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

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Front cover illustration. *Cyclura lewisi* (Grand Cayman Blue Iguana) © Frederic J. Burton . See article on page 19.

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NEW TECHNIQUE FOR ESTIMATING LIZARD BODY MASS FROM MEASUREMENTS.

Lizards are an important indicator species for understanding the condition of specific ecosystems. Their body weight is a crucial index for evaluating species health, but lizards are seldom weighed, perhaps due in part to the recurring problem of spontaneous tail loss when lizards are in stress.

Now ecological researchers have a better way of evaluating these lizards. Dr. Shai Meiri has developed an improved tool for translating lizard body lengths to weights. Dr. Meiri's new equations calculate this valuable morphological feature to estimate the weight of a lizard species in a variety of different ecosystems.

Dr. Meiri evaluated hundreds of lizard species: long-bodied, legless species as well as stout, long-legged species; some that sit and wait for prey, others that are active foragers. Based on empirical evidence, such as well-established behavioral traits, he built a statistical model that could predict weights of lizards in a reliable, standardized manner, for use in the field or at the lab.

Based on a large (>900 species in 28 families) dataset of lizard and amphisbaenian weights, equations were generated to estimate weights from the common size index used in lizard morphometrics (snout-vent length). Species level phylogenetic hypotheses were then used to examine the ecological factors that affect the variation in weight-length relationships. Legless and leg-reduced lizards are characterised by shallower allometric slopes and thus long-bodied legless species are lighter than legged lizards of comparable length. Among legged species, the foraging strategy strongly influences the weights, with sit-and-wait species being bulkier at comparable lengths than active foraging species. Environmental productivity and activity times are only significant when using non-phylogenetic models. The need for effective locomotion is a major factor affecting lizard shape and thus previously used allometric equations are inaccurate in their estimates.

In the future, zoologists will be able to use Dr. Meiri's method to better predict which communities of animals will shrink, grow or adapt to changing conditions.

Meiri, S. (2010). Length-weight allometries in lizards. *J. Zool.* **281**, 218–226.

SNAKE FANGS EVOLVED FROM GROOVED TEETH

Venom delivery systems occur in a wide range of extant and fossil vertebrates and are primarily based on oral adaptations. Teeth range from unmodified to highly specialized fangs similar to hypodermic needles (proteroglyphous and solenoglyphous snakes). Developmental biologists have documented evidence for an infolding pathway of fang evolution, where the groove folds over to create the more derived condition. However, the oldest known members of venomous clades retain the same condition as their extant relatives, resulting in no fossil evidence for the transition.

The late Triassic reptile Uatchitodon is known only from its teeth, that are tall and serrated . Several have been found, and the two youngest examples date from 220 mya possess venom canals. An older set has grooves of different depths but no canals. Until now it was unknown whether the variations reflected evolutionary changes or different stages of tooth development, or teeth from different positions in the mouth.

Jon Mitchell and colleagues from the University of Chicago discovered 26 Uatchitodon teeth in North Carolina. Their age places them between the other two sets, and examining all the teeth showed how grooves that initially formed at the surface gradually lengthened and deepened until they became enclosed canals. Mitchell's work suggests that snake fangs probably evolved independently of Uatchitodon but the sequence of events was most likely similar.

Mitchell, J.S., Heckert, A.B. & Sues, H.D. (2010). Grooves to tubes: evolution of the venom delivery system in a Late Triassic "reptile". *Naturwissenschaften* **97** (12), 1117-1121.

TURTLE POISONING IN MURILO ATOLL, CHUUK STATE, FEDERATED STATES OF MICRONESIA.

On Sunday, October 17 2010, the Federated States of Micronesia (FSM) Department of Health and Social Affairs (DHSA) and the World Health Organization (WHO) were notified of the sudden death of three children and the sickening of approximately 20 other persons on Murilo Island, Chuuk State. The illness was suspected to be the result of mass consumption of a hawksbill turtle (*Eretmochelys imbricata*) which had been prepared and served on the afternoon of Friday, October 15. Upon receipt of the reports of sudden illness, an emergency response team was dispatched to Murilo to set up a field hospital for treatment of victims. Concurrently, an investigation team was assembled to confirm the cause of the outbreak, describe the epidemiology of cases, and provide recommendations for control.

The investigative team conducted interviews with key members of the community in order to determine the cause of the outbreak, undertook environmental investigation, and questioned all sick persons and a large proportion of healthy community members.

Four children and two adults died in the outbreak, and a number of others were sickened; approximately 80% of those who ate turtle became ill. A variety of samples were collected for analysis, though no autopsies were performed. No laboratory results are available at this time.

The investigators concluded that turtle poisoning (also called chelonitoxism) was the cause of the mass illness on Murilo; there does not appear to be any other likely explanation for the mass illness. Persons from Murilo affected by the illness are not a risk to others. Because all of the tissue from the turtle has been consumed or otherwise disposed of, there is no remaining turtle meat which could lead to further illness. There is no reason to suspect that reef fish around Murilo are toxic.

The range of illness described in the investigation is consistent with previously reported cases of chelonitoxism. There is no antidote or other medicine that can specifically treat chelonitoxism. Children are expected to be more severely affected. It is not clear why the two adult males developed serious disease and died, though they may have consumed a larger amount of turtle than other victims.

All turtles, but particularly hawksbill turtles, are known to be capable of being poisonous. There is no way to determine which individual turtles are or are not poisonous. Because there is nothing unique about Murilo that would result in only Murilo turtles being toxic, there is no justification for continuing to single out Murilo (or the Hall Islands) as being at increased risk for chelonitoxism. Instead, it should be emphasised that any turtles or their eggs, anywhere, may be toxic.

Since all turtles and their eggs are capable of being toxic, the only way to insure public health is to avoid consuming any turtles or their eggs. The FSM DHSA therefore recommends a complete ban on the consumption of all species of turtles and their eggs in Chuuk and the rest of FSM. The health sector will be working with lawmakers and other relevant stakeholders to update turtle management policies.

Though this incident has come to an end, future incidents are certain to occur unless action is taken to alter turtle-eating behavior in Chuuk and the rest of FSM.

This has been posted on behalf of Dr. Vita A. Skilling, Secretary of the Department of Health and Social Affairs, FSM National Government, Palikir Pohnpei.

DYNAMICS OF *RANAVIRUS* DISEASE UK FROG POPULATIONS

Common frog (*Rana temporaria*) populations across the UK are suffering declines from a number of causes. One such is infection from the emerging disease *Ranavirus*. Using data collected from the public by the Frog Mortality Project and Froglife, scientists from the Zoological Society of London found that, where disease outbreaks were recurrent, populations experienced an 81% decline in adult frogs over a 12 year period from 1996-2008.

There is a preliminary indication that common frog populations can respond differently to the emergence of disease: emergence may be transient, catastrophic, or persistent with recurrent mortality events. Despite a number of populations suffering from infection year-on-year, other populations bounced-back from mass-mortality events. This suggests that some populations of frogs may have some form of immunity to ranaviral infection.

In the 1980s and 1990s, the disease was particularly associated with the southeast of England. In recent years new 'pockets' of diseases have turned up in Lancashire, Yorkshire and along the south coast.

Comparable uninfected populations (n=16) showed no change in population size over the same time period. Regressions showed that larger frog populations may be more likely to experience larger declines than smaller populations, and linear models show that percentage population size changes were significantly correlated with disease status, but that habitat age had no significant effect on population size change. The results are the first evidence of long-term localized population declines of an amphibian species which appear to be best explained by the presence of *Ranavirus* infection.

Teacher, A.G.F., Cunningham, A.A., Garner, T.W.J. (2010). Assessing the long-term impact of *Ranavirus* infection in wild common frog *Rana temporaria* populations. *Anim. Cons.* **13** (5), 514-522.

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A possible case of mimicry involving a heteropteran insect and an anuran tadpole

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ABSTRACT - We report on the occurrence of similar aposematic colour pattern between two phylogeneticaly unrelated aquatic organisms, an insect and a tadpole. The limnocorid Heteroptera *Limnocoris porphyrus* and tadpoles of the hylid frog *Scinax machadoi* are found in sympatry and syntopy in several streams in the Serra do Cipó, a pristine area located in the Espinhaço Range, Minas Gerais state, southeastern Brazil. The similarity between these two organisms makes it difficult to distinguish them at first sight. We suggest that they are possibly part of a process of Müllerian mimicry, but we recognize an evaluation of palatability and population size estimates are needed to ascertain our suggestions.

APOSEMATISM, the use of bright colour patterns by noxious animals to deter predators, is a well-documented phenomenon in nature (Mallet & Joron, 1999; Joron, 2003; Wüster et al., 2004). In the evolutionary process of mimicry a species evolves coloration similar to another species. In Batesian mimicry a palatable prey species mimics the appearance of a noxious species reducing its risk of being attacked. In Müllerian mimicry, two aposematic organisms conform to the same aposematic signal to their mutual benefit (Joron, 2003).

Predators learn to avoid brightly patterned or otherwise conspicuous noxious prey items more rapidly than cryptic prey items (Guilford, 1986; Rowe & Guilford, 2000), and consequently aposematism and/or Batesian mimicry have usually been inferred in cases where the presumed mimic matches a brightly patterned model. Most of aposematism theory is based on two-species interactions, with one noxious prey (the signaller) and one predator (the receiver) (Wüster et al., 2004).

Many organisms present bright or conspicuous patterns of colour and observations under experimental conditions simulating naive avian predators have shown how these species are involved in so-called mimicry rings (Mallet & Joron, 1999; Joron, 2003). Elucidating conditions favouring co-evolution in mimicry is one of the oldest problems in Evolutionary Biology (Gilbert, 1983). This work presents a case of two sympatric aquatic species, an insect and a frog tadpole. The bright colour pattern of the insect and the tadpole is found in their early stages of its development.

The Serra do Espinhaço is a mountain range located in the states of Minas Gerais and Bahia, Brazil, and observations have been made at two localities at 95 km in a straight line from each other. In Serra do Cipó (19º12'-19º20' S, 43º30'-43º40' W), a high altitudinal area covered by savanna vegetation, xeric habitats and an abundance of sclerophylous plants. Above 900 m ASL campo rupestre vegetation dominates with fragments of high altitude grassland vegetation (Ribeiro et al., 1990). Serra do Caraça (20º05'S, 43º28'W) has altitudes between 900 and 2000 m ASL. It is characterised by Atlantic Rainforest and Savanna at low parts and campo rupestre vegetation at higher altitudes.

From surveys made between October 1999 and October 2001, young instars of *Limnocoris porphyrus* Nieser & Lopez Ruf, 2001 (Heteroptera, Naucoridae) and tadpoles of *Scinax machadoi* (Bokermann & Sazima, 1973) (Anura, Hylidae) (Fig. 1) were found sharing the same stream habitats.

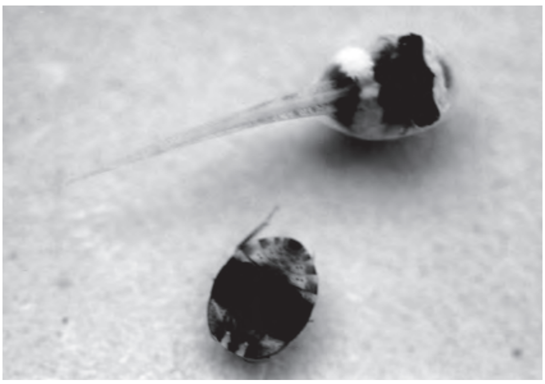

Figure 1. Larval stages of *Scinax machadoi* (Anura, Hylidae) and *Limnocoris porphyrus* (Heteroptera, Naucoridae) from Serra do Cipó, Southeastern Brazil.

In Serra do Cipó individuals of both species were collected in streams of clear water with a depth of about 40 cm and width varying between 1 and 3 m. In Córrego Indaiá, a stream located about 1400 m, the tadpoles and nymphs were found foraging next to each other on rocks in the stream. Due to their initial resemblance it was almost impossible for an observer to distinguish between them. Both were attached to the rocks and easily seen in the flowing water. In sampled aquatic habitats few organisms were seen as easily as the ones from this study though several other anuran and insect species also inhabit these streams (Nieser & Melo, 1997; Eterovick & Fernandes, 2001). The tadpoles of other anuran species that inhabit the freshwater habitats are cryptically colored, except those of *Bufo rubescens*, which are black and often observed in schools of hundreds of individuals.

The Naucoridae, or creeping water bugs, are predatory insects common in tropical aquatic systems (Sites & Nichols, 1990). Among Heteroptera, this group are the best adapted to life in running water although many species live beneath or among submerged rocks or attached to leaves and branches on the stream bottom. *Limnocoris* is a widespread genus (Southeastern Brazil to Argentina) and the main representative of subfamily Limnocorinae (Nieser & Melo, 1997). *Limnocoris porphyrus* was only recently described from individuals collected in Serra do Cipó (Nieser & Lopez Ruf, 2001). Like the other members of the subfamily, *L. porphyrus* inhabits first and second order streams. These insects seem to be diurnal and are constantly moving on the rocks. The bright colour pattern is only present at the larval forms before the insect becomes adult. The young insects have a flattened-round body and non-developed wings covering the thorax. The body is yellowish with a single black stripe on the dorsal region over the pronotus. Adult body lengths averaged 7.8 (males) and 8.0 mm (females) (Nieser & Lopez Ruf, 2001). After its final moult, *L. porphyrus* loses its pattern and a brownish colour is observed for all adult forms that become cryptically colored. A behavioural change is also observed after last moult. The adults were no longer found foraging over the rocks.

Bokermann & Sazima (1973) described *Hyla machadoi*, later considered as *Scinax machadoi* (Duellman & Wiens, 1992), and pointed out the peculiar coloration of tadpoles (see Figure 7 in Bokerman & Sazima, 1973). However, these authors considered the tadpole colour as cryptic in relation to its freshwater environment. The tadpoles were also considered as nocturnal animals but presenting some activity during the day (Bokermann & Sazima, 1973). Like the naucorids, *S. machadoi* tadpoles present an oval body in dorsal view. The body has a yellowish coloration with two black stripes crossing it. The tail presents some conspicuous dark dots visible mostly when laterally viewed. Most of the time they remain attached to stones or beneath aquatic vegetation. The tadpoles observed herein were observed close to the *Limnocoris porphyrus* bugs, becoming almost impossible to distinguish them for an observer. The bright colour pattern of the tadpoles appeared to vary with age. Younger tadpoles had a more contrasting pattern in relation to the older ones. As individuals grow, the black stripes became larger and the contrast between black and yellow decreased.

