtis occidentalis*), and Willow (*Salix* sp.). The most common shrubs were sumacs (*Rhus copallina*, *R. vernix*). The most abundant ground plants were Poison Ivy and Poison Oak (*Rhus radicans*, *R. toxicodendron*), and Raspberries (*Rubus* sp.). Skunk Cabbage (*Symplocarpus foetidus*) was common in the damp parts bordering the marsh. The eastern side of the pond was 25-65 cm deep, and mostly shaded by large trees. The western side was more shallow, 5-30 cm, and had less dense woodlands along its banks making it more open to sunlight during the day. At the northeastern and southeastern corners of the pond were small areas of grass lawn (*Poa* sp.). Other amphibians and reptiles collected in the vicinity were the anurans *Acris crepitans*, *Bufo americanus*, *Rana catesbeiana*, *R. clamitans*, *R. palustris*, and *R. pipiens*; the salamanders *Eurycea bislineata*, *Plethodon cinereus*, and *Pseudotriton ruber*; the turtles *Chelydra serpentina*, *Chrysemys picta*, *Clemmys guttata*, *Glyptemys insculpta*, *G. muhlenbergii*, *Sternotherus odoratus*, and *Terrapene carolina*; and the snakes *Nerodia sipedon*, *Thamnophis sauritus*, and *T. sirtalis*.

The south side of the dam was over 3 m deep at a 20% grade. Its walls contained numerous shallow, 10-55 cm, cracks between the rocks, or under the asphalt paved surface on top. Two sluice gates drained the pond into the creek below. At their bases were erosion pools 1-3 m deep. Downstream from the dam, Big Chickies Creek was 5-8 m wide, shallow, rocky, bordered with woods of the same vegetation as above, and contained many crayfish (*Cambarus* sp.). Large rocks and logs were present along the banks, and were used for retreats by the Queen Snakes.

Procedures

Snakes were hand collected. Each snake was marked by the scale clipping method of Blanchard & Finster (1933) and Fitch (1949). At each capture, the total body length (TBL), snout-vent length (SVL), and tail length (TL) were recorded with a metric tape measure accurate to 1.0 mm, and the snake was weighed with a spring scale accurate to 1 g. Each snake was sexed using the methods of Conant & Collins (1998) and Palmer & Braswell (1995). The following data were also recorded: date, military time, type of activity (activity was defined in terms of thermal dormancy; snakes were considered active if responsive to disturbance, dormant if not responsive), air temperature (AT), surface temperature (ST), water temperature (WT), cloacal temperature (BT), presence or absence of a food bolus, and any signs of injury or parasites. BT was taken with a quick reading Schultheis cloacal thermometer, and AT, ST and WT were recorded with a standard laboratory mercury thermometer. Snakes swollen with food were gently palpitated to force regurgitation of the prey. These prey and others from natural observations of feeding were recorded.

RESULTS AND DISCUSSION

A total of 205 individual *Regina septemvittata* were captured 290 times during the study; 280 of these were of active snakes. Capture data allowed the following conclusions to be drawn.

Habitat

Habitat characteristics were recorded at each capture. Five different habitats were occupied. Four individuals were captured once each (1.4%) in the clear brooks flowing through the boggy pastures to the north of the marsh. Water depth in the brooks was 15-61 cm, but the Queen Snakes were captured in areas of 15-20 cm depth. The bottoms of the brooks consisted of sandy-loam to gravel, with a few larger rocks scattered along them. Crayfish were common throughout the brooks. Few surface retreats were present, and it is thought that the snakes used Muskrat (*Ondatra zibethicus*) bank burrows for retreats, as 10 captures were made at or near the entrance of such

burrows. Three Queen Snakes were captured once each (1.1%) in the shallow pools or drainage channels of the marsh where crayfish occurred. These sites had mucky sandy-loam bottoms and water depths of 10-15 cm. Four captures (1.4%) were made in the western shallows of the pond at depths of 15-25 cm. The bottom there was of sandy-loam, and some crayfish were present.

Sixty-five captures (22.4%) were made on the rocky south-facing wall or in the numerous shallow cracks in the wall of the dam above the water line. The dam site was not considered a foraging area, instead it served as a basking site and one of nighttime and winter retreat. It also served as a refuge during frequent spring and summer flooding of Big Chickies Creek. The dam was the major aggregation site for snakes at the southern portion of the Sanctuary; in addition to the Queen Snakes, 25 Northern Water Snakes (*Nerodia sipedon*) and 5 Common Garter Snakes (*Thamnophis sirtalis*) were also captured there.

Most, captures (216, 74.5%) of *R. septemvittata* occurred in the 100 m stretch of the Big Chickies Creek below the dam. No *R. septemvittata* were found in the two deep pools at the base of the dam, although *Nerodia sipedon* was occasionally seen there. The bottom of the creek consisted of alternating stretches of sandy-loam, gravel, or rocky areas, and water depths along the 100 m stretch were 3-20 cm. Most crayfish were observed and most foraging by the snakes in all areas occurred in the gravel and rock areas, where 216 captures were made.

The stone dam was a focus of activity for the *R. septemvittata* in the southern end of the Sanctuary. All but seven (2.4%) of the total Queen Snake captures were made at the dam or downstream from it. Only those snakes taken to the north in the marsh or boggy pastures were not originally captured or recaptured there. The number of captures in the Big Chickies Creek below the dam indicates that it was the principal foraging habitat for the population at the dam site. Of the four Queen Snakes caught foraging above the dam in the pond, two were also captured at the dam. The importance of the dam and downstream habitat is even more important when it is considered that most research time in 1965-1967 was centered on the capture of turtles, the prime research subjects then, in the pond, marsh and boggy pastures above the dam.

From the above data, prime habitat for *Regina septemvittata* can be described as gravel or rocky bottomed, clear waters, with depths of 10-25 cm, an abundance of crayfish, good daily refuges in the form of fallen logs or large stones on the banks, and a suitable hibernation site nearby. This description essentially fits those reported by Branson & Baker (1974), Judd (1955), LeRay (1928), Neill (1948), and Wood (1949).

Population

A total of 205 *R. septemvittata* were captured 290 times at White Oak from May 1965 through July 1967. Eighty-five individuals (41.5%) were recaptured one or more times. The number of captured individuals per day averaged 1.8 (0-5); and the overall proportion of recaptures of marked individuals did not increase significantly as more individuals were marked after 1965 (Spearman's coefficient of rank correlation; $r_s = 0.388$, $p > 0.05$). Only 16 (7.8%) of the marked snakes were recaptured more than once: one adult female and two adult males were recaptured four times, and eight adult males and five adult females were recaptured twice each. No neonates were recaptured.

The population size was calculated using the 'weighted least squares' procedure of Schumacher & Eschmeyer (1943) recommended by Turner (1977). This method has the advantage of eliminating bias caused by unequal recapture rates, as it is based on a series of collecting periods rather than only two, as in the Peterson Estimate (Begon, 1979). Data from a series composed of the last 100 collections of *R. septemvittata* in 1966-1967 were used to calculate the population size, and the population size limits were determined by adding and subtracting two standard errors (S.E., 95% confidence level) from the population size estimate (Schumacher & Eschmeyer, 1943). The overall population size was estimated to be 216 (S.E. 19) *R. septemvittata*, with a possible range of 178-254 individuals.

	Months								
Time (hrs)	A	M	J	J	A	S	O	N	Total
0600	0	0	0	1	0	0	0	0	1
0700	0	1	1	1	1	4	0	0	8
0800	0	8	6	5	7	5	0	0	31
0900	0	9	9	14	9	6	1	0	48
1000	1	15	8	10	9	12	1	0	56
1100	2	5	4	6	5	10	3	0	35
1200	1	7	1	0	1	3	0	0	13
1300	0	3	2	0	2	2	1	1	11
1400	3	4	4	4	6	8	2	2	33
1500	1	2	6	5	5	1	2	1	23
1600	1	0	6	4	4	1	0	0	16
1700	0	0	2	2	1	0	0	0	5
Total	9	54	49	52	50	52	10	4	280

Table 1. Frequency of capture of active *Regina septemvittata* by months and hours.

The total area of available crayfish-bearing waterways at White Oak in 1965-1967 was estimated to be 3 ha, and the total density of *R. septemvittata* was estimated to be 68.3/ha. However, 178 of the Queen Snakes were captured at the dam site or within 300 m downstream from it, clearly indicating the aggregation area for the White Oak population. That estimated waterway area was approximately 1 ha; a density of 178/ha, or 59.3 snakes per 100 m of stream.

Males were considered mature at a SVL greater than 30 cm; females at a SVL greater than 34 cm (Ernst & Ernst, 2003). Based on these estimated lengths of maturity, the combined White Oak population was composed of 68 juveniles (31.7%, including neonates), 81 mature males (37.6%), and 66 mature females (30.7%). The mature male to female ratio was 1.23:1; not significantly different from 1:1 (Chi square test, 1 d.f.). The juvenile to adult ratio was 46.3:1, significantly different from 1:1.

The *R. septemvittata* were measured and weighed at each capture. The mean SVLs and masses of captured Queen Snakes were as follows (ranges in parentheses): adult males (97 captures) had a mean SVL of 39.6 cm (34.5-48.0 cm) and a mean mass of 10.8 g (9.5-12.0 g), adult females (75 captures) had a mean SVL of 48.2 cm (36.0-66.9 cm) and a mean mass of 13.5 g (10.3-14.9 g), yearling or older juveniles (65 captures) had a mean SVL of 25.6 cm (20.5-28.0 cm) and a mean mass of 4.8 g (3.2-6.83 g), and 53 neonates averaged 15.6 cm (12.5-18.1 cm) in SVL and 2.9 g (2.7-3.1 g) in mass. Ernst (2002) reported that the average SVLs of adult males and adult females are 39.5 cm and 45.1 cm, respectively. *Regina septemvittata* is a naturally slender snake, so, while the masses recorded at White Oak seemed somewhat low, they were probably within normal ranges for the species. The total biomass *R. septemvittata* at White Oak was 2.29 kg, with 2.10 kg centered at the dam and stream below it.

