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

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**Front cover illustration.** Tibetan hot-spring snake, *Thermophis baileyi*. © S. Hoffman. See article on page 8.

### Update on the British Herpetological Society Conservation Committee, and future plans

At the recent Council meeting it was agreed that following an absence of ten years I would again look after the conservation interests of the Society. Previously I was chairman of the BHS Conservation Committee from 1992–97. I have continued to be a BHS member and also continued with my voluntary herpetofauna conservation work by establishing and running Warwickshire Amphibian and Reptile Team, and for the last three years Amphibian and Reptile Groups of the UK (ARG UK).

When I took over the Conservation Committee in 1992, the Herpetological Conservation Trust (HCT – established 1989) and Herpetofauna Groups of Britain and Ireland (HGBI - established 1990) were also involved with herpetofauna conservation and the BHSCC supported their work by being advisors and working with them on common projects. This resulted in the creation of several posts within HCT & the new organisation called Froglife (the HGBI secretariat). This meant that more professional herpetologists could work full time on specific projects and conservation action started to move more away from the reliance on volunteers who had limited time. This was a fantastic development and resulted in positive conservation measures. The Committee continued to concentrate primarily on the conservation of rare herpetofauna such as the Sand lizard, Smooth snake and Natterjack toad, and encouraging members to carry out monitoring and habitat management.

Due primarily to the work of the HCT and government initiatives the conservation of our rare herpetofauna is now hopefully ensured and funded but the next priority is to look at the conservation status of the ‘so-called’ widespread or common species. A recent review of the UK Biodiversity Action Plan has in addition to the rare herpetile species recognised the need to improve the conservation status of the Slow worm, Common lizard, Grass snake and the Common toad. This is reinforced by recorder observations in the field, such as the decline of the adder in the West

Midlands and long term declining toad populations in SE England.

The BHS continues to be a learned Society with excellent articles in all three publications that outline a wealth of information that can be applied to the conservation of herpetofauna both locally and worldwide. Over the past few years the work of the committee has concentrated on managing BHS/HCT reserves in Dorset, Surrey and Hampshire which is commendable and must continue. However, I feel that more BHS members could be further involved with conservation action for all the UK herpetofauna in the light of recent developments.

The past three years has seen ARG UK and the ARG network revitalised and rapidly developing into the country’s leading voluntary organisation for herpetofauna conservation. With over 50 groups up and running the network continues to grow and develop. ARG UK and HCT now have a Widespread Species Project Post who will continue to support the ARGs and organise the annual Herpetofauna Recorders Meeting. I would like to encourage all BHS members to join their local group. You will be given training in reptile and amphibian ecology and surveying techniques together with a free insurance scheme.

Individual BHS members can also get involved with the National Amphibian and Reptile Scheme (NARRS). This involves visiting sites in your locality and reporting back on the conservation status of any amphibians and reptiles seen.

Plans are underway to reintroduce the BHSCC annual visit to areas of herpetological interest, so members can gain first hand valuable herpetological experience. Details to follow in *The Natterjack*. Dates for management tasks in Dorset, Surrey and Hampshire will also continue to be published in *The Natterjack*.

In conclusion, I feel that BHS members have an important role to play in the conservation of our native herpetofauna and the following websites can help you get started: [www.arg-uk.org.uk/contacts.htm](http://www.arg-uk.org.uk/contacts.htm); [www.narrs.org.uk](http://www.narrs.org.uk)

Jan Clemons

# Toxicity of a garden herbicide to the larvae of two amphibians: a cautionary tail

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AS populations of many amphibian species continue to decline on a global scale, habitat alteration has become recognized as a major threat (see Skelly *et al.*, 2003; Stuart *et al.*, 2004). However, the past 10 or so years also has seen a surge of evidence that implicates chemical contamination as an additional factor that may contribute to populations declines, especially with regard to agricultural chemicals that are toxic to amphibians (see Berrill *et al.*, 1997).