Bokermann & Sazima (1973) observed *S. machadoi* tadpoles throughout the year in freshwater habitats of Serra do Cipó. Information on population dynamics and distribution, life cycle, and larval development may elucidate aspects involving a possible coevolution of aposematism. Natural selection acting on larval forms might guarantee the future of the adult forms, that are likely to undergo other selective pressures. Nevertheless, changes in colour pattern may not mean lacking in protection. Although bright colours and patterns may enhance predator learning, experiments using captive birds have demonstrated that cryptic, noxious prey also gains protection against attack, albeit more slowly than conspicuous prey (Sille´n-Tullberg, 1985). Mallet & Joron (1999) argued that any pattern could potentially generate predator avoidance, provided it is recognisable and memorable, even if no conspicuous coloration is involved. Endler & Mappes (2004) argued that conspicuous colours and patterns may have selective disadvantages. Such cases include those where an aposematic species has a specialist predator that can overcome its noxious features or the aposematic species is itself a predator. Wüster et al. (2004) argued that although it is in the signaller's interest to advertise its noxious qualities to a generalist predator, it will also be in its interest to avoid detection by specialist predators and by its own prey.

Despite the phylogenetic distance between *L. porphyrus* and *S. machadoi*, biotic and abiotic factors may create selective constraints that induce these organisms to develop their bright colour pattern. Duping predators can be the main reason for a species to resemble another one. Nevertheless the resemblance between both species is not the only aspect involved in this study but also the aposematic coloration. Mimicry has an adaptive value when a predator learns which species is unpalatable in association with its colour.

That Batesian mimicry could be acting in these organisms is possible if one of the species is palatable and resembles a protected noxious model, followed by an accumulation and selection of characteristics that would progressively refine the mimicry (Nijhout, 2003). However, for Batesian mimicry to be truly accepted it would be necessary that the model organism would be more abundant than its mimic (Joron, 2003). Observations herein indicate that *L. porphyrus* and *S. machadoi* are equally abundant in the sampled streams. Additional collections are needed to quantify their relative abundance throughout a defined period of time. In cases of Batesian mimicry, simulated models have shown that for mimicry to evolve it is necessary that the mimic approaches the model faster than the model moves away and so long as the appearance of the two players is different (Holmgren & Enquist, 1999).

Müllerian mimics are sympatric aposematic species that share the same or similar warning patterns. If a predator learns to avoid a warning pattern of a species by a fixed number of encounters, then Müllerian mimics benefit as fewer individuals of each species would be killed educating naive predators (Skelhorn & Rowe, 2005). If observations described in this paper would be a case of Müllerian mimicry then it is expected that *L. porphyrus* and *S. machadoi* are noxious with similar abundance acting together to advertise noxious qualities to a generalist predator. Skelhorn & Rowe (2005) show that the presence of two defence chemicals in a Müllerian mimicry system enhances predator learning and memory. However, the authors point out that this is only true if the species involved possess different defence chemicals.

Therefore if mimicry is occurring between *L. porphyrus* and *S. machadoi* its proof is still unanswered. We suggest that further investigations must define the system of mimicry and the involved species. If a mimicry system is acting behind the aposematic pattern then observations and laboratory experiments should investigate the predators involved (generalists and specifics) and the lack of bright colour pattern in adult *L. porphyrus*. Tests of palatability and data on relative abundance would greatly further this interesting paradigm.

Voucher specimens of insects were deposited in the collections of the Departamento de Parasitologia, Universidade Federal de Minas Gerais (DPIC, registered in ARNETT et al., 1993); vouchers specimens of tadpoles were deposited in the Herpetological Collection of the Departamento de Zoologia (UFMG).

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Distribution, abundance and habitat preference of an undescribed species of blind snake (Serpentes: Typhlopidae) on Ant Atoll, Federated States of Micronesia

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ABSTRACT - Twenty-eight specimens of an undescribed species of blind snake (*Ramphotyphlops* sp.) have been recorded from Ant Atoll, Federated States of Micronesia since 1999; 25 were collected and preserved, two were captured and released, and another was observed but not collected. All are from Pasa Island and nearly all were found inside rotting coconut logs. None was observed during a search of 26.9 man-hours among the 11 other islands on the atoll during June and July 2009. Food resources (ants and termites) are abundant on all the islands. If the snake is proven to be confined to Pasa, we suggest that potential predators such as rats, cats and pigs, all of which are widely distributed among the islands, are main factors in limiting its distribution on the atoll. Pasa, along with Wolouna, a tiny isolated islet with little suitable habitat for blind snakes, are the only two islands on the atoll where rats (*Rattus* spp.) are unrecorded. The snake remains unknown outside of Ant Atoll, but possibly differentiated elsewhere and colonised Ant from an unknown source.

OVER 200 species of blind snakes (Typhlopidae) are known worldwide, mainly in the tropics and subtropics (McDiarmid et al., 1999). With the exception of *Ramphotyphlops braminus*, a parthenogenetic species endemic to southern Asia that has been widely introduced throughout the world (often in the root masses of translocated plants), none have been recorded in the Federated States of Micronesia (FSM). This study is an assessment of the habitat, distribution and abundance of a recently discovered and undescribed species of *Ramphotyphlops* known only from Ant Atoll, Pohnpei State, FSM. The study is based largely on our two surveys totalling five days during June-July 2009, together with other unpublished sighting and specimen records. The species is currently being described (Wynn et al., pers. comm.).

Ant Atoll is located approximately 15 km southwest of Pohnpei in the eastern Caroline Islands, in the west central Pacific Ocean (Fig. 1). Twelve islands are distributed along a reef surrounding a large lagoon (74 km^2) with a single, deep water channel (Fig. 2). Maximum elevations are only 2.5-3.0 m ASL (U.S. Geological Survey, 1944), the total land area is approximately 1.8 km^2, and Pamuk (0.6 km^2) is the largest island. Coconut forest is the main vegetation type, and coconut (*Cocos nucifera*) is the dominant tree on most of the islands (e.g. Fig. 3a). Other common trees include *Artocarpus* sp., *Barringtonia asiatica*, *Guettarda speciosa*, and *Neisosperma oppositifolia*. Thickets of *Scaevola taccada* and *Tournefortia argentea* form a discontinuous band between the forest proper and the beach; rocky beaches predominate on the ocean side and sandy beaches on the lagoon side. The substrate consists of varying amounts of coral sand with decomposed organic matter along with coral rubble and boulders.

Ant Atoll is privately owned and shared by the Nanpei and Hawley families. Currently, there are no settlements on the atoll, but the islands are frequently visited by hunters, fishermen, and snorkeling and diving enthusiasts from Pohnpei. Ayres et al. (1979) reported a radiocarbon date of AD. 800 ± 100 for a charcoal sample from a fire pit at Imwinyap Island and stated that "site distributions on Ant appear to reflect intensive occupation over a substantial period of time". Galipaud (2001, 2004) found evidence of human occupation in the form of pottery radiocarbon-dated to 2,000 years ago.

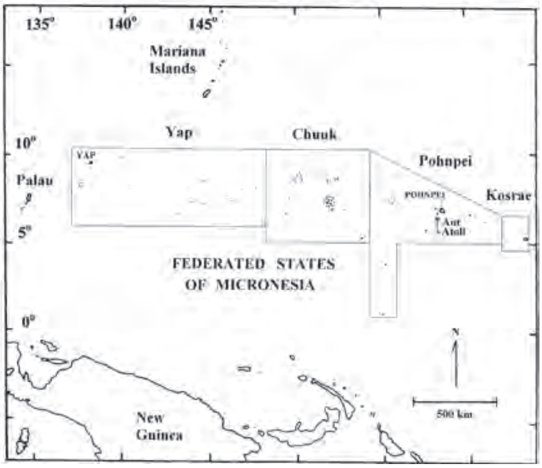

Figure 1. Location of Ant Atoll and the Federated States of Micronesia in the west central Pacific Ocean.

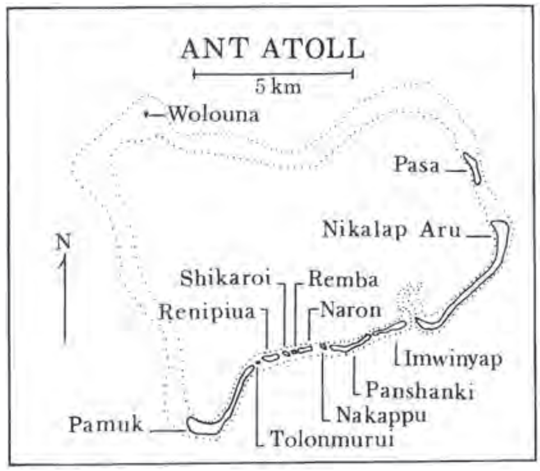

Figure 2. Map of Ant Atoll, showing location of islands.

METHODS AND MATERIALS

Searches were conducted on Pasa, Renipiua, and Shikaroi Islands on 5 and 6 June 2009 and on all twelve islands during 16-18 July 2009. We cut open rotten logs and termitaria, turned over large rocks and solid logs, and looked through piles of *Cocos* trash while walking unpredetermined routes along the long axes of the islands. All islands were surveyed from one end to the other with the exception of sampling being limited to three separate sites in the eastern, central and western parts of Nikalap Aru. Search effort was recorded in man-hours calculated as the sum of the search times (in minutes) contributed by each searcher and divided by 60. In June, we received assistance from several students. Two worked together in close proximity to each other during searches on Renipiua and Shikaroi and their times were treated as a single-person effort. Five people worked together loosely in two teams on Pasa during an 85 minute search and their times were treated as a two-person search effort. The July surveys were conducted solely by the authors, synchronously, but independently, and along parallel routes about 20-50 m apart, except on the smallest islands where such separation was not possible.

Place names are from Bryan (1971), a 1:15000 scale map of Ant Atoll produced by Pohnpei State Land Commission in 1985, and verbal contributions by Pohnpeian residents; alternative names for the islands and variations in spelling are numerous. Island areas are from Bryan (1971) and are based on measurements made prior to 1946 (see United States Commercial Company, Research Section, 1946). A small island (Wachikichiki, 0.77 ha) shown between Imwinyap and Panshanki in Bryan's map has apparently been merged with Imwinyap. We combined the two island areas, but did not add the small area contributed by the narrow filled-in channel between them.

RESULTS AND DISCUSSION

Number of Specimens Recorded

Eight specimens of the undescribed species of *Ramphotyphlops* were found on Ant Atoll during a search effort totaling 34.8 man-hours over a period of five days in June and July 2009. This included all 12 islands. This brings the total number of snakes recorded from Ant Atoll to 28, all of them from Pasa Island. The first was collected by a coconut crab hunter in 1999. Subsequently, a College of Micronesia Marine Field Studies field trip on 30 August 2008, organised specifically to search for the snakes, resulted in 16 additional specimens. Two others were captured, photographed, and released by Danko Taborosi and Maricruz Sanchez Collazo on 28 March 2009, and one other was observed in a termitarium during a search for coconut crabs in April or May 2007 (D. Manglay, pers. comm.).

Distribution and Ecology

The evidence to date suggests that this species

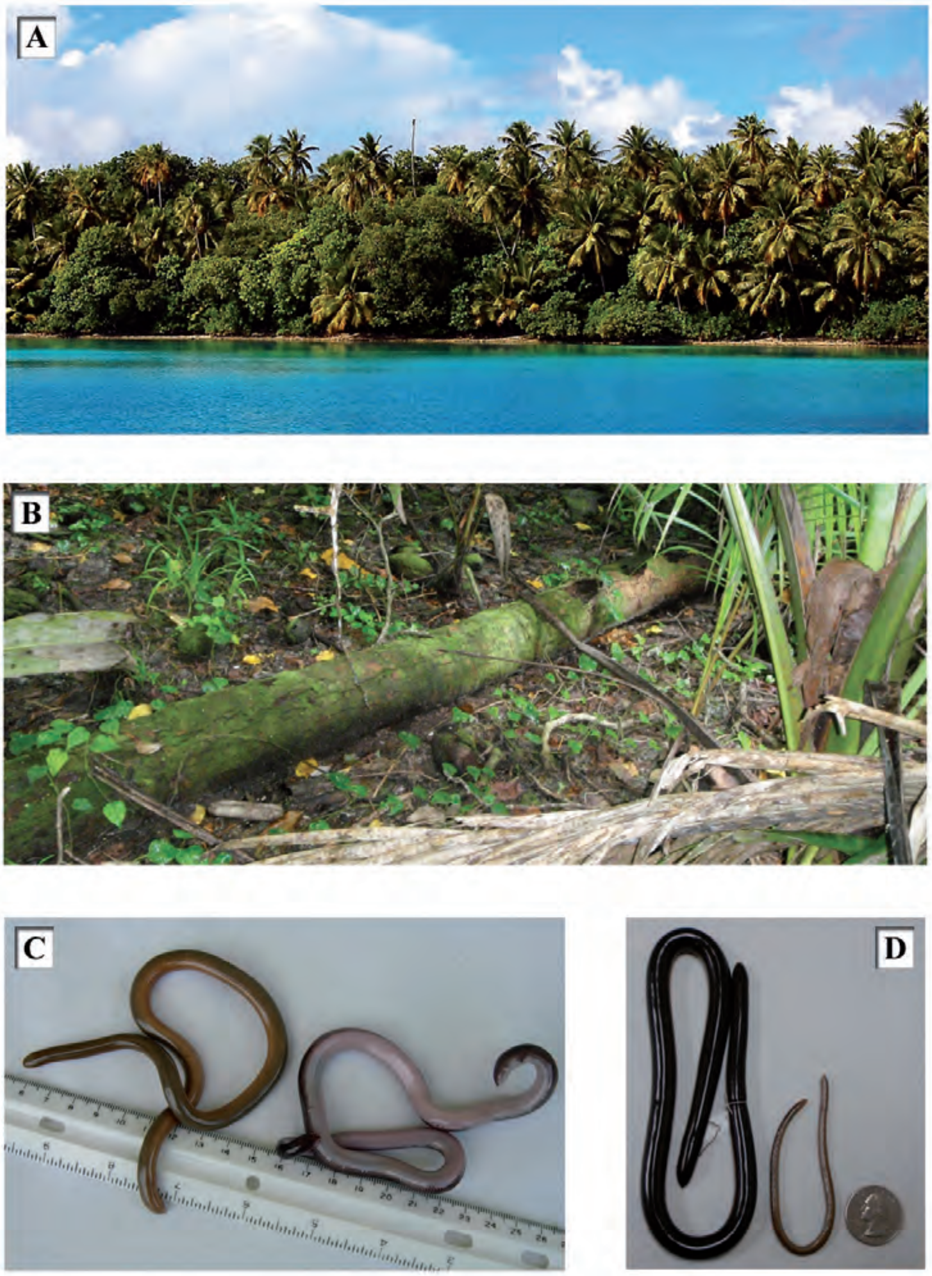

Figure 3. Habitat and habitus of *Ramphotyphlops* sp. on Ant Atoll. A, lagoonside view of Pasa Island [photo courtesy of Danko Taborosi and Maricruz Sanchez Collazo]; B, decayed coconut tree trunk, the preferred habitat of *Ramphotyphlops* sp.; C, living *Ramphotyphlops* sp.; D, preserved specimen of *Ramphotyphlops* sp. (left) and *R. braminus* (right) with U.S. 25-cent coin for size comparison.

is confined to Pasa Island, where our search represented only 22% of the time spent among the 12 islands during the June/July surveys but resulted in 100% of the sightings. All other known sightings of the snake are also from Pasa. However, additional surveys are needed, especially among the larger islands of Nikalap Aru, Imwinyap, and Pamuk, to be able to assess the distribution of *Ramphotyphlops* sp. on the atoll with greater confidence.