Only limited data have been published on the population dynamics of *R. septemvittata*. The Kentucky Queen Snakes studied by Branson & Baker (1974) had a 1:1 sex ratio (113 males, 116 females), and the sex ratio of 128 neonates born in captivity during their study was also 1:1 (65

	Temperatures			
Activity (N)	**Body**	**Air**	**Surface**	**Water**
Hibernate (10)	2.8(2.0-4.1)	3.0(2.0-4.0) r=0.92	26(2.0-4.0) r=0.95	--
Under Shelter, active (41)	17.5(14.0-20.5)	19.3(12.2-24.5) r=0.89	18.0(12.2-24.5) r=0.98	20.1(8.5-22.4) r=0.63
Basking (59)	26.3(18.5-31.6)	25.0(17.5-33.0) r=0.92	26.1(17.0-33.0) r=0.95	19.3(7.5-22.5) r=0.75
Moving on Land (8)	20.8(19.3-28.7)	23.0(20.0-29.5) r=0.92	21.5(20.0-29.5) r=0.94	19.7(18.0-22.0) r=0.78
Foraging in Water (115)	24.2(16.3-26.8)	26.1(18.0-34.0) r=0.89	--	24.0(17.0-26.8) r=0.99
Mating on Land (4)	24.6(22.8-26.8)	25.1(22.5-28.2) r=0.95	25.4(23.0-30.0) r=0.90	21.3(19.0-23.5) r=0.86

Table 2. Body and environmental temperatures (°C) of *Regina septemvittata* by activities.

males, 63 females). The sex ratio of adult Queen Snakes at White Oak was slightly skewed toward males 1.23:1, and if the estimated sexes of the juveniles and neonates are included in the calculations, 115 males and 90 females were present at White Oak; a 1.27:1 sex ratio. Neither ratio is significantly removed from equality. Branson & Baker (1974) found Queen Snake densities of 35 per 192 m and 62 per 237 m along two Kentucky waterways, and Wood (1949) collected 124 individuals within 92 m in Ohio. At White Oak, 178 of these snakes were collected in the 300 m below the dam, a density of 59/100 m; in addition, four others were collected in the mill pond within 100 m above the dam, and 16 individuals were first caught at the dam. The number of first captured individuals using the dam area was 198, 96.6% of the total 205 *R. septemvittata* captured at White Oak. The stream below the dam apparently offered the best foraging opportunities in the area, and the dam served as the principle hibernation site for the population.

Annual Activity Cycle

During the three years of study, responsive *R. septemvittata* were found from 3rd April to 6th November, a maximum annual period of activity of 217 days. In the only complete year of study, 1966, active queen snakes were observed from 10th April to 6th November, 210 days. In 1965, the latest capture of an active individual was on 4th November; in 1967, the first spring capture occurred on 5th April. There was no indication of a bimodal activity pattern, as the snakes were active throughout the summer. Once the snakes became active in the spring, about equal numbers of individuals were observed or captured in every month from May through September (Table 1). Fewer snakes were seen or captured in October, so some may have entered hibernacula earlier than others. Nighttime temperatures in southeastern Pennsylvania normally drop below 4°C by late October, and generally continue to drop to below freezing by late November.

Juveniles (>35 cm SVL) appeared later in the spring and disappeared earlier in the fall than did adults. The earliest juvenile was found on 22

April, and the latest on 1st October (163 days). No significant difference occurred in adult males or females in either the length of the annual activity period or the dates of spring emergence or final fall entrance into hibernacula. However, gravid females basked more often and for longer periods in the spring than did adult males. Thirty females were found basking on the dam in April and May; only 11 males were observed basking during the same period. Individual, undisturbed females basked an average of 2.3 hrs (1.2-3.0 hrs); males basked for an average of only 1.5 hrs (1.0-2.2 hrs). The difference of the basking duration is significant at the 0.05 level (one-way ANOVA, $F = 2.75$, $p = .05$).

Cracks or other openings in the dam which led to below frost depth were used as communal hibernacula, and 10 *R. septemvittata* were found in such places during the winters of 1966 and 1967. All had been previously captured and marked when active, but none of the hibernating snakes were recaptured the next winter. Fall aggregations of 10-25 snakes were observed basking on the downstream slope of the dam in late September and during October. All were positioned near the openings to suspected hibernation sites. Aggregated dormant Queen Snakes were found on 20th (2 snakes) and 28th (5 snakes) January 1966 and on 4th February 1967 (3 snakes) at a mean depth of 18.3 cm (16-21 cm). The two snakes found on 20th January and the five found on 28th January were in cracks on the side of the dam at depths of 16 cm and 18 cm, respectively. The three snakes found on 4th February were in an opening which extended from the side of the road about 18 cm beneath the asphalt. Undoubtedly, other Queen Snakes had retreated to greater depths within the dam.

White Oak *R. septemvittata* were surface active over 200 days from early April to early November. In the more southern parts of its range, *R. septemvittata* is active for longer periods, possibly in every month (Ernst & Ernst, 2003). North Carolina Queen Snakes are surface active from late March to late October (Palmer & Braswell, 1995), and those in Virginia from late February to early October (Mitchell, 1994). In Kentucky, active Queen Snakes were found from 5th April to 15th November (225 days) by Branson & Baker (1974). Farther north, Conant (1938) reported them active from 6th May to October, over 149 days in Ohio, and this species was found active for 136 days from 10th May to 23rd September in western New York (Raney & Roecker, 1947).

In southeastern Pennsylvania, *R. septemvittata* is forced to hibernate during the winter. Queen Snakes gathered at the entrances to cavities in the dam in late September and October, where they basked during the day. Such pre-hibernation aggregations have also been noted by Neill (1948) in Georgia, and by Wood (1944) and Wood & Duellman (1950) in Ohio, but not by Branson & Baker (1974) in Kentucky. By the end of the first week of November, all of the White Oak *R. septemvittata* had retreated into the dam for the winter. Occasionally, *R. septemvittata* may be active later in the season in southeastern Pennsylvania; Reinert (1975) found a sluggish one basking at 13:30 hrs on 5th December in Berks County, Pennsylvania. So some may possibly emerge on warm winter days to bask, even as far north as Pennsylvania. Conant (1951) found one in Ohio lying on ice in January.

At White Oak, adult snakes emerged in the spring earlier than juveniles, but the juveniles entered hibernation earlier in the fall. This pattern is typical of most hibernating snakes in North America (Ernst & Ernst, 2003). Gravid females were less active than males and nongravid females, and spent more time basking than foraging; only two were found foraging.

Daily Activity Period

Although the dam site and the creek below it were examined for nocturnal activity, no Queen Snakes were found active after dusk (Table 1). The earliest snake was observed at 06:30 hrs, and the latest at 17:49 hrs. Activity was bimodal, with most activity in the period 08:00-11:00 hrs and another period, although of somewhat reduced activity, from 14:00 hrs to about 18:00 hrs. Surface activity included foraging (159, 56.8% of captures of active snakes; while foraging, the snakes crawled or swam along the bottom of the waterway and

Regina septemvittata from Central Kentucky. Photograph by author.

explored possible crayfish retreats, such as beneath or on the downstream side of rocks), basking (59, 21.1%), hiding under cover of large stones or logs (41, 14.6%), or crawling along the bank (8, 2.9%) (Table 2).

Branson & Baker (1974) also found *R. septemvittata* active only during the daylight hours, but did not report bimodal activity. In contrast with this study, they reported that 95.6% of their captures were of snakes found beneath rocks, and that only 1.8% of their snakes were basking. Aquatic versus land captures were in a 1.26:1 ratio. At White Oak, 172 (59.3%) captures occurred in water, and 118 (40.7%) were terrestrial; a 1.46:1 ratio.

Thermal Ecology

Body (cloacal) temperatures and environmental temperatures were recorded at the time of capture of all adults and juveniles, resulting in 237 records, of which 227 were of snakes considered active (Table 2). Because of their smaller size, body temperatures were not recorded for neonates. Active snakes had BTs ranging from 14.0°C to 31.6°C, and averaged 25.1°C; BTs of the 10 hibernating snakes averaged 2.8°C (2.0-4.1°C) (Table 2).

BTs of active White Oak *R. septemvittata* were similar to those reported in Kentucky by Branson & Baker (1974), who recorded mean 25.6°C (12.2-30.4°C) BTs. They also reported that the CTmax of their adult snakes varied from 43.4 °C and 44.5°C, and that of juveniles were 39.5-41.5°C. The CTmax was not determined for White Oak *R. septemvittata*, but no BT approached the critical limits reported by Branson & Baker (1974). Hibernating White Oak Queen Snakes had BTs averaging 2.8°C (2.0-4.1°C). BTs of all White Oak Queen Snakes were highly correlated with environmental temperatures, although the highest correlation varied by activity and collection site (Table 2).

Movements

The greatest straight-line distance moved between captures was by a 53.0 SVL male which was recaptured two days later 101 m from its last capture point. The greatest straight-line distance moved between captures by a female was 60 m by one nongravid with a 43.3 cm SVL. Eleven recaptures of gravid females indicated that they moved only short distances, 0-12 m (mean, 4.0 m); four were recaptured at the same place as their last capture. Juveniles moved 0-30 m (mean, 12.0 m) between recaptures. Of those snakes first captured at the dam, the greatest recapture distance from the dam was 55 m by a 40.0 cm SVL male, and 80% of the 75 recaptures of snakes at the dam were within 25 m of it. No significant difference was found between the distances moved by adults of either sex (t-test, 4.04, $p > 0.5$), and most juveniles were found no more than 10 m from their last capture point.

Based on the limited recapture data, White Oak *R. septemvittata* seemed to occupy small home ranges, as no individual was captured over 101 m from its last collection point. The home ranges seemed essentially linear, extending along the bank of the stream below the dam. No Queen

Snake was collected inland farther than 6 m from the stream. Of 13 Kentucky recaptures by Branson & Baker (1974), the straight-line distances from point of release to that of recapture were 3-137 m (mean 22.6 m). Most activity at White Oak centered around the stone dam which was used both as a summer and winter retreat.

Reproduction

Mating *R. septemvittata* were found on 6th May 1966 and 30th April 1967. The males had SVLs of 36.5 cm and 39.2 cm, and the females were 55.8 cm and 66.9 cm in SVL. Temperature data for these matings are presented in Table 2. Unambiguously gravid females were captured or observed basking from 1st July to 28th August. The first neonates were found on 2nd September. The 53 neonates captured had TBLs of 16.6-23.1 cm (mean, 20.5 cm), SVLs of 12.5-18.1 cm (mean, 15.6 cm), and weighed 2.7-3.1 g (mean, 2.9 g). Gravid females averaged 3.9 g (3.2-4.8 g) more than nongravid females.

The main breeding period of *R. septemvittata* is the months of April and May, although Branson & Baker (1974) thought that some matings possibly occur in the fall. Ford (1982) reported spring courtship activity by recently captured snakes, and Ashton & Ashton (1981) thought mating occurred in the spring in Florida, possibly as late as June. Observations of mating activity by wild *R. septemvittata* have only occurred on 30th April and 6th May (this study), and 28th May in Indiana (Minton, 1972). Reported births have occurred from 6th July to 1st October, but most take place from mid-August to mid-September (Ernst & Ernst, 2003). White Oak Queen Snakes followed this pattern.

Diet and Foraging Behaviour

Although crayfish were abundant in all four foraging habitats, the shallow, rocky stretches of the creek below the dam were clearly preferred by the Queen Snakes. The greater number of foraging and feeding observations there corresponds to this area supporting the largest number of snakes, due largely to the various retreats in the dam.