It was more than 25 years ago that Beebee (1979) stressed the importance of suburban parks and gardens as refuges and breeding sites for British amphibians; interest among British homeowners in maintaining existing ponds or creating new ones is increasing (Beebee & Griffiths, 2000; see also Beebee, 1996). Of concern in the context of garden ponds as effective amphibian refuges should be the ready availability of insecticides and herbicides for residential use. Chemicals used to manage pests (often the same or similar compounds to those employed in agriculture) are easily purchased by homeowners and, even if not applied directly to ponds used as breeding sites by amphibians, may enter the water incidentally via aerial drift and run-off. Here we describe a test for toxic effects of such a pesticide in two species of amphibians.

Ortho® GroundClear® Triox Vegetation Killer (hereafter GROUND CLEAR) is a terrestrial, broad-spectrum herbicide that is freely available commercially in the United States, where it is recommended for use by landscapers and gardeners to control unwanted weeds. Its primary active ingredient is isopropylamine salt of glyphosate at 5% by mass. Imazapyr is the secondary active ingredient, also as isopropylamine salt and at 0.08% by mass. Remaining ingredients are listed as 'inert' and include surfactant to facilitate penetration into plant tissues. Pure glyphosate has a mean half-life of 47 days in soil and a half-life ranging from 12 days to 10 weeks in aquatic habitats (Extoxnet, 2006).

Residential use of glyphosate-containing formulations has increased in the United States as former fields and wildlands have been converted into housing developments. Indeed, the overall use of glyphosate as a herbicide in the United States is second only to atrazine (EPA, 2006), the latter notorious for its action as an endocrine disruptor (see Hayes, 2005). Even though many glyphosate-containing formulations (including GROUND CLEAR) are not intended for aquatic application, and are so labeled on their containers, with use by homeowners comes the potential for careless application in the vicinity of habitats used as breeding sites by amphibians. Thus, it is important to determine whether formulations such as GROUND CLEAR might impact non-target species, especially those life stages the survival of which is crucial for population persistence. We exposed larvae of the African clawed frog, *Xenopus laevis* (a model amphibian species in ecotoxicological studies), and of the North American long-toed salamander, *Ambystoma macrodactylum*, to a range of concentrations of GROUND CLEAR, and determined mortality as an end-point after 96 hrs of exposure.

We obtained fertilized *Xenopus* eggs from Xenopus 1, Inc (Dexter, Michigan), a commercial supplier, approximately 48 hrs after fertilization. They were maintained in aged tap water at 15°C through hatching until they had progressed to larval developmental stages 48–50. We captured gravid female *Ambystoma* from a pond near Pullman, Washington, in February and March 2003. They were placed in plastic boxes containing aged tap water and rocks, and allowed to lay eggs. These eggs then were transferred into larger aquaria containing aerated and aged tap water at approximately 15°C. Hatched larvae were removed and placed into similar aquaria until they had progressed to developmental stages 6–9.

Our testing protocol was adapted from FETAX (see Hoke & Ankley, 2005). The manufacturer's

recommended concentration of GROUND CLEAR for use (one part formulation to four parts water) was set as '1'; all other concentrations were serial dilutions of this. Concentrations of 1, 0.1, 0.01, 0.001, 0.0001 and 0.00001 were used. All solutions were made using aged, double-distilled tap water, and all studies included appropriate controls consisting of aged, double-distilled tap water only. In the *Xenopus* study, we included two replicates for each pesticide concentration and the water control, with 7 larvae per replicate. In the *Ambystoma* study, we included two replicates for each pesticide concentration and the water control, with 5 larvae per replicate. These are minimum numbers stipulated for FETAX.

Larvae of appropriate developmental stages were allocated randomly to treatments and placed into plastic boxes that each contained 1 L of the respective solutions. They were then left at approximately 15°C for 96 hrs of static exposure, during which time they were not fed and their media were not aerated. Survivors at 96 hrs were counted and then euthanized in a saturated solution of chlorotone (1,1,1-trichloro-2-methyl-propanolol).

We obtained 100% mortality for *Xenopus* larvae in all concentrations of GROUND CLEAR greater than and inclusive of 0.001 of that recommended for application. In the three highest concentrations, we observed that the death of all larvae occurred within minutes of initial exposure. At a concentration of 0.001, all larvae were dead within 4 hrs. Frog larvae at concentrations of 0.0001 and 0.00001 exhibited no mortality; neither did larvae in the water control (Table 1).