Little is known about the ecological requirements of this species that might contribute to its apparently very limited distribution, but lack of food resources is not likely among them. Typhlopid snakes are fossorial and feed almost exclusively on various stages in the life cycles of ants and termites (e.g. Cogger, 2005; Webb et al., 2006). Both ants and termites are abundant throughout the atoll. We encountered numerous termitaria on all the larger islands and observed ants and termites on all the islands. Clouse (2007) recorded 20 species of ants on Ant Atoll (21 if two species of *Tapinoma* are present) and 72 species on nearby Pohnpei Island.

If the blind snake is restricted to Pasa Island, we suggest that a combination of factors that include lack of suitable habitat and presence of potential predators may account for its absence elsewhere on the atoll. With the exception of three or four specimens found under decaying plant debris, all snakes were found inside rotted logs, the interiors of which had decayed nearly to the consistency of soil (Fig. 3b). On some of the smaller islands (e.g. Nakkapu, Naron, Shikaroi, and Tolonmurui) we found no more than 1-4 logs to search, compared with 20-50 logs each on the larger islands such as Pasa, Nikalap Aru, Imwinyap, and Pamuk. Additionally, unlike Pasa, which has predominately sandy soil throughout, many of the islands have large areas of coral rock and rubble, which is less hospitable for burrowing snakes.

Pigs (*Sus scrofa*), cats (*Felis cattus*) and rats (*Rattus* cf. *tanezumi* and *R. exulans*) are among the potential predators of snakes on Ant Atoll (Table 1). Interestingly, Pasa and Wolouna are the only islands where rats are unrecorded. Wolouna is one of the smallest (1.8 ha) and the most isolated of the islands, and has few coconut trees; Marshall (1957) counted only four or five old trees in the

Island	Area (ha)[a]	Search Effort (hr)[b]	Snakes Observed	Potential Predators Rats[d]	Cats	Pigs
Wolouna	1.81	0.31	-	-	-	-
Pasa	18.64	7.9	8	-	Sa	Se
Nikalap Aru	46.61	5.11	-	+/B/M	+/M	+/M/B
Imwinyap	24.08	2.46	-	B/A	+	+
Panshanki	15.53	2.48	-	B	+[e]	+
Nakkapu	4.14	0.28	-	B	-	+
Naron	6.21	0.86	-	B	-	+
Remba	1.03	0.21	-	B	-	+
Shikaroi	0.77	1.18	-	B	-	+
Renipiua	4.92	3.35	-	B	-	+
Tolonmurui	1.29	0.26	-	+/B	-	-
Pamuk	60.86	10.43	-	+/B	+/M	+/M

a. From Bryan (1971); see methods for additional information.
b. Calculated as the sum of the search times (in minutes) contributed by each searcher divided by 60.
c. Sources of records: + = this study, A = Ayres et al. (1979) [bones found at archeological sites], B = Buden 1996, M = Marshall (1957), Sa = S. Santos (in Buden 1996), Se = Harvey Segal (in Buden 1996) [animals were reported present at least into the 1980s].
d. Records pertain to *Rattus tanezumi*, or *R. exulans*, or both.
e. Tracks observed on the beach.

Table 1. Results of searches for *Ramphotyphlops* sp. on the 12 islands of Ant Atoll during June and July 2009, with records of potential predators.

centre of the island. Dominant trees on Wolouna include *Pisonia grandis*, *Terminalia samoensis*, and *Tournefortia argentea*. During our visit, however, many appeared to be dead possibly from storm damage, and the large number of nesting and roosting seabirds usually present on the island were lacking. The soil is a combination of coral rock, rubble and sand, and it potentially has a large nitrogen component from accumulated guano.

Nikalap Aru would appear to be the most likely island on the atoll to share a population of blind snakes with Pasa. It is one of the largest islands on the atoll, the one nearest to Pasa, and it has extensive areas of sandy soil and large numbers of coconut trees. Also, Nikalap Aru and Pasa are the only two islands located on the eastern side of the deep water passage into the lagoon. However, Nikalap Aru has a large number of potential predators. Rats are especially common throughout the island and feral pigs have uprooted vegetation in many areas, leaving behind overturned rocks and turned over soil. Marshall (1957) recorded rats along with domestic cats, dogs, pigs and chickens on Nikalap Aru during his visit in December 1955, when there was a small village that no longer exists.

Behaviour

The behaviour and activity patterns of *Ramphotyphlops* sp. are unknown, although it tends to occur in small aggregations. Most of our specimens were collected in small groups of 2-4, and with a maximum of eight occurring in a single log. Greene (1997) remarked that large colonies of *Ramphotyphlops braminus* sometimes live in rotting wood, and Ehmann & Bamford (1993) gave examples of aggregation behaviour in two other species of Australian typhlopids, which they believe as being related to mating activity.

Colonisation and Possible Modes of Dispersal

The origin of *Ramphotyphlops* sp. on Ant Atoll is uncertain, but given the young ages of Pacific atolls it is more likely a relatively recent colonist as opposed to an ancient autochthon. During the last glacial maximum, ca 20 ka, when sea level was estimated at about 120 m below present level (e.g. Peltier, 2002), Pacific atolls were broad, steep-sided subaerial limestone plateaus (Dickinson, 2004, 2009). Post-glacial eustatic rise in sea level drowned the platforms by 8-9 ka (Dickinson, in litt.) and reached a highstand 1.6-2.6 m above present level about 4,000 years ago (Dickinson, 2003, 2004, 2009). Transient sand cays may have existed at different times and at different locations throughout the Holocene (Dickinson, 2004, 2009), but it is unlikely that sufficient (if any) habitat would have been available to sustain a population of fossorial snakes during this time of extensive flooding. Ray and Connell (1991) reported that radiocarbon dates of material from supratidal parts of atolls are mostly less than 4,000 years, and Richmond (1993) similarly reported that atoll islands were less than 4,000 years old. Furthermore, Dickinson (2004, 2009) remarked that present day atoll configurations of stable, "pinned" islands have an even more recent timeline of about 1-2 ka, dating from when ambient high tide fell below mid-Holocene low tide level and the emergent palaeoreefs formed a protective barrier forestalling erosion.

Although it is known only from Ant Atoll, *Ramphotyphlops* sp. was possibly more widespread in the past and may have since been extirpated throughout most of its range, leaving a relict population on Ant. Small peripheral or satellite islands may be refugia for species extirpated on the mainland or on adjacent large islands (Perry et al., 1998). Alternatively, *Ramphotyphlops* sp. may still be extant elsewhere, either broadly distributed or in a few disjunct populations, but undiscovered owing to rarity, remote locations, lack of concerted search, or combinations thereof. On geographic grounds, Pohnpei, the nearest high island would be a likely source for the Ant Atoll population. With the exception of *Ramphotyphlops* sp., the terrestrial vertebrate fauna of Ant Atoll is a subset of more broadly distributed species, all of which occur on Pohnpei (Buden, 1996). However, this snake is unknown from Pohnpei, and, given the amount of excavation on the island (farming and construction), its presence is unlikely to have gone unnoticed. The possibility of its presence in the more distant past should not be completely discounted. Whether it arrived by natural dispersal (e.g. drift logs), or by human assistance is also a matter of conjecture. Possibly it was transported to Ant by early aboriginal colonists from more distant areas via Pohnpei or other islands, or by more recent visitors including those in the wake of European exploration. Pregill (1998) recorded fossils of *R. braminus* in probable pre-cultural strata in the Northern Marianas thus suggesting it is indigenous, though Pregill and Steadman (2009) pointed out that chronology could be skewed if these burrowing snakes penetrate older strata. DNA studies on Pacific populations of *Ramphotyphlops* spp. in progress will likely shed light on the phylogeography of the Ant Atoll population as well as on other disparate populations of typhlopids in the Pacific (Fisher, pers. comm.).

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On terrestrial hunting by crocodilians

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CROCODILIANS are generally considered to be specialised predators hunting in the water or at the water edge (Neil, 1971). Their terrestrial activities such as nesting, migrating, aestivating/hibernating and basking are well known and documented in most overviews of crocodilian biology. Despite abundant anecdotal evidence of terrestrial hunting (mostly in the form of scary campfire stories), this aspect of crocodilian behaviour has never been studied nor scientifically described. Observations made during a study of crocodilians in the wild in 2006-2010, mostly on American alligator (*Alligator mississippiensis*), Nile crocodile (*Crocodylus niloticus*), and to a lesser extent on other species, suggest that terrestrial hunting may be more common than previously thought.

American Alligator (*Alligator mississippiensis*)

Alligator attacks on humans sometimes occur away from water. At least 3 of 13 fatal attacks recorded in the US in the last 10 years happened on land. A 28-year-old woman was apparently attacked by a 3 m alligator while jogging at night along a trail atop a 2 m high dyke parallel to a canal (Harding & Wolf, 2006). An 81-year-old man was attacked by a 3.5 m alligator while walking his dog on a trail at night (Florida Fish and Wildlife Conservation Commission, 2009). A 54 year old woman was attacked by a 4 m alligator while working in her garden 25 m away from a pond (Yarrow, 2008).

During night time observations in southern Florida in April-October of 2006-2010, American alligators 1.5-3.5 m (all sizes were visually estimated) were occasionally observed lying motionless for many hours at the edges of forest roads and public trails (Fig. 1). In some cases the alligator's snout protruded 30-70 cm onto the road, and in one case a 2 m alligator was lying across a narrow trail, completely blocking it. During approximately 200 hours of walking and driving along trails and backcountry roads, such behaviour was observed in Big Cypress National Preserve (n=25), Everglades National Park (n=30) and adjacent private lands (n=13), Fakahatchee Strand National Preserve (n=9), Arthur R. Marshall Loxahatchee National Wildlife Refuge (n=7) and Picayune State Forest (n=1). One such observation was made just 20 minutes after sunset, but on all other occasions animals were observed by roadsides at night. The longest distance from the water edge to the road/trail was 50 m, but in most cases the animals were less than 10 m from water.

When approached by foot, most alligators remained motionless until the observer or the car was 1-2 m. At closer than 1-2 m, they slowly moved into surrounding vegetation or the water. Although the attacks mentioned above might seem to indicate otherwise, American alligators, especially those less than 3 m long, very rarely display predatory behaviour toward people, and tend to avoid close contact (Neil, 1971). However, approximately one quarter of the animals in this study did not move away and thus it was sometimes necessary to walk or drive around them in a circle. One large (>3 m) alligator made a swift turn towards the observer when approached to about 1-1.5 m, and slapped its jaws. One 2 m long animal held and then consumed a Virginia opossum (*Didelphis virginianus*).

On October 7 and 8, 2006, twelve alligators were counted along the edge of a 24 km road (Shark Valley Road, Everglades National Park) on a clear night with full moon, between 21:30-06:00. Ten animals were positioned at an angle to the road edge in such a way that only their heads and sometimes chests were on the pavement. The other two were lying parallel to the road just off the pavement. No alligators were located entirely on the pavement or more than 1 m outside the pavement. The distance from the edge of pavement

Figure 1. American alligator (*Alligator mississippiensis*) on a roadside at night. Everglades National Park (Florida, USA).

to a canal located parallel to the road was mostly 2-3 m (up to 10 m at some locations). This road was closed to vehicles at night and there was no foot or bicycle traffic at the time of observation.

In May-June of 2008-2009, alligators were observed lying on roadsides at night in other parts of American alligator's range: twice in Ocala National Forest (northern Florida), twice in Aransas National Wildlife Refuge (Texas), and once in Cat Island National Wildlife Refuge (Louisiana).

My initial assumption was that this behaviour was possibly performed by individuals either migrating from dried-up ponds and channels, or using warm road surfaces for thermoregulation. However, many alligators moved to the roads from lakes and channels >1 m deep. Some animals spent hours lying near a road/trail and never attempted to cross it, but instead returned to the water before dawn. This behaviour was recorded on both warm (25-30^{o}C) and cool (17-25^{o}C) nights. Alligators were almost always observed on roadsides, not on the pavement where the surface would likely be warmest.

To check if thermoregulation was the reason for such behaviour, temperatures were measured at night during April 17, 2010 on a narrow paved road with no night time traffic at Merritt Island National Wildlife Refuge (Florida). A 2.5 m alligator, that apparently had emerged from a brackish lagoon 3 m from the road, was found at 23:05 lying in low, sparse grass on the roadside, with its head on the gravel-covered road shoulder. Temperatures of the water in the lagoon, the air, the pavement, the gravel road shoulder and the soil under the grass were taken using a Rayteck™ RAYMT6 infrared thermometer and a mercury thermometer every hour until the animal returned to the water. The results (Table 1) showed that when the animal was found, the temperatures of all land surfaces were not greatly different from the air temperature, and

	Thermometer Type	**Time of day**			
		23:10	00:10	01:10	02:10
Air 1 m above the road	mercury	21	20.6	20.1	19.7
Water surface in the lagoon	infrared	23	23	22	22
Lagoon water at 5 cm depth	mercury	23.5	23.2	22.8	22.2
Road pavement	infrared	22	21	21	20
Gravel on the road shoulder	infrared	21	21	20	20
Soil near the road	infrared	21	20	20	20

Table 1. Temperature readings (^{o}C) recorded when an American alligator was observed lying near a paved road 3 m from the shore of a brackish lagoon. Infrared thermometer - accurate to 1^{o}C and a mercury thermometer - accurate to 0.1^{o}C. Merritt Island National Wildlife Refuge (Florida, USA).

lower than water temperature. They also showed that the pavement was warmer than the gravel or soil on which the animal had positioned itself.