One hundred sixty-eight captures (57.9%) were of snakes either foraging for (n = 159, 94.6%) or ingesting (n = 9, 5.4%) crayfish (*Cambarus* sp.). All feeding observations occurred downstream from the Sanctuary dam. Of those foraging, 148 (93.1%) were in the rocky creek below the dam, 4 (2.5%) were in the shallow brooks flowing through the pastures to the north of the Sanctuary, 4 (2.5%) were in the western shallows of the pond, and 3 (1.8%) were in the marsh. The observations occurred at 07:50-11:04 hrs and at 15:09-17:49 hrs; with 149 (88.7%) observations in the morning, and 19 (11.3%) in the late afternoon.

When a crayfish was discovered, it was seized and was swallowed tail first. All of the prey ingested were small and appeared to have recently molted. Vomodor was probably an important cue to finding prey, as the snakes frequently tongue-flicked. Pinder (1996) observed that much tongue flicking is done while these snakes forage underwater; and Burghardt (1968) tested the response of naive neonate *R. septemvittata* to water extracts of several small animals, but the snakes only responded to extracts of crayfish, particularly those that had recently molted.

Predation, Parasites and Injuries

Predation, ectoparasitism and natural injuries were relatively rare among adults (n = 27, 13.2% of the population). These consisted of 14 *R. septemvittata* (6.8%) with bobtails; 10 individuals (4.9%) with healed or fresh scars on their head or body; 1 (0.5%) apparently predated by a Red-shouldered Hawk (*Buteo lineatus*), which was found feeding on its freshly killed carcass; and 1 (0.5%) parasitised by a leech, *Placobdella parasitica,* which was attached to the snake's cloacal wall with about 33% of its body protruding from the vent. Although all of the scars and 5 (45.4%) of the bobtails appeared to have been caused by predators, or possibly by crayfish during feeding bouts, 6 (54.5%) of the tail injuries were probably the result of winter frostbite.

The amount of recorded predation, parasitism and injuries in the White Oak population was not particularly high. However, these records were only from adults and larger subadults. None of the

neonates or small juveniles captured during the study showed evidence of predation or parasitism, but individuals of these age classes were small enough to be swallowed whole by a predator. Recorded predators of *R. septemvittata* include mice and other snakes during hibernation (Huheey & Stupka, 1967), the Racer (*Coluber constrictor*) (Palmer & Braswell, 1995), and the Hellbender (*Cryptobranchus alleganiensis*) (Branson & Baker, 1974). Branson & Baker (1974) had several captive neonates trapped underwater and killed by crayfish. They also reported that a male captured in mud had three leeches (*Placobdella rugosa*) attached to it. In addition, many of their Kentucky *R. septemvittata* had white blisters on their bodies caused by fungus (*Verticellium*); no White Oak Queen Snake had such an infection.

Human damage to White Oak queen snakes was more severe, and involved 53.6% of the individuals. Unfortunately, the Queen Snakes residing at the dam site and below it in the creek were extirpated due to multiple causes. During the summer months of 1966, local teenage boys shot and killed 107 adult and subadult *R. septemvittata* (52.2% of the entire population), 32 *Nerodia sipedon* and 6 *Thamnophis sirtalis* while the snakes basked on the sides of the dam or on the bank of the creek. In addition, from May 1965 through July 1967, 3 *R. septemvittata* (1.5% of the population), 12 *N. sipedon*, and 4 *T. sirtalis* were killed by motorised vehicles on the road crossing the dam. Still, some *R. septemvittata* survived, and the species was seen there into June 1972. In that month an approximately 3 m wall of flood water resulting from the torrential rains of Hurricane Agnes swept through the valley and over the dam (Ernst, 1974). Since then no Queen Snakes have been found at either the dam or along the creek below it. In addition, in the mid-1970s the Pennsylvania Department of Transportation repaved the road crossing the dam, filling many of the cracks used as hibernacula by snakes. While this was being done, asphalt was also spilled into the frames of the dam's sluice gates, making it impossible to close the gates completely. By 1980, the pond and marsh had been drained, resulting in less water flowing downstream from the dam, and greatly reducing the available crayfish habitat. Crayfish were restricted to a narrow channel flowing through what was the old pond and over the dam, and several small brooks flowing through the marsh and pastures which still supported a reduced crayfish population. A few *R. septemvittata* still occur along the brooks in the pastures, as evidenced by a shed skin found in July 2001. In contrast, the populations of *N. sipedon* and *T. sirtalis* at and below the dam survived and grew in numbers until they appeared near preflood numbers by 1988.

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New records of *Salamandra salamandra* (Linnaeus, 1758) in Latium (Central Italy)

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SALAMANDRA salamandra (Linnaeus, 1758) is present in Italy with two subspecies: *S. s. salamandra* is distributed in the Alps, pre-Alps and (probably) the Northern Apennines, while *S. s. gigliolii* is found in peninsular Italy. At present it is possible to ascribe with certainty only the southernmost populations to *gigliolii*, i.e. in Calabria (Steinfartz et al., 2000). The subspecific identity and distribution of the remaining populations are uncertain. The presence of *Salamandra salamandra* in Latium (Central Italy) deserves particular mention in that so far only two population nuclei have been recorded within the region (Bologna, 2000).

In August 2001 we were informed of the presence of *S. salamandra* larvae in some ponds along the Rio Chiaro brook (Vallerotonda, Frosinone province) in Latium. Shortly afterwards, we conducted some field surveys to verify these observations, and to explore additional sites in the area expected to be suitable for the species: we confirmed the occurrence of salamanders at the Rio Chiaro, and also at the Melfa River, in the area of Val Canneto (Frosinone province) (Fig. 1). We carried out further visits to both sites until July 2002.

The section of the Melfa River that we investigated ranges in altitude between 1330 and 1025 m: this is the upper section of the river, which flows in a N-S orientated valley close to mount La Meta (2242 m). The vegetation is dominated by *Fagus silvatica*, with growths of *Acer* sp. and *Salix* sp. in the valley bottom. The river is permanent, although in summer it can dry up in places. *Bombina variegata pachypus*, *Bufo bufo* and *Rana italica* also breed in the river, and except in the highest reaches, fish are also present.

Larvae of *Salamandra salamandra* were found at three different sites along the river ranging in elevation between approximately 1100 and 1315 m, the first site being 1400 m in distance from the second, and the latter being 850 m from the third. Although the larvae could have been carried downstream by the natural flow of water, it seems appropriate to consider the areas as three different breeding sites, because (1) reproduction was verified at the lowest site, indicated by the observation of a gravid female (see below), and (2) at the intermediate sites larvae were also found in rock pools away from the main stream channel. The first observation record of larvae in 2002 occurred on May 7th (larvae of the former year disappeared in September 2001); their total body lengths (TL) correspond to the sizes measured at birth (see below), or a little larger. However, on the same day, we found two larvae of 57 and 58 mm long, substantially nearer to metamorphosis. On July 17th 2002 we also measured several larvae that had recently been born. Consequently, we suggest that larvae of *Salamandra salamandra* in this region are produced mostly between the middle of April and May, but earlier and later births are possible. This appears to be valid at each of the three different breeding sites along the Melfa River; reproduction therefore does not appear to vary with altitudinal phenologic variation. We recorded adults on only three occasions; these were identified by their dorsal patterns (Table 1).

After seven hours the female found on May 7th produced 33 larvae (mean TL ± S.E. 32.4 ± 0.2 mm, range 29-34 mm), 5 dead larvae, which did not emerge from gelatinous envelopes, and 5 unfertilised eggs. This individual was found in the middle of a stream pond at 1100 m together with

four males, about 70 m apart. On the vents of all specimens were flesh-red spots and never yellow ones; even on the back there may have been flesh-red variegations, but less concentrated and, therefore, less visible. On the basis of their colour patterns it was not possible to ascribe the five adult specimens to either of the Italian subspecies, because of their apparent intermediacy between *S. s. salamandra* (characterised by a prevalence of black rather than yellow on the back) and *S. s. gigliolii* (which has a prevalence of yellow on the back, and the vent may also be predominantly yellow with flesh-red spots). In accordance with Andreone et al. (1999), this suggests the existence of clinal hybridisation between the two subspecies in this region. Populations in Campania (just a little south of Latium) have been similarly difficult to identify, even using bio-molecular data (Steinfartz et al., 2000; Odierna et al., 2001). In reaching this conclusion, however, we appreciate that the number of adults examined was relatively small, and further research is clearly needed before populations in the region can be ascribed to a particular subspecies.

day	hour	air t	water t	sex	TL (mm)	SVL (mm)	W (g)	B/Y	b/y
21/10/2001	6.15 PM	13.5°C		m	167	96	23	1.27	1.20
	6.45 PM	13.5°C		m	179	98	28	1.17	0.99
08/11/2001	7.20 AM	8°C		m	174	101	29	1.30	1.18
	7.35 AM	8°C		m	160	90	17	1.12	1.02
07/05/2002	5.30 PM	12.5°C	7.5°C	f	175	95		1.87	

Table 1. Discovery dates, environmental parameters, and morphology characteristic of specimens found. TL = total length; SVL = snout-vent length; W = weight; B/Y = black/yellow area ratio of head, trunk and tail; b/y = black/yellow area ratio of head and trunk (limbs excepted in these last two categories).

The Rio Chiaro brook arises at 1550 m, flowing in a valley N-S oriented close to Catenella delle Mainarde mountains (maximum height 1652 m). We investigated the stretch between 1375 and 1200 m. Vegetation in the area is dominated by *Fagus silvatica*, with scattered *Salix* sp. and riparian vegetation in the valley bottom. The brook is permanent, although may occasionally dry out during the summer. *Salamandrina terdigitata* and *Rana italica* also breed in the brook, but fish are absent.

Salamandra salamandra larvae were located in a small tributary arising at 1330 m (approximately 200 m long), and in some ponds of the main stream downstream from its confluence (1300 m) to at least 1200 m (distance from the confluence is about 960 m). At this site, the larvae metamorphosed before October (2001) also, and new larvae were found on May 7th 2002: on this occasion the smallest individual measured 28 mm and the longest 32 mm. On July 7th 2002, we found some larvae (the longest measuring 55 mm) near metamorphosis. Consequently, there seems to be only one period for parturition in the Rio Chiaro, between the middle of April until May. We did not find any metamorphosed specimens.