Larval mortality was complete for *Ambystoma* in all concentrations of GROUND CLEAR greater than and inclusive of 0.001. Observations of larvae exposed to the highest concentrations indicated that they ceased to move, and likely died, within minutes of initial exposure. At lower concentrations, death occurred within hours to days. Larval mortality was 70% at a concentration of 0.0001, and zero both at 0.00001 and in the water control (Table 1).

These data indicate that, under controlled conditions in the laboratory, acute exposure to GROUND CLEAR results in rapid death for larvae of *X. laevis* and *A. macrodactylum* even at very low concentrations (discussed further below). Since we used a formulation that is a chemical 'cocktail,' we cannot attribute mortality to any particular component. However, surfactants added to

Percent mortality:		
Solution	<i>X. laevis</i>	<i>A. macrodactylum</i>
1.0	100	100
0.1	100	100
0.01	100	100
0.001	100	100
0.0001	0	70
0.00001	0	0
Water control	0	0

**Table 1.** Percent mortality for larvae of the frog *Xenopus laevis* and the salamander *Ambystoma macrodactylum* exposed to solutions of six concentrations of GROUND CLEAR, plus water controls, for 96 hrs.

formulations such as GROUND CLEAR may be as or more toxic than glyphosate alone (Howe *et al.*, 2004; Mann & Bidwell, 1999; Perkins *et al.*, 2000). Of course, it is to all components of formulations that organisms will be exposed simultaneously. In addition, all of our solutions were made up in aged, double-distilled water. The physicochemical properties of natural pond water are both complex and diverse, and it is possible that the relative toxicities of the components of herbicide formulations may be affected.

GROUND CLEAR is a formulation that is not intended for aquatic use (and is so labeled), and thus should not be applied directly to habitats in which amphibians breed (we note that there are available other glyphosate formulations that are designed for use in water to control weeds). However, aquatic habitats could be contaminated by aerial drift and/or run-off of terrestrial pesticides such as GROUND CLEAR, especially in the confines of a residential garden; we stress that such habitats are increasingly important as amphibian breeding sites.

In addition, formulations such as GROUND CLEAR are most likely to be applied in the spring and early summer, times when embryos and larvae of many amphibians may be in adjacent bodies of water. Thus, at least on a local scale, application of formulations such as GROUND CLEAR in the vicinity of breeding ponds in principle could compromise the survivorship of young life-history stages. We note that studies of community effects in semi-natural aquatic mesocosms of glyphosate formulations intended for

terrestrial use demonstrated considerable to complete mortality for the larvae of five anuran species (Relyea, 2005).

What are the magnitudes of the risks imposed by residential pesticides to amphibians in garden ponds in reality? These are difficult to assess, but (very?) rough estimates can be obtained by some simple calculation: we provide an example. GROUND CLEAR is recommended for use with one part formulation mixed in four parts water. Imagine that 5 L of such a mixture is applied in the vicinity of a small garden pond containing a volume of 100 L of water. Assume that 0.1 L of the mixture enters the water by drift/run-off. That would give a concentration of 0.001 GROUND CLEAR in the pond, which would appear to be sufficient to kill both species used in our study (see Table 1). Of course, the risk would decline as the volume of drift/run-off decreases and/or the volume of water in the pond increases.

We certainly acknowledge the artificiality of aspects of our laboratory study. Nevertheless, our results lead us to advocate use of the precautionary principle concerning application of pesticides in the vicinity of ponds in gardens used by breeding amphibians: do not do it unless you know it is safe. At present, this is tantamount to saying “don’t do it at all;” we stress the crucial need for additional research to determine the extent to which weed-free patios may result in frog-free ponds.

This work was conducted to fulfill undergraduate requirements of the Honors College of Washington State University for authors Faxon (*Ambystoma*) and Van Buskirk (*Xenopus*), under permission from the University’s Institutional Animal Care and Use Committee. We thank Cyndi Gill for kindly catching female salamanders for us, and Arnold Cooke for comments that improved the manuscript.