Crocodilians need to dry their skin regularly to get rid of parasites and algal growth (Huchzermeyer, 2003). Interestingly however, Alligators were frequently observed on roadsides during nights characterised by high relative humidity and abundant dewfall, conditions that arguably may have promoted algal or fungal growth on skin. Alligators at all sites were basking for many hours in late morning and early afternoon, at which time all or almost all adult animals would be out of water. These basking times could be sufficient for skin care. A reasonable alternative explanation is that alligators lying on roadsides and trails are attempting to ambush terrestrial vertebrates. All observed animals were >1.5 m, possibly because smaller alligators would risk predation if they moved further from water at night. Note that two of three aforementioned fatal attacks on humans occurred on trails during the night.

Nile Crocodile

Pooley (1982) mentioned his observation of two Nile crocodiles carrying a recently killed Nyala (*Tragelaphus angasii*) overland, but it was not clear if the animal had been killed on land.

In September 2008 in South Luangwa National Park (Zambia), at 02:15, I observed a 2.5 m Nile crocodile unsuccessfully chase a juvenile Bushbuck (*Tragelaphus sylvaticus*) for 5-6 m across a dry, elevated river terrace at least 100 m from the water edge. Interviews with local hunters, safari guides and game rangers suggested that Nile crocodiles are occasionally seen on roadsides during night drives in South Luangwa and Lower Zambezi National Parks (Zambia), Mudumu and Mamili National Parks (Namibia), Chobe and Moremi National Parks (Botswana), Lilongwe National Park (Malawi), and Murchison Falls National Park (Uganda).

I have observed terrestrial behaviour at the Oromo River Delta, Ethiopia (n=1 in 44 hours of nocturnal searching), Mahango Game Reserve, Namibia (n=2 in 56 hours of nocturnal searching and driving), and at Simangaliso Wetland Park, South Africa (n=1 in 6 hours of nocturnal searching). Terrestrial behaviour on these occasions was always by crocodiles of between 2-3.5 m. In the latter case, a 2.5 m long crocodile was observed catching and swallowing a large toad (Bufonidae) as it was moving along the trail. Once located, each crocodile was observed for 20-30 min to see if it would start moving, but no attempts to change location were ever seen. The fact that predation attempts were seen twice in less than 2 hours of observing Nile crocodiles on land at night suggests that terrestrial hunting is possibly an effective alternative hunting strategy.

Other Crocodilian Species

In August 2009, local residents in a suburb of Sorong (West Papua Province, Indonesia) reported that a dog had been taken during previous night by a large saltwater crocodile (*Crocodylus porosus*) from a trail 25 m from the water edge. The witnesses claimed that the dog had been following a group of people, who passed by the crocodile and did not notice the reptile until it attacked the dog.

Mugger crocodiles (*Crocodylus palustris*) were observed far from water twice in 68 hours of night time observations. In January 2007 in Kateraniaghat Wildlife Sanctuary (Uttar Pradesh, India), a 3 m *C. palustris* remained on the side of a game trail 30 m from a forest pond for 3 hours during the second half of a night, while the air temperature dropped to 12°C. In the same month in Sasan Gir National Park (Gujarat, India), two 2-2.5 m animals were observed on the side of a trail following a small permanent river, also on a cold (14-16°C) night. They were approximately 100 m apart.

A 2.5 m American crocodile (*Crocodylus acutus*) was observed on three consecutive nights in March 2006 at Everglades National Park, lying just outside the pavement of a parking lot, where its tail and body were concealed by mangrove vegetation. It was approximately 12 m away from the water edge.

A nocturnal observation of an Orinoco crocodile (*Crocodylus intermedius*) near a trail far from water was made at Rio Capanaparo, Venezuela (J. Thorbjarnarson, pers. comm.).

In August 2007 at Caranambu Ranch (Rupununi, Guyana), a 2.5 m black caiman (*Melanosuchus niger*) was observed for 2 hours as it was lying at the side of a trail 15 m from water, in a location frequently used for river access by domestic and wild animals.

However, such behaviour has never been observed during hundreds of hours of night time observations of three smaller species: Yacare caiman (*Caiman yacare*), spectacled caiman (*Caiman crocodilus*), and broad-snouted caiman (*Caiman latirostris*) in South America. On a few occasions when these animals were seen at night >5 m from water, they were actively moving in the direction of a nearby body of water.

During a study in Costa Rica, Grant et al. (2008) observed spectacled caimans of all sizes frequently moving overland between temporal ponds in the forest, apparently in pursuit of fish trapped in those ponds, but with no evidence of hunting terrestrially.

Magnusson & Lima (1991) found that radiocollared Cuvier's dwarf caimans (*Paleosuchus trigonatus*) spent considerable amounts of time away from water. These animals apparently used shelters deep in the forest rather than hunted on land.

According to hunters in Okoyo (Congo) and rangers in Korup National Park (Cameroon), central African dwarf crocodiles (*Osteolaemus tetraspis*) also use den sites in the forest far from water. None of the interviewed claimed any knowledge of dwarf crocodiles hunting on land.

Unsurprisingly, there seems to be a lack of data on terrestrial hunting by specialised piscivorous species – slender-snouted crocodile (*Mephistops cataphractus*), false gharial (*Tomistoma schlegeli*) and Indian gharial (*Gavialis gangeticus*). The latter is not as agile on land (Neil, 1971).

It appears that terrestrial hunting is a regularly occurring behaviour in large omnivorous species of crocodilians. Other species leave water to nest, den, bask, or move between aquatic habitats, but there are no observations yet that prove they hunt on land.

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Artificial retreats for restoration of Grand Cayman blue iguanas to the wild: a report to the British Herpetological Society (BHS)

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THE endemic Grand Cayman blue iguana, *Cyclura lewisi*, is the most endangered of the West Indian rock iguanas, having reached functional extinction in the wild by 2002. Once native in coastal and dry shrubland habitats throughout Grand Cayman, it had declined severely by 1925, as a result of the introduction of dogs, cats and rats, and the colonisation of coastal habitats by humans. By 1993 the population was estimated to have declined to around 150-200 individuals, and by 2002 that number had further plummeted to 10-25 individuals.

The Blue Iguana Recovery Programme was established as a self-contained programme of the National Trust for the Cayman Islands in 2002. It evolved from captive breeding and research efforts commenced by the Trust in 1990, forming significant international partnerships after a workshop to develop the first Species Recovery Programme for the blue iguana. This was held on Grand Cayman in 2001 with the IUCN-SSC Iguana Specialist Group.

The Queen Elizabeth II Botanic Park (QEIIBP) on Grand Cayman continues to be an ideal site to pilot techniques to restore Grand Cayman blue iguanas to the wild. Although the 26 ha site is too small to sustain a genetically viable wild population in isolation, a managed, free-roaming breeding population has been established there (from captive bred stock), since 2001. Easy access throughout the QEIIBP combined with the presence of the Blue Iguana Recovery Programme's two Blue Iguana Wardens provide an excellent opportunity to test techniques which can subsequently be used for large-scale population restoration in the Salina Reserve and other areas on Grand Cayman.

The use of artificial retreats for blue iguanas was first developed in the QEIIBP, arising from observations of iguanas released there and the unexpected preference they showed for retreats in artificial structures rather than natural rock holes. By 2004 a series of experimental designs led us to a "Mark 5" wood retreat for two-year-old iguanas which showed remarkable efficacy in anchoring newly released iguanas within the (unfenced) protected habitat, and also providing some protection from predators. This retreat design was used (sized for two-and three-year-old iguanas) in subsequent large scale releases in the Salina Reserve. It has become apparent over the years that natural retreats of suitable configuration for various ages of iguanas are a significant factor limiting population density both in the QEIIBP and the Salina Reserve.

The purpose of the current BHS Captive Breeding Committee funded project was to design and investigate the use of retreats with both younger and older age groups, to help manage the increasing numbers of wild hatched juveniles, and to aid in retention of the Park's older breeding iguanas as they outgrow the existing Mark 5 retreats.

Hatchling Retreats

Observations on the behaviour of newly emerged *Cyclura lewisi* hatchlings (Fig. 1) are extremely sparse, as indeed are such observations for any *Cyclura* species. The first few months of life are characterised by extremely low observability, and radio tracking studies are limited in value due to possible effects of transmitter weight on escape acceleration during snake strikes.

What little information as was available at the start of this work indicated that hatchlings spend the majority of their time in trees, so it was hypothesized that they would be more likely to adopt arboreal retreats than simulated rock holes. A simulated tree hole retreat was developed that could be strapped to tree branches using cable ties. The retreat was initially fashioned from a piece of driftwood, split lengthways and carved internally to provide a straight resting space and a turning chamber, dimensioned to an average sized hatchling. We molded the resulting 2-piece retreat in rubber, supported by a fibreglass shell, and poured the production retreats using a lightweight concrete (vermiculite, Portland cement and a minimal amount of sand).

In September 2006 twelve of these retreats were installed in trees along the QEIIBP woodland trail, and a single hatchling was released in each. The retreats, and as many wild hatched hatchlings as we were able to, were then monitored over the following 2 weeks.

The results were opposite to the known success of the Mark 5 two-year-old retreats. No hatchlings returned to their arboreal retreats after their first day in the wild, and no other wild hatchlings occupied them subsequently. All hatchlings observed spent every night resting camouflaged on exposed tree branches, anywhere between 2 and 10 m off the ground. None showed any sustained interest in tree cavities or other enclosed spaces, even during rainy conditions.

It was concluded that hatchlings did not use enclosed retreats in the way older age classes did, and so artificial retreats may have no role in maximizing population density or controlling dispersal of this age class. Preliminary observations suggested that the iguanas may move down to the ground and start occupying rock holes from approximately 5 months of age.

Yearling Retreats

In November 2006 a "Mark 6" retreat design was developed, specifically sized for yearlings (Fig. 2). It is da modified version of the standard Mark 5 design, made by curving the sleeping passage to produce a more compact unit. The master was created using a combination of clay and natural rocks, so that the exterior form would blend into the natural terrain. Again, molds were created from the master using rubber and fibreglass, and poured production units in lightweight concrete.

A series of these Mark 6 retreats were placed in the QEIIBP in January 2007. By July one of the five 2006 hatchlings still regularly seen in the Park was occupying one of these Mark 6 units, while the other four were occupying natural rock holes. It has become apparent that these smaller iguanas are able to find suitable natural rock holes more easily than larger ones, so retreats of this size have proved to be far less important.

Adult Retreats

Retreat availability for mature iguanas in the QEIIBP is undoubtedly a severe limit on population density. The few rock hole retreats in the QEIIBP which are used by adult iguanas, flood seasonally and so are periodically abandoned. Retreats in accidentally suitable man made structures (for example under enclosed steps, in cavities under shipping containers, in spaces between stacked utility poles, and under a pile of discarded doors) are used year-round and form the centres of stable territories. After deaths or territorial takeovers, new iguanas occupy and defend the same retreats just vacated by their predecessors. By 2006 the oldest of the QEIIBP's free roaming iguanas had all outgrown the Mark 5 and other prototype retreats used for releasing two-and three-year-old iguanas and several were becoming more rarely seen as they shifted their territories outside the QEIIBP boundaries. Increasing the availability of suitably sized artificial retreats seemed likely to be effective in increasing the number of adults able to coexist within the protection of the Park.

Two alternative designs were built and tested in 2006/2007. One was a scaled-up version of the standard Mark 5 wooden retreat. Three of these were placed in the QEIIBP and were in use at the time of writing, though we now plan to relocate them to sites with better micro-environments. At this scale the Mark 5 design is visually very intrusive, which is undesirable given the role of the QEIIBP in displaying Cayman's natural environment to the public. Burying these retreats would greatly shorten their life expectancy, since they would remain damp for long periods and soon start to rot. Therefore a "Mark 7" retreat was designed in concrete, suitable for burying in soil or loose

Figure 1. Hatchling Grand Cayman blue iguanas, *Cyclura lewisi*.

Figure 2. Yearling Grand Cayman blue iguanas, *Cyclura lewisi*.

rocks. This design used a 'tennis racket frame' configuration to minimize the surface area occupied by the retreat and to limit the volume of concrete needed. A single entry leads to a looped sleeping passage that allows the iguana to enter and exit head first (Figs. 3 and 4).

A cast test unit in the third-smallest size (size C) for this model was built in December 2006, and deployed next to an existing retreat which was in use by a roaming female. This iguana was using a cavity in a pile of concrete building blocks, but was close to outgrowing it. She took up residence in the new retreat the first night it was available to her, showing a clear preference over the long established concrete blocks' cavity. Some weeks later she was displaced from the new retreat by the dominant male in the area, and had to return to the concrete blocks' cavity. Clearly the design was attractive enough to be worth competing for, and so can be considered a success (Fig. 5).

Figure 3. Looped sleeping passage of Mark 7 artificial refuge. ▲

Radio-tracked adult breeding Grand Cayman blue iguanas, *Cyclura lewisi*. ◀ ▲

Figure 5. Roaming *Cyclura lewisi* showing a keen interest in the artificial refuge. ◀

Figure 4. A prepared, covered and ready to use artificial refuge. ▲

A majestic adult male Grand Cayman blue iguana, *Cyclura lewisi*. ◀

Mass Production and Deployment

The final phase of this project has been to cast and deploy more of the smaller Mark7 retreats (sizes C, D and E), and to commence building molds and casting components for additional sizes of the same model. The local branch of the structural engineering company Halcrow-Yolles provided technical advice leading to selection of a high performance cementaceous grout (Sika 212 Grout) in place of concrete for casting the new larger retreats. This enabled a modified design to minimize wall thickness, and therefore reduce weight. Minimizing retreat weight is crucial for backpacking the larger retreats into remote areas.

The first mold for each size was built in-house, and cast to ensure its performance and accuracy. The mold was then passed to a local fibreglass workshop where a fibreglass "master" copy was created and used as the basis for manufacturing three to five more production molds for each retreat size. Costs at this stage surpassed the BHS grant but we were fortunate to gain additional grant funds for this work, from a local reinsurance company, Greenlight Re.