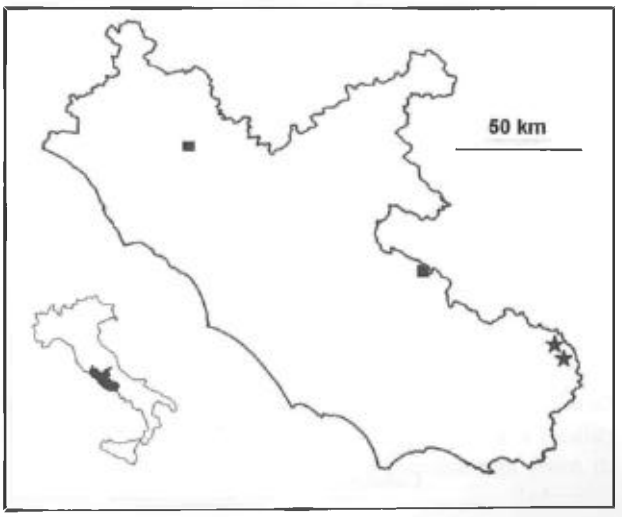

Figure 1. Distribution of *Salamandra salamandra* in Latium, Italy. Stars indicate new records; squares denote population nuclei already know (Bologna, 2000).

Salamandra salamandra is considered at 'critical risk' in Latium (Scalera et al., 2000), and it is our view that the two populations described herein should thus be protected. From a practical viewpoint, protection of the Val Canneto population would be easier, this site being located within Abruzzo, Latium and Molise National Park.

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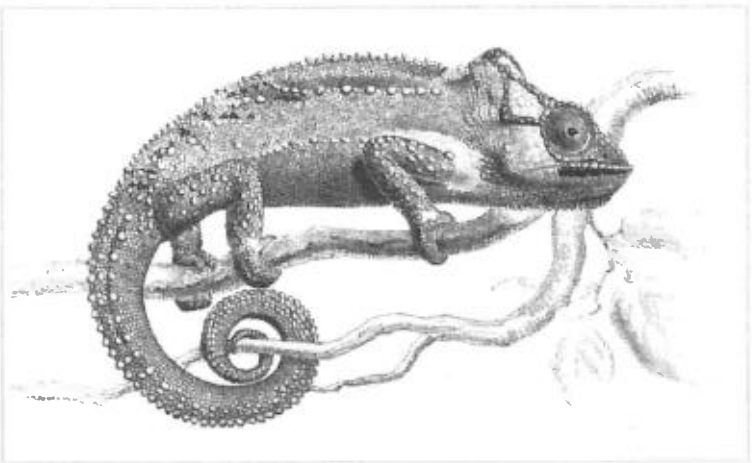

Chameleon (= *Bradypodion*) *damaranus*. Knysna Dwarf Chameleon. Reproduced with permission from The Natural History Museum from *Catalogue of the Lizards*, Vol. 3, by G. A. Boulenger.

Morelet's Crocodile (*Crocodylus moreletii*) in the Macal River watershed, Maya Mountains, Belize

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ABSTRACT — Results are presented of an investigation into the status of Morelet's Crocodile in the Macal River watershed, a little known upland tributary system in Belize. During spotlight surveys in February 2001 and September 2002, numerous individuals were observed representing a wide range of size classes. Sequence analyses of mtDNA from captured animals show that crocodiles in the area represent a genetically pure strain of *C. moreletii*. No evidence of hybridisation with the American Crocodile (*C. acutus*) was detected, as observed in animals from other sampled localities (northern lowlands). Due to their relative isolation, crocodiles in the Macal watershed may thus function as a regionally important population source for *C. moreletii* should introgression with *C. acutus* spread over time. Differences between *C. moreletii* in the Macal and northern lowlands were apparent also in aspects of ecology.

MORELET'S Crocodile (*Crocodylus moreletii*) is one of two species of crocodilian found in Belize (Lee, 1996; Stafford & Meyer, 2000). It occurs primarily in freshwater habitats, especially in the northern part of the country, a flat limestone shelf dominated by extensive lagoons, alluvial swamps, and flooded sinkholes. The remaining species, *C. acutus*, is restricted to offshore islands and coastal areas of the mainland (Platt & Thorbjarnarson, 2000a). Commercial harvesting for its high quality leather had depleted populations of *C. moreletii* throughout its entire range, and by the late 1960s the species is believed to have been nearly exterminated in Belize (Neill, 1971; Frost, 1974). Following legal protection afforded in 1981, however, its numbers have since recovered significantly.

Surveys undertaken recently of *C. moreletii* in Belize have focused mostly on the northern lowlands (e.g. Abercrombie et al., 1980, 1982; Platt, 1996; Rainwater et al., 1998; Platt & Thorbjarnarson, 2000a), where at some localities the species appears to be common. At Gold Button Lagoon in the Orange Walk District, Platt (1996) counted 159 individuals representing an encounter rate of 22.08 crocodiles per km of the shoreline. More recent observations have confirmed the presence of *C. moreletii* at various localities in southern Belize east of the central mountain divide (Platt et al., 1999). Crocodiles are also known to inhabit some of the larger rivers and streams that drain the western slopes of this little known mountain range (Maya Mountains), particularly the Macal and its larger tributary, the Raspaculo Branch, but with only a small number of records available the occurrence and distribution of populations in the area remain inadequately assessed. In this paper we review the status of *C. moreletii* in the Macal watershed based on recent surveys and other data collected periodically over the last ten years. Much of this system is threatened with flooding should plans to construct a hydro-electric storage dam at Chalillo, a locality on the Macal some 12 km downstream from its

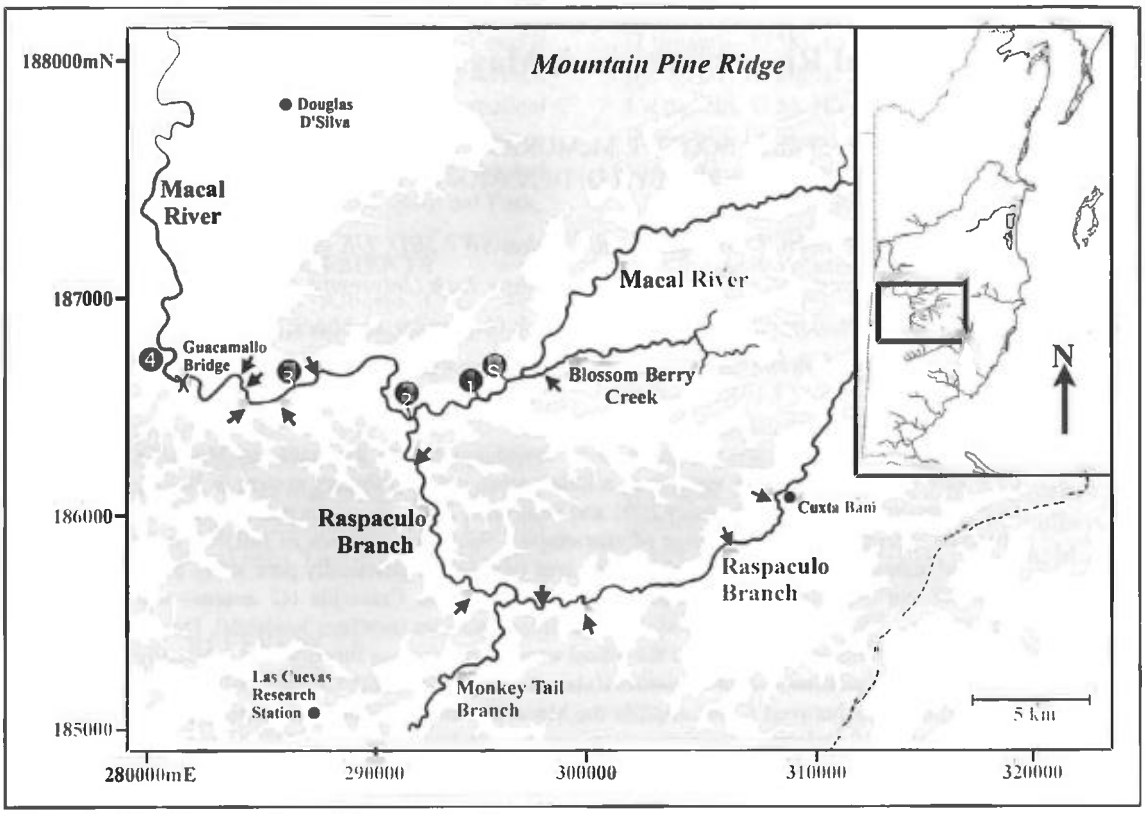

Figure 1. Macal River watershed showing location of survey route. S = start point; 1 = site 1; 2 = site 2 and end point of 2002 survey; 3 = site 3 and end point of 2001 survey; 4 = site 4. For coordinates see text and Appendix 1. Black arrows represent other known distributional records of crocodiles (Stafford, 1991; Rogers, 1994, 2002; J. Meerman, unpublished data; C. Minty, pers. obs.). The dotted line marks the position of the main divide of the Maya Mountains; areas shaded in grey denote elevations above 600 m. Only principal tributaries are shown.

confluence with the Raspaculo Branch, not be repealed.

Survey area

The Macal River is located in west-central Belize in the provincial district of Cayo (Figure 1). From its headwaters in Mountain Pine Ridge it extends for a distance of approximately 80 km, flowing west and then north to its confluence with the Belize River near San Ignacio. Over its wider catchment area the river flows through a region of considerable relief, where much of the flanking ground lies above 600 m. Most of its larger tributaries arise from sources in these highlands. No important tributaries enter from the west, which is probably due to subsurface drainage through porous limestone and highly developed karst topography of the Vaca Plateau (Hartshorn et al., 1984). Rainfall in the area can exceed 2000 mm per year with most (> 80 %) falling during a pronounced wet season extending from June-December. Fluctuations in river levels during this period are often substantial and in parts of the system water levels may rise by up to 5 m or more, occasionally with devastating effects (Figure 2). Hartshorn et al. (1984) described the Macal as 'the most tumultuous river in Belize'.

Although several localities in the watershed have specific colloquial names, there are no major settlements and the entire region remains largely uninhabited. Encompassed within the boundaries of three national parks (Chiquibul Forest Reserve, Chiquibul National Park, and Maya Mountains Biosphere Reserve), the area provides sanctuary

for crocodiles and many other vulnerable species of wildlife, among them the Jaguar (*Panthera onca*), Tapir (*Tapirus bairdii*), Neotropical River Otter (*Lutra longicaudis*) and a recently described subspecies of Scarlet Macaw (*Arao macao cynoptera*).

METHODS

Sightings of crocodiles in the Macal drainage have been recorded on an intermittent basis since 1991 (Stafford, 1991; Rogers et al., 1994, 2001; J. Meerman, pers. data; C. Minty, pers. data). For the purposes of this specific assessment, however, two periods of fieldwork were undertaken, the first for 3 nights between February 20th and 23rd 2001 (McMurry and Barr) and the second for 5 nights between September 4th and 10th 2002 (Stafford, McMurry and Rainwater). On each occasion the same general section of river was surveyed, beginning at GR 0296753E 1864400N (Francelia) and extending downstream to 1864900N in 2001 (approx. 15.5 km), and 1863431N in 2002 (approx. 8 km). In 2002 an additional 1 km section of the Macal was surveyed below Guacamallo Bridge (location 4 on map).

