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Contents

Use of transponders in the post-release monitoring of translocated spiny-tailed lizards (*Uromastyx aegyptia microlepis*) in Abu Dhabi Emirate, United Arab Emirates

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THE United Arab Emirates (UAE) is experiencing a massive increase in development projects, which mosty comprise extensive urban developments, construction of industrial areas, expansion of existing and construction of new airports. These projects are encroaching on the habitat of a variety of species both along the coast and inland. A species which is being affected by this development is the spiny-tailed lizard (*Uromastyx aegyptia microlepis*). This lizard, locally known as 'Dhub', is a large, mainly herbivorous lizard belonging to the family Agamidae. Dhubs live colonially in burrows and so are readily susceptible to negative impacts of development projects. A recent taxonomical review suggests that the UAE may now host two species, namely *Uromastyx aegyptica* and *Uromastyx leptieni*, as a result of taxonomical work by Wilms & Böhme (2007). The Environmental Impact Assessments (EIA) from many development projects recommend the capture and translocation of Dhubs from development threatened areas. Therefore it is important to have a reliable method of post-release monitoring of translocated individuals to gather data on their survival and adaptation to environments, and gauge the success of such translocations.

MATERIALS AND METHODS

During 2005 an international airport expansion project in the emirate of Abu Dhabi was to impact a Dhub colony. Dhubs from this site were captured to avoid harm, kept in captivity (for ~ 6 months) and later released in suitable habitat elsewhere within the emirate, within 10 - 53 km of the original capture site.

Whilst in captivity the Dhubs underwent basic veterinary assessments which involved treating one individual for an abscess and providing those Dhubs in poor condition with subcutaneous fluids that included vitamin B complex, electrolytes, amino acids and dextrose. During this period they were also injected with an AVID® (DNAchip) (Norco, California, USA) passive induced transponders (PIT) which was subcutaneously implanted beneath 'loose' skin, ventrally, in the abdominal region, distal to the hind limb, and caudal to the thorax.

To implant the transponder, the skin was first swabbed with surgical spirit and the implantation needle then inserted with the bevel of the needle parallel to the side of the body to minimize accidental injury. A dab of tissue glue (Vetbond Tissue Glue - 3M Vetbond™, St. Paul, Minnesota, USA) was used to close the skin post needle puncture to prevent accidental loss of the PIT. The PIT was checked for functionality pre and post insertion. It was noted that some Dhubs (usually younger specimens) 'inflated' themselves when handled, probably as a stress response, and for these we avoided inserting a PIT until they had 'deflated'. During capture and during monitoring of PIT tagged Dhubs each individual could be easily identified using a Planet ID reader (Essen, Denmark - www.planetid.com) and cross-checking the transponder ID in our database.

Male Dhub lizard	12th October 2005		4th July 2006*		21st August 2006*	
AVID® 977200000431465	weight (g) 855	length (cm) n/a	weight (g) 1,050	length (cm) 55	weight (g) 1040	length (cm) 56.2
	* the same individual was recaptured twice in July and August 2006.					

Table 1. The weight and length of '*Dhub*' over a period of 11 months with two recapture occasions

## RESULTS

One of the Dhubs captured at the Abu Dhabi International Airport site (N 24.445126º, E 54.642424º) in approximately mid-2005 was released at Wrsan farm (N 24.609011º, E 54.801969º) of Abu Dhabi Emirate in October 2005 which was approximately 24 km from the original capture site. This Dhub was part of a group of 13 individuals that were released and had been implanted with AVID® transponders. This Dhub was recaptured during a routine health survey of Dhubs in Wrsan and a radiograph revealed a transponder whose unique ID was recorded (see Fig. 1). This individual also had a complete physical examination including weighing and measuring, blood sampling for haematology, blood chemistry analyses, faecal sampling and oral swabbing for parasite analysis and microbiology examination (Table 1).

DISCUSSION

PIT tags have been used successfully to mark many species, including pets, saker falcons, and a variety of wildlife (see www.avidmicrochip.com & www.arrowheadreptilerescue.org / wildlife / pittag.htm). Our work shows that the use of transponders can provide a safe method for the post-release monitoring of Dhubs, which can be individually identified using a PIT reader. Other methods of marking, such as the use of ink, are not permanent as these marks will gradually disappear after successive sloughing of the skin (Bennett, 1999). There have been reports of dead Dhubs being found with numbers written on their dorsum, however, because there is no unified numbering scheme there has been no way of knowing which project captured and released these Dhubs. Other methods such as the use of colored beads or belts can also pose a certain degree of risk to individual lizards and can also

be lost or dislodged (Bennett, 1999). Whilst in captivity there was some mortality of Dhubs, and in a number of cases the highly decomposed/dried carcasses were still identifiable as the PIT's were still present. However, in some cases the PIT was not detected with a reader indicating a loss of the PIT to an individual.
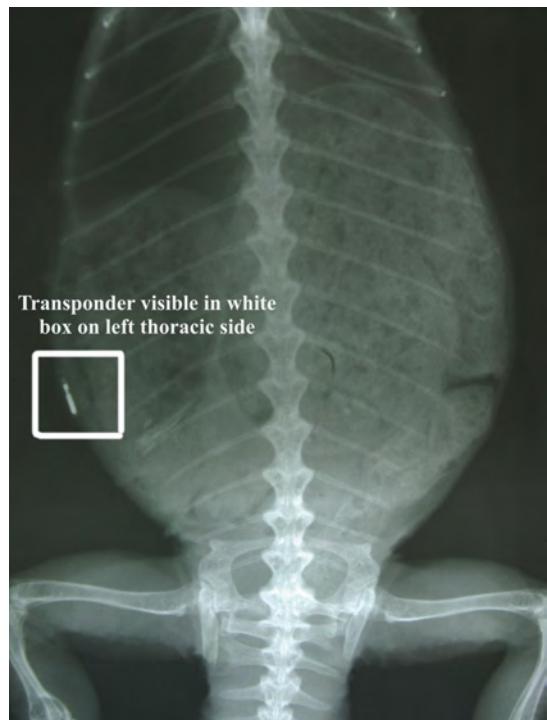
Figure 1. X-ray of 'Dhub' lizard showing transponder on left thoracic side

CONCULUSION

The use of transponders can provide a safe and reliable way of post-release monitoring of Dhubs. Projects undertaking translocations should be encouraged to use transponders and the unique ID stored in a central database. Translocation projects involving Dhubs should be set up as proper mark-

recapture experiments and any translocated individuals with PIT's remotely monitored by using readers in and around burrows to record individuals. Using mark-recapture and PIT would also greatly improve post-release monitoring and further improve release protocols of Dhubs in translocation projects.

ACKNOWLEDGEMENTS

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Gastrointestinal helminths of three species of *Dicrodon* (Squamata: Teiidae) from Peru

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ABSTRACT – Three species of *Dicrodon* from Peru (*D. guttulatum, D. heterolepis* and *D. holmbergi*) were examined for helminths. Found were one species of Cestoda *Oochoristica fretisai,* and three species of Nematoda, *Pharyngodon micrurus, Skrjabinodon capacyupanquii,* and *Thubunaea parkeri.* Three new host records are reported. Previous helminth records of *Dicrodon* are listed.

THREE species have been assigned to the genus *Dicrodon*, two, *Dicrodon heterolepis* and *Dicrodon holmbergi*, are endemic to Peru; the third, *Dicrodon guttulatum*, is known from Peru and Ecuador (Peters & Orejas-Miranda, 1986; Lehr, 2002). There are reports of nematodes from *D. heterolepis* and *D. holmbergi* (Table 1) but to the best of our knowledge there are no reports of helminths from *D. guttulatum.* The purpose of this study is to establish the initial helminth list for *D. guttulatum,* add to the helminth list of *D. heterolepis* and to summarize the helminths recorded from *Dicrodon* sp. as part of an ongoing survey of helminths from the lizards of Peru.

MATERIALS AND METHODS

Five specimens of *D. guttulatum* (mean snout-vent length [SVL] = 112 mm ± 31 SD, range = 74-143 mm, 2 females, 3 males LACM 122797-122801, collected June 1976, Lambayeque Department, 7 km SW Motupe, 06°09'S 79°43'W, Peru), 4 specimens of *D. heterolepis* (SVL = 106 mm ± 5 SD, range = 100-111, all male, LACM 76923, 76925, 76927, 76928, collected November 1968, Ancash Department, 18 km N Huarmey, 10°05'S 78°05'W, Peru) and 5 specimens of *D. holmbergi* (SVL = 108 mm ± 13 SD, range = 90-120, all females, LACM 122750, 122754, 122760, 122762, 122763 collected 6 June 1976, La Libertad Department, 1 km N Puente Chao, 8°31'S, 78°40'W Peru) were borrowed from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California and examined for helminths. These specimens had been fixed in 10% neutral buffered formalin and preserved in 70% ethanol. The body cavity was opened by a mid-ventral incision and examined under a dissecting microscope. Helminths were removed, placed on a glass slide in a drop of glycerol, covered with a coverslip and examined under a compound microscope. Nematodes were identified from the glycerol slides; cestodes were regressively stained in hematoxylin and mounted in Canada balsam for identification.

RESULTS AND DISCUSSION

Helminth number, prevalence (number infected hosts/total number hosts X 100), mean intensity (mean number helminths) ± 1SD and range for the three host species examined in this study are shown in Table 2. Voucher specimens were deposited in the United States National Parasite Collection, Beltsville, Maryland, USA: *Dicrodon guttulatum*: *Pharyngodon micrurus* (USNPC 100635), *Skrjabinodon capacyupanquii* (USNPC 100636); *Dicrodon heterolepis*: *Oochoristica freitasi* (USNPC 100637), *Pharyngodon micrurus* (USNPC 100638), *Thubunaea parkeri* (USNPC 100639); *Dicrodon holmbergi*: *Skrjabinodon capacyupanquii* (USNPC 100640).

O. freitasi was originally described from specimens taken from the small intestine of a *D. heterolepis* collected at Trujillo, Peru by Rêgo & Ibáñez (1965). The life cycle of *O. freitasi* has not been studied, but Conn (1985) reported insects to

Lizard	Helminth	Reference
Dicrodon guttulatum	*Pharyngodon micrurus*	this paper
	Skrjabinodon capacyupanquii	this paper
Dicrodon heterolepis	*Oochoristica freitasi*	Rêgo & Ibáñez (1965); this paper
	Pharyngodon micrurus	Freitas & Ibáñez (1963); this paper
	Thubunaea parkeri	this paper
Dicrodon holmbergi	*Skrjabinodon capacyupanquii*	Freitas *et al.* (1968); this paper
	Thubunaea parkeri	Baylis (1926)

Table 1. Helminth species and corresponding *Dicrodon* sp.

serve as intermediate hosts for the congener *Oochoristica anolis*.

P. micrurus was described from specimens taken from *D. heterolepis* also collected at Trujillo, Peru (Freitas & Ibáñez, 1963). *P. micrurus* is a member of the Oxyuroidea, which have direct life cycles and do not require intermediate hosts (Anderson, 2000); infection presumably occurs through ingestion of eggs. *D. guttulatum* is the second host known to harbour this helminth. *S. capacyupanquii* was described from *D. holmbergi* collected at Viru, Peru by Freitas *et al.* (1968). The mode of infection is probably similar to that of *P. micrurus*. *D. guttulatum* is the second known host to harbour *S. capacyupanquii*. *T. parkeri* was described by Baylis (1926) from specimens taken from *Tropidurus occidentalis* (currently *Microlophus occidentalis*) and *Dicrodon calliscelis* (currently *D. heterolepis*) collected in Peru. The life cycle of *T. parkeri* has not been studied but the congener *Thubunaea baylisi* presumably utilizes an insect intermediate host (Anderson, 2000).

D. guttulatum represents a new host record for *P. micrurus* and *S. capacyupanquii*; *D. heterolepis* represents a new host record for *T. parkeri*. Peru has a diverse lizard fauna consisting of over 170 species (Lehr, 2002); thus, it is of interest to note that the helminths listed in Table 1 are not shared by a large number of hosts. Subsequent studies are required to adequately characterize the helminth diversity exhibited by Peruvian lizards.