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# Dietary habits of the Burmese python, *Python molurus bivittatus*, in Everglades National Park, Florida

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THE Burmese python (*Python molurus bivittatus*), a subspecies of the Indian python (*Python molurus*), is one of the largest snakes in the world, attaining lengths of up to six meters and over 90 kg in weight (Ernst & Zug, 1996; Minton & Minton, 1973). Native throughout southeast Asia, *P. molurus* is known to consume a wide variety of prey items including various mammal, amphibian, lizard, snake, bird and fish species (Bhupathy & Vijayan, 1989; Ernst & Zug, 1996; Minton & Minton, 1973). A formidable predator, large *P. molurus* have been reported to even prey upon adult leopards, jackals, deer, and boar (Ernst & Zug, 1996; Minton & Minton, 1973; Wall, 1921). However, information specific to *P. m. bivittatus* in the wild is scant and limited to data available for *P. molurus*.

Instances of pet release have lead to *P. m. bivittatus* becoming established within Everglades National Park (ENP), Florida (Snow, 2006). The number of individuals captured or sighted in ENP has increased dramatically since large specimens were first reported in the 1980s (Meshaka *et al.*, 2000) (see Figure 1). From 1995 through 2005, *P. m. bivittatus* have been observed and removed along Main park road, Long Pine Key, Shark Valley, Tamiami trail, and along the eastern park boundary (Snow, 2006). The majority of sightings have been along roads and canal levees. More troubling is that pythons have been observed in remote areas such as the mangrove backcountry and recovered along the 18 mile stretch leading to the Florida Keys (Snow, 2006). This suggests a far broader invasion than initially thought and one that appears to be expanding. Given the ability of *P. molurus* to

consume large and varied prey, *P. m. bivittatus* poses a serious threat to the majority of native fauna in ENP and surrounding areas. Determining which native species may be most at risk is of particular concern. In an effort to understand the potential ecological impact of this invasive species, we investigated the diet of sub-adult and adult *P. m. bivittatus* through analyses of stomach and lower intestines of captured specimens.

Fifty-six *P. m. bivittatus* recovered in or adjacent to ENP between January 2003 and March 2006 were examined for prey. These individuals were located along elevated roads and canal levee corridors associated with habitat including coastal prairie, mangrove, freshwater marl prairie, cypress, pinelands, hardwood hammocks, freshwater slough, and farmland (both active and former). Sex, snout-vent length (tip of snout to posterior of anal plate), weight and total length were recorded where possible. Stomach and lower gastro-intestinal tracts were then examined stereoscopically for feathers, hair, teeth, bone fragments, claws and scales. An attempt was made to identify mammal, bird and reptile remains to species level, however, most were identifiable only to genus, with others to order.

Fifty (89.3%) of the 56 *P. m. bivittatus* examined (mean total length 265.14 ± 10.90 cm, range 69.5–427 cm) contained prey remains from twelve species of mammal and five species of birds. This included two bird species listed by the Florida Game and Freshwater Fish Commission as species of special concern (Table 1). Eighty six percent (43 out of 50) of these pythons had prey items in an advanced stage of digestion and found

Prey	No. of records	% of sample
<b>Mammals</b>	<b>38</b>	<b>70.37</b>
<i>Sylvilagus</i> (Cottontail rabbit)	9	16.67
Rodentia (species uncertain)	6	11.11
<i>Sigmodon</i> (Cotton rat)	5	9.26
<i>Peromyscus gossypinus</i> (Cotton mouse)	3	5.56
<i>Sciurus</i> (Tree squirrel)	3	5.56
<i>Felis</i> (Cat)	2	3.70
<i>Procyon</i> (Raccoon)	2	3.70
<i>Rattus</i> (Old World rats)	2	3.70
Unidentifiable remains	2	3.70
<i>Didelphis</i> (Large American opossums)	1	1.85
<i>Felis rufus</i> (Bobcat)	1	1.85
<i>Neofiber</i> (Round tailed musk rat)	1	1.85
<i>Oryzomys</i> (Rice rat)	1	1.85
<b>Birds</b>	<b>15</b>	<b>27.78</b>
Aves (uncertain identity)	9	16.67
<i>Podilymbus podiceps</i> (Pied-billed grebe)	2	3.70
<i>Aramus guarauna</i> (Limpkin)*	1	1.85
<i>Eudocimus albus</i> (White ibis)*	1	1.85
<i>Fulica americana</i> (Coot)	1	1.85
<i>Troglodytes aedon</i> (House wren)	1	1.85
<b>Reptiles</b>	<b>1</b>	<b>1.85</b>
<i>Alligator mississippiensis</i> (Alligator)* <sup>1</sup>	1	1.85