Crocodiles were located from two-man canoes at night using 12-volt headlights to detect eyeshine reflections. All animals sighted or captured were classified by total length (TL) as hatchlings (<35.0 cm), juveniles (35.1 to 75.0 cm), subadults (75.1 to 140.0 cm), or adults (>140.1 cm); individuals that could not be approached close enough to estimate TL were classified as 'eyeshine only' (EO). Following Bayliss (1987), the number of crocodiles encountered per km of survey route was used as a measure of relative density (Platt & Thorbjarnarson, 2000b). Distance traveled on the river was calculated with a Magellan Global Positioning System (GPS) 2000 satellite navigator and confirmed using UTM 1:50,000 topographical maps of the area. At each of the main survey sites we recorded air temperature (AT), water temperature (WT), and an estimation of mid-stream flow rate by measuring the distance covered in 30 seconds by a small rubber ball. Evidence of nesting activity along the route was also investigated by searching suitable sites.

Figure 2. Aerial photograph of upper Macal showing floodwater devastation in May 1990. Photograph © D.A. Sutton.

Small crocodiles (TL < 90 cm) were captured by hand, while larger individuals (> 90.1 cm) were noosed using self-locking breakaway snares. For each captured animal we recorded sex (determined by cloacal examination; Allsteadt & Lang, 1995), TL, scutellation features, cloacal temperature (CT), and evidence of external parasites, injury, or abnormalities. Juveniles captured in 2002 were also stomach flushed for dietary data (Platt, 1996; Platt et al., 2002). Crocodiles were then marked for identification and future monitoring purposes by clipping four of the caudal scutes following the method of Jennings et al. (1991); using the number of the first animal marked as an example (4522), the digits 4 and 5 represent the 4th and 5th scutes of the single row tail series (moving in a posterior direction), the first 2 is the second scute of the double row on the right side, and the second 2 is the second scute of the double row on the left side. Finally, a blood sample was collected from the post-cranial sinus and placed in an extraction

buffer (ACD-B, see White & Densmore, 1992) for DNA analysis, following which the animal was returned to its original capture site and released.

RESULTS

Time constraints and the practical limitations of operating in a remote area precluded us from conducting a detailed survey of the entire watershed. Surveys were therefore restricted to the vicinity of four main localities in the upper Macal and adjoining section of the Raspaculo (Figure 1). Observations recorded at each of these localities are summarised in Appendix 1.

During the 2001 survey a total of 23 crocodiles was observed, representing an encounter rate of 1.48/km. These included 7 juveniles, 4 subadults, 9 adults, and 3 for which size could not be determined (identified by eyeshine only). In 2002, 21 crocodiles were observed, 10 between the survey start point and junction of the Macal and Rapsaculo (1.25/km), and the remainder along a separate 1 km stretch below Guacamallo Bridge (locality 4). Of these, 12 were juveniles, 3 were subadults, 4 were adults, and 2 were detected by eyeshine only. As is the nature of such surveys, many animals will have been overlooked and the number of individuals recorded is therefore likely to represent the minimum number present. Of 14 animals that were captured and marked, 9 were juveniles (3 males and 6 females), 2 were subadults (males), and 3 were adults (1 male and 2 females). None of the animals captured in 2001 were recaptured in 2002.

Species identification

All captured individuals exhibited dorsal and subcaudal scutellation patterns consistent with those of Morelet's Crocodile (Brazaitis, 1973; Ross & Mayer, 1983; Ross & Ross, 1974; Platt, 1996). DNA sequence analyses of 534 bases of mitochondrial (mt) control region DNA, isolated from blood collected from 11 specimens, revealed that haplotype A (Ray et al., in review) is the most common mitochondrial haplotype (9 of 11 animals) in this population. Two rare haplotypes (J and K) are each represented by single individuals. There is no suggestion of any Macal animals having mitochondrial haplotypes resulting from hybridisation with American Crocodiles, as has been found in other populations in Belize (Ray et al., in review). The within-population haplotype diversity for the 11 animals sampled is 0.182; the nucleotide diversity is 0.0003, which is the lowest amount found in any single Morelet's Crocodile population (Ray et al., in review).

Distribution and ecology

The furthest upstream locality at which crocodiles have been recorded in the Macal watershed is Cuxta Bani in the Raspaculo (Stafford, 1991; Rogers et al., 1994, 2001). Crocodiles at this locality and one other observed a short distance further upstream at approximately 450 m a.s.l. represent the highest known elevational records for *C. moreletii*. Crocodiles were encountered mostly at night in slow-flowing water, usually near the bank or in small side pools away from the main current. The largest aggregation of juveniles (5) was observed in a small deep ox-bow with dense reed growth at the edges on 4th September 2002. Three individuals captured at this locality (Site #1) between 19:00 and 21:00 hrs had a cloacal temperature of 27.5°C. Water and air temperatures were 27.5°C and 25.0°C respectively. A large adult (> ca. 210 cm total length) was also observed in the vicinity of this pool, possibly a parent.

Of seven yearlings examined for dietary data, six contained food. Two had eaten damselflies (Zygoptera; Odonata) and orthopterans (Acrididae and Gryllidae), one had eaten an unidentified crustacean, and another contained eight snail opercula, snail flesh, and the limb bones of an unidentified anuran. Other items recovered from stomachs included unidentified tissue remains and, in one individual (#4679), ten nematodes. Gastrolith numbers ranged from 0-61 per stomach, all of them small, rounded, uniformly-sized pieces of gravel. Most crocodiles appeared to be in a good state of general health with no evidence of injury, and also remarkably free of ectoparasites. *Paratrichosoma* spp. (Moravec & Vargas-Vazquez, 1998; Moravec, 2001) were observed on the ventral scales of only two individuals, both yearlings from the same locality (4).

Population size

In the absence of comprehensive survey data it is not possible to provide an accurate estimation of population size of *C. moreletii* in the Macal watershed as a whole. Based on the observed encounter rate, however, a crude approximation of non-hatchling numbers in its two principal tributaries – the Macal and Raspaculo Branch – can be obtained by extrapolating this value over the length of river along which crocodiles are known to occur. Using standard topographical maps (see Methods), we conservatively measured a total distance of 68.5 km from the furthest upstream localities at which crocodiles have been sighted in each river (Cuxta Bani in the Raspaculo, and locality 1 in the Macal to its confluence with the Belize River). Multiplying this value by the average number of crocodiles observed per km of route (1.37 based on combined 2001 and 2002 data) accordingly yields a total non-hatchling population size of 94. This should be considered a minimum estimate as not all individuals are sighted during nocturnal spotlight surveys, and along some parts of the route observations were made only by day (most crocodiles are seen at night). Furthermore, a large section upstream of the known distributional limit of crocodiles in the Macal remains uninvestigated. In our attempt to estimate population size in the area, however, we are aware of the various potential sources for error, and recognise the need for qualitative estimates of abundance throughout the entire watershed.

DISCUSSION

This report is based on observations of crocodiles along a minimal stretch of the Macal River and a limited number of other localities. Nonetheless, the survey data reveal several interesting characteristics of *C. moreletii* in this watershed.

Results of the mtDNA analyses suggest that crocodiles in the area represent a genetically pure strain of *C. moreletii*. This is of potential significance in that analyses of mtDNA from individuals tested elsewhere in Belize (northern lowlands) have shown evidence of introgression with *C. acutus* (Ray et al., in review). Due to their relative isolation, crocodiles in the Macal watershed may thus function as a regionally important population source for *C. moreletii* should introgression with *C. acutus* spread over time. However, given that *C. acutus* is restricted to coastal areas, it may be that *moreletii* is actually the more 'pervasive' of the two species, and introgression between them is proceeding mostly in the other direction (S. Platt, pers. comm.). This is also suggested by the fact that hybrid crocodiles in the northern lowlands are morphologically identical to *C. moreletii* (S. Platt, pers. comm.). That some hybridisation events appear to have taken place so far inland, however, is surprising. Additional data are clearly needed on populations of crocodiles from other areas, but it may be that genetically pure *C. moreletii* are much rarer in Belize than has previously been assumed.

Unlike typical habitat of *C. moreletii*, the Macal watershed is situated in mountainous topography at 400 m or more elevation. Water temperature in the upper Macal recorded during the 2001 trip was consistently at 23 to 24°C (73 to 75°F). In comparison, water temperatures for a lowland lagoon site (New River Lagoon) taken in March averaged 28.6°C (range = 27.7 to 29.7), essentially five degrees warmer than the Macal. As a dynamic mountain river system this habitat is subject also to pronounced seasonal fluctuations in water levels, flow rate, and turbidity. During periods of high floodwater crocodiles are seen infrequently, and their movements on such occasions remain almost completely unknown. It is possible that some disperse into surrounding floodplain areas, perhaps using small ephemeral pools or concealing themselves in submerged vegetation, although we have no direct observations of this. How crocodiles contend with flooding in this system, and to where they apparently 'disappear', would benefit from particular further investigation.

In the northern lagoons of Belize, *C. moreletii* eats a variety of prey, a large part of the adult diet being comprised of Apple Snails (*Pomacea flagellata*) and fish (Platt, 1996; Platt et al., 2002). Other prey items available to populations in this area include a plethora of animals encompassing almost all vertebrate and non-vertebrate groups. In the Macal and Raspaculo rivers, however, we observed relatively few potential prey items. Aquatic river snails were abundant and appear to

comprise one species, but all were probably less than 20 grams in mass. During an earlier survey several fish species were observed (Rogers et al., 1994), but relatively few compared to those in some of the northern lagoons studied, and most were small (<10 cm; e.g. *Astyanax fasciata*, *Gambusia* sp. *Cichlasoma salvini*, *C. spilurum*). Catfish (Pimelodidae; *Rhamdia* sp.?) appear to be the only suitably large fish species available (> 20 mm), at least in some upper sections of the watershed. However, none of our observations on potential prey in either the lagoons or the Macal and Raspaculo rivers were quantified, therefore precluding anything other than anecdotal comparisons. In 2000, a large adult *C. moreletii* near site 2 was observed feeding on a dead adult Tapir purportedly killed by a Jaguar (S. Snider, R. and C. Foster, pers. obs.), and another adult was seen feeding on a Tamandua (*Tamandua mexicana*) (M. Meadows, pers. obs.).

Although no direct evidence of nesting was observed, nests have been seen in the area (S. Matola, M. Meadows, pers. obs.) and the population is clearly breeding. We observed a wide-range of size classes, including several individuals likely to have hatched during the previous year (0.5 m class). These yearlings, coupled with the number of animals in successively larger size classes, indicate successful sustained reproduction. In northern Belize, *C. moreletii* nests during the wet season, but given that water levels at this time of year in the Macal can rise by several metres, it is difficult to envisage how nests survive the incubation period without being flooded. Dry season nests of crocodiles have been found in southern Belize but appear to have been the work of hybrids (S. Platt, unpubl. data).