ACKNOWLEDGMENTS

	D. guttulatum				**D. heterolepis**				**D. holmbergi**			
Helminth	N	P	X±SD	Range	N	P	X±SD	Range	N	P	X±SD	Range
Cestoda												
O. fretisai			———		1	25	1±0	—			———	
Nematoda												
P. micurus	359	40	180±180	52-307	1204	100	301±170	76-486			———	
S. capacyupanquii	728	100	146±181	34-468			———		1733	100	347±260	64-720
T. parkeri			———		22	50	11±7	6-16			———	

Table 2. Number (N), prevalence (P), mean intensity ± 1 SD (X±SD) and range of occurrence for gastrointestinal helminths in three species of *Dicrodon* from Peru.

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Notes on the natural history of the eublepharid Gecko *Hemitheconyx caudicinctus* in northwestern Ghana

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*H*EMITHECONYX is an African genus of relatively large terrestrial eublepharid geckoes. Two species are known. *Hemitheconyx taylori* (Fig. 1) has a small range in northern Somalia and eastern Ethiopia (Largen & Spawls, 2006). *Hemitheconyx caudicinctus*, the African Fat-tailed Gecko, occurs in the West African savanna. Loveridge (1947) gives its range as 'Nigeria west to Senegal' but it also occurs further east, in Cameroon. There is a specimen in the British Museum from the Adamoua massif in west-central Cameroon and Ineich (1993) lists a specimen from Garoua in the north of that country (shown as a single locality in Chirio & LeBreton [2007]).

These two clearly defined and morphologically similar species must have a recent common ancestor. So it is of zoogeographical interest that they are apparently separated by a gap of over 3000 km and a mountain range (the north-western Ethiopian plateau) largely over 2000 m high and 50-75 million years old (Mohr, 1971). *H. caudicinctus* is a large, attractive and docile lizard that is popular in the pet trade (Bartlett & Bartlett, 1999). Although it is sometimes bred in captivity, significantly large numbers are also taken from the wild. The impact of such collecting is not assessed and there are no CITES quotas (CITES, 2008).

Most of the literature on *H. caudicinctus* consists of descriptions of specimens collected and capture localities (e.g. Papenfuss, 1969; Böhme, 1975, 1978; Miles *et al.*, 1978; Bauer *et al.*, 2006; Leache *et al.*, 2006). Dunger (1968) provides some natural history notes and there are a number of studies of captive specimens,(Werner, 1972; Rösler, 1981; 1983; 1984; Kugler & Kugler, 1984).

The following natural history notes arise from a study I made of the herpetology of the 'Wa' area, northwest Ghana, between September 1979 and September 1981.

CLIMATE & STUDY SITES

Wa town is the regional capital of northwest Ghana, at longitude 02° 30' W, latitude 10° 03' N. I lived at Wa Secondary School, a government school 1.5 km southeast of the town. The vegetation of the Wa area is wooded savanna, usually described as Guinea Savanna Woodland (Survey of Ghana, 1969). White (1983) refers to it as Sudano-Zambezian savanna. Canopy cover in undisturbed Guinea Savanna is around 100% (Baker, 1962) but in the study area (see Fig. 2) the canopy was extensively reduced by exploitative agriculture to less than 2%, although a few undisturbed patches remained. The area is subjected to periodic burning in the dry season.

The only natural permanent water is the Black Volta River, 20 km west of Wa town. The topography of northwestern Ghana is a generally subdued pediplain. In the study area the altitude ranged from 320 to 370 m. About 1% of the land surface is covered with sheet outcrops or low, heavily eroded inselbergs of granodiorite, manifestation of an ancient Precambrian crystalline basement.

There is a single rainy season, with about 1000 mm of rain falling mostly between April and September. January and February are the driest months; at this time the Harmattan (a cold wind from the Sahara) blows. Daily temperatures range from 22 to 39 °C in the rainy season and 16 to 40 °C in the dry season (Wills, 1962).

MATERIALS AND METHODS

Twenty-four specimens of *H. caudicinctus* were collected during the two years of the study. Twenty-one were found by driving roads at night using a motorcycle, two were found by walking at night and one was dug out of a burrow by day. An average of twelve hours per month were spent night hunting by motorcycle and at least four

Figure 1. *Hemitheconyx taylori* from Dagah Bur, Ethiopia.
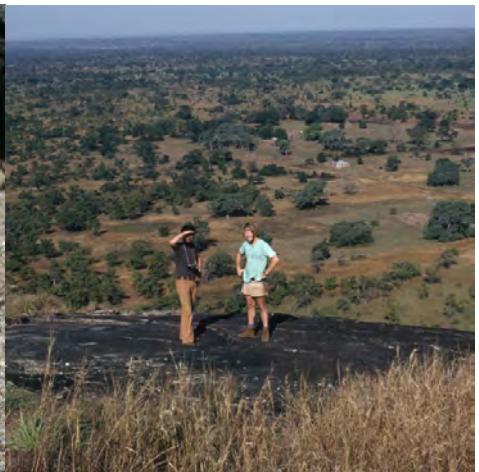
Figure 2. Guinea Savanna woodland, Wa.

hours per month were spent collecting on foot with a torch. The only exception were in August and September 1980 when I was absent from the area. Time and distance covered was recorded after every hunt. When specimens were captured the air temperature at one metre above the ground was usually recorded. In some cases the lizard's body temperature and the ground temperature at 1 cm depth were also recorded using a cloacal thermometer. Relative humidity was also recorded using either a whirling or a hair hygrometer. Snout-vent length (SVL), total length (TL) and mass (g) were also recorded for most specimens within a day of capture. Several specimens were maintained alive in captivity for periods up to eight months. Of the 24 captures, eight were preserved; four specimens were donated to the California Academy of Sciences, three to the Natural History Museum (London) and one to the Natural History Museum of Zimbabwe at Bulawayo. Four specimens died in captivity and were not preserved; twelve specimens were released after having a toe clipped. No recaptures were made.

RESULTS

Activty Patterns

H. caudicinctus is nocturnal. Twenty-three captures were made in 379 hrs of night hunting; this is 16.5 hrs per specimen, (0.061 specimens per hour). The data indicate that *H. caudicinctus* becomes active about an hour after sunset; sunset times in Wa varied from 17.34 hrs in November to 18.30 hrs in June. The earliest night capture was at 19.05 hrs on the 12th February 1981, fifty-five minutes after sundown. Activity continues to midnight at least. No captures were made after 23.55 hrs, although 27 hours were spent hunting after midnight. No specimens were observed above ground during daylight hours, although another species of African eublepharid, *Holodactylus africanus*, is known to show diurnal activity (Drewes, 1971).

There is some evidence that *H. caudicinctus* is more active during the rainy season than during the dry. Taking the rainy season to be those months when the median rainfall is over 50 mm, the rainy season in Wa is from April to October inclusive, dry season from November to March (Wills, 1962). While I was in Wa the only exceptions to this were a dry October 1979 (46 mm rain) and a wet March 1981, (91 mm rain).

Capture rates for the dry season months during this study were 0.6 per month (6 specimens, 10 months); for the wet season months 1.5 per month (18 specimens, 12 months) (Table 1). Nineteen out of 23 (82%) of the night captures were made either on the night following an afternoon rainstorm, or on the following night (when the humidity ranged from 60 to 95%), although out of a total of 360 night hunts, only 161 (44.6%) were on such nights. Rainfall and high humidity appear to stimulate *H. caudicinctus* to activity.

Nevertheless, this gecko is also active during very dry months. Two specimens were collected in

Capture Rates

Time	17.00-17.59	18.00-18.59	19.00-19.59	20.00-20.59	21.00-21.59	22.00-22.59	23.00-23.59	24.00-06.00
No. Capt.	0	0	8	4	4	5	2	0
Hrs hunted	19	31	49	88	76	56	33	27
Capt. rates/hr	0	0	0.163	0.045	0.053	0.089	0.061	0

Table 1. *Hemitheconyx caudicinctus* capture rates over 24 hr.

February 1981; both were active at night. There was no measurable rainfall that month or the month before. Relative humidity for the specimen collected on 12th February was 29%, and 17% for the one taken on the 27th February; no traceable rain had fallen in 62 and 77 days respectively prior to the date of capture. Joger (1982) reports collecting 3 specimens in January, which is generally the driest month in West Africa. Böhme (1978) suggested that *H. caudicinctus* aestivates during the dry season, relying upon the fat reserves in its tail.

In Wa, nocturnal snake activity was greatly reduced during the dry season. Significant activity during this time was noted for only two species (*Echis ocellatus* and *Telescopus variegatus*), out of the 37 snake species recorded in the area (Spawls, 1992). These two species are essentially inhabitants of the Sahel, which has lower humidity and night time temperatures than the moister woodland further south.

Table 2 shows temperature and relative humidity data for the 20 captures where at least one temperature value (air, body, substrate) was recorded. The mean midnight temperature at Wa was 25.8 °C. Fifteen captures were made at air temperatures above this. Decline in temperature may explain the apparent cessation of activity after midnight. However, *H. caudicinctus* can tolerate lower temperatures. Four individuals were taken when the air temperature was below 25.8 °C, all on rainy season nights while feeding on emerging alate termites. In all cases (where recorded) the body temperature was found to lie between the air temperature and the substrate temperature, as is usual for nocturnal reptiles (Pianka, 1977). Werner (1976) notes that, in terms of temperature sensitivity, the optimal range for this species is

Capture Date	Capture Time	Air Temp. °C	Body Temp. °C	Substrate Temp. °C	RH %
04 02 1980	21.30 hrs	28.0	-	-	23
12 04 1980	23.55 hrs	30.1	-	31.1	54
15 04 1980	20.30 hrs	31.6	-	-	56
15 04 1980	21.50 hrs	30.0	-	-	65
08 11 1980	19.00 hrs	28.9	29.2	29.9	64
12 02 1981	19.05 hrs	30.6	31.1	31.8	29
27 02 1981	23.05 hrs	29.8	-	-	17
06 03 1981	19.45 hrs	27.9	28.2	-	64
25 03 1981	22.04 hrs	31.7	-	-	41
27 03 1981	21.10 hrs	24.2	26.6	27.1	75
28 03 1981	22.15 hrs	28.8	-	-	60
28 03 1981	22.25 hrs	28.7	28.8	29.6	60
11 05 1981	19.20 hrs	27.5	28.6	30.1	73
27 05 1981	19.55 hrs	22.2	24.1	-	95
28 05 1981	19.30 hrs	30.3	32.2	-	63
19 06 1981	20.10 hrs	27.2	28.0	29.1	75
02 07 1981	21.20 hrs	24.4	-	-	92
14 07 1981	19.48 hrs	27.6	29.1	30.0	69
17 07 1981	20.15 hrs	22.5	24.6	25.1	93
21 07 1981	19.40 hrs	26.3	-	-	76