**Table 1.** Prey ingested by 56 *Python molurus bivittatus* recovered in or adjacent to Everglades National Park, Florida, between January 2003 and March 2006. <sup>1</sup> This python (386 cm total length) died consuming an *A. mississippiensis*. \* Indicates species listed by Florida Game and Freshwater Fish Commission as special concern species.

in the lower intestine. The ratio of male *P. m. bivittatus* to females was almost 1:1, with 27 identified males and 29 females. Males were a mean total length of  $253.35 \pm 13.37$  cm and mean mass of  $8301.35 \pm 1234.54$  g, while females were a mean total length of  $277.50 \pm 17.16$  cm and mean mass of  $12116.12 \pm 2126.73$  g. Eight of the 56 *P. m. bivittatus* were under 200 cm, with the majority of individuals (85.71%) considered either sub adult or adults given that sexual maturity is around 260 cm (Lederer, 1956; Wall, 1921).

In addition, one female *P. m. bivittatus* (378 cm total length) consumed a subadult Bobcat (*Felis rufus*), and a male (386 cm total length) attempted to consume an American alligator (*Alligator mississippiensis*) (210 cm approx. total length) but died in the process.

The presence of *F. rufus* and *A. mississippiensis* in two large *P. m. bivittatus* indicates that almost any native species within ENP is vulnerable to predation. Native threatened and endangered species such as the Florida panther (*Puma concolor coryi*), Wood stork (*Mycteria Americana*), Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) and Mangrove fox squirrel (*Sciurus niger avicennia*) have not been observed as prey to date but are of special concern. The distribution of *P. m. bivittatus* within ENP overlaps with all four of these species with a large number of sightings or captures occurring in close proximity to birding hot spots, including Wood stork rookeries (Snow, 2006).

Another concern is the many federally listed endangered mammals that inhabit the Florida Keys (Reed, 2005). This includes the Key Largo woodrat (*Neotoma floridana smalli*) and Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*). To date there have been in excess of 14 pythons recovered along the 18 mile stretch leading to the Keys (R.W. Snow, pers. comm.)

Our observations agree with the information available for *P. molurus* in its native range, suggesting a broad diversity of diet and the ability to prey upon other large predators (Bhupathy & Vijayan, 1989; Ernst & Zug, 1996; Minton & Minton, 1973). While studies such as Bhatt & Choudhury (1993) found birds constituted the main prey item of *P. molurus*, Ernst & Zug (1996) have noted mammals as the dominant prey type. This variation can be expected given different prey species associate with specific habitat types, and seasonal fluctuations in abundance are common among migrating birds and especially many rodent species (Madsen & Shine, 1999; Smith & Vrieze, 1979).

The broad dietary and habitat diversity, ability to consume large prey, long lived nature, and high reproductive output (up to 100 eggs in a single





**Figure 1.** A 3.14 m (total length) female *Python molurus bivittatus* located on a tree island a few kilometres south of Pa-hay-o-kee Lookout, ENP. The snake was subsequently removed. © Jemeema Carrigan (University of Florida).

clutch) of *P. m. bivittatus* (Ernst & Zug, 1996; Minton & Minton, 1973) have the potential to create a huge ecological problem in ENP. It is essential that initiatives are developed specifically to manage and mitigate python impacts and to protect and monitor native fauna, especially endangered species.

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# The ecological specialist, *Thermophis baileyi* (Wall, 1907) – new records, distribution and biogeographic conclusions