None of the individuals examined at close quarters showed evidence of scarring or other indications of physical combat, even in the largest adult male. This may reflect a state of low intraspecific competition between males in this river system. In northern Belize, virtually all adult male crocodiles were found to have suffered injury in one form or another (Rainwater, pers. obs.).

The importance of mountain habitat for crocodiles and other wildlife inhabiting the Macal watershed should not be understated. Our observations and those of others (e.g. Rogers et al., 1994, 2002) indicate that this area remains virtually untouched by humans, and its remoteness makes it an invaluable natural resource for wildlife. Projected plans for the Macal include construction of a hydroelectric storage dam that will flood much of the area east of locality #3 (approx. 20 km upstream in the Macal and 10 km in the Raspaculo), the eventual reservoir having a total surface area of 9.53 km^2 (BECOL, 2001). Although one could argue that creation of a 'lake' due to back-flooding would enhance crocodile habitat, in reality the dynamic changes in river levels from water release at the dam will most likely hinder crocodile productivity. Fluctuating water levels not only destroy nesting/nursery habitat and the nests themselves, but also potentially disrupt life cycles of aquatic invertebrates and other organisms required by crocodiles for food. Additionally, the dam itself – a 49.5-metre high wall with power plant and associated installations – is likely to form a barrier to the movement of crocodiles between upstream and downstream areas. Should impoundment of the area go ahead as planned, the impact on crocodiles might to some extent be mitigated by not allowing water levels to rise and fall during the nesting season. In the Mollejon hydro reservoir further downstream in the Macal, such fluctuations appear to have resulted in the loss of shoreline vegetation and increased sedimentation, many of its banks now being coated with mud. These conditions are unlikely to be favourable to nesting crocodiles, and surveys have not revealed a large population in that area (J. Meerman, pers. comm.).

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Appendix 1. Observations of *C. moreletii* recorded at each of the main survey localities. Confirmed sightings are crocodiles that were seen and for which size could be estimated. Sizes given are total lengths. EO = eyeshine only.

Locality	Date	Number observed	Size (m)	Sex	Comments
Site #1 GR 295850E, 1864290N This locality included a small ox-bow pool approx. 30 m across at its widest point, and adjoining section of the main river channel extending about 100 downstream.	21/02/2001	1	0.5	?	Confirmed sighting
		3	1.0	?	Confirmed sightings
		1	1.62	♀	Captured; #4522
		1	2.0	?	Confirmed sighting
		1	?	?	Heard vocalising
	22/02/2001	1	0.4	♀	Captured; #4524
		1	0.5	?	Confirmed sighting
		1	0.655	♀	Captured; #4526a
		1	0.815	♂	Captured; #4525
		1	1.5	♀	Captured; #4523
		2	1.8	?	Confirmed sightings
	04/09/ 2002	3	0.54	2♂ + 1♀	Captured; #4675, 4676, 4677
		1	2.10	?	Confirmed sighting
		2	0.5	?	Confirmed sightings

Locality	Date	Number observed	Size (m)	Sex	Comments
Site #2	05/09/2002	1	2.54	♂	Captured; #04
		1	0.5	?	Confirmed sighting
GR 292700E, 1863405N Confluence of the Macal and Raspaculo Rivers.		1	?	?	EO
		1	0.51	♀	Captured; #4678
	06/09/2002	1	0.51	♀	Recapture (#4678)
Site #3	23/02/2001	2	0.5	?	Confirmed sightings
		1	0.54	♀	Captured; #4526b
GR 287994E, 1864900N This locality included two pools upstream from camp, and several pools extending to a point approx. 0.5 km downstream.		1	0.815	♂	Recapture (#4525)
		2	1.5	?	Confirmed sightings
		1	1.5	♀	Recapture (#4523)
		1	1.8	?	Confirmed sighting
		1	2.4	?	Confirmed sighting
		1	?	?	EO; possibly >1 m but poor visual
		1	?	?	EO; middle of river; appeared large but poor visual
		1	?	?	EO; appeared large but poor visual
Site #4	09/09/2002	1	0.47	♂	Captured; #4679
		1	0.77	♂	Captured; #4682
GR 282750E 1865600N This site included two small pools and a wide continuous stretch of the Macal between Guacamallo Bridge and a point approx. 1 km downstream.		2	0.60	?	Confirmed sightings
		1	0.90	?	Confirmed sighting
		1	?	?	EO; yearling?
	10/09/2002	1	0.5	♀	Captured; #4683
		1	0.60	?	Confirmed sighting
		1	1.20	?	Confirmed sighting; pool at side of bridge
		1	0.90	?	Confirmed sighting; likely to be same 0.90 m individual observed on previous night
		1	1.50	?	Confirmed sighting
		1	2.10	?	Confirmed sighting

Diurnal body temperatures in semi-captive Tokay Geckos (*Gekko gekko*); evidence for thermoregulation?

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DIURNAL reptiles have long been known to thermoregulate but relatively little is known about thermoregulation in nocturnal forms (Avery, 1982; Huey, 1982). The observation that some nocturnal geckos may bask during the day, led to a series of investigations into their diurnal thermal biology (e.g. Werner, 1965,1966; Bustard, 1967, 1968a, b; Dial, 1978; Kearney & Predavec, 2000). The results indicated that diurnal thermoregulation is a fundamental dynamic and integral aspect of their ecology (Huey, 1982). The present paper gives details of the thermal ecology of four male Tokay Geckos (*Gekko gekko*) living freely in a reptile housing complex consisting of both tropical and desert enclosures. The Tokay Gecko is a large (up to 35cm) species from south east Asia (Rogner, 1997) commonly seen in the pet trade and well known for its unfriendly disposition. Although it is primarily inactive during the hours of daylight we measured body temperatures and environmental temperatures to test for evidence of diurnal thermoregulation and also for any differences in body temperatures between individuals. The results are based on a second year Higher National Diploma research project at Huddersfield Technical College carried out by D.S. and supervised by R.M.

METHODS AND MATERIALS

The body temperatures of 4 adult *G. gekko*, all males, were recorded between 11:30 - 16:00 hrs from September 2001 to April 2002 under both sunny (n = 222) and overcast weather (n = 460). Skin surface temperature was measured at a distance of 6-7 cm from the animals dorsal region. This non -invasive method of measurement has the benefit of minimising behaviour disturbance. The core body temperature of lizards is in good agreement with skin surface temperature (Alberts & Grant, 1997) with the differences becoming greater with increasing body mass (Meek, 1999) suggesting little differences in the relatively small lizards used in this study. The lizards were free ranging in a large glasshouse unit (12 by 31 metres and 5 m in height) used to house a variety of species of reptile. Glasshouse temperatures varied with weather conditions due to being exposed to natural light and ranged from extremely hot during sunny weather in summer to more moderate temperatures on winter days. Humidity also varied from 30% during summer in the dry units to above 90% in the tropical enclosures, although these were not systematically recorded during the study.

All animals were initially liberated in a tropical house, the central animal unit within the complex, but with the exception of lizard D dispersed throughout the building. Two lizards took up residence in each of the dry habitats (housing desert reptiles and monitor lizards) and two in each of the tropical units (housing iguanas, water dragons, boa constrictors, terrapins etc). The lizards in the dry units are here defined as A and B with lizards C and D living in the tropical units. Each individual was relatively easy to identify visually either from head size, body markings or broken and regenerated tails. Heating pipes around the periphery of each unit gave the animals the opportunity to bask by positioning in their close proximity and this included access to the heating units in the walk-through enclosures.

	Mean ± Std. Dev.		s^2	Range	n
Sunny					
Lizard A	30.0	1.9	3.6	27-41	74
Lizard B	28.5	3.2	10.2	22-39	74
Lizard C	29.1	5.1	26.0	16-41	74
Model 1	35.6	6.2	37.9	22-46	74
Model 2	28.4	2.7	7.6	24-40	74
Model 3	21.7	2.8	8.1	16-31	74
Model 4	24.9	3.3	11.1	17-36	74
Overcast					
Lizard A	27.3	1.2	1.4	25-31	131
Lizard B	24.6	2.1	4.4	20-30	102
Lizard C	26.1	4.6	21.2	16-33	126
Lizard D	25.0	2.6	6.7	21-30	101
Model 1	25.6	2.5	6.1	22-32	131
Model 2	26.3	1.9	3.8	23-30	131
Model 3	18.2	1.7	3.1	15-25	131
Model 4	21.1	1.9	3.7	17-36	131

Table 1. Body temperatures of semi captive Tokay geckos under overcast and sunny weather with corresponding model temperatures. Mean temperatures are given with one standard deviation, variances (s^2), ranges and sample sizes (n). Sample sizes are based on the data collected from each lizard or model during the study period.

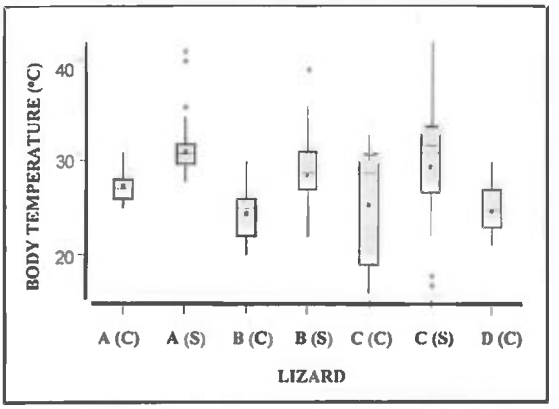

Figure 1. Box plots of body temperatures for individual lizards during different weather conditions. Overcast weather is shown as C and sunny weather S alongside lizard identifications A to D. The rectangular boxes indicate the interquartile ranges with the means shown as solid circles and medians as horizontal bars. The lines either side of the interquartile ranges represent the general ranges of the data but during sunny weather asterisks indicate outliers – data that are between 1.5 to 3 times from the interquartile ranges. There was insufficient data available for lizard D during sunny weather for inclusion.

Four water filled cylinders constructed from sheets of copper 1mm thick 16.5cm in length and 5.5cm in diameter were placed in various locations in the building where the maximum and minimum temperatures were expected to occur. Model 1 was placed in an open situation so that if the sun was shining it would receive maximum heat, with Model 2 about 10 cm from a heat pipe in the desert unit. Model 3 was located in a fully shaded position in a cool area of one of the dry units and Model 4 in a shaded area in a tropical unit. Models 1 and 2 therefore represented potentially the hottest areas, and Models 3 and 4 the coolest areas available to the lizards. These cylinders were slightly larger than the lizards but were painted black to enhance their heating rates and were measured simultaneously with lizard body temperatures using the infrared detector. Comparison of inanimate models (indicators of operative temperatures) and lizard body temperatures can be used as a test for thermoregulation with the assumption of no thermoregulation in the models (Bakken & Gates, 1975). The type of model used is less critical than originally thought (Vitt & Sartorius, 1999; Shine & Kearney, 2001). The low heat capacity of hollow-walled copper tubes respond readily to changes in radiation levels and have value in predicting the amounts of time operative temperatures exceed given thermal thresholds. Generally speaking, at the temperatures recorded in this study, the differences in model size, colour, amount of contact with the substrate and orientation have little influence on model temperature, but heating and cooling rates may differ because of differences in thermal time constants (Shine & Kearney, 2001).