Table 2. *Hemitheconyx caudicinctus* ambient air temperature, body temperature, and substratre temperature.
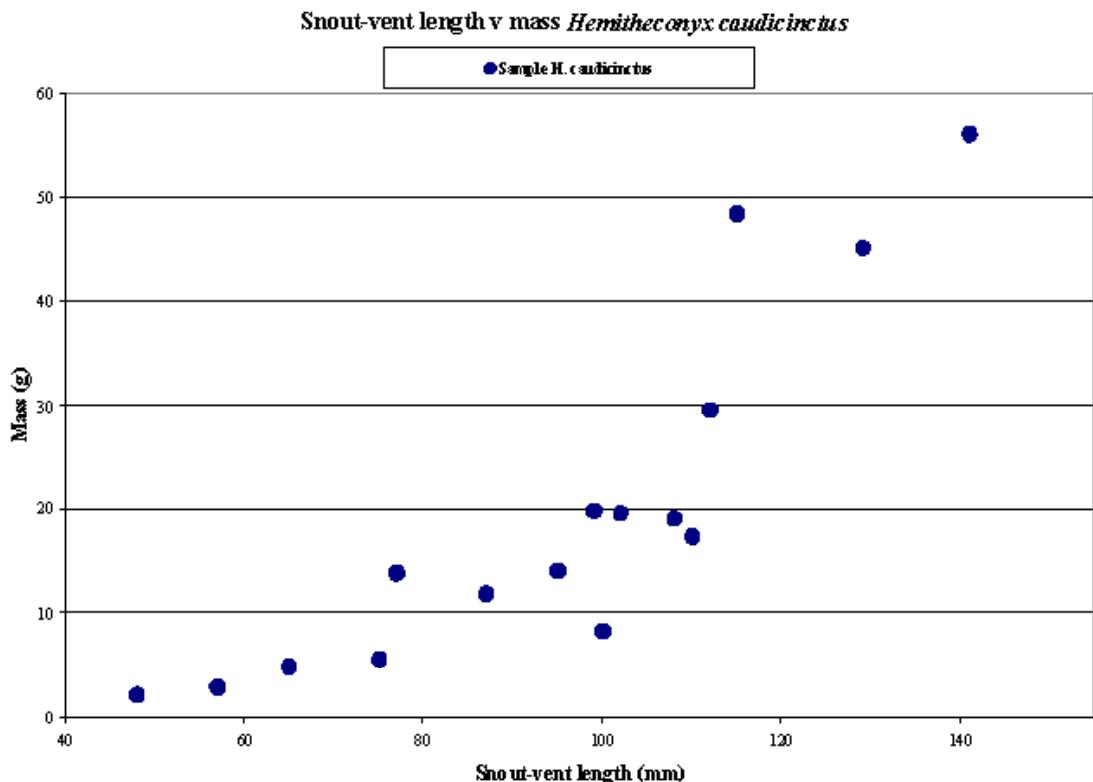
Figure 3. A sample of Meristic data for 15 collected *Hemitheconyx caudicintus*.

28-33 °C; between dusk and midnight the temperature of most nights in Wa was between 26 and 33 °C, with the exception of nights at the end of the rainy season (Spawls, 1992). The individual captured on the night of 17th July 1981 attempted to escape into a hole; Joger (1981) has recorded similar evasion behaviour. The burrows may also be used as heat sources/buffers. Earth temperatures at 30 cm depth at Wa weather station ranged between 27.9 and 33.3 °C over the two years of this study.

Meristic Data
Fig. 3 shows mass against snout-vent length for 15 of the specimens collected. The largest individual was 196 (141 + 55) mm in length; mass was 56.2 g. Loveridge (1947) and Dunger (1968) note larger individuals, of 210 (130+80) and 198 (155+43) mm respectively. The smallest Wa individual was 60 (48+12) mm; tail truncated, mass 2.13 g, captured in late March 1981. This was probably a hatchling, as captive hatchlings were recorded

varying from 1.2-2.5 g and 6.3 to 7.0 total length (Kugler & Kugler, 1984). Eight of the fifteen individuals measured had their original tails; these could be identified as being thin, uniformly banded, 35-43% of total length. Seven individuals had regenerated tails, which were stumpy, grossly swollen, colours discontinuous and less than 30% of total length.

Colour
There is some variation in colour amongst the Wa *H. caudicinctus* (Fig. 4). All specimens had a dark patch stretching from the orbit to the nape of the neck and two dark brown or black bars across the dorsal surface. Between these patches, skin colour varied from deep red brown to bright orange, juveniles had a tendency to be orange. The tail was banded in orange, white, black and brown; some juveniles had blue bands. Seven of the 24 individuals had a prominent white dorsal stripe from between the eyes to the base of the tail (see Front Cover, this edtion). One juvenile had a

poorly developed stripe (Fig. 5); sixteen had no stripe. Dunger (1968) states that only males have this stripe, but the gravid female captured was striped. Subsequent examination of specimens in the Natural History Museum (London) indicated that either sex may be striped, or unstriped.

Habitat Selection
Twenty-three captures were made in flat or gently sloping open savanna; the local habitat. Twenty captures were at distances greater than 500 m from the nearest rock outcroppings; four were more than 5 km from the nearest outcroppings. One specimen was found within the confines of a sheet rock outcrop, but was on soil, not on the actual rock surface. These data conflict with Loveridge's (1947) description of the habitat as 'between

rocks', and Dunger's (1968) statement that they are found 'in or near rocks'. Böhme (1975) mentions two specimens found at a fissured stone wall. An average of two hours per week, over 150 hours total, were spent on the granodiorite outcroppings at night, studying a colony of *Ptyodactylus ragazzi*, but no *H. caudicinctus* were seen on the rocks. They seem to prefer open savanna and are terrestrial, as are other eublepharid geckoes. Rösler (1984) examined the location of *H. caudicinctus* during unhurried movement, noting that the legs are greatly extended and the ventral surface touches the ground. He concluded that this gecko is strongly adapted to a terrestrial way of life. This is supported by my field observations in Wa, although two captive specimens utilised a hollow branch placed vertically in the cage as a refuge, ascending

Figure 4. *Hemitheconyx caudicinctus* exhibiting dorsal colour variation.

Figure 5. *H. caudicinctus* juvenile exhibiting prominent white dorsal stripe.

inside the branch to a height of about 30 cm. The female captured in daytime was dug out of an underground chamber of approximately 20 cm in diameter, at the end of a rodent burrow 1.3 m in length, and with a maximum depth of 60 cm. The final 40 cm of the burrow ascended into the chamber, the top of which was 35 cm below the surface and contained dried grass and rodent fur. In the study area, no *H. caudicinctus* were ever found under rocks or any other ground cover (logs, vegetation heaps, building debris) although a large number of such objects (always over 200 per month, often many more) were routinely turned

during collecting activities. It would seem that the Wa specimens of *H. caudicinctus* shelter in holes, as does *H. taylori* (Largen & Spawls, 2006).

Breeding & Courtship
Rösler (1983) states that during courtship *H. caudicinctus* uses mostly visual cues, and believes this is characteristic of diurnal species, which initially seems odd considering that in Wa the species appears to be totally nocturnal. Rösler (1983) documents three aspects of courtship behaviour; tail waving, vibration of the body and vibration of the tail. However, the latter two are

presumably audible. Werner (1976) noted that, out of 14 taxa of gecko examined, including four eublepharids, *H. caudicinctus* had the most sensitive hearing.

A female weighing 10.8 g, length 126 (100 + 26) mm, captured on 28th March 1981 laid one egg on 16th April 1981. The egg was 2.3 x 1.2 cm; mass 1.8 g. The eggshell was soft and pliable, as is typical for eublepharid geckoes. The egg was incubated, but failed to hatch. Werner (1972) records an egg size of 2.7 x 1.3 cm. Captive specimens laid five batches of two eggs each in an interval of approximately 6 months (Kugler & Kugler, 1984). Castellenos (2008) states that up to eight clutches a year, of 1 or 2 eggs, may be laid by captive specimens. The specimen donated to the NMZB, collected on 25th March 1981, contained 2 unshelled ova (D. G. Broadley, *pers. comm.*). Joger (1981) states that the maturation of the eggs takes place during the later half of the dry season (i.e. January to March) and this is supported by Rösler's (1983) records, but the Wa hatchling was captured in late March. Werner's (1972) specimen had laid shortly before 27th December and Kugler & Kugler's (1984) specimens laid their five clutches between April and July. In captivity, *H. caudicinctus* digs a small hole to deposit its eggs (Rösler, 1983). Egg-laying behaviour in wild specimens is apparently not documented.

Population Density, Ecology & Diet
In light of the number of specimens collected for the pet trade, some values of the population density of *H. caudicinctus* may be useful. No intensive searching specifically for this species was carried out; all captures were made during general herpetological searching. However, twenty-three of the specimens found were within an area of 9 km^2, giving a density of 2.5 per km^2. Seventeen of these were within an area of 2.2 km^2, and eleven specimens were found in an area of 1 km^2. This is liable to be an underestimate of the true population density.

Twenty species of lizard were recorded in the Wa area during the survey. Of these, four were geckoes; *H. caudicinctus*, *P. ragazzi*, *Hemidactylus angulatus* and *Tarentola ephippiata*. *P. ragazzi* was found only on sheet rock and inselbergs, it is entirely rupicolous. Only a single specimen of

Tarentola ephippiata was found, it was on a road at night, but this species is normally arboreal, showing a predilection for Fig trees (Dunger, 1968). *H. angulatus* was common throughout the study area, active at similar times and was also found on the ground. Niche overlap with *H. caudicinctus* is unlikely, however. *H. angulatus* is a faster-moving, much smaller species, (the largest individual had a snout-vent length 60 mm and mass 6.2 g), it climbs trees and will live on building walls.

No *H. caudicinctus* were found in the stomachs of the approximately 480 snakes collected in the area, and no evidence of direct predation on the species was found. The individual collected on 11th May 1981 at 19.20 hrs was observed for fifteen minutes before capture, it was on a dirt road close to a barn owl (*Tyto alba*) and a pearl-spotted owlet (*Glaucidium perlatum*). Although these two owl species are known to eat lizards in southern Africa (Maclean, 1985), both birds and the gecko were feeding on emerging alate termites. Captive specimens were fed wild-caught grasshoppers, crickets and termites.

Defence
When I approached *H. caudicinctus* at night with a torch or motorcycle headlamp, they either froze as soon as the beam touched them, or ran away. Those that froze responded when approached closely by either pressing themselves to the ground, or running as I stooped to pick them up. If picked up, they gyrated and some individuals bit. Captive specimens approached in the daylight responded with a threat display. They stood up as tall as possible, stiff-legged, and then slowly curled the tail up into the air, Carpenter & Ferguson (1977) call this the 'high stand and tail wave'. If touched, these geckoes would lash simultaneously with both head and tail at the hand, at the same time producing a single loud hiss. They would then move away obliquely, with mouth open, hissing more quietly. If held, they would bite. Both freshly caught and captive individuals, when biting, would gyrate clockwise and anticlockwise, alternating rapidly; Dunger (1968) noted similar behaviour. A bite from an adult *H. caudicinctus* on a human hand is strong enough to draw blood; the gyrations with locked jaws can tear human skin; these

actions would be an effective defence against a small predator. Violent combat between males, resulting in the death of an individual, has been observed in captivity (Kugler & Kugler, 1984). Rösler (1983) states that during courtship the male frequently bites the female on the tail, sides and neck, sometimes causing wounds.

Local Knowledge

The Dagarti and Wali people of the Wa area were greatly afraid of this gecko, believing it to be highly venomous. When the specimen was dug out of a hole in daylight, the observers objected strongly to prevent me picking it up. My science students refused to hold or even touch specimens. When asked to explain why I was able to freely handle the specimens, they argued that its venom was selective in whom it could hurt. Durrell (1954) encountered similar arguments regarding a West African skink, *Lygosoma fernandi*. The Dagarti name for *H. caudicinctus* in Wa is 'Jenibasi', which is said to mean 'your skin drops off'. Local people believed that if this gecko bit someone, the victim's skin would begin to fall off fairly rapidly, and sometimes change colour, to be followed by death. This suggests confusion with some snakes that exhibit tissue destroying venom that causes local discoloration, for example the puff adder, *Bitis arietans*. However, in much of the Arab world, geckoes are associated with leprosy and skin disease, and thus such local beliefs might be based on observations of geckoes shedding their skin.

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Significant range extension for the Central American Colubrid snake *Ninia pavimentata* (Bocourt 1883)

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ABSTRACT — The second specimen of the snake *Ninia pavimentata* is reported from Honduras, significantly extending the known distribution of the species. This record reduces the distributional gap between this species and its presumed sister taxon, *Ninia maculata*, while supporting their continued recognition as distinct species. Relative measurements, scale counts, and pattern descriptions are provided.