At the completion of this project, volunteers are now pouring two to three new retreats per day for ongoing deployment in the QE II Botanic Park (both for the wild population and for captive breeding pens where upgraded retreats were also needed); and also into the Salina Reserve where iguanas released as three-year-olds in 2004 are facing the same limitations as we had observed in the QE II Botanic Park.

As expected, the thin-walled final production model required covering with rocks or other naturally available thermal insulation to prevent overheating inside. This also disguises the retreats which is desirable anyway, for reasons relating to tourism and aesthetics. With that requirement met, the retreats deployed in the Park are being taken up readily by free roaming iguanas, and the Salina deployments are expected to perform equally well.

Direct measurement of the effect this retreat deployment will have on the overall long-term carrying capacity of the two sites will now require several years of monitoring. Early indications are very positive, and this work positions us very well for the anticipated first iguana releases into a new protected area on Grand Cayman, in 2010.

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Changes in relative abundance of the western green lizard *Lacerta bilineata* and the common wall lizard *Podarcis muralis* introduced onto Boscombe Cliffs, Dorset, UK

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ABSTRACT - Introduced populations of *Lacerta bilineata* and *Podarcis muralis* were discovered on Boscombe cliffs in 2002. Since then both species have been breeding successfully. This investigation plotted their territory in 2007 and compared their population trends with that of the native *Zootoca vivipara*. Fifteen survey visits were undertaken between April and September 2007 during which time observations were made of 214 non-native and 44 native lizards. The two introduced species dominated the central area of the site with the native species found in substantial numbers only on the periphery. Comparison with previously collected survey data show that the relative abundance of non-native species has increased; between 2002 and 2007 *P. muralis* increased by 40% and *L. bilineata* by 36%; compared with *Z. vivipara* which declined by 75%. Sufficient habitat favourable to the introduced species means that there is the potential for unimpeded range expansion along the cliffs, which raises concern for a sand lizard *Lacerta agilis* population to the west of this site. Eradication of the non-native species may be impractical because they occur on a relatively inaccessible cliff face.

THE second leading cause of biodiversity declines, after loss of habitat, is the impact of introduced species (Meffe et al., 1997). There are numerous examples from around the world of destruction caused by introduced herpetofauna (Savidge, 1988; Patrick, 2001). Great Britain, too, has its own history of non-indigenous reptiles in the wild. Beebee & Griffiths (2000) list six reptile species that are known escapees or releases in the UK.

The two species of lacertid introduced at Boscombe, Bournemouth (50°43'N, 1°49'W) are the common wall lizard (*Podarcis muralis*) and the western green lizard (*Lacerta bilineata*) (Gleed-Owen, 2004). Both of these species occur naturally on the northwest coast of France, where they are at the northern edge of their range (Arnold & Ovenden, 2002). There is no fossil evidence to suggest that they colonised Great Britain after the last glaciation. Genetic analysis indicates that Boscombe populations of both species originated from northern Italy close to the Slovenian border (Deichsel et al., 2007). The viviparous lizard (*Zootoca vivipara*) is the only native lizard found within the survey area, although a population of sand lizards (*Lacerta agilis*) is present west of this site. There have been numerous, deliberate attempts to introduce *L. bilineata* and, more frequently, *P. muralis* into Great Britain with varying degrees of success (Quayle & Noble 2000; Wycherley & Anstis, 2001; Lever, 2009). *P. muralis* has proved to be a successful coloniser in other countries, too (Münch, 2001; Walker & Deichsel, 2005; Allan et al., 2006; Burke & Deichsel, 2008). *L. bilineata* has become established in Kansas, USA (Gubanyi, 2000; Burke & Deichsel, 2008).

Since the discovery of the introduced lacertids in 2002, surveys have been undertaken annually with differing degrees of survey effort (C. Gleed-Owen, pers. comm.). The current study aimed to determine the recent extent of the range of introduced *P. muralis* and *L. bilineata*, to determine habitat preferences and possible impacts on *Z. vivipara*.

METHODS AND MATERIALS

The survey location was selected around the suspected introduction site for both *P. muralis* and *L. bilineata*. A preliminary visit to the site determined where suitable habitat was located

Figure 1. An aerial photograph of the survey site (outlined) showing locations of sightings of *Lacerta bilineata* (green dots), *Podarcis muralis* (yellow dots) and *Zootoca vivipara* (brown dots).

and this information was transposed onto an aerial photograph. Suitable habitat comprised mature gorse (*Ulex europaeus*) thickets, marram grass (*Ammophila arenaria*) tussocks and herbaceous vegetation covering the cliff edge. Between these habitat patches comprised open, short sward grassland which is unfavourable for the species in question. A transect was plotted to cover as much of the suitable habitat as possible and 15 surveys were carried out from April to September 2007. For each lizard observed, location was recorded using a hand-held global positioning system (GPS). Four age cohorts were identified: neonate (juveniles born in 2007), juvenile (less than a year old, but excluding neonates), immature (over one year but not showing full adult markings) and adult. When species identification could not be made positively, sightings were not recorded. Lizard sightings were plotted onto the geographical information system software MapInfo© to illustrate the number of individuals seen and their location within the survey area (Fig. 1).

Historical data of lizard sightings between 2002 and 2006 were supplied by the Herpetological Conservation Trust (now Amphibian and Reptile Conservation). These records are, however, random sightings rather than data gathered during systematic survey.

RESULTS

During fifteen surveys two hundred and fifty-eight lizard sightings were recorded. (*L. bilineata* n = 104, *P. muralis* n = 110, *Z. vivipara* n = 44). For a clearer geographic representation thematic maps were generated in MapInfo©. The survey area was arbitrarily split into polygons with smaller polygons near the centre where the greatest concentrations of sightings occurred (Fig. 2). These maps show *Z. vivipara* at the periphery of the survey area, whilst higher counts of both *L. bilineata* and *P. muralis* are concentrated around the centre.

The numbers of juveniles observed (Table 1) suggest that *L. bilineata* and *P. muralis* reproduced successfully the previous year, although in 2007 *Z. vivipara* showed the highest breeding success; there were no observations of juvenile *L. bilineata* and few *P. muralis* from that year.

Examination of the historical and current data reveals changes in the relative abundance of *Z. vivipara* and introduced lacertids (Fig. 3). In 2002 *Z. vivipara* made up 93% of all lizard sightings (mean 5.29 sightings per survey visit) but in 2007 this decreased to 17% (mean 2.93 sightings per survey visit). *L. bilineata* rose from 33% of all sightings in 2003 (no observations of this species were made in 2002) (mean 1.45 sightings per survey visit) to 40% (average 6.8 per survey visit) in 2007 and *P. muralis* increased from 7% in 2002 (mean 0.43 per survey visit) to 43% in 2007 (mean 7.47 per survey visit).

DISCUSSION

Analysis of data has revealed that both *L. bilineata* and *P. muralis* are firmly established at Boscombe

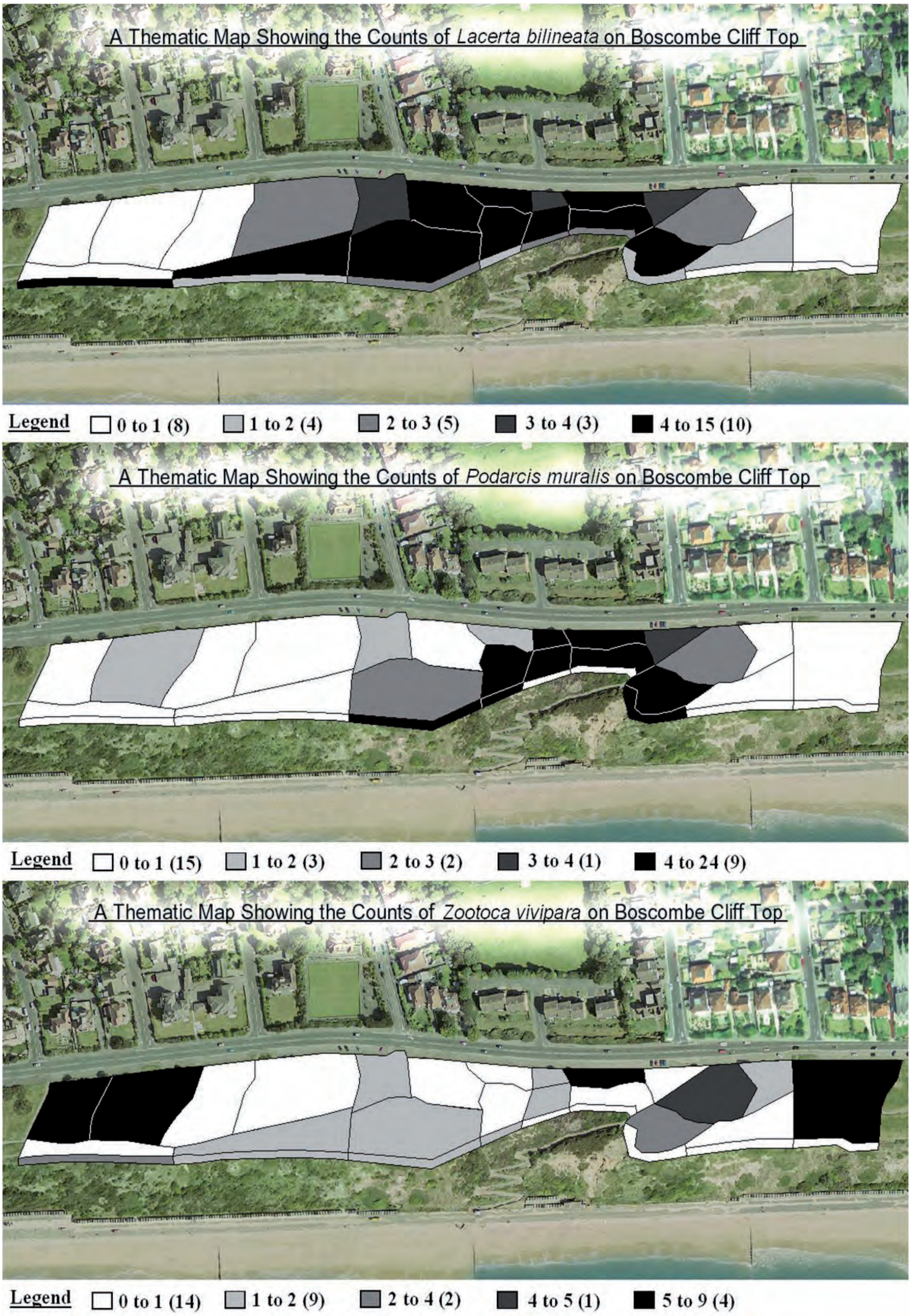

Figure 2. Thematic maps of (top) *Lacerta bilineata*, (middle) *Podarcis muralis*, and (bottom) *Zootoca vivipara* counts. Numbers in brackets indicate frequency of counts.

Species	Born/hatched 2007	2006	Immature	Adult	Total
Zootoca vivipara	7	2	5	30	44
Lacerta bilineata	0	11	7	84	102
Podarcis muralis	4	18	12	78	112

Table 1. Age cohorts of lizards observed in 2007.

and have been breeding successfully and increasing their range since their introduction in 2002. The optimal habitat within close proximity to the survey site, for all three lacertid species, is likely to be the cliff face, which is south-facing, at a 45° angle, supporting heterogeneous vegetation interspersed with patches of bare sand. *L. bilineata* is most likely moving along the cliff face and spreading from there onto the cliff top, as indicated by the distribution to the west of the site where it has colonised the marram grass verges to the path adjacent to the cliff edge (Fig. 1). *L. bilineata* is more widely distributed over the study area than *P. muralis*. *P. muralis* has not spread far along the cliff top from the original introduction site. Short distances between gorse patches have been traversed, but not longer distances, over open ground. Nevertheless, additional sightings of *P. muralis* have shown that it has spread further west, and east, of this investigation's boundary, along the cliff face.

It may be argued that the current observations were biased towards seeing *L. bilineata* and *P. muralis* due to the time of day and relatively warm air temperatures under which the surveys were completed i.e. warm sunny days that were ideal for both introduced species. Previous data were collected, however, with the intent of observing non-native species, too. So past observations, and those of this investigation, were conducted under similar conditions, making data comparable.

There are data suggesting that introduced *P. muralis* competitively exclude *Z. vivipara* when the latter is present at a low population density (Münch, 2001). The changes in abundance of introduced lacertids and *Z. vivipara* in the current study are consistent with interspecific competition, as are the thematic distribution maps, which indicate that *Z. vivipara* has been forced to the periphery of the site (Fig. 2). Fig. 4, showing the west of the survey site in 2004 and 2007, demonstrates the displacement of *Z. vivipara* from the centre of the survey area

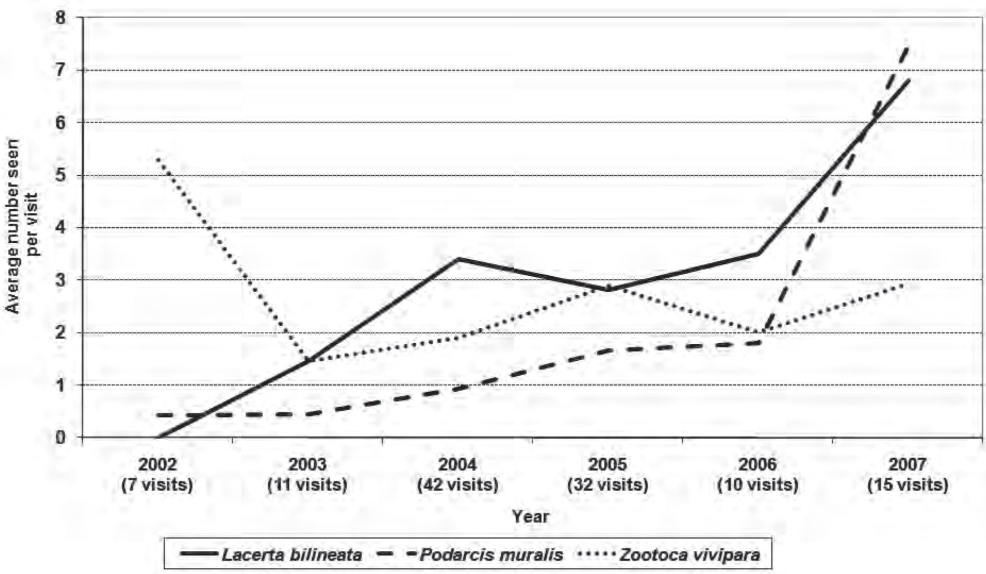

Figure 3. The average numbers of *Lacerta bilineata*, *Podarcis muralis* and *Zootoca vivipara* seen per visit from 2002 to 2007.