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**ABSTRACT** – *Thermophis baileyi* (Wall, 1907) is a small montane colubrid snake, endemic to the Tibetan Plateau with unknown distribution. The species has previously been recorded from only three sites. We aimed to provide new records and to gather the baseline information on ecology and biogeography necessary to understand its origin and evolutionary history. Data were collected on several expeditions between 1999 and 2006 in Tibet (A.R., China). We surveyed selected locations that offered suitable habitat conditions for *T. baileyi* and determined every position using GPS. A map of hot-spring distribution on the plateau was then superimposed on these records. We report 13 new localities for *T. baileyi*, which is known only from hot-spring areas and has probably the highest altitudinal distribution among all reptiles, ranging from 3600 to 4900 m asl. The new localities extend the known range of the species considerably. Although *T. baileyi* is rare in Tibet as a whole, it seems locally common at selective sites; these populations may be relatively small and isolated. We infer that *T. baileyi* found glacial refugia in hot-spring locations during the uplift of the Tibetan Plateau and cooler periods of the ice ages. Owing to the availability of suitable habitats and high density of hot springs in China, a more extensive distribution in Sichuan and even in the northern parts of Yunnan seems likely. Because of its restricted wider distribution, and specific habitat preferences, we emphasize the need for populational and phylogenetic studies on *T. baileyi*, particularly with respect to continuing habitat destruction in the region.

**T**HERMOPHIS *baileyi* (Wall, 1907), the Tibetan hot-spring snake (Hot-spring keel-back, Bailey's snake; type species: *Tropidonotus* (= *Natrix*) *baileyi*, F. Wall, 1907 by monotypy) has one of the highest known altitudinal distributions outside the tropics of any species of reptiles. This non-venomous colubrid snake (subfamily Xenodontinae, incertae sedis; Malnate, 1953; Lawson *et al.*, 2005) is known only from Tibet AR (Xizang), and there is very little information regarding details of its distribution (see cover illustration). It was recorded in Tibet for the first time in 1907 by Wall near Gyantze at 4300 m asl

(no exact coordinates available) and reported from the Yangbajain hot-spring area (Loc. 11; Table 1) in 1990 and 1991 by Macey and Papenfuss (California Academy of Science, online collection catalogue, <http://www.calacademy.org>). In 1993, Papenfuss collected 11 specimens near Maizhokunggar (c. 70 km northeast of Lhasa) for the Museum of Vertebrate Zoology, Berkeley. Apart from the record at Yangbajain, no other records provide detailed coordinates.

The snake had previously been found only at high-altitude geothermic locations, where it occurs mainly in habitats associated with thermal springs close to rivers. Despite being listed as a rare species on the IUCN Red List, almost nothing is

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known about its ecology, life history and distribution except for some notes about threats at the Tibetan Plateau.

Here we present new distribution records and information about the habitat requirements of *T. baileyi* in Tibet, which seem to be especially interesting with respect to the glacial history of the plateau.