NINIA pavimentata (Bocourt 1883) is a small semifossorial snake reported from pine-oak and cloud forest areas in central Guatemala, as well as from a single locality in northwestern Honduras (Smith & Campbell, 1996; Townsend *et al.*, 2005). Until recently, this species was considered a synonym of *Ninia maculata* (Peters, 1861), a situation clarified by Smith & Campbell (1996), who resurrected *N. pavimentata* to species level on the basis of non-overlapping segmental count ranges and other morphological characteristics. The distributions of *N. maculata* and *N. pavimentata* are presently known to be separated by a 315 airline km gap in Honduras, with *N. pavimentata* reaching its easternmost known distribution in the Sierra de Omoa, outside of Parque Nacional Cusuco, Depto. de Cortés (15º30'N, 88º11'W), 1250 m elevation, and *N. maculata* its northernmost known locality at Quebrada Machín, Reserva de la Biósfera Río Plátano, Depto. Colón (15º19'N, 85º17'W), 540 m

elevation (McCranie *et al.*, 2001; Townsend *et al.*, 2005).

On 10 April 2008, a female *Ninia pavimentata* (Florida Museum of Natural History [UF] 152810; Figure 1) was collected from under a rock at the edge of a fragment of cleared cloud forest in Refugio de Vida Silvestre Texiguat (15°26.502'N, 87°18.092'W), 1715 m elevation, Departamento de Yoro, Honduras. This habitat is similar to that of the localities of most *N. pavimentata* specimens, which have been collected between 1120 and 1825 meters from pine-oak or cloud forest (Smith & Campbell, 1996), and to the disturbed habitat (a shade *cafetal*) where the other Honduran specimen originated.

Relevant measurements and scale counts for UF 152810 are as follows: snout-vent length 131 mm, tail length 47 mm, ventrals 141, subcaudals 72, segmental count 213, supralabials 7/7, infralabials 7/7, temporals 1+2, postoculars 2/2. The specimen possessed 39 dorsal crossbands on

its left side, 3 of which split in half at the mid-dorsal scale row and continue onto the right side as two bands. The ventrals exhibited a boldly checkered pattern. These characteristics fall within the known variation in *N. pavimentata* (Smith & Campbell, 1996; Townsend *et al.*, 2005), providing further evidence for the specific status of this taxon.

This record extends the known range of *Ninia pavimentata* approximately 65 airline km east from its known distribution. The new locality also narrows the geographic gap between *N. pavimentata* and its most similar congener and presumed sister taxon, *N. maculata*, to approximately 250 airline km. This gap in distribution is consistent with gaps

documented in other snake taxa, and was termed the "Honduran hiatus" by Savage & Crother (1989) in their review of the colubrid genus *Pliocercus* in Central America.

The semi-fossorial colubrid *Rhadinaea decorata* has long been known to occur from Mexico to Guatemala, and from Nicaragua to Ecuador, but was unknown from Honduras until discovered in La Mosquitia in 2004 (McCranie, 2004). This is also the case for the terrestrial colubrid *Dendrophidion vinitor*, which was finally reported from Honduras in 2003. Additionally, the colubrid taxon *Scaphiodontophis venustissimus* was recently resurrected from synonymy with *Scaphiodontophis annulatus*, based on evidence

Figure 1. Female *Ninia pavimentata* (UF 152810), Refugio de Vida Silvestre Texiguat (15°26.502'N, 87°18.092'W), 1715 m elevation, Depto. de Yoro, Honduras. Photograph by JHT.

from recently collected specimens in eastern Honduras, yet another distributional "hiatus" that had previously been hypothesized as a zone of integration between the two forms by Savage & Slowinski (1996). This region contains contact zones between closely related species of *Scaphiodontophis* (McCranie, 2006) and the aforementioned *Ninia*, where species in both genera maintain diagnosable species boundaries and exhibit no evidence of integration in morphological characteristics. Continued field work in this area may reveal additional taxa supporting this biogeographic pattern.

RESUMEN

Se reporta para Honduras el segundo espécimen de la serpiente *Ninia pavimentata,* ampliando significativamente la distribución conocida para esta especie. Este registro reduce la separación entre esta especie y su supuesto taxón hermano, *Ninia maculata*, mientras que al mismo tiempo sustenta su reconocimiento como especies distintas. Se proveen las medidas relativas, conteo de escamas, y descripciones del patrón.

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Predation on Italian newt larva, *Lissotriton italicus* (Amphibia, Caudata, Salamandridae), by *Agabus bipustulatus* (Insecta, Coleoptera, Dytiscidae)

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ABSTRACT — Predation of a larva of *Lissotriton italicus* by adults of a diving beetle (*Agabus bipustulatus*) on the Aurunci Mountains (central Italy, Latium region) is recorded. This is the first identified invertebrate predator of this Italian endemic newt. The possible role of this beetle in the local demographic control of the newt is briefly discussed.

THE Italian Newt, *Lissotriton italicus* (Peracca), previously referred to the genus *Triturus* (Rafinesque), is endemic to central and southern Italy. The northern most limits of its distribution include an oblique area extended from the Ancona province (Marches region) South to Lepini Mountains (Latium region, Rome province), on the Adriatic and Tyrrhenian sides of the Apennines, respectively (Corsetti *et al.*, 2005; Balletto, 2006; Scillitani *et al.*, 2006; Scillitani & Tripepi, 2007). It is a euryoecious species living in a wide range of habitats, from the sea level up to 2000 m, which should be considered endangered since over 30% of the known populations have disappeared over the last 10 years (Scillitani *et al.*, 2006; Scillitani & Tripepi, 2007). Its ecology was recently the subject of various studies (cf. Corsetti, 2000b; Scillitani *et al.*, 2004, 2006; Scillitani & Tripepi, 2007), even though "specific predators are not known, but fishes, other species of newts, water snakes, dragonfly nymphs and hydroadephagous coleoptera can prey upon both larvae and adults" (Scillitani *et al.*, 2004: 51).

On 13th June 1995, during field research on the herpetofauna of the Aurunci Mountains (Latium region) (Corsetti, 2000a; 2000b; 2004), many larvae of *L. italicus*, close to metamorphosis (body length 30-40 mm), were found in a small muddy residual pond, about 1 m across and 15 cm deep, located in an open *Quercus pubescens* wood (Latina province, Castelforte, Monte Siola W-SW slope, 240 m a.s.l). No other amphibians occurred in the pond, which was probably feebly trickle fed by a very small spring. In this pond about 15 adults of a predaceous diving beetle, *Agabus bipustulatus* (Linnaeus) (Insecta, Coleoptera, Dytiscidae) were observed attacking a larva of the Italian Newt. The larva was initially attacked by a single beetle that was quickly followed by the others and was devoured, almost completely, in about 10-15 seconds. *A. bipustulatus* is the commonest and one of the most widespread Italian dytiscids; it is a very good flyer and euryoecious (Franciscolo, 1979; Rocchi, 2006), generalist predator and scavenger (Bosi, 2001). It also commonly colonizes some breeding sites of *L. italicus* of Latium, which are chiefly (60%) artificial water bodies such as fountains, livestock drinking pools, stone wells and tanks (Corsetti, 2000b, 2004; Corsetti *et al.*, 2005). Killings of amphibian larvae by dytiscids are obviously well known (cf. Franciscolo, 1979). *A. bipustulatus* is one of the very few 'large' dytiscids (body length 9.5-11.6 mm) syntopic with *L. italicus* in Latium (Corsetti & Nardi, unpublished), and thus could play a role in the local demographic control of Italian Newt larvae.

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Behaviour, time management, and foraging modes of a West Indian Racer, *Alsophis sibonius*

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*A*LSOPHIS sibonius (Fig. 1), formerly considered a subspecies of *Alsophis antillensis* (Hedges *et al.*, submitted)*,* is a West Indian Racer endemic to Dominica, Lesser Antilles.

Common habitat associations include rain forest, rain forest edges, coastal scrub, mountain pastures, mangrove edges, deciduous forests, and orchards/plantations. High densities appear to occur in areas with abundant rocks (Schwartz & Henderson, 1991). These snakes are predominantly diurnal, with activity peaks at mid-morning and late afternoon (Malhotra & Thorpe, 1999; Muelleman *et al.*, submitted). Henderson & Sajdak (1996) indicated that species of *Alsophis* primarily consume lizards, particularly anoles, but eat other vertebrates including frogs, other snakes, birds, and rodents.

Snakes in the genus *Alsophis* once were known to occur on more than 100 islands from the Bahamas through Dominica in the Lesser Antilles (Henderson & Sajdak, 1996). Due to habitat degradation, human persecution, and the introduction of invasive Indian mongoose (*Herpestes javanicus*) and Black rat (*Rattus rattus*), they have undergone 'more extirpations and extinctions than any other reptilian or amphibian genus in the region' (Barun *et al.*, 2007).

Several Lesser Antillean species, including *Alsophis antiguae*, *Alsophis rijgersmaei*, and *Alsophis rufiventris*, are considered threatened or endangered (Daltry *et al.*, 2001; Henderson & Powell, 2009). Despite the wide distribution of these snakes, little is known about their daily activity and time management.

The purpose of this study was to investigate the daily activity, time allotment, and foraging modes of *A. sibonius*.

METHODS AND MATERIALS

From 6–24th June 2008, we conducted focal animal observations along established trails in Cabrits National Park, Dominica. The area was clear-cut by British troops during the 18th and 19th centuries for the construction and occupation of Fort Shirley. Since 1850, the fort has been largely abandoned, and the forest has recovered to form a xeric woodland. The annual average temperature is 26 ºC, with average rainfall of 1870 mm. January through June is classified as the dry season. The canopy is moderately dense, with little sunlight reaching the forest floor except during the dry season, when the deciduous trees that dominate the area shed their leaves. At least 40 species of trees have been identified within the park, with *Lonchocarpus latifolius* the most common. The polychrotid lizard *Anolis oculatus* is abundant, especially near ruins and rock outcrops. Although *Anolis* lizards of Cabrits are well adapted to the forest environment and utilize trees for escape, they frequently forage on the forest floor.

Habitats along trails provided visibility that facilitated observations of snakes without disturbing them (Heinz *et al.*, 2004). Once a snake was identified and clearly had not responded to the observer, we conducted focal observations of 5–22 min. Observations were terminated after 15 min or when the snake was lost from view or reacted to the observer's presence. When snakes were

Figure 1. Dominican Racer (*Alsophis sibonius*) adult (top) and juvenile (below). Photographs by Jeffrey W. Ackley and Robert Powell.

engaged in recognizable feeding or foraging behaviour, observation times were extended. We recorded time using an iPod (Apple, Inc., Cupertino, California 95014, USA) stopwatch feature capable of separately monitoring movements and stationary periods within a single session.