RESULTS

Table 1 gives a statistical summary of the body and model temperature results including sample sizes; Figure 1 a graphical summary of the body

	Model 1 (open location)	Model 2 (10cm from heat pipe)	Model 3 (shaded/desert)	Model 4 (shaded/tropical)
		Overcast		
Lizard A	48.9 *	26.2*	2369.9*	725.7*
Lizard B	34.8**	52.7**	405.9*	103.5*
Lizard C	*n.s.*	8.3**	177.9*	57.66*
Lizard D	30.2**	38.4**	359.2*	99.45*
		Sunny		
Lizard A	50.1**	17.22*	372.6*	118.4*
Lizard B	78.5**	*n.s.*	184.6*	43.9*
Lizard C	40.7**	*n.s.*	111.9*	35.7*

Table 2. Matrix of F-values comparing lizard body temperatures to corresponding model temperatures under overcast and sunny weather obtained using analysis of variance. When lizard body temperatures were significantly higher than model temperatures a single asterisk is attached to the F statistic; when body temperatures were significantly lower than model temperature two asterisks are attached with no significant difference between lizard and model temperatures shown as n.s. See text for an interpretation of these results.

temperatures. There were significant differences between the means of body temperatures whatever the weather conditions (sunny, F (2,219) =3.36, p = 0.036; overcast F (3, 456) = 20. 96, $p < 0.0001$). The details of the differences are as follows: - when the weather was overcast lizard A was significantly higher than lizards B and D ($p = 0.01$) which were not significantly different from each other (p = 0.66) with lizard A also higher than lizard C (p = 0.005). Lizard C body temperatures were also significantly higher than lizards B and D (p = 0.003). When the weather was sunny the only significant difference was between the body temperatures of lizard A and lizard B with A higher ($p < 0.0001$). Body temperatures were significantly lower during overcast weather than in sunny weather in the three lizards that data were available for under both sets of weather conditions; lizard A, F (1, 203) = 154.0; lizard B, F (1,174) = 93.54; lizard C, F (1, 198) = 17.9, all $p < 0.0001$.

Table 1 shows standard deviations and variances of body temperatures around the means. A test of variance ratios (Martin & Firth, 1983) between lizards indicated that the variance in body temperature of lizard C was significantly greater than the other lizards; sunny weather lizard C versus lizard B, F = 2.54, $p < 0.001$, lizard C versus lizard A, F = 7.2, $p < 0.0001$ both at d.f. = 73 for v1 and v2. Lizard B also had a significantly greater variance than lizard A, F = 2.83, $p < 0.0001$ (v1 and v2 again at d.f. = 73).

The pattern of differences in body temperatures was similar during overcast weather. Again lizard C had a significantly greater variance than the other lizards (F-tests from 3.13 - 14.69, all $p < 0.0001$). The between weather conditions variance of lizard C was not significantly different (F = 1.03, $p > 0.05$ at v1 = 125, v2 = 73) but lizards A and B (there was no useful data during sunny weather for lizard D) had greater variances during sunny weather; lizard A, F = 3.4, v1 = 130, v2 = 73; lizard B, F = 2.28, v1 = 101, v2 = 73, both $p < 0.0001$.

In summary the body temperature results indicate that irrespective of weather conditions Lizard A had the highest mean and the lowest variance and Lizard C the greatest variance in body temperature. Means and variances in body temperatures were in general higher in sunny weather.

Table 2 shows a matrix of F-values based on analysis of variance of lizard and model temperatures. The results show that, in the main, the differences were between lizard A and the other lizards in respect to models 1 and 2. Lizard A was significantly higher than this model (the model close to a heat pipe) whilst the other lizards were either significantly lower or not different. Model 1, the model exposed to open situations, had significantly higher temperatures than all lizard body temperatures during sunny weather but

was significantly lower than lizard A during overcast weather. Under either sunny or overcast weather all lizards had significantly higher body temperatures than the shade models 3 and 4.

DISCUSSION

Given that research into the thermoregulatory behaviour of geckos has received less attention than most other groups of lizards, it is nevertheless the case that when evidence for diurnal thermoregulation has been sought it has been found. The difficulty with geckos lies in determining overt thermoregulatory behaviour when they are inactive, since it is often inconspicuous. However the general departures of *G. gekko* body temperatures from model temperatures, particularly the models that reflected operative temperatures at the extreme ends of the ranges, provide good evidence for thermoregulation. For example, had body temperatures been in agreement with the hottest model during sunny weather, the animals would have died from overheating – thermoregulation must also involve avoiding critically high temperatures as well as heating to optimum physiological temperatures. During overcast weather, the lizards generally had body temperatures that were above most model temperatures suggesting active thermoregulation to achieve target body temperatures. In the absence of any pronounced basking or posturing in respect to heat sources, the conclusion must be that thermoregulation is achieved through microhabitat selection. Other geckos may thermoregulate diurnally but in different ways, for instance *Heteronotia binoei* and *Gehyra variagatus* thermoregulate during the day through movement beneath the bark of dead trees after nocturnally foraging for food (Bustard, 1967, 1968a, b) and apparently consists of the animals attaching themselves to the part of the bark being heated by the sun and moving onto the bole of the tree when they begin to overheat (R. Bustard, pers. comm.).

The high mean and low variance in body temperature of lizard A irrespective of weather conditions appears to have been achieved through the occupation of a diurnal home site that had favourable thermal characteristic since model temperatures in this animals territory were close to optimal for Tokay Geckos, in the sense that they were close to the mean body temperatures of between 26.8 to 27.8°C recorded in a laboratory thermal gradients by Sievert & Hutchison (1988). The greater precision in body temperature of lizard A was probably due to its occupation of a narrow space (just wide enough to insert the 6cm wide infra red detector) between two wooden vertical surfaces, one end of which was only 12 cm from heating pipes. This facilitated a ready access to a heat source without moving any distance from cover (defined as 'protected basking' by Werner & Whitaker, 1978). Additionally the area was subject to only limited sunshine and remained thermally stable, at least on a day-to-day basis. The other lizards occupied similar types of home sites but with larger gaps between the occupied spaces (at least 12 cm) and greater distances from the heating pipes (at least 60 cm). In theory, had the other males been able to occupy the home site of lizard A, they would have had a similar thermal profile. Current theory predicts that the precision with which a reptile thermoregulates, estimated from variance in body temperature (Sievert & Hutchison, 1988), reflects the potential costs that the environment imposes on its behaviour; an ability to thermoregulate to optimum physiological temperatures produces the benefits of increased growth, greater locomotory ability, avoidance of predators and rate of egg production among others (Huey, 1982).

The less precise body temperatures observed in lizard C could in part reflect higher levels of activity in a heterogeneous environment, which in theory should increase variance in body temperature. For instance, casual observations (simple daily checks) of the presence of each lizard at their normal location showed that lizard A was the most likely to be present and lizard C (the largest in the study) the most likely to be absent. Lizard C additionally often showed injuries that were apparently sustained through inter-male conflict, probably in disputes over thermal resources since heat has been identified as an environmental resource (Magnuson et al., 1979) and may be defended in lizards (Huey, 1982). In this respect it is of interest that 2 female *G. gekko* introduced in May 2002 after the present study was completed, took up residence with lizard A and where repeated successful reproduction has since taken place – there was no human interference with reproduction, and the young could still be

found in association with the adults over 1 year later. This has already been observed in other geckos, for example in *G. variagatus* where offspring remained with the parents until they were sexually mature after which they were driven away by the adults – females by the dominant female and males by the dominant male (R. Bustard, 1967 and pers. comm.). It is well known that the thermal properties of an environment may influence the development of certain reptilian embryos, including those of geckos, and thus selection of home sites with thermally favourable characteristics may be crucial in gecko reproduction.

Although the present results provide evidence for diurnal thermoregulation we have no information concerning nocturnal thermoregulation in *G. gekko*. Sievert & Hutchison's (1988) laboratory study of 10 individual *G. gekko* in a thermal gradient showed selection of higher and greater precision of body temperatures at night and a distinct influence of light on thermoregulatory behaviour. They went on to suggest that *G. gekko* may be pre-adapted for utilising human habitations and exploits differences in microhabitat temperatures to maintain preferred body temperatures, a view supported by this study.

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***VARANUS NILOTICUS* (Nile Monitor): CAPTIVE ADULT FEEDING ON ANTS.** In May 1993, a five-foot (total length) male Nile Monitor was donated to one of the authors (BP) at his home in Las Vegas, Nevada. The lizard was given a screened out-door enclosure (3.3 m (length) x 1.5 m (width) x 2 m (high), with a pool to bathe in, and wooden logs to climb upon.

Almost at once, this animal began to dig a nine-foot deep burrow among the roots of a fig tree (*Ficus moraceae*) growing just outside and adjacent to the enclosure's screen fence. During the first week of August 1993, the ambient air temperature was excessive (for humans), reaching 38°C (100°F) by 09:00 hrs! By 12:00, the temperature had reached 41.6°C (107°F). This 'aquatic' varanid was observed basking in direct sunlight with no outward discomfort (i.e. panting, lying in shade or burrow). The Nile Monitor appears to tolerate arid regions where permanent water sources are present in the Sahara desert, or in captivity (Cloudsley-Thompson, 1967, 1969).

In this same yard where the Nile Monitor resided was another enclosure with six Savanna Monitors (*V. exanthematicus*). These lizards would retreat into their ten-foot deep burrows (see Bayless, 1994 for burrow discussions) when the ambient temperature reached 36°C (95°F). Physiological tolerances of ambient temperature between the 'aquatic' Nile Monitor and grassland-inhabiting Savanna Monitor seem apparent.

During the week of 9th August 1993, fruit began to drop from branches of the fig tree overhanging the Nile Monitor's enclosure. The lizard paid no attention to the falling figs, or those that lay scattered about on the ground, but the ants certainly did! The ants were probably Texas Carpenter Ants (*Camponotus festinatus*), or perhaps the Arid Land Honey Ants (*Myrmecocystus* sp.). The ant bivouac laid siege to the fallen figs, taking this sweet nectar back to their subterranean lair. During this same week, the monitor was observed lapping up the ants with its long blue tongue, much as an anteater (*Myrmecophagidae* sp.) does. The lizard lapped up the swarming ants for several minutes. After ten minutes had elapsed, the ants became too numerous for the lizard to tolerate, as by now they were crawling all over its body, especially about the head and face region. The animal dashed into the nearby pool, completely submerging itself beneath the water, cleansing itself of the marauding ants. The lizard then emerged from the pool when it was apparently satisfied that the ants had all fallen away from its body and drowned.