## MATERIAL AND METHODS

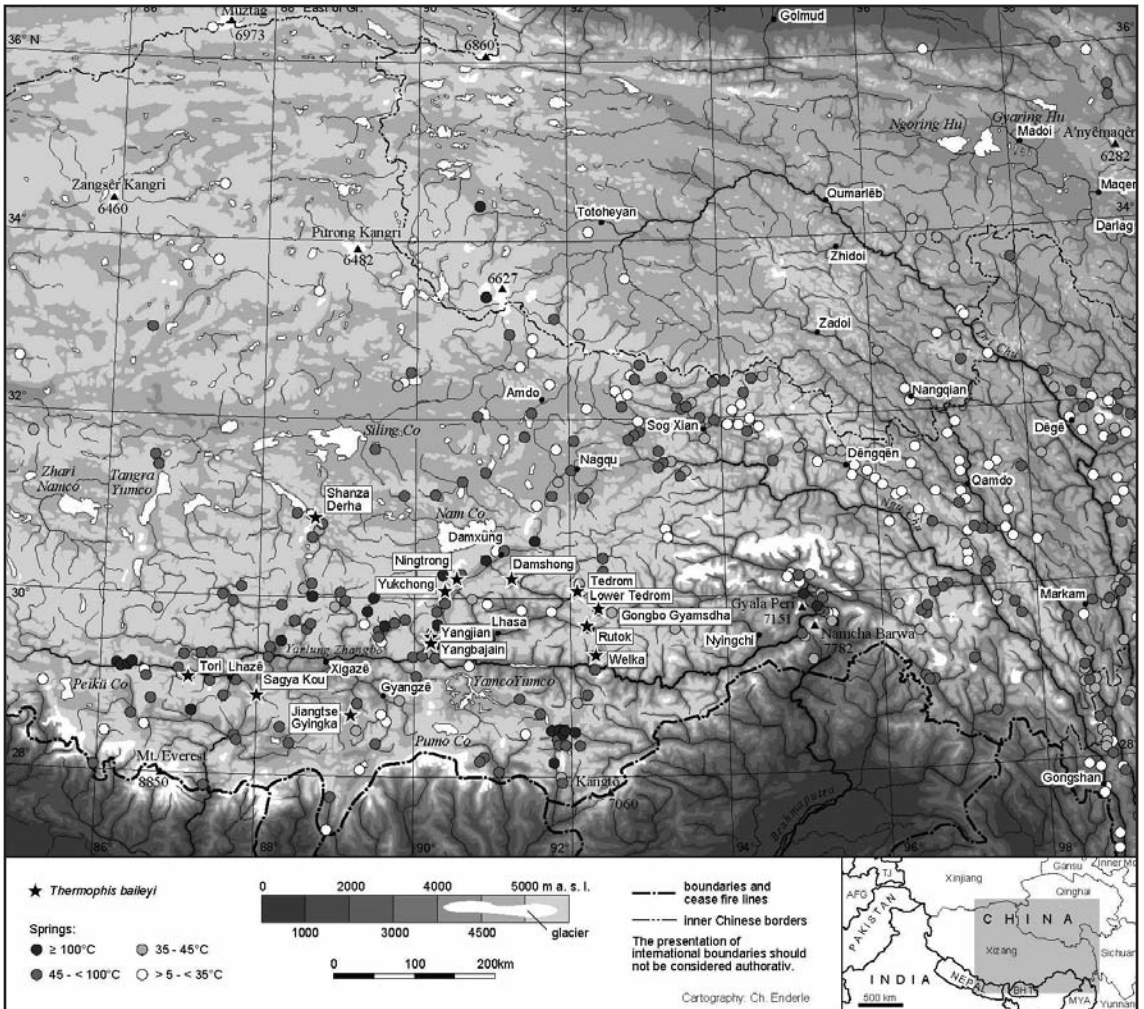
Data on the distribution and habitats of the hot-spring snake were gathered during several expeditions between 1999 and 2006. Areas offering suitable living conditions for *T. baileyi* were surveyed based on recent sightings reported by local Tibetans. Most sites were visited at least

twice; those with particularly many references were checked more frequently. Occupied sites were checked annually. Every location was specified by GPS coordinates. The snakes were captured by hand and a set of standard measurements was taken for every individual. In addition, several environmental parameters were recorded (ground and water temperatures, humidity).

## RESULTS

We recorded the snake in 14 of more than 25 surveyed sites at high altitudes between 3600m and 4900m asl in the central part of the Tibetan

**Figure 1.** Known distribution of *Thermophis baileyi* (Wall, 1907) and hot spring locations in Tibet (Xizang) province.





**Figure 2.** Typical habitat of *T. baileyi* (Yangbajain, AR Tibet). © S. Hofmann.

Plateau (Fig. 1, Table 1). Considering all these records, *T. baileyi* is known from *c.* 28°70' to 30°90'S and 87°12' to 92°14'E. The wide range of vegetation types surrounding the hot springs covers potential natural juniper forests, alpine dwarf shrublands, high alpine *Cyperaceae* mats and open scree vegetation (Figure 2).

To estimate the area in which *T. baileyi* might occur with relatively high probability, we overlaid our records with the distribution of hot springs (Chinese Academy of Sciences, 1990) using the computer programs Mapinfo ver. 7.5 (Mapinfo, New York) and ArcView ver. 3.2 (ESRI). Our results indicate that *T. baileyi* is relatively sparsely dispersed on the plateau and is probably more abundant in the eastern and central parts. If suitable habitats are available, it might also occur in hot springs in Sichuan and probably even in the northern parts of Yunnan.

The populations in Tibet appear to be more or less isolated from each other. As it is assumed that

the snakes disperse only over short distances, we plan to track several adult individuals in spring 2007 to obtain specific information about their dispersal capacity.