We conducted focal observations during 'peak activity times' in the morning and late afternoon (Malhotra & Thorpe, 1999; Muelleman *et al.*, submitted). For each observation, we recorded habitat, initial posture, time spent moving, distance moved, presence or absence of tongue-flicking, and foraging behaviours. For habitat, we noted the level of disturbance, insolation, and substrate. Disturbance levels were ranked 1–5, with 1 indicating the least disturbed situations (no signs of human activity, generally occurred >10 m from

even the smaller trails), 2–4 representing various intermediate stages of human disturbance considering factors such as trail width and extent of human traffic, and 5 being the most disturbed, which in this study was a paved sidewalk entrance traversed by everyone entering or leaving the park (Fig. 2). Insolation was classified as shade, sun-shade mosaic, or direct sun. Substrates included leaf litter, rock, soil, ruins (generally consisting of old rock walls and buildings), and trees or fallen trees. Movements were classified as stationary or moving, and then narrowed into sub-categories, sprawled ('stretched along substrate, with no part of the body touching another'; Heinz *et al.*, 2004) or loosely coiled for stationary snakes (no snakes were tightly coiled) and traveling slowly (no tongue-flicking, slow movement, possibly scanning

intermittently), traveling (no tongue-flicking, steady rapid movement), and actively foraging (rooting in leaf litter or moving while tongue-flicking). Snakes assuming a foraging posture at the base of a tree were categorized as "sprawled" because the 'foraging' category was originally designated for active foraging behaviours, and because of the difficulty in determining whether a snake was resting or exhibiting a sit-and-wait ambush foraging strategy.
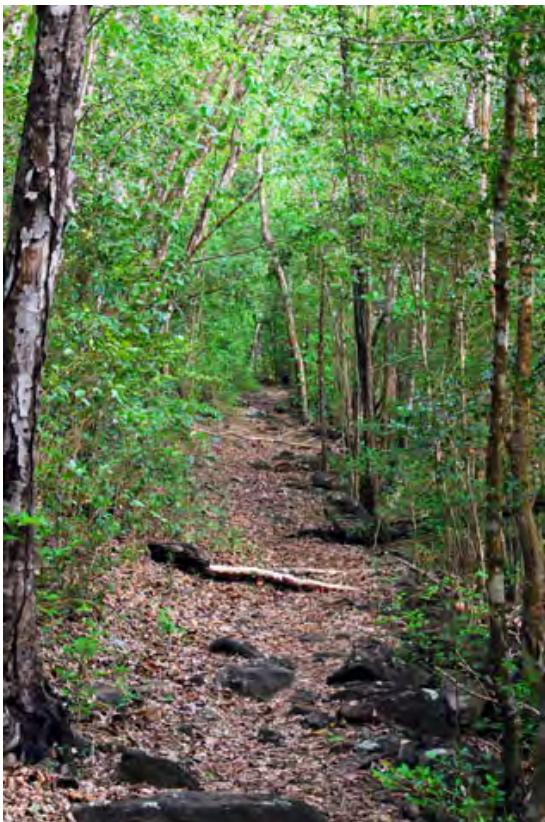
RESULTS AND DISCUSSION

We recorded a total of 267 min of focal animal observations on 19 snakes from 0719–1115 h and 1613–1732 h. Although we have relatively few observations, this study was conducted in conjunction with a survey on snake activity and habitat associations (Muelleman *et al.*, submitted), enabling observers to select focal subjects that were farther from the trail and less likely to be
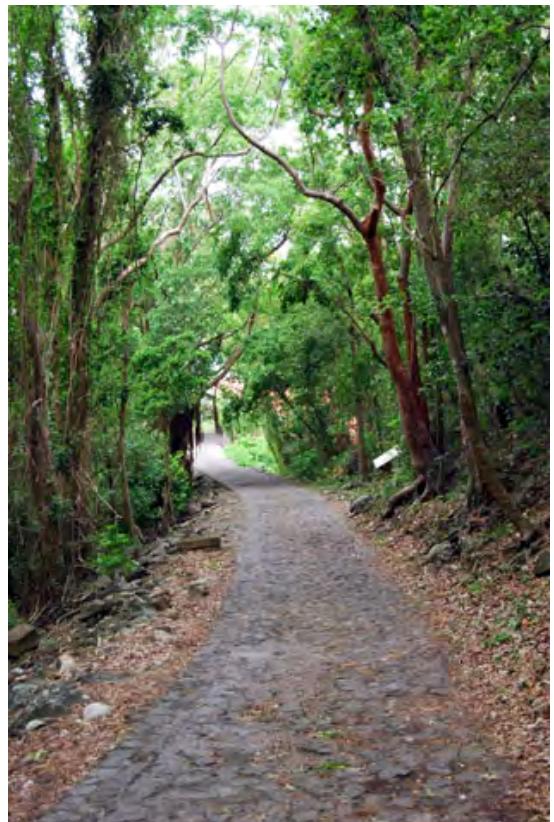
Figure 2. Trails showing 'disturbance'; disturbance level 3 (moderate impact; left), and disturbance level 5 (most disturbed of areas sampled during this study). Photographs by Lauren A. White.

disturbed. If a snake responded noticeably to an observer's approach or at any time during the observation, focal time was stopped and we moved to the next snake. This method ensured that behaviour of animals considered in the study accurately represented 'typical' behaviour.

Individual snakes often spent extended periods or even entire focal periods engaged in a single activity or posture. Collectively, snakes spent the greatest percentage of time foraging (32.3%), traveling (30.6%), and sprawled (28.2%) (Table 1,

Fig. 3). Very little time was spent moving slowly, and this category was exhibited only after extended stationary periods. Only one snake was "coiled," and it was loosely coiled. Because focal observations were conducted at peak activity times, large percentages of time devoted to traveling and foraging were not unexpected. Little sunlight penetrated the relatively contiguous canopy in the park and 17 of 19 snakes observed were in full shade. Most of the ground was covered with leaf litter and 13 snakes were sighted initially

either wholly or partially on leaf litter. Every one of these snakes was in contact with leaf litter at some point during the observation.

Heinz *et al.* (2004) examined behaviour and time allotment of *A. rufiventris* on St. Eustatius, and found snakes traveling 21 %, foraging 28 %, and sprawled 35 % of the time (in various degrees of insolation). Barun *et al.* (2007), during a study of *A. portoricensis anegadae* on Guana Island (British Virgin Islands), noted that 40.4 % of snakes were moving when first seen, 47.8 % were sprawled and 11.7 % were coiled. Those data are generally comparable to ours, although snakes on St. Eustatius and Guana moved less and were stationary (sprawled, 'scanning', and coiled) more frequently than snakes on Dominica. However, those differences may be attributable largely to the fact that observations made during those other

Number	Habitat			Moving			Stationary	
(time)	Substrate	Disturbance	Insolation	Travel Slowly	Travel	Foraging	Sprawled	Coiled
1 (7)	2	4	3	-	-	-	7	-
2 (10)	1	3	3	-	-	10	-	-
3 (15)	1	3	2	-	-	15	-	-
4 (16)	1,4	3	3	-	-	-	16	-
5 (15)	3	4	3	-	-	14	-	-
6 (15)	3	4	3	3.5	-	6.5	5	-
7 (10)	3	4	3	-	-	-	6	-
8 (5)	3	4	3	1	-	-	3	-
9 (15)	1,3	3	2	1	-	-	11	-
10 (16)	1	3	3	-	-	-	16	-
11 (15)	1	3	3	-	-	-	15	-
12 (22)	2	3	3	-	-	-	22	-
13 (17)	1	3	3	2	-	-	15	-
14 (14)	1,2	3	3	-	-	8	1	-
15 (18)	1	3	3	-	-	12	5	1
16 (16)	1	3	3	-	-	-	-	-
17 (15)	1	3	3	-	-	-	15	-
18 (10)	1	3	3	-	7	-	3	-
19 (16)	1	3	3	-	12	-	4	-

Table 1. Data collected on 19 *Alsophis sibonius* during focal animal observations at Cabrits National Park in Dominica.

studies were not restricted to peak activity periods.

We observed several unusual behaviours during focal observations. We saw snakes rooting and digging in loose soil and probing small holes in a fashion similar to that described by Heinz *et al.* (2005) for *A. rufiventris*. During one observation, an adult *A. sibonius* was probing in leaf litter and a small hole for approximately 10 min, after which the snake was seen swallowing an unidentified object. Subsequently, three other snakes were observed swallowing small eggs, most likely deposited in the litter by the lizard *Anolis oculatus*. On 11 June at 1634 h, we saw a snake with approximately 8–10 cm of its head and anterior body elevated and adpressed against a tree trunk. For 15 min, the snake was completely motionless with no tongue-flicks. At 1827 h, the snake was seen again in the same pose, presumably not having moved during the interim. An anole on the tree at a height of approximately 80 cm was doing push-ups movements in the snake's general direction. The lizard was clearly alarmed, but the snake did not respond in any way. At 1835 h, the snake abandoned this posture and circled the tree, where it tongue-flicked the trunk and base of the tree, then left and was lost from view. Subsequently, four other snakes were observed assuming or in this position, above two of which we observed anoles. One snake made an unsuccessful strike at

an adult anole from this position on the side of a large rock on which the anole was eating an insect. Powell & Henderson (2008) described and illustrated a similar posture assumed by a snake at the base of a tree after dark on which anoles regularly extended their activity to forage for insects attracted to the light. The 'sprawled' posture abundantly documented in our data, despite our study being conducted primarily at peak activity

times, suggests that these snakes employ both active and ambush foraging strategies for arboreal anoles and their eggs. Ambush behaviour also is common in *A. antiguae* (Daltry *et al.*, 2001).

During another encounter, a focal was initiated but quickly discontinued because the snake became aware of and increasingly alarmed by the observer, who then slowly approached the snake, almost touching it near the head with the end of a pencil.
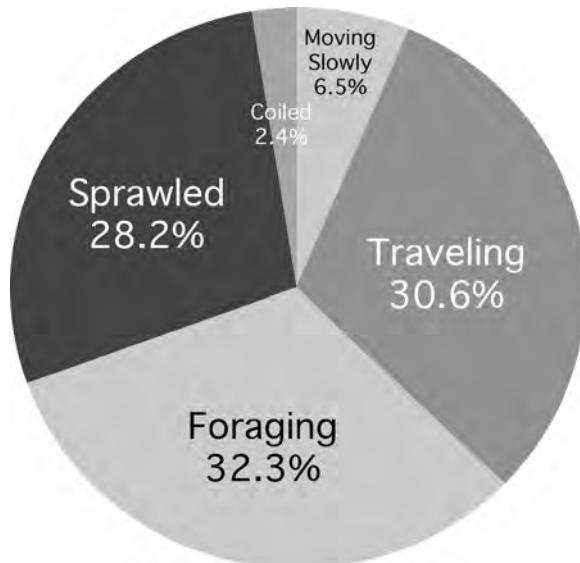
Figure 3. Percent time allotted to various activities and postures by 18 *Alsophis sibonius* during focal animal observations at Cabrits National Park on Dominica.

At that point, the snake fled approximately 1 m, assumed a sprawled position facing away from the observer, and proceeded to move the tip of its tail (ca. 5–6 cm) in a slow, apparently intentional wriggling motion with its head turned as if monitoring the threat. Similar behaviours have been observed in other snakes, for which it has been associated with ambush foraging and caudal luring (Heatwole & Davison, 1976). Because we observed it in only one animal, we cannot attribute any motive to the behaviour, although it appeared to function as a means of enticing a predator to direct its attack to the tail instead of the head, rather than serving a foraging or luring role (Green, 1988).

Very similar behaviour was observed in *A. rufiventris* (Heinz *et al.*, 2004), although whether that snake was responding to an observer (i.e. a threat) is unclear.

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Communal egg-laying and nest-sites of the Goo-eater, *Sibynomorphus mikanii* (Colubridae, Dipsadinae) in southeastern Brazil

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FOR oviparous reptiles without parental behavior, female nest-site selection plays a significant role in the evolution of life histories (Resetarits, 1996; Shine, 2004). Nevertheless, nest-sites and oviposition modes of neotropical snakes are relatively unknown, mostly because mothers are so successful at hiding their eggs that nests are rarely found in nature. Additionally, much emphasis has been placed on life history components such as body size, number and size of offspring, and age at maturity (Stearns, 1992; Resetarits, 1996).

Snakes oviposit under rocks, logs, or any other surface cover, in preformed subterranean chambers (Packard & Packard, 1988) and within nests of other animals such as alligators (Hall & Meier, 1993), ants and termites (Riley *et al.,* 1985). With regard to oviposition modes, snakes oviposit both in solitary and communal nests (Vaz-Ferreira *et al.,* 1970; Graves & Duvall, 1995; Blouin-Demers *et al.,* 2004).

Communal oviposition is a widespread phenomenon and occurs when several females, conspecifics or not, share the same nest cavity to deposit their eggs (Graves & Duvall, 1995). Among neotropical species, reports of nest-sites and communal nests are scarce and are mostly related to colder climates (e.g. Vaz-Ferreira *et al.,* 1970; Cadle & Chuna, 1995). Recently, Albuquerque & Ferrarezzi (2004) reported one communal nest for the neotropical colubrid snake *Sibynomorphus mikanii* in an anthropized area in southeastern Brazil. Herein we describe another three nest-sites, nesting areas and oviposition modes of the goo-eater snake *S. mikanii* in southeastern Brazil.