Figure 4. Map showing the displacement of *Zootoca vivipara* (brown dots) by *Lacerta bilineata* (green dots) between 2004 (top) and 2007 (bottom).

towards the periphery over this time period.

Climate is likely to affect the future relative success of the lacertids studied. Viviparity gives *Z. vivipara* an advantage in colder climates as it can reproduce more successfully even under poor summer conditions (Uller & Olsson, 2003), but climate change may favour the two non-native lacertids, increasing incubation success, possibly increasing their competitive impacts on *Z. vivipara.* Colonisation of new areas by the non-native species does not bode well for *Z. vivipara*, nor for the *L. agilis* population further to the west, where it is present only in small numbers.

In 2007 three surveys were conducted in September, when juveniles may be expected to be evident. However, no *L. bilineata* juveniles were recorded and very few *P. muralis*; in contrast to juvenile *Z. vivipara* which were seen in greater numbers (Table 1). This contrasted with the sightings of first year juveniles; of lizards presumed to have hatched in 2006 (which was an especially dry summer), both *L. bilineata* and *P. muralis* were more abundant that *Z. vivipara*. If climate change brings hotter, drier summers it seems likely that recruitment among the non-native populations will continue to be successful and increase, leading to territory expansion, but if summers turn wetter they are unlikely to fare as well.

The cliff habitat from Poole Harbour eastwards to Hengistbury Head is similar to that adjacent to the current study area, providing ample potential habitat for the non-native lacertids. It was however apparent that there were some areas avoided by the non-native species. When a map of vegetative structure is overlaid with the locations of lizard sightings (Fig. 1), it is clear that the taller scrub patches supported the higher numbers of non-native lacertids. Both species require hot, dry areas where they can thermoregulate and oviposit. As gorse matures it becomes leggy, which in turn opens up the ground to the sun creating warm microhabitat whilst still providing the protection of cover. This structural nature of the gorse has allowed the spread of the non-native lacertids from the central introduction site on the cliff top. The gorse on site is cut back when it is deemed too big, but this is not done to an annual management plan. Due to financial constraints the gorse has been allowed to ‘overgrow’. This ‘overgrown’ state appears to be the preferred successional stage of the non-native lacertids. Gorse management may affect the success of the introduced lacertids at Boscombe.

It would appear that these unintentional invaders are here to stay and it is extremely unlikely that they could now be eradicated from the cliffs at Boscombe. Even if all the scrub were to be removed from the cliff top, the cliff face would act as a source population for re-colonisation.

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Helminths of *Gonatodes hasemani* and *Pseudogonatodes guinanensis* (Squamata, Gekkonidae) from Brazil, South America

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GONATODES hasemani Griffin, 1917 is known from southwestern Amazonia in Brazil, eastern Peru and northern Bolivia (Uetz et al., 2010). An isolated population exists in forest along the Rio Xingu south of Altimíra as well collected by LJV in 1985 and deposited in the Museu de Zoologia, Universidade de Sao Paulo (MZUSP), Brazil. *Pseudogonatodes guianensis* Parker, 1935 occurs in Amazonian Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname and Venezuela (Uetz et al., 2010). We know of no helminth records for these species. The purpose of this note is to establish the initial helminth lists for *G. hasemani* and *P. guinanensis* as part of an ongoing investigation of helminth distribution in Neotropical lizards.

METHODS AND MATERIALS

Forty individuals of *Gonatodes hasemani* (mean snout-vent length [SVL] = 35.1 ± 6.8 SD, range = 19-45 mm) and eleven individuals of *Pseudogonatodes guinanensis* (SVL = 24.1 mm ± 2.2 SD, range = 21-27 mm) collected by LJV were borrowed from the Department of Herpetology, Sam Noble Museum of Natural History (OMNH), University of Oklahoma, Norman Oklahoma, USA, and examined for helminths. Four individuals of *G. hasemani* (OMNH 36898-36901) were collected in Acre State, 5.0 km N Porto Walter, 8°15'S, 72°46'W, February-April, 1996; 11 (OMNH 37114-37124) were collected in Amazonas State, Rio Ituxi at Madeirera Scheffer (8°20'S, 65°42'W) February-March, 1997; and 25 (OMNH 37281-37305) were collected in Rondônia State, Rio Formoso, Parque Estadual Guajará-Mirim, 90.0 ± km N Nova Mamoré (10°19'S, 64°33'W) January-March 1998. All individuals of *P. guinanensis* (OMNH 36920-36930) were collected in Acre State, 5.0 km N Porto Walter, February-April, 1996. Lizards had been field-fixed in 10% formalin, preserved in 70% ethanol and the stomachs removed for ecological studies (see Vitt et al. 2000 for *G. hasemani* and Vitt et al. 2005 for *P. guinanensis*). For this study, the small and large intestines, liver and body cavities were examined for helminths under a dissecting microscope. Nematodes were cleared in glycerol on a microscope slide. Cestodes and acanthocephalans were stained in hematoxylin and mounted in Canada Balsam. All helminths were studied as whole mounts under a compound microscope. Helminth community terminology is in accordance with Bush et al. (1997).

RESULTS

Number of helminths, prevalence (number of infected hosts divided by number of hosts examined X 100), mean intensity (mean number of helminths per infected host ± 1 SD) and range (lowest and highest intensities) are presented in Table 1. Found in *G. hasemani* were one species of Cestoda, a tetrathyridium of *Mesocestoides* sp. (small intestine) and one species of Nematoda, *Skrjabinelazia galliardi* Chabaud, 1973 (small and large intestines). One species of Acanthocephala, *Acanthocephalus saurius* Bursey & Goldberg, 2003 was found in the small intestine of *P. guinanensis*. Voucher helminths were deposited

Reptile Species	Helminth Species	Number	Prevalence (%)	Mean Intensity	Range
Gonatodes hasemani	*Mesocestoides* sp.	1	3	1.0	---
	Skrjabinelazia galliardi	4	8	1.7 ± 0.58	1-2
Pseudogonatodes guinanensis	*Acanthocephalus saurius*	9	36	1.8 ± 0.84	1-3

Table 1. Species and number of helminths, prevalence, mean intensity and range of infection in 40 *Gonatodes hasemani* and 11 *Pseudogonatodes guinanensis* from Brazil.

in the United States National Parasite Collection, USNPC, Beltsville, Maryland, USA as *G. haesmani*: *Mesocestoides* sp. (USNPC 103208), *Skrjabinelazia galliardi* (USNPC 103209) and *P. guinanensis*: *Acanthocephalus saurius* (USNPC 103207).

DISCUSSION

Tetrathyridia (second larval stage) of *Mesocestoides* sp. are cosmopolitan in amphibians and reptiles (Goldberg et al., 2004). Ants (Formicidae) have been suggested as first intermediate hosts while the strobilar stage occurs in mammals (Padgett & Boyce, 2005). *Skrjabinelazia galliardi* was described from *Gonatodes humeralis* from Belem, Brazil by Chabaud (1973). It was reported in *Tropidurus torquatus* from Belém, Brazil, *Gonatodes albogularis* from Panama and *Anolis limifrons* from Nicaragua (Vrcibradic et al., 2000; Bursey et al., 2007; Goldberg et al. 2010a). Two types of eggs are produced. One is thought to be autoinfective whereas the other is released to the environment and ingested by insects, which are thought to serve as paratenic (transport) hosts (Chabaud et al., 1988). The genus *Acanthocephalus* is cosmopolitan in distribution (Kennedy, 2006). *Acanthocephalus saurius* was described from *Anolis limifrons* from Costa Rica by Bursey & Goldberg (2003) and is also known from *Anolis capito*, *A. humilis* and *A. lionotus* from Nicaragua and *Anolis nitens* and *Prionodactylus oshaughnessyi* from Brazil (Bursey & Goldberg, 2004; Bursey et al., 2007; Goldberg et al. 2010a, 2010b). *Acanthocephalans* also require an arthropod intermediate host (Kennedy, 2006).

In each case, infection was a product of diet brought on by ingestion of an infected arthropod. Further work will be necessary to determine the extent of helminth infections in these geckoes and whether diet or habitat is more consequential. *Gonatodes hasemani* represents a new host record for *Mesocestoides* sp. and *Skrjabinelazia galliardi. Pseudogonatodes guinanensis* represents a new host record for *Acanthocephalus saurius*.

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TRACHEMYS DORBIGNI (Brazilian Slider Turtle): BICEPHALY. *Trachemys dorbigni* is from the family Emydidae and is found in Uruguay, Argentina and the state of Rio Grande do Sul in Brazil. Although the conservation status of *T. dorbigni* is of least concern, human activities may be contributing to declining populations of this species (Molina & Gomes, 1998). The most significant impacts appear to be direct mortality from roadkill, habitat loss and egg exploitation associated with collection of wild specimens for the pet trade (Bager et al., 2007).

Neonate twinning in turtles is relatively well documented for both freshwater (Tucker & Janzen, 1997) and marine species (Eckert, 1990). In captive, artificial conditions, a single record of a polycephalic *T. dorbigni* hatchling has previously been recorded (Molina et al., 1996). Herein, we report the first known occurrence of polycephaly in a specimen from a natural environment.

The individual was located in Pelotas, Rio Grande do Sul State, Brazil (31°46' S, 52°21' W). The animal was found alive and could feed independently through each of the two heads, which originated from two separate necks. The hatchling was kept alive for four months in captivity before accidentally drowning. The specimen's morphology presented a tail, two posterior limbs, three anterior limbs, two heads, a single plastron and two pseudo-carapaces. The third anterior limb, located between the two heads, presented a structure of two limbs. There was only a single insertion point of the yolk sac in the plastron. The only anomaly in the number of scutes on the plastron was the presence of four gular scutes. The number of scutes in the carapace was significantly larger than usual for this species. Each pseudo-carapace presented all the vertebral scutes (even if dislocated), one set of costal scutes and half the number of marginal scutes. The other scutes were fused forming a central crest. No internal postmortem was made.

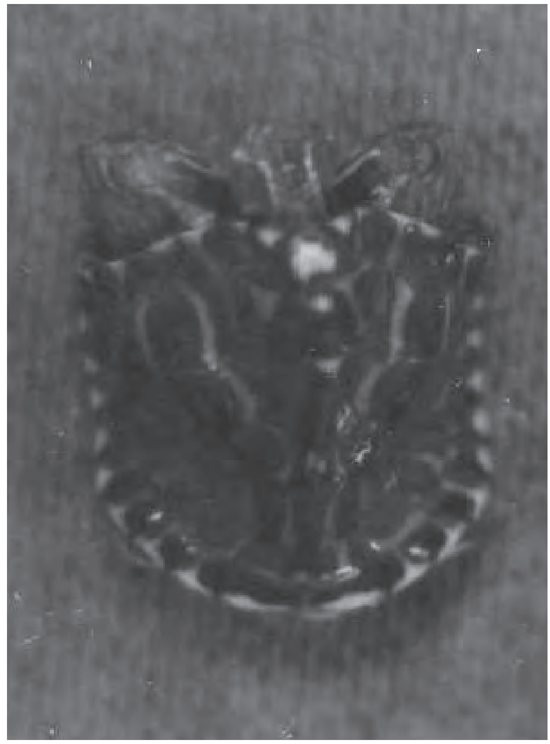

Figure 1. Bicephalic *Trachemys dorbigni*.

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LITHOBATES CATESBEIANUS (American bullfrog): DIET. The American bullfrog is a large frog species with generalist feeding habits, including small vertebrates in its diet (Bury & Whelan, 1984). It was introduced in several countries associated with aquaculture, arriving in Brazil in the 1930s (Giovanelli et al., 2008). Farming escapes (due to poor management practices) and intentional introductions allowed this species to establish invasive populations in wild habitats of several regions on the next decades (Giovanelli et al., 2008; Silva et al., 2009). Here we summarize the stomach contents of 13 feral bullfrogs (seven females and six males) from a small farm located at the locality of Córrego dos Dutras (20°12'37.79"S, 42°08'14.86"W), municipality of Manhuaçu, Minas Gerais state, southeastern Brazil.

The frogs were collected at night, on 27 and 28 February 2009, from sunset until ca. 21:00. The sampling site consists of four small fishery ponds surrounded by grass. After collection, the specimens were double pithed (brain and spinal cord) and put on ice to retard digestion. The snout-vent length (SVL) was recorded to the nearest 0.01 mm, and prey items were identified to the lowest possible taxonomic level. Four specimens were housed as vouchers at the herpetological collection of Museu de Zoologia João Moojen (MZUFV), Universidade Federal de Viçosa, municipality of Viçosa, Minas Gerais state, Brazil, under the register numbers MZUFV 9608, 9609, 9610 and 9611.

The SVL of the frogs varied from 47.04 to 151.84 mm (mean ± SD: 109.07 ± 39.23 mm), and the number of prey items ingested by each frog varied from 1-15 (mean ± SD: 6.62 ± 4.39). Plant remains were found in nine stomachs (69.23%), and were considered accidently ingested. Among the 83 prey items recorded, the most common were Zygoptera (Odonata), larvae of Lepidoptera, Araneae and Ephemeroptera, which together represented 60.24% of the total prey items ingested (Table 1). However, regarding the number of frogs analysed, the most frequent preys were Zygoptera and Diplopoda followed by Araneae. Two fishes, one tadpole of *L. catesbeianus* and an unidentified post-metamorphic anuran were found among preyed vertebrates (Table 1). We thank Caio A. Figueiredo-de-Andrade for the English revision of the manuscript and IBAMA/ICMBio for collection permit (number 17152-1). ETS also thanks Programa de Apoio a Planos de Reestruturação e Expansão das Universidades Federais (REUNI) for scholarship.