Dr. Robert Mertens (1894-1975) wrote the most comprehensive treatise on the monitor lizards, Family Varanidae, in 1942. In this treatise he speculated that the Roughneck Monitor, *V. rudicollis* might use its tongue in a similar ant-feeding (and termite) manner as seen for this captive Nile Monitor in the middle of the North American southwestern Nevada desert in 1993; this behaviour in a Nile Monitor confirms what Dr. Mertens' only speculated upon in 1942: that varanids do use efficient feeding strategies to manipulate their environment to their advantage, among them a tongue-collecting technique for gathering these formic-acid bearing insects.

Monitor lizards maintained in semi-natural outdoor enclosures no doubt enhances or brings to bear natural behaviours not often, if ever, seen in in-door, sometimes cramped terraria. The more varied behaviour a captive animal displays, the prospects for its enrichment and a healthier life while in captivity improve (see Stanner & Mendelssohn, 1999).

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***ZOOTOCA VIVIPARA* (Common or Viviparous Lizard): GREEN COLOURATION**. Reports of green-coloured Common Lizards are fairly well documented. Colin Simms (1970) noted that 30% of the lizard population of the Ayres, Isle of Man, 30% of the lizards on the Lancashire coastal dunes, 25% of those at Newborough Warren, Anglesey, and 15% of those on Strensall Common, Yorkshire, were 'green'. Simms described some specimens found in a park near Ramsay, Isle of Man, as 'approaching the green of the grass they live in'. BHS member Charles Montgomery of Edinburgh (pers. comm.) has had reports of green Common Lizards found near Stranraer, in S.W. Scotland. Although I have been looking at British Common Lizards since 1940, I had never seen a green example until 18th April of this year while monitoring a site that I had first found lizards at in 2000. This site lies roughly six miles north of Dundee, on a road cutting through the Sidlaw Hills, and consists of a small roadside strip of rubble and vegetation covered earth adjacent to the entrance of a quarry, lying at the foot of a south-facing artificial stone cliff, created by the road builders. We saw the green male lizard basking on an old log. Although the head and fore-part of the body was an olive colour, the centre of the dorsal surface was pea green fading to an incredible azure hue at the base of the tail and on the limbs. The animal must have recently sloughed because over and above the azure colour, there was an iridescent turquoise sheen. The darker lateral stripes were a viridien colour and most of the body was less marked than usual, being bereft of spots on the bluish tail base and adjacent lower back. I took what I thought were two distant slide photographs, but in my haste I forgot to wind the film on (Shades of Baron Munchausen I can hear you say!). The bluishness of the rear of the animal's body and the base of the tail was a little reminiscent of the turquoise colour that is so often seen in dead specimens of this species, and I was wondering whether the pigment of the epidermis could have been changed either through disease or chemical contamination. David Bird informs me that not only has he heard of green Common Lizards from near Salisbury, but has also seen them himself, showing a turquoise sheen similar to the specimen seen by us. He states that he thinks that this sheen is not caused by pigment, as it changes when seen from different viewpoints; in different lighting conditions, and when photographed. He also states that the change in colour occuring in dead lizards is maybe due to a fairly minor change in the chemical structure of the pigment or a change in chromatophores, as it happens so quickly.

Green variant of *Zootoca vivipara*. Illustration by author.

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BOOK REVIEWS

Pythons of Australia: A natural history

Geordie Torr

Illustrations by Eleanor Torr
University of New South Wales Press Ltd., and
Krieger Publishing Company

First published 2000. ISBN 1-57524-1149-8
Price £20.95

Over recent years Australian Pythons have been well documented in popular books. So the prospects of yet another volume on these snakes may seem a little slim. However, Kreiger have identified a niche in the herpetological market with previous publications and this is another excellent example that bridges the void between scientific treatise and monograph intended primarily for the reptile keeper.

The author, Geordie Torr, completed a PhD on the ecology and life history of rainforest lizards under the tutelage of probably the World's most prolific herpetologist (in terms of publications at least!) Prof. Richard Shine at the University of Sydney. The book also draws on an unpublished Master's thesis by Gavin Bedford.

Chapter 1 gives a succinct analysis of the fragmented fossil history of snakes and the debut of modern pythons. Within this chapter the evolving morass of taxonomy, the biogeography of pythons and the phenomenon of convergent evolution are briefly addressed.

Chapter 2 covers anatomy and physiology, information that is generally available. The remainder of this chapter, covering metabolism, digestion and water relations, is an up-to-date analysis of the extraordinary metabolic rearrangements pythons can achieve during these apparently simple acts.

The next two chapters (Behaviour and Reproduction) are amongst the most useful to the amateur as they explain the extensive work of Slip and Shine particularly with Water and Diamond Pythons. You will not find this wealth of information elsewhere in such an accessible form.

Chapter 5 covers food and feeding – and here the information is highly detailed, again drawing heavily on the research of Richard Shine. Chapter 6 covers conservation and management with up-to-date figures.

Chapter 7 is devoted to basic, but adequate, advice on captive care.There then follow accounts of thirteen species. The range of each species is shown on a separate map and the descriptions cover habitat, diet and additional comments on aspects of behaviour, including breeding. The accounts are augmented by a portfolio of 34 colour plates. There are some unusual forms shown including an albino Olive python (*Liasis olivaceous*), a striped Jungle Carpet python (*Morelia spilota cheynei*) and a beautiful silver morph of this subspecies. There is an excellent photograph of the rare Rough Scaled Python (*M. carinata*). The plates are from various authors and are excellent.

The dilemma facing any author of semi-technical publications is whether to include references. The annual loss of reptiles to amateur collecting in Australia has been estimated as being equal to just 0.0005% of the annual mortality*. A useful figure to have to hand in the face of the relentless, hysterical, onslaught against reptile keeping; this is just one example of a piece of data, that is not ascribed or referenced. The information within this slim book is incredibly useful but the origins of the material are not obvious. As far as the general reader is concerned, this probably does not pose a problem. The standard practice in scientific literature identifying all quoted references within the text does disrupt the flow of the writing and, as far as the amateur is concerned, is simply an irritation. Tracing original papers (even with the aid of the Internet) is still problematical and often of limited value as they are normally written in language comprehensible only by other scientists. However, whilst references are omitted, a substantial reading list is included. This will direct the truly determined reader to the source of much of the information used.

This is an excellent book. It seamlessly blends what any python keeper should already have learned, with a digest of the results of a vast amount of field and metabolic studies. Full credit must go the author for his efforts and to Krieger for bringing this work to the market place.

*This figure is from data published by Harold Cogger.

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Amphibians and Reptiles of Mount Kinabalu (North Borneo)

Rudolf Malkmus, Ulrich Manthey, Gernot Vogel, Peter Hoffmann and Joachim Kosuch. 2002.

424 pp. A.R.G. Gantner Verlag K.G. Hardback with dj. ISBN 3-904144-83-9. Distributed by Koeltz Scientific Books, Königstein, Germany. Price € 112 / £ 80

Mount Kinabalu, or Gunung Kinabalu as it is correctly known, is a very special place. Reaching an altitude of 4095m (13,455ft), it is the highest point between the Himalayas and the highlands of New Guinea. It literally dominates the East Malaysian state of Sabah, in northeastern Borneo, the world's third largest island. As a tall mountain rising out of a tropical environment, Mt Kinabalu sits with its toes in the verdant, monsoon-drenched, lowland tropical rainforests but its beard is grass and its head is bald, the bare rock of a high mountain peak, occasionally coated with snow. Kinabalu is therefore, inhabited not only by numerous lowland animals and plants but it is also home to a vast array of localised montane endemics which show greater affinities to Himalayan flora and fauna than to their lowland rainforest neighbours. This is not therefore, a guide to the amphibians and reptiles living on a simple, insignificant mountain; this is a guide to the terrestrial lower vertebrates of an entire, enormous chunk of Borneo. To encompass the herpetofauna of this complex mountain, and its surrounding hinterland, into a single book must have been a major challenge but it is a challenge the five extremely experienced German authors have taken on, and completed admirably.

An initial section explains how to use the book and includes a map of Borneo for orientation. The Introduction that follows provides an essential summary of the topography, geology, geomorphology, climatology, zoogeography, flora and fauna of the Kinabalu region. A series of graphs accompany this section, effectively illustrating the decrease in herpetofaunal diversity with increasing altitude. This is followed by an herpetofaunal overview of Kinabalu and a fascinating set of figures which illustrates graphically the number of Borneo endemics and Kinabalu endemics on the mountain itself (193 and 19 species respectively). A look at human activities in the region, the local farmers, the tourists and the herpetologists who have pioneered research around Kinabalu, completes this section. A graph well illustrates how Borneo is going through a new golden age of herpetological discovery with more new species being described during the 1990s than in the final decades of the 19th Century. What more encouragement to investigate tropical herpetofaunas could a student ask for at the start of the 21st Century. These figures demonstrate that 'it' will not 'all be done' by the time they get into the field; there are still many species out there, unknown to science, awaiting discovery.

The species account sections of course, take up the main body of the book. The authors set out to include all known amphibians and reptiles recorded from Mount Kinabalu and additionally any related taxa from the rest of Borneo, a total of 77 amphibian and 112 reptile species by 2000. They admit to having omitted three colubrid snakes due to a lack of reliable locality data, and they acknowledge that some lizard taxa were undergoing revision when they went to press, and could not be included. Despite these necessary omissions the authors have tried to be as up-to-date as possible and an early section of the book includes brief notes on five species that were described in the herpetological literature too late for inclusion in the main species accounts.

Each family section contains a dichotomous key to the genera and each generic section, a key to the species, as one would expect in a good quality field guide. The individual species accounts follow in a standard, easy to follow and well tested format. The information provided is excellent and well researched, with many of the frog accounts including sonagrams and oscillograms of their calls. The authors/publishers have also gone to considerable extremes to provide photographs of almost every species in this guide, a virtually impossible task when one considers the rarity of some snakes etc. To this end they have drawn on the photographic libraries of noted herpetologists and photographers worldwide and I would not be surprised to discover that some of the species illustrated here, in glorious full colour, are not to be found in any other publication. In a few cases, where no photograph exists, the authors have resorted to line drawings, more than a few prepared specifically and expertly for the current work.

So excellent is this field guide that I would say anybody with an interest in herpetology who ventures onto the island of Borneo without a copy in the top of the rucksack is making as big a mistake as leaving the mosquito repellent at home.

MARK O'SHEA

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