S. mikanii is a dipsadine colubrid snake that feeds on slugs (Laporta-Ferreira *et al.,* 1986; Oliveira, 2001) and is distributed in Central, Atlantic and Meridional Brazilian uplands in cerrado and tropical forest areas (Franco, 1994). Females oviposit from September (early spring) to February (mid-summer) and clutch size varies from three to 10 eggs, averaging 5.9 eggs (Oliveira, 2001).

On 5th February 2007, 41 eggs and 11 empty shells (Fig. 1C) were found together inside a hole, 20 cm below ground surface, at the edge of a degraded wood inside Instituto Butantan (IBSP), São Paulo city, Brazil. The nest (hereafter nest #1) was situated 17 m away from the wood and 9 m away from the backyard of a house on a slightly steep slope (Fig. 1A). A small hole (50 mm diameter), at the side of the nest may have provided access for the snakes (Fig. 1B). Temperature at the same depth around the nest averaged 27.3°C (range = 27 - 28°C). Four empty shells contained fluids indicating recent hatchings whereas seven were completely desiccated. Two dead hatchlings were found near the nest (± 1 m away). Nest #2 and #3 were discovered by a farmer in two different spots, in a 5000 m² house backyard, in Vargem city, Brazil. Nest #2 was discovered under dry grass accumulated after ground weeding and contained nine eggs. Nest #3 was found 30 m away from nest #2 under a large rock (30 x 60 x 15 cm) and had a total of 12 eggs. Eggs were donated to IBSP on 1st March 2007,

some days after collection and by this time one egg had hatched. In the laboratory, we counted four fresh empty shells and 17 eggs (three dehydrated and one parasitized by fungi). In both backyards, dogs circulated freely over the nesting areas. After the donation of the eggs, the farmer found a dead hatchling of *S. mikanii* near nest #3. Eggs were measured, weighed (Table 1), and incubated in laboratory at 27 °C (temperature of nest #1). Fungal infection precluded eight eggs (19.5 %) from nest #1 and five eggs (45.5 %) from nest #2 and #3 from hatching. Eggs were dissected but we were unable to find or to identify the embryos. One hatchling from nest #2 died half emerged from the eggshell. Thus, 33 successful hatchings from nest #1 occurred between 6th February and 16th April 2007, whereas from nest # 2 and #3 five occurred between 1st March and 31st May 2007. Hatchlings were measured, weighed, and sexed by eversion of hemipenis (Table 1). Based on mean clutch size of the species (5.9 eggs [Oliveira, 2001]), we inferred that nearly seven to nine different oviposition events may have occurred in nest #1 (six to 17), one to two in nest #2 (one to three), and two in nest #3 (two to four) in the current reproductive season. These
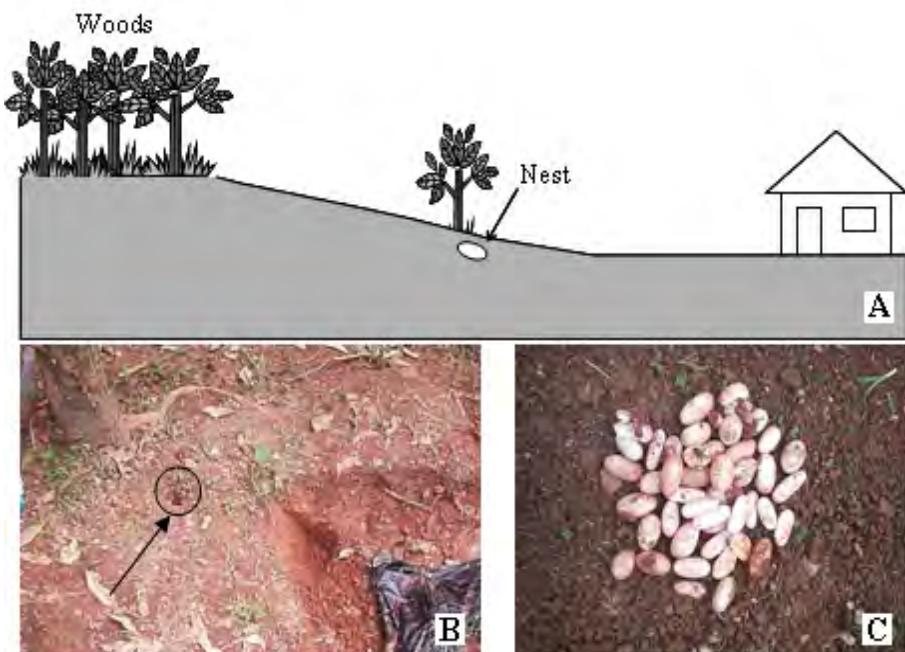
Figure 1. (A) Diagrammatic vertical section of the terrain surrounding nest #1; (B) view of the destroyed nest and its likely entrance; (C) Eggs of *Sibynomorphus mikanii* found within nest #1.

assumptions are strengthened if we take into consideration hatching dates (seven in nest #1 and three in nest #2 and #3). Although communal oviposition in nest #1 and #3 is evident, there is some doubt over nest #2 as it is quite possible that one single female laid the nine eggs.

Nest-sites and nesting areas are described for few species of neotropical snakes (e.g. Vaz-Ferreira *et al.,* 1970; Cadle & Chuna, 1995; Albuquerque & Ferrarezzi, 2004). Despite the fact that some snakes dig a hole in the soil to oviposit (e.g. Burger & Zappalorti, 1986), most species

apparently are unable to construct a nest and rely on pre-existing sites for oviposition (Packard & Packard, 1988). This seems to be the case for *S. mikanii* (Albuquerque & Ferrarezzi, 2004; this study). Although eggs of nest #1 were found inside a hole, it is unlikely that any female of *S. mikanii* actually excavated it because the soil was very compacted. Moreover, in the laboratory, gravid *S. mikanii* tend to hide the eggs under the water bowl or under rocks instead of burying them (H.B.P. Braz & S.M. Almeida-Santos, unpublished data). In addition, other dipsadine snakes also oviposit in

pre-existing sites (Brandão & Vanzolini, 1985; Riley *et al.,* 1985; Cadle & Chuna, 1995; Greene, 1997).

Thermal conditions are often suggested as a factor driving maternal choice of nest-site (Blouin-Demers *et al.,* 2004; Shine 2004) because incubation temperature affects offspring phenotypes (Deeming, 2004) and therefore may influence organismal fitness (Elphick & Shine, 1998; Brown & Shine, 2004). Females frequently oviposit in forest clearings (Fowler, 1966; Brodie *et al.,* 1969; Covacevich & Limpus, 1972; Burger & Zappalorti, 1986; Albuquerque & Ferrarezzi, 2004) and nests located in these areas generally are hotter than nests located in shaded areas because shading reduces insolation and heating of

the soil (Magnusson & Lima, 1984; Shine *et al.,* 2002). As well as nest #1, several nests have also been found in slopes (e.g. Brodie *et al.,* 1969; Covacevich & Limpus, 1972; Burger, 1976; Albuquerque & Ferrarezzi, 2004; James & Henderson 2004) and factors like direction and slope influence the absorption of solar radiation (Burger, 1976). Thus, mothers may have selected these sites in seeking to maximize sunlight exposure to accelerate embryonic development or optimize phenotypic traits of the resulting hatchlings. Therefore thermal conditions could also be a major factor influencing communal nesting behavior. Temperatures in communal nests are usually higher than in solitary ones (e.g. Blouin-Demers *et al.,* 2004) due to metabolic heat

Measurements	Nest #1	Nest #2 and #3
Eggs	n = *41*	*n* = 13
Length (mm)	27.9 ± 2.7	25.7 ± 3.0
Width (mm)	14.5 ± 2.0	12.6 ± 0.9
Mass (g)	3.5 ± 0.9	2.5 ± 0.4
Hatchlings	*n* = 33	*n* = 5
SVL (mm)	171.8 ± 13.5	170.0 ± 5.8
TL (mm)	34.0 ± 4.7	29.4 ± 2.6
Mass (g)	2.3 ± 0.4	2.0 ± 0.5
Sex (male/female)	19/14	2/3

Table 1. Measurements of eggs and hatchlings of three natural nests of the goo-eater snake *Sibynomorphus mikanii*. SVL = Snout-vent length; TL = Tail length.

generated by embryos (Burger, 1976; Ewert & Nelson, 2003). Therefore, communal nesting might be adaptive because higher temperatures in nests enhance hatchling phenotypes (Blouin-Demers *et al.,* 2004). However, studies on the thermal and hydric requirements of *S. mikanii* embryos would be needed to test these hypotheses. In parallel, egg aggregations also offer other potential advantages such as protection (Graves & Duvall, 1995; Jackson, 1998) and predator satiation (Eckrich & Owens, 1995; Graves & Duvall, 1995). If communal oviposition offers such advantages to hatchlings (e.g. phenotype improvement, predator satiation), why, then, would one female oviposit in a solitary nest as is likely to have occurred in nest #2? Blouin-Demers *et al.* (2004) suggested that the disadvantages of solitary nests may be compensated by lower risk of egg parasitism by

fungi. Additionally, in communal nests availability of water is less than in solitary nests (Marco *et al.,* 2004; Radder & Shine, 2007). This modifies hydric exchange between the eggs and the environment and the consequences to hatchling phenotypes may be more detrimental to aggregated eggs (Marco *et al.,* 2004). Thus it is reasonable to suggest that there are trade-offs between these two modes of egg-laying that result in similar fitness payoffs (Blouin-Demers *et al.,* 2004).

In summary, there are two (but nonexclusive) reasons for the occurrence of communal nesting behavior: scarcity of suitable nesting sites (e.g. optimum moisture and temperature; protection against predators) or adaptive behavior; that increases reproductive success due to aggregation in large clusters. Our findings plus literature data indicate a preference of gravid *S. mikanii* to nest

communally even when similar potential nest-sites were present in nesting areas. We suggest that such widespread behavior might result from adaptation. However, the adaptive significance of communal oviposition remains unknown.

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BUFO BUFO (Common toad): FUNGAL OUTBREAK. In species with complex life cycles, like amphibians, early developmental stages like eggs or larvae are the most vulnerable. Predators or pathogens may cause embryo mortalities close to 100% (Petranka & Kennedy, 1999). Episodes of high mortality due to unknown factors have been reported (Carrier & Beebe, 2003) but pathogens are likely causal within these occurrences (Blaustein & Kiesecker, 2002). Fungal infections such as chytridiomycosis (Berger *et al.*, 1998; Welldon *et al.*, 2004) or *Saprolegnia* infections (Blaustein *et al.*, 1994) are important factors causing embryonic mortality in amphibians. Mass mortalities associated with pathogens and chytridiomycosis have been reported in the Iberian Peninsula (Bosch *et al.*, 2001, Bosch & Martinez-Solano, 2006), but episodes of *Saprolegnia* infections have been described only recently (Fernandez-Beneitez *et al.*, 2008).

Bufo bufo reproduction has been monitored over the past decade in the Gándaras de Budiño e Ribeiras do Louro wetland. This wetland is included in the European network of protected places in Natura 2000. It is one of the last remnants of large wetland and gallery forest areas associated with the river Louro basin, which are threatened by industrial development (Ayres & Cordero, 2007). This area consists of a complex of wetlands, gallery forests (*Salix* sp., *Betula* sp., *Alnus* sp.), swamps, bogs, flooded areas, and artificial ponds created by extraction for clay. Reproduction of amphibians has been monitored in more detail during the last five years in these naturalized clay pits.

I monitored a number of clay pits 2-3 times per week, between January and March 2008, walking along the shore in order to detect egg-laying sites, and also to assess the impact of predation by breeding pairs of European otter (*Lutra lutra*). In the third week of January 2008, reproduction of *B. bufo* was detected. I found up to 100 strings in the clay pits during peak breeding. Due to the severe draught that Spain was suffering (the driest autumn-winter in the last 60 years [Xunta de Galicia, unpublished report]) there were few suitable places for egg-laying. Females were forced to spawn in shallow water, and in a variety of unusual places such as among floating pine branches that drapped over the surface of water.