Stomach contents	Np	%Np	Nf	% Nf
Arachnida (Araneae)	10	12.05	5	38.46
Diplopoda	6	7.23	6	46.15
Crustacea (Isopoda)	1	1.20	1	7.69
Coleoptera				
Scarabaeidae	2	2.41	2	15.38
Hydrophilidae	1	1.20	1	7.69
Unidentified	2	2.41	2	15.38
Diptera	1	1.20	1	7.69
Ephemeroptera	7	8.43	3	23.08
Hemiptera				
Auchenorrhyncha (Cicadellidae)	1	1.20	1	7.69
Auchenorrhyncha (unidentified)	5	6.02	2	15.38
Heteroptera (Belostomatidae)	1	1.20	1	7.69
Heteroptera (Hydrometridae)	1	1.20	1	7.69
Hymenoptera				
Formicidae	2	2.41	2	15.38
Vespidae	1	1.20	1	7.69
Lepidoptera (larvae)	12	14.46	2	15.38
Odonata				
Anisoptera	4	4.82	3	23.08
Zygoptera	21	25.30	6	46.15
Orthoptera (Gryllidae)	1	1.20	1	7.69
Chordata (Actinopterygii)				
Poecilidae	1	1.20	1	7.69
Cichlidae (*Geophagus brasiliensis*)	1	1.20	1	7.69
Chordata (Anura)				
Lithobates catesbeianus (tadpole)	1	1.20	1	7.69
Unidentified (post-metamorphic)	1	1.20	1	7.69
Plant remains and sediments	---	---	9	69.23

Table 1. Summary of stomach contents of 13 specimens of *Lithobates catesbeianus* from Córrego dos Dutras, municipality of Manhuaçu, Minas Gerais state, Brazil, collected in 27 and 28 February 2009. Np: number of prey items; Nf: number of frogs.

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BOKERMANNOHYLA CARAMASACHII (Caramaschi's treefrog): DEFENSIVE BEHAVIOUR. Amphibians are subject to predation by a vast array of invertebrates and vertebrates, being known to display a wide variety of defensive behaviours, including tonic immobility (Duellman & Trueb, 1994; Wells, 2007). In this strategy the frog or toad usually flips itself on its back and remains immobile. Although this behaviour is widespread in frogs there are few descriptions of it for *Bokermannohyla* species. *Bokermannohyla caramaschii* is a moderate sized frog belonging to the *B. circumdata* group (Faivovich et al., 2005). This species is restricted to the northern part of the Serra da Mantiqueira mountain range, southeastern Brazil (Napoli, 2005).

On 7 December 2009 at 20:30, an adult male *B. caramaschii* was captured inside a bromeliad leaf next to a rivulet in the Serra do Brigadeiro State Park, an area of montane rainforest in municipality of Araponga, state of Minas Gerais, Brazil (20º43'19"S, 42º28'43"W, elev. 1320 m). While manipulated, the frog flipped all four limbs in close to the abdomen remaining motionless (Fig. 1). When it was turned belly up, it remained in the same position for about 20 seconds and then quickly became alert and active. The adult male *B. caramaschii* also released a strong odour. The frog was then handled again and repeated the behaviour twice. This is the first record of this behaviour for *B. caramaschii* although death feigning has been reported in the *Bokermannohyla circumdata* group previously (Toledo et al., 2010). Some functions have been suggested to explain

Figure 1. An adult male *Bokermannohyla caramaschii* in death feigning behaviour.

the adaptive value of the motionlessness behaviour. Sazima (1974) reported this behavior as a strategy to avoid the anuran predation by common water snakes *Liophis miliaris*. Marchisin & Anderson (1978) classified its behaviour as one of the most common anuran responses to the approach of snakes. It has been suggested that the use of this immobility tactic is in response to predator attack and happens after a frog falls from height in vegetation (Azevedo-Ramos, 1995). It has also been suggested to be in response to terrestrial anuran predators (Toledo et al., 2005, 2010). However, there are few data concerning the functional significance of this behaviour as well about the efficiency of tonic immobility in reducing risk of predations in frogs (Azevedo-Ramos, 1995; Toledo, 2004a, 2004b; Toledo et al., 2005; Wells, 2007).

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CNEMIDOPHORUS OCELLIFER (Spix's whiptail): PREDATION. *Cnemidophorus ocellifer* (Spix, 1825) is a heliothermic teiid lizard widely distributed in south America, occurring in Argentina, Bolivia, Paraguay, and throughout Brazil, excluding Amazonia (Vanzolini et al., 1980). To date, six cases of predation by lizards on Brazilian species of *Cnemidophorus* have been recorded, including *C. ocellifer* as prey of *Tropidurus itambere* (Faria & Araújo, 2004), *T. torquatus* (Kokubum & Lemos, 2004) and *T. hispidus* (Costa et al., 2010), and *C. littoralis* and *C. nativo* of *T. torquatus* (Kiefer et al., 2006; Peloso & Pavan, 2007). Additionally, a case of cannibalism by a female *C. ocellifer* was described in a Caatinga area in the state of Rio Grande do Norte (Sales et al., 2010a). Other predators of *Cnemidophorus* lizards include birds (Morais & Pinho, 2007; Carvalho-Filho, 2008), centipedes (Bocchiglieri & Mendonça, 2009) and snakes (Peloso & Pavan, 2007; Bocchiglieri & Mendonça, 2009). Herein we document the first recorded case of ingestion of *C. ocellifer* by the teiid lizard *Ameiva ameiva* and a fortuitous event of predation by the cuculid bird *Guira guira* in the Caatinga of northeast Brazil.

In the context of an ecological investigation in a lizard assemblage, an *A. ameiva* population was studied in a forest enclave (06°08'14"S, 36°44'81"W, 680 m above sea level) inside the Caatinga biome, in the municipality of Tenente Laurentino Cruz, Rio Grande do Norte, Brazil. The climate is classified as semi-arid, hot and dry, with rainfall of 705.9 mm/year, mean temperature of 26.6°C and relative air humidity of 65% (Beltrão et al., 2005). On 29 January 2010, we collected an adult female *A. ameiva* (142.7 mm SVL) with a headless specimen of *C. ocellifer* (length: 86.4 mm; width: 17.6 mm and 14,006.10 mm^3 in volume) in its stomach contents (Fig. 1). The bluish colour of the ventral row of scales and the greenish colour of the granular dorsal scales in *C. ocellifer*, typical of reproductively active individuals, leads us to conclude that it is an adult lizard.

The diet of *A. ameiva* is composed mainly of arthropods, but also includes fruits and gastropods (Zaluar & Rocha, 2000). Orthopterans, termites, beetles and insect larvae are the most numerically important items in the diet of the populations of this species in different Brazilian ecosystems (Vitt & Colli, 1994; Gainsbury & Colli, 2003). Volumetrically, beetles, insect larvae, cockroaches, spiders and orthopterans were the most important items (Vitt & Colli, 1994). In addition to invertebrates and plant matter, *A. ameiva* occasionally feeds on small vertebrates (Vitt, 1995), including lizards (Zaluar & Rocha, 2000). Published diets of *A. ameiva* report *Mabuya agilis* and *T. torquatus* as prey items in a restinga ecosystem in southeast Brazil (Zaluar & Rocha, 2000), *Kentropyx striata* in an Amazonian savanna in northern Brazil (Vitt,

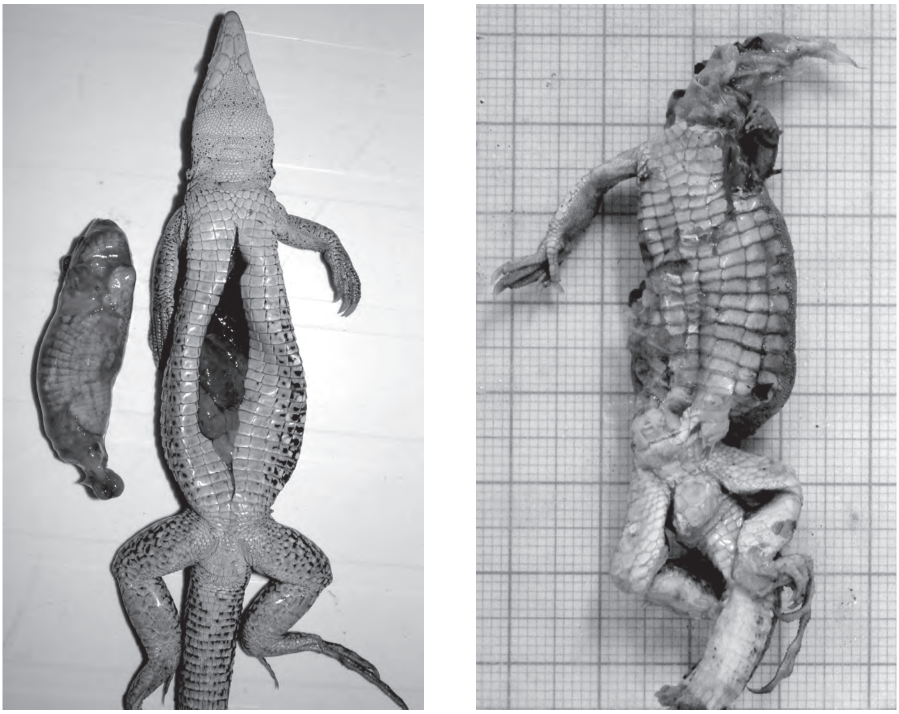

Figure 1. *Cnemidophorus ocellifer* predated by an adult female *Ameiva ameiva* (142.7 mm SVL): (left) stomach removed, (right) adult predated specimen (length: 86.4 mm); note absence of the head.

2000) and *Vanzosaura rubricauda* in the caatinga of northeast Brazil (Sales et al., 2010b). According to Siqueira & Rocha (2008), lizards from the family Teiidae do not usually appear as prey of other lizards and this is very likely owing to the fact that they are wide-foraging predators, moving actively in the habitat, and because they use flight as an anti-predation behavioural response. These characteristics make them potentially difficult to capture.

However, the high abundance of *C. ocellifer* in our study area, representing approximately 45% of the total of lizards captured (n = 707), might have facilitated the encounter between predator and prey, providing the predation by *A. ameiva*. Events such as these may be due to their generalist and opportunistic feeding habits, as observed in other studies (Vitt, 1995; Mesquita & Colli, 2003). Like cannibalism, saurophagy may provide nutritional benefits such as the access to an additional source of energy, increasing the availability of potential foods (Rocha & Siqueira, 2008). Nevertheless, Vitt (2000) reports that owing to the large body size of *A. ameiva* compared to many sympatric lizard species, saurophagy may be more frequent than is currently represented in the literature. The *A. ameiva* (CHBEZ 3330) was deposited in the herpetological collection of the Universidade Federal do Rio Grande do Norte, Natal, Brazil.

The second predation case occurred on 21 November 2010 ca. 14:10 in the same area as the aforementioned predation event, where we witnessed a Guira cuckoo *Guira guira* preying on *C. ocellifer*. On this occasion, the Guira cuckoo was sighted flying from the ground to a tree and subsequently jumping on the branches carrying the lizard in its bill. The lizard was limp and seemed dead. After one minute of observation, the bird flew out of view with its prey because one member of its flock tried to steal the lizard (kleptoparasitism). A similar record was observed for the teiid *C. lemniscatus* in the Amazon region, when the lizard was also captured by a *Guira guira* (Carvalho-Filho, 2008).

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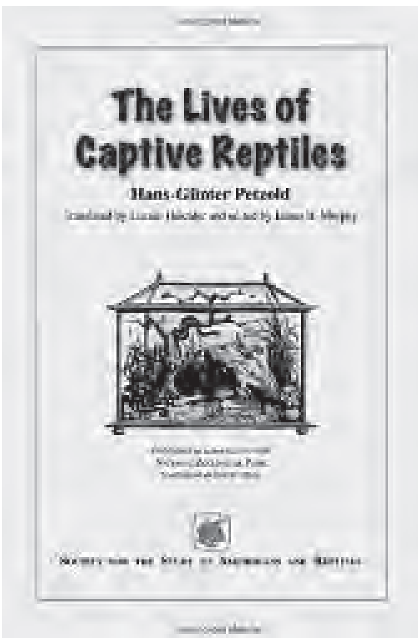
Book Reviews

The Lives of Captive Reptiles

Hans-Günter Petzold

Translated by Lucian Heichler
and edited by James B. Murphy

2008, Society of the Study
of Amphibians and Reptiles,
Ithaca, New York, USA, 275 pp.



‘*In the long history of humankind (and animal kind, too) those who learned to collaborate and improvise most effectively have prevailed*’

Charles Darwin

The above quote by the ‘father’ of evolution is a fitting statement for the importance of shared knowledge throughout all fields of scientific study. In ‘*The Lives of Captive Reptiles*’ Hans-Günter Petzold has given a systematic comparison of collective research and observations carried out in the captive environment that have changed the way that we understand the incredible creatures we call the ‘reptiles’.

This book first published in 1982 originally as a Ph.D. thesis under the title ‘*Aufgaben und Probleme der Tiergärtnerei bei der Erforschung der Lebensäußerungen der Niederen Amnioten* (*Reptilien*)’ (translated into English: tasks and problems of zoo biology in studying the life manifestations of lower Amniotic animals) was submitted just three days before Petzold suffered an untimely fatal myocardial infarction, at just 51 years of age.

This English translated edition has received very little alteration in its content and organisation from its former work, with numerous translatory discrepancies inordinately occurring throughout. Editorial notes are added and indicated where applicable, which are predominantly utilised within the footnotes (255 in total), often indicating recent advances in the literature post 1982, e.g., Müller & Kranenberg’s (2004) discovery about the propulsion of the chameleon tongue using contraction energy in the musculus accelerator linguae.

A good knowledge of taxonomic status is often required throughout with various outdated nomenclature being utilised, i.e., *Crocodilus lucius* in chapter two, this name has been largely abolished since the early 19th century and is now what we know as *Alligator mississippiensis* (however, it is worth noting that this is purposely done to demonstrate what old ‘manageries’ were keeping but there is no indication of the correct modern day nomenclature in the text). A further example that was not intentional, as with many others recognised throughout, was *Natrix stolata* which is now *Amphiesma stolata* (Chapter 3.1.4).

The book contains seven well defined chapters with large sub-sections, with an addition to the English edition of colour plates, providing imagery of Petzold’s former work place, Tierpark, Berlin. Many of the plates are of species discussed during the course of the volume.