One week later I detected the first viability problems. Some strings began to desiccate due to a lack of rain and because they were attached to grass in shallow water that was less than 10 cm deep. Other clutches began to develop a fungal coat, with eggs failing to hatch correctly. At least 20% of the clutches failed to hatch, due to desiccation, fungal attack, or both causes. This may be an underestimation because some affected strings could pass unnoticed in places with difficult access; the clay pits have almost vertical banks in some places.

Strings affected by fungal attack presented a "black & white" coloration of eggs in the first stages, changing to a "cotton-like" appearance in the last stages of the pathogen's development. This cotton-like appearance is typical of Oomycete, *Saprolegnia* infection (Fernandez-Beneitez *et al.*, 2008). I detected clutches affected by this pathogen not only in not suitable egg-laying places, but also among suitable underwater vegetation, typical egg-laying areas for *B. bufo*.

This is the first time that I have detected such a large failure in the reproductive success of *B. bufo* in this area. In previous years less than 1% of the strings failed to develop tadpoles (Ayres, unpubl. data). This fact, combined with the impact of predation by Otter on breeding pairs of adults (Ayres & Garcia, 2007), could have a negative impact on the breeding population of *B. bufo* in this wetland.

Emergent pathogens such as *Saprolegnia* are known to be the origin of embryonic die-offs in many amphibians (Blaustein *et al.*, 1994; Kiesecker *et al.*, 2001), including mass die offs of the eggs of European species like Natterjack toad (*Bufo calamita*) and European common frog (*Rana temporaria*) (Banks & Beebee, 1988; Beattie *et al.*, 1991).

However, there are few reports about amphibian die-offs in the Iberian Peninsula from Oomycete attack. Recently an episode affecting *B. calamita* in Sierra de Gredos mountains, Central Spain was described (Fernandez-Beneitez *et al.*, 2008). Observations herein now present a new episode of egg mortality, involving a new species, *B. bufo*, in the NW of Spain at low altitude (30 m a.s.l.).

It is possible that climate-induced reductions in

water depth at oviposition sites may have increased mortality of embryos by increasing their exposure to UV-B radiation, and consequently, their vulnerability to infection (Kiesecker *et al.*, 2001). In Europe, the hatching success of *B. bufo* is generally lower for UV-B exposed eggs than for those shielded from UV-B (Lizana & Pedraza, 1998).

In the area studied it was the driest autumn in the last sixty years, with low water level, and vritually no typical vegetation to lay eggs among such as *Typha* sp. or *Potamogeton* sp. As a result females were forced to lay in 'unsuitable' places like pine branches over the surface of the ponds, that quickly desiccate due to the lack of rain. These unsuitable places likely increased the vulnerability fo the eggs to fungal attack. Strings attached in deep water also suffered from fungal attack. Unfortunately no sample of the pathogen was identified to species level.

One species of *Saprolegnia* shown to be involved in natural infections is *Saprolegnia ferax* (Blaustein *et al.*, 1994; Kiesecker *et al.*, 2001). Fernandez-Beneitez *et al.* (2008) states, other species such as *Saprolegnia diclina* could also be responsible for die-offs in Spain. *Saprolegnia diclina-parasitica* complex was also determined as lethal to *R.temporaria* and *B.bufo* eggs under laboratory conditions (Robinson *et al.*, 2003).

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DIPSAS INDICA (Snail-eating snake): REPRODUCTION. The genus *Dipsas* is a well diversified taxa composed of nocturnal, semi-arboreal and malacophagous species (Greene, 1997) widely distributed in Central and South America (Peters & Orejas-Miranda, 1970). In Brazil eight species occur (SBH, 2008) and published reproductive data are restricted to half of them (Porto & Fernandes, 1996; Martins & Oliveira, 1999; Hartmann *et al.*, 2002; Alves *et al.*, 2005).

Herein, we present unpublished data about oviposition, hatching, clutch size, relative clutch mass (RCM) and size of hatchlings of *Dipsas indica*. This species is distributed in South America and five subspecies are recognized (Peters & Orejas-Miranda, 1970; Hoge & Romano, 1975).

On 10th November 2006, a gravid female *D. indica* with a snout-vent length (SVL) of 600 mm, tail length (TL) of 170 mm, and mass of 60.8 g was collected in Mogi Mirim (22°25'S, 46°57'W, 632 m), São Paulo State. On 17th November 2006 it was housed in 40 x 80 x 50 cm terraria, with a water dish, moistened soil, leaves and branches.

Until oviposition, veronicellid slugs were offered as prey. During this period the snake fed on two slugs with 2.5-3.0 cm. On 27th December 2006 it laid 5 eggs, being 2 weakly adhered and 3 separated. The snake was found under the leaves semi-coiled around the eggs. No behavioral changes of the female were observed during collection of the eggs.

Figure 1. Difference in color pattern of hatchling *Dipsas indica*. Upper: Female. Lower: Male.

Eggs averaged 29.2 ± 1.9 mm in length (range = 27.3-31.7 mm), 12.7 ± 0.4 mm in width (range = 12.2-13.2 mm) and 3.0 ± 0.1 g in mass (range = 2.8-3.1 g). Clutch mass was 14.9 g and after oviposition the female weighed 36.0 g. Relative clutch mass (RCM; total clutch mass/body mass of mother after oviposition + clutch mass; cf. Seigel & Fitch, [1984]) was 0.29. The RCM calculated according to Shine (1980) (total clutch mass/body mass of mother after oviposition) was 0.41. Four out of five eggs were incubated in a plastic container with moistened vermiculite, at room temperature averaging 24 °C (range = 22-26 °C). On 13th April 2007, three eggs hatched after an

incubation period of 107 days. Hatchlings averaged 180.3 ± 8.0 mm SVL (range = 172-188 mm), 55.7 ± 4.0 mm TL (range = 51-58 mm) and 2.6 ± 0.2 g (range = 2.4-2.8 g) and were similar to other hatchling *Dipsas* sp. (Hartmann *et al.*, 2002; Alves *et al.*, 2005). Male hatchlings (n = 2) were clearer than female (n = 1) (Fig. 1). The egg not hatched was dissected and contained one dead full term embryo. Hatchlings were placed in terraria (30 x 15 x 20 cm), with soil, leaves, branches, a water dish and fed with snails. Initial growth rate during the first 14 weeks was 2.64 mm by week.

D. indica is a semi-arboreal species (Sazima, 1989; Greene, 1997) but despite this, until oviposition, the female was never seen on the branches. Instead, it was frequently found coiled under the leaves. Conversely, hatchlings were frequently found resting on the branches within the terraria even during the day. Pregnancy may have disuaded the adult female snake from arboreal habits. Fecundity (clutch size, RCM) was low and this is also a common trait within other *Dipsas* sp. (Zug *et al.*, 1979; Martins & Oliveira, 1999; Hartmann *et al.*, 2002; Alves *et al.*, 2005; Cadle, 2005). Low fecundity may have two different (but non-exclusive) reasons: the small body size of the adult female (larger females tend to produce larger clutches; Shine [1994]), or a reflection of the genus' arboreal habits (Pizzatto *et al.*, 2007). Seemingly, species of *Dipsas* show aseasonal reproduction in lower latitudes (e.g. Zug *et al.*, 1979; Porto & Fernandes, 1996; Alves *et al.*, 2005) and seasonal reproduction in higher latitudes (e.g. Marques, 1998; Hartmann *et al.*, 2002; Marques & Sazima, 2004). Our observation strengthen the suggestion of seasonal (spring-summer) reproduction in *Dipsas* from higher latitudes, however, more data on southern Brazil populations of *D. indica* would be necessary to provide concrete evidence of this definition of reproductive cycle for the species.

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MASTIGODRYAS BODDAERTI (Boddaert's Tropical Racer): PREDATION. Frogs do not have nails, teeth and hair per se, and since they are able to rapidly convert ingested food into biomass, they often represent a high quality meal (Wells, 2007). Thus, many different animals are known to attack frogs, such as arthropods like arachnids, centipedes (McCormick & Polis, 1982; Forti *et al.,* 2007). Vertebrates such as snakes one of the more significant predators on adult amphibians (Toledo *et al.,* 2007).

This paper presents a predation behavior record of the snake, *Mastigodryas boddaerti* on the frog, *Leptodactylus fuscus* in natural conditions, in Cuiabá municipality, state of Mato Grosso, Brazil. This region has annual precipitation varying from 1,250 to 1,500 mm. Two different seasons (rainy/dry) are recognized, with mean air temperature about 24 - 26 ºC Carvalho & Nogueira (1998).

Mastigodryas boddaerti occurs in Colombia, Venezuela, Brazil, Bolivia, Ecuador, Trinidad, French Guiana and Peru (Cunha & Nascimento 1993; Uetz, 2008). It is a terrestrial and diurnal species whose diet is composed mainly of lizards, frogs of the families Leptodactylidae and Hylidae (Vanzolini, 1986; Carvalho & Nogueira, 1998; Bernarde, 2004; Leite *et al.* 2007), reptile eggs, birds, and small mammals (Bernarde, 2004). On this occasion the victim was *Leptodactylus fuscus* (Leptodactylidae), which occurs throughout Brazil, Argentina, Bolivia, Paraguay, and the eastern Andes (Frost, 2007). Males of *L. fuscus* are approximately 36 mm and females 39 mm of Snout-vent length (SVL). Reproduction is restricted to the rainy season, when males build nests on the mud and actively vocalize to attract females (Martins, 1988).

The predation event was observed on the 29st February 2008, at 14:05 hrs (approximately 36.0 ºC air temperature) by the first author, who documented the entire event photographically. The *L. fuscus* individual invaded the backyard area of a rural residence (approximately 15º 20' S 55º 53', 250 m elevation) in Cuiabá, state of Mato Grosso, Brazil. The snake appeared, possibly attracted by the prey movement, a feature common to snakes with diurnal habits (Ota, 1986), and slowly, by lateral undulations approached the victim. The snake stopped to 20 cm from the frog and struck the left pelvic region of the victim rapidly, without releasing the frog. In response, the frog started to emit a 'release call', but the snake held it by the left posterior limb with the mouth. The ingestion process occurred from cloacae to head direction, after about 1 minute from the initial strike (Fig. 1). Two minutes from the ingestion process commencing, the snake consumed the entire captured prey.

The snake was then collected and deposited as a voucher specimen at Coleção Zoológica da Universidade Federal de Mato Grosso, UFMT

6505 (SVL: 791 mm; TL: 298 mm; M: 85 g, female).

Three main kinds of attacks and subjugations have been described in snakes: standstill, constriction, and poisoning (Pinto & Lema, 2002). Generally, constriction is used by members of Boidae family and sometimes by Colubridae (Pinto & Lema, 2002). Viperidae, such as the Lancehead (*Bothrops jararaca*), subjugate prey by poisoning (Sazima, 1989); Sueiro & Brites, 2006). On this occasion *M. boddaerti* did not act by constriction during the attack, possibly due to the relative small size of the frog. However, it is possible that prey with claws, that are considered fast moving and able to promote injury (such as lizards), are

taken using constriction by *M. boddaerti* to immobilize and kill prey.

Further natural observations with different prey would be required to confirm this hypothesis. Other species of amphibians are known from the diet of *M. boddaerti* but to the best of our knowledge we believe this is the first detailed record of predation on *L. fuscus* in natural circumstances.

Figure 1. *Mastigodryas boddaerti* preying on *Leptodactylus fuscus.*

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AMPHISBAENA ALBA (Worm Lizard): DEFENSIVE BEHAVIOUR. *Amphisbaena alba* (Linnaeus, 1758) occurs in forested lowlands of South America, from Panama through Venezuela, Trinidad, and the Guyana; Colombia, Peru, and Bolivia eastern the Andes; Brazil and northern Paraguay (Gans, 2005). It shows fossorial habits and diet that comprises varied arthropods and their larvae, and occasionally some vertebrates, such as small rodents and lizards (Colli & Zamboni, 1999).