The first chapter gives an insight into the four principle roles that zoological gardens play in modern zoo biology: public education, research, environmental protection and recreation. It also produces a foundation that it builds on in chapter two. There are numerous references to the Marxist theory of class struggle in this chapter, which without the book would not have been published in the former German Democratic Republic. The second chapter looks systematically at how reptiles (and amphibians) have been kept throughout history from the earliest of *Crocodylus niloticus* (Egyptians) and *Gavialis gangeticus* (Indus culture) from ca. 3000 B.C. to modern day zoos. There are numerous tables included throughout, principally outlining numbers of species/individuals in various collections at comparative intervals in time. Chapter 3 comprises three large subsections: 3.1 functional system of reproduction; 3.2 functional system of ontogeny; and 3.3 functional system of nutrition. Each section has been broken down further into sub-subsections, with this chapter comprising the main body of the book with >180 pages detailing the huge array of information available and pooling it for different taxonomic groupings. Chapter 4 draws on current (1980s) work in behaviour and other functional systems providing a good resource, however, suggestions for future research, which is the primary target of the chapter, is often out of date now with much work being carried out after the book was written e.g., aspects of snake bite. Recent methodological advances and research focus has given rise to a vast wealth of knowledge, better bite protocol and antivenom in the field post publication (e.g. Otero et al., 2006; Casewell et al., 2009). Chapter 5 looks into the relevance of terrarium data for herpetological research and is evaluated with acute accuracy. Three main topics are investigated during this chapter: general behaviour, reproduction, and nutrition. These sections are then broken down further e.g. general behaviour: "tameness." Chapter 6 summarises conservation programmes and perspectives of various orders and families. As this section relies heavily on species status, which can and has fluctuated since the book was written, many of the areas are outdated. However it gives an excellent insight into breeding programmes/successes up until 1982. The final section is Petzold's final remarks, giving a good overview of the vast amounts of information displayed throughout the entire book.

With over a thousand references (many hard to obtain, even with access to online databases) and Petzold's extensive personal experiences, the depth of knowledge presented on captive research of reptiles is not easily matched despite the book now being over 25 years old. The pooled sources of information from numerous languages provided are often dismissed by the majority of people from countries where English is the primary language. Despite often producing important statistically sound results and findings, which contributed significantly to our knowledge, there is arguably little doubt that much of the knowledge surrounding the vast issue of captive reptiles is ever fully documented. Anyone who works with terrarium animals should keep records of their individuals and professional herpetoculturists should ideally record detailed aspects of health, feeding, locality, defecation, feeding, lighting and temperature etc. Such information is useful for those involved with reptile husbandry.

To conclude, despite numerous out of date works and translatory discrepancies, this book is superb for an overview and grounding for further research into terrarium husbandry. I think that it is an essential item on the book shelf of any herpetologist involved in the captive environment, especially research and zoological institutes. At a price of £50-70 a serious consideration by amateur herpetologists should be made and I would suggest only those who have a passion for learning about the potential for research in terrarium animals and the considerable work that has gone into the study of herpetology should contemplate a purchase. This is due in part to the intensity of the volume, which at times is very unforgiving and hard reading despite being such a wonderfully informative tool.

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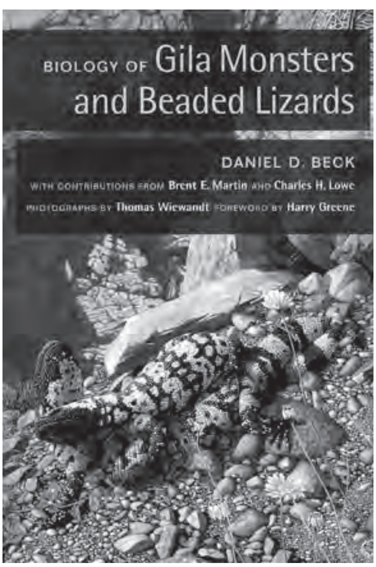
Biology of Gila Monsters and Beaded Lizards

Daniel D. Beck

2009, University of California Press, California, 211 pp (softback edition).



"*Biology of Gila Monsters and Beaded Lizards*" was first published in 2005 in hardback and is now available in soft back at a lower price. The general topics covered are ecology, physiology and behaviour. The book has some excellent photos (both in colour and black and white), tables and a plethora of different graphs and charts showing results from field research studies. The text can be difficult to read due to the amount of referencing. However, the author does not over complicate sentences with unnecessary jargon. The book lacks one major subject, *Heloderma* in captivity. Nevertheless information on temperature preferences, breeding statistics etc. is sufficiently detailed to be used as a basis for the husbandry of captive lizards.

The first chapter is titled "Monsters in Our Midst". This is an introduction and a historical account about helodermatid lizards including information about folklore, medicine and early techniques for field studies. It is apparent from this chapter that helodermatid lizards were poorly studied until recently. This chapter also shows these lizards showing off in a film called "The Giant Gila Monster" produced in 1959. These lizards were used much the same as green iguanas *Iguana iguana*, in "Jason and the Argonauts" to strike fear in humans due to their physical appearance.

The second chapter is "Evolution, Distribution and Systematics." Accurate head drawings clearly show scalation differences between the two subspecies of *Heloderma suspectum* and the four subspecies of *Heloderma horridum*. A three angled view of the skull of *H. horridum* shows and names all scalation present, which is always handy as a reference. All species and subspecies have been described in some detail in this chapter. Maps plotting their distribution always simplify geography if the reader is not too familiar with central America. An interesting look at their relationship with snakes and varanids is also touched on.

The third chapter is "The Venom System and Envenomation." This was my favourite chapter as it describes the venom delivery system, effects of venom and chemical makeup, which makes this genus so fascinating and the information has been thoroughly researched. Diagrams of the venom delivery system, structure of the lower mandible and teeth are excellent. The major components in the venom are all listed and simplified in a table format with notes on their physiological effects. The peptide exendin 4, which is only found in *H. suspectum* venom, is explained with reference to its effects on stabilizing blood glucose levels and helping to combat type 2 diabetes.

Chapters four, five and six and seven are mainly about *Heloderma* ecology including temperature variations, habitat preferences, metabolic rates, growth rates, diet, feeding, population density and longevity. All information is from specimens that have been observed and studied in the wild. All results are put in table or graph form. Diet and feeding is important especially when keeping these animals in captivity to guide what, and how much to feed. Field data in this book can be relevant to captive animals. Whilst reading this book, it was surprising how little the lizards eat in the wild. I personally keep *H. horridum* in captivity and have found this chapter essential for the captive maintenance of my animals.

The eighth chapter is "Reproduction, Behaviour and *Heloderma* in Captivity". The latter subject in this chapter is basic as much of this book is about field research. Reproductive issues are touched on, in captivity including incubation of eggs. This chapter has some very clear and informative drawings and photographs showing combat sequences in *H. suspectum* and *H. horridum*. Information about reproductive biology is clearly presented in subheading format making it easier for the reader to sort and digest such information.

One of the last chapters is "Conservation". This chapter explores the threats to helodermatid lizards including information about invasive plants, fire threats, habitat threats, human population and agriculture. The current legal status of helodermatid lizards is also explored and it is amazing how it differs between states. This chapter is particularly interesting for any field researchers who may want to work on this genus. It highlights areas of work that need addressing in the future.

Overall this book is an excellent read. If you are an avid fan, keeper, or just interested in this genus of lizards from a biological or ecological point of view, this book is for you. The information is thoroughly referenced and is the most complete and comprehensive book I have seen. The reader can indulge themselves in some chapters (e.g. conservation), whereas others can be skimmed over due to the complexity of the work (e.g. chemical makeup of the venom). The new soft back edition has lowered the price, making it affordable to most. "*Biology of Gila Monsters and Beaded Lizards*" is a welcomed addition to my collection and has not spent too much time on the shelf.

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De Amfibieën en Reptielen van Nederland

Raymond Creemers
and Jeroen van Delft

2009, Foundation Ravon,
Holland, 480 pp.

This book is the result of a ten year project that built a complete national database of amphibian and reptile (distribution) data for the Netherlands. "*De Amfibieën en Reptielen van Nederland*" is published by the RAVON (Reptile, Amphibian and Fish Conservation Netherlands) foundation. RAVON is a non-governmental organisation (NGO) with over 1500 volunteers, more than 1000 contributors and about 35 professional staff members with offices in Nijmegen and Amsterdam.

RAVON's main goals are to inform and educate, conserve species and their habitats, organise national monitoring networks and collect distribution data for the conservation of reptiles, amphibians and fish in the Netherlands. They give advice and carry out research for a wide range of clients. An important task is also to instruct and support the volunteers in their work. In short, they have all the knowhow on the reptiles and amphibians in the Netherlands (for more information visit www.ravon.nl). RAVON has now published its magnum opus, part nine in the series "The Netherlands Fauna" published in cooperation between the National Natural History Museum Naturalis, the Society European Invertebrate Survey and the distributors KNNV.

"*De Amfibieën en Reptielen van Nederland*" has been sponsored by 15 different societies and organisations such as WWF as shown by the extensive list on the final page of the book, which shows the great interest in the subject of this book. Over 2400 observers have given their data and 1800 references are cited and used. Each chapter is richly illustrated with excellent colour pictures, tables, figures, maps and a number of beautiful drawings of each species by Bas Teunis and Paul Veenvliet.

The book contains 14 chapters and an extensive appendix. An extensive English summary is provided for each species chapter and finally an English summary of the whole book is provided. In many other chapters the figures and tables are also bilingual, though sadly not always. In total 45 authors have been writing their pieces. The book includes 420 photographs by a total 60 photographers.

The first chapter is an introduction to the book. The book is dedicated to Dr. Henk Strijbosch, who "raised" a new generation of herpetologists at the animal ecology department of Nijmegen University in the seventies, eighties and nineties. His dedication and warm personality makes him a herpetological father for many students that worked with him. Many of his former students, including myself, are still in close contact which shows his dedication to his pupils.

Chapter 2 describes general systematics, taxonomy and diversity of reptiles and amphibians in general. This chapter is especially important for the reader who is not so well versed in these species. Chapter 3 describes the cultural history of amphibians and reptiles in facts and fiction. It is a unique chapter rarely seen in books like this and gives some nice new information on the attitiudes of humans towards these species groups. For instance, it describes the works of the important Flemish author Jacob van Maerlant who published an important book about nature in 1270. Even Harry Potter arrives in this chapter!

Chapter 4 deals with the history of herpetology in the Netherlands. It starts with the works of Frederick Ruysch (1710) and moves on to Eli Heimans and Jac. P. Thijsse around 1900 who are the founding fathers of nature conservation in the Netherlands. The birth of the first national coordination of amphibian and reptile distribution data was during the Second World War when the Netherlands Society of Herpetoculture "*Lacerta*" was founded in 1942 and under its wings the Herpetogeographical Services, by Dick van Wijk and Johannes ter Horst. Then the different professional, mainly by the Universities of Amsterdam and Nijmegen, and private activities, started by voluntary nature protection groups are described that have taken place through the years. The main focus of the chapter is the development of the different private organisations consisting of volunteers who focussed especially on conservation, monitoring and collecting distribution data. These organisations formed the foundations for what has become RAVON.

Chapter 5 describes the ecology and life history of reptiles and amphibians in the Netherlands. Many excellent and unique pictures are used to illustrate the various facets of herpetofaunal ecology such as predation, feeding, breeding and shedding. Chapter 6 describes the database that has been used for this book. Building a complete and accurate database was one of the key elements for this book. All the data has been re-checked, focusing on the odd old records, museum records and doubtful records which have been published in earlier atlases or even unpublished data. In total 451,710 validated records have been used. Interesting to see is that there is a fast growing record input in the last decades, especially due to the internet applications which makes it now very easy to just enter your data every day with a few simple cursor presses.

In chapter 7 different methods of searching, investigating and monitoring are described, including the use of individual recognition in many species and the use of equipment. One can also read how they are applied by a regional group of runners who map every slow-worm they see and about national coordinated monitoring activities for reptiles and amphibians.

Chapter 8 is the core of the book (totalling 250 pages) and describes all the different species and their distribution and how that has changed over time. Every chapter follows the same strict set up. For each species detailed information is given on recognition, natural history, distribution within Europe and the Netherlands, habitats, conservation measures and investigation methods. And every species has four national distribution maps, which shows the distribution between 1971-1995, from 1996-2007, all sightings and the changes. Also a European distribution map is shown. Sadly the maps are not in English but they show fascinating data.

The species chapters have been written for the most part by volunteers. One of the disadvantages of using different authors for every species chapter is that this could lead to imbalance between the different chapters. Although one can still see some style differences the editors have done a great job. The only flaws are in some picture captions. Several newt species (e.g., *Triturus cristatus*, *Lissotriton vulgaris* or *Lissotriton helveticus*) are depicted with the caption "during courtship", but actually nothing of the courtship is shown; they are just in their water phase.

A special part of this chapter describes the exotic species that have become naturalised in the Netherlands, including the Italian crested newt, the American bullfrog, red-eared sliders. It is followed by a part dedicated to Prof. Dr. Leo D. Brongersma and finally concludes with a review of all sea-turtle sightings and observations written by Dr. Rinus Hoogmoed. This is the very first time a complete review on all sea turtle sightings on the Netherlands coasts has been published.

The book then closes with three chapters. Chapter 9 is on herpetofauna in the Netherlands landscape; where distribution of species is related to the geographical areas of the Netherlands. Chapter 10 focuses on changes in time and in the Red list. Chapter 11 describes the successes and failures in protection and management of the species. Chapters 12 and 13 are a glossary and an extensive reference list respectively, and finally chapter 14 summarises the whole book in English. A nice addition to the book is the CD with 21 different original recordings of the vocalisations of all 11 anurans native to the Netherlands. Most of these were recorded in the Netherlands by Baudewijn Odé for this publication.

The authors and editors are passionate about the animals and one can read that between the lines. It makes the book attractive for professional and non professional biologists, but also for policy makers and non Netherlands herpetologists. The previous Netherlands atlas by Bergmans & Zuiderwijk (1986) has clearly resulted in a growing interest for these species groups. Several regional volunteers have started collecting new data on distribution, ecology and conservation, and this has resulted in something which is far more than an atlas. If one looks at all the details written down in this review, one could state that the "*De Amfibieën en Reptielen van Nederland*" is just as relevant to the whole of Europe.

It is the aim of RAVON to increase the number of sustainable populations of amphibians, reptiles and fish in the Netherlands via accumulated knowledge. With this book all the current knowledge is combined and it will be the standard for at least the next twenty years.

If there ever was a reason to learn the Dutch language, it would be this book, or go for the simple way and start with the English summaries and many bilingual figures and tables. I can guarantee it will not disappoint you.

REFERENCES

Bergmans, W. & Zuiderwijk, A. (1986). *Atlas van de Nederlandse Amfibieen en Reptielen en hun Bedreiging*. KNNV: Hoogwoud.

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