This report describes for the first time the defensive behavior of an *A. alba* (approximately 400 mm total length) in nature under predatory circumstances.

The specimen was found in Santa Rosa Farm, district of Curvelo-MG (18°45'S 44°25'W), and observed in January 2008, at about 8:30 a.m. crossing a lawn. The worm lizard was noticed by some chickens and a rooster (*Gallus* sp.) which attacked it, pecking its body randomly (Fig. 1). The amphisbenid reacted to all lunges by opening the mouth, lifting the tail and trying to strike a bite, eventualy forming a semicircle with the body seemingly trying to defend itself (Fig. 2 and 3). Some chickens got away after some time, however one chicken continued pecking the worm lizard in an apparent predatory attempt, and the amphisbenid tried to escape. Eventually it reached a tree stub hidding in a hole.

The pursuit lasted about 15 minutes when pictures were taken. No injuries were observed in the *Amphisbaena*. This behavior described as defensive (Gans, 1962) had been observed only when confrontations were provoked experimentally (Gans, 1962; Greene, 1973; Brito *et al.*, 2001). Caudal autotomy did not occur in *A. alba* (this case) on this occasion. This may have been becasue of the lack of an intravertebral caudal fracture plane and consequently absence of external caudal narrowing (Gans, 1962), a feature different from species such *A. mertensi* (Brito *et al.,* 2001) which used it as an important survival strategy like other amphisbenids (Vanzolini, 1948, 1951).

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Figure 1. The worm lizard was pursued by a chicken.
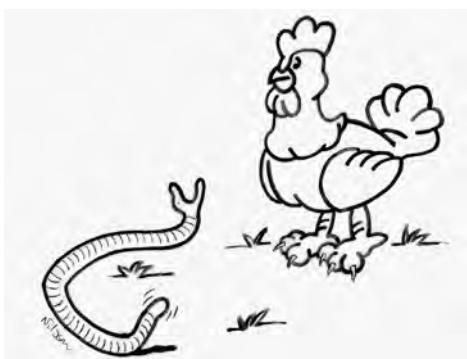
Figure 2. It is forming a semicircle with the body seemingly trying to defend itself.
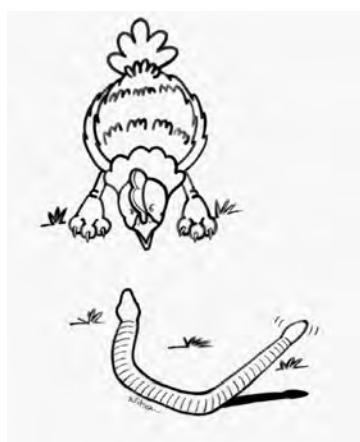
Figure 3. The amphisbenid reacted to all lunges opening the mouth, lifting the tail and trying to strike a bite.

BOOK REVIEW

Biology of Turtles: from structure to strategies of life

Jeanette Wyneken, Matthew H. Godfrey and Vincent Bels

2007. CRC Press, Florida, 408 pp.

'Were there no turtles living, we would look upon the fossil turtles as the strangest of all vertebrates- animals which had developed the strange habit of concealing themselves inside their ribs, for that is literally what turtles do.'

Samuel Williston, 1914

The quote by Williston is a fitting synopsis of the Biology of Turtles - a book about chelonian anatomy. To be precise, this book is about how the distinct anatomy of turtles influences every aspect of their biology, including feeding, growth, locomotion, physiology, and reproduction. This novel approach was the result of the Sixth International Congress of Vertebrate Morphology held in Jena, Germany in 2001. Fittingly, the symposium occurred precisely where Ludwig Heinrich Bojanus compiled Anatome Testudinis Europaeae, an incredibly detailed atlas of the morphology of the European Pond Turtle (*Emys orbicularis*) some 180 years prior (Bojanus, 1819).

Chapters one and three of the Biology of Turtles provide an in-depth treatise of the single most important morphological adaptation of the chelonian condition: the shell. In Chapter 1, authors Gilbert *et al.* discuss the anatomy of the turtle shell. From colour photos of early embryological stages to the formation and ossification of the carapace, plastron, and nuchal bones, the authors provide a tentative outline of how the shell is formed. Much remains to be discovered, however. For instance, what causes plastral concavity in the males of certain species or how the hinge develops to permit plastral kinesis is still unknown. Nevertheless, in Chapter 3, Pritchard draws upon his extensive osteological

collection at the Chelonian Research Institute in Florida to delve not only into the standard configuration of the shell but also into known deformities such as 'pyramiding' and other scute abnormalities. Clear black and white photographs are used to compare and contrast various morphological adaptations such as hinges, fontanels, and buttresses. The degree of morphological variability within the Chelonia is truly astounding and the reader will get a true sense of it in this chapter.

Chapters two and four describe how turtle long bones grow. In Chapter 2, Snover and Rhodin discuss how annuli within these bones, termed 'lines of arrested growth', can be used to estimate age and growth, a technique known as skeletochronology. Most interesting, however, is the pattern of accelerated skeletal growth in the Leatherback (*Dermochelys coriacea*). The presence of unique vascularised cartilage canals permits the Leatherback to grow at an astounding rate, an 8000-fold increase in mass from hatching to sexual maturity. Until reading this chapter, one really has no idea just how unique a life form the Leatherback is. Indeed, as the authors stated, 'it is the most remarkably specialized turtle in the world.' In Chapter 4, Llorente *et al.* investigate limb bone allometry; that is, they analysed turtle limb bone diameters and lengths and then compared and contrasted the proportions of these bones in 11 chelonian families. Based on their results, the authors concluded that turtle long bones have less in common with the proportions of quadrupedal mammal long bones than they do with those of avian hind limbs.

Chapters five and six build upon the previous chapters by providing an in-depth exploration of locomotion in turtles. In Chapter 5, Renous *et al.* begin by examining the fossil record; what do the sediments that the fossils were found in tell us about a given fossil species? Can we infer that a species was terrestrial or an aquatic bottom- walker based on a combination of anatomy and geology? On occasion, the scientific community is favoured with outstanding discoveries. For instance, Fig. 5.21 illustrates the fossilized tracks

of two Jurassic turtles. In extant chelonians, the authors explore the morphological adaptations of the shell and limbs based on a continuum ranging from terrestrial tortoises to highly aquatic sea turtles. The rest of the chapter examines the motions involved in the propulsion and limb coordination of representative aquatic species such as *D. coriacea*, *Trachemys scripta*, *Chelydra serpentina*, and *Carettochelys insculpta*. From these, one discovers that alternating limb movements are the norm in all but the most highly aquatic species - those with foreflippers. Chapter 6 focuses more on the function of hindlimbs in locomotion. Blob *et al.* compare and contrast the movements of adult and juvenile *T. scripta* and *Apalone spinifera* using high-speed video and electromyographic signals from muscles. Interestingly, the authors observed that interspecific differences observed between adults were not evident in the juveniles. The research in Chapters five and six provide the reader with a better understanding of how morphologically diverse genera are adapted to survive in a wide variety of habitats.

Chapters seven and eight delve into the anatomy of the chelonian neck, particularly with regards to extension and retraction during such necessary activities as snorkelling and foraging. In Chapter 7, Herrel *et al.* chose two genera to represent both primary modes of neck retraction. The genus *Apalone* represented the Cryptodira (turtles that retract their neck straight back like a tortoise) and Chelodina represented the Pleurodira (turtles that fold their neck to the side). Of particular interest is that the authors conclude that the neck morphology of *Apalone* is highly specialized and may not be representative of the general Cryptodiran condition. Chapter 8 examines the ingestion of food items in both terrestrial and aquatic environments. Bels *et al.* used series of photographs and x-rays to break down foraging episodes in millisecond increments for *Geochelone radiata*, *Kinixys belliana*, and *Malaclemys terrapin*. The chapter concludes with an examination of feeding in young *D. coriacea*.

Chapter nine discusses several novel characteristics of the chelonian circulatory system. Wyneken reveals that the turtle heart, for instance, is not simply three-chambered as

commonly held; the ventricle is subdivided functionally into three compartments. Although it comes as no surprise that freshwater and sea turtles are particularly adept at holding their breath, what is surprising is that, in contrast to mammalian lungs, turtles have no bronchial tree or alveoli in their lungs. Moreover, the lungs of deep-diving migratory sea turtles are more complex than those of more sedentary hunters, such as *C. serpentina*. Here, as throughout this book, anatomy informs ecology.

Chapters ten and eleven provide a comprehensive review of turtle reproductive structures and strategies. In Chapter 10, Miller and Dinkelacker discuss several rarely covered topics such as cloacal and urinary bladder morphology. As to strategies, the implications of egg morphology are particularly interesting. Typically, turtles that incubate their eggs in moist environments have pliable eggs that absorb water; whereas, those that incubate them in arid or semi-arid environments produce non-porous or 'hard-shelled' eggs, presumably to limit water loss. In addition, spherical eggs are typically produced by large turtles and oblong eggs by small turtles. Thus, even egg morphology can inform ecology. In Chapter 11, Hulin *et al.* examine the implications of temperature-dependent sex determination (TSD) in 64 of the 79 species of turtles examined thus far. If offspring sex ratio is dependent upon incubation temperature, what effects might rapid climate change have? Likely scenarios are discussed at length.

Chapter twelve discusses the complex anatomical and physiological adaptations necessary for the turtle brain to tolerate hypoxic (low oxygen) and anoxic (no oxygen) conditions during brumation. At 3 ºC, Common Musk (*Sternotherus odoratus*), Northern Map (*Graptemys geographica*), and Eastern Painted Turtles (*Chrysemys picta picta*) can survive anoxic waters for 22, 45, and 150 days, respectively. This ability is a result of specific brain adaptations at both the molecular and physiological level.

In the final chapter, Rieppel examines the relationship of turtles within amniotes. Chapter 13 explores such questions as; did turtles begin as aquatic or terrestrial organisms? Ultimately, the

author concludes that many of the questions posed in this chapter will remain unanswered until intermediate forms are discovered in the fossil record. One such fossil, *Odontochelys semitestacea* - meaning half-shelled turtle with teeth, was described from China after the publication of this book (Li *et al.,* 2008).

Although well-written, the Biology of Turtles is not without errors and omissions. For instance, Figure 3.16 is mistakenly labelled as '*Podocnemis gabonensis'* rather than *Pelusios gabonensis*, as specified in the text. Moreover, in Section 8.5.1.3, the authors indicate that ingestion of mealworms by *Terrapene carolina* is depicted in Figure 8.3; whereas, the figure actually depicts *K. belliana* consuming lettuce. Although Figure 12.1 clearly depicts the anatomy of a turtle brain, it would have been helpful if the turtle species had been indicated.

The title of this book suggests a much broader subject matter, yet a title such as 'Anatomy of Turtles' would not have done this volume justice. It is much more that an anatomical description - rather it is an exploration of how anatomical features influence the ecology of chelonians. Those contemplating the lofty purchase price (£78-£99) will need to assess where they are personally on their quest of chelonian knowledge. One may safely surmise that this book was intended for an advanced audience comprised primarily of 'students' of chelonian anatomy, taxonomy, and physiology. The book is replete with technical jargon and makes no apology for it. Consequently, readability is an issue; if one does not read at least ten chelonian research papers per year, then much of the merit of this book will be lost. Advanced professional herpetologists that conduct ecological research on turtles will surely benefit from the much broader exposure to the scientific literature that this compendium provides. Conversely, few naturalists or pet turtle hobbyists will derive much benefit from this book; they should peruse this book at the nearest university library before deciding on a purchase. The Biology of Turtles belongs in the library collections of every major research university with degrees in biology, ecology, paleontology, wildlife biology, and zoology. For the bibliophiles of chelonian

literature, the Biology of Turtles is certainly required to complete one's book collection.

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Front cover illustration. African Fat-tailed Gecko (*Hemitheconyx caudicinctus*). © S. Spawls. See article on page 7.