Wall (1907) noted that *T. baileyi* “can be obtained in winter and summer alike”, which seems doubtful if only because of the fact that food is very limited in winter. Local residents we spoke to all said that they had never seen a snake in winter time. At the type locality, the mean monthly temperature between November and February remains below 0°C and the mean minimum temperature of the coldest month is -14.5°C (data from the Meteor. Service China, as cited in Miede *et al.*, 2001). We infer that the seasonal activity period of *T. baileyi* thus begins between mid-April and May and extends until September or October.

We found *T. baileyi* in the vicinity of hot springs where they basked on the warmed up ground between rocks or along river banks. They were particularly active after rain. In contrast to Wall (1907), who stated that *Thermophilis* “are reported

not to enter the water”, some individuals were observed in the warm pools of hot springs and in adjacent rivers.

The water temperatures of the hot springs were relatively constant over the season and ranged from 29 to 33°C. River temperatures were much lower (8–11°C) and did not vary during a given day. At ground level, temperatures rose to 35°C as early as March (depending on solar radiation and ambient temperature).

*Thermophis baileyi* feeds primarily on metamorphs of the widely distributed *Nanorana parkeri* (synonym: *Altirana Stejneger*, 1927) and fishes of the genus *Schizopygopsis* (Tsering Dorje *et al.*, pers. obs.); in turn it is preyed on by raptors such as buzzards (*Buteo hemilasius* and *B. buteo*), and the Tibetan sand fox (*Vulpes ferrilata*).

## DISCUSSION

With elevational records of up to 4900 m asl, *T. baileyi* achieves the world’s highest altitude distribution among all snakes. The only other snake species with comparable altitudinal ranges are the Himalayan pit viper (*Gloydius himalayanus*; Günther, 1864) found in Pakistan, India and parts of Nepal at 1500-3050 m altitude (Khan *et al.*, 1986; McDiarmid *et al.*, 1999) and some small montane rattlesnakes of the genus *Crotalus* (*C. tancitarensis*, *C. triseriatus*; Alvarado-Díaz & Campbell, 2004), which live at elevations up to 3700 m on the Mexican Plateau and associated highlands. Some lizards of the genus *Sceloporus* and *Phrynosoma* reach elevations above 3500 m (Hodges, 2004) and several *Liolaemus* species occur even up to 5000m (Andrews, 1998). The Himalayan agama *Phrynocephalus theobaldi* is common in the alpine steppe of the Tibetan central highland in 4750 m and “may be found as high as seventeen thousand feet” (Schaller, 1997).

Species living at high elevations must be able to cope with strong winds, cold temperatures and desiccation, since rainfall is low and what little there is drains away quickly. Only a few of the hot

Ref. no.	Hot spring name	Latitude	Longitude	Alt. (m)
1	Shanza Derha	30°90'	88°70'	4680
2	Yukchong	30°09'	90°39'	4891
3	Ningtrong	30°23'	90°54'	4250
4	Damshong	30°23'	91°25'	4260
5	Terdrom	30°09'	92°09'	4412
6	Lower Tedrom	30°06'	92°10'	4401
7	Gongbo Gyamsdha	29°89'	92°36'	4470
8	Rutok	29°70'	92°21'	4359
9	Welka	29°37'	92°32'	3600
10	Yangjian	29°58'	90°21'	4410
11*	Yangbajain	29°51'	90°21'	4395
12	Jiangtse Gyinkinga	28°70'	89°20'	4200
13	Sagya Kou	28°90'	88°00'	4320
14	Tori	29°09'	87°12'	4120

**Table 1.** Geographic coordinates of the new records of *Thermophis baileyi* (Wall, 1907). To avoid adverse effects on these sites caused by private or commercial collectors, coordinates are given only with a precision of 0.1d. \*Site “11” was first recorded by Macey and Papenfuss in 1990 (California Academy of Sciences, catalog number CAS 177878, <http://calacademy.org>).

springs on the Tibetan Plateau seem to provide suitable optimal habitat for the snakes in terms of food conditions and appropriate holes for refuge. The limiting habitat factor appears to be the existence of a stream or river beside the hot spring.

Because of its adaption to exceptional high-altitudes, the distribution and phylogeographic evolution of *Thermophis baileyi* might reflect the climatologic effects of the uplift of the Tibetan Plateau and the glacier extension of the last ice age. Neither of these environmental impacts is well understood. There is geological evidence that the hot springs listed in Table 1 were not covered by an ice sheet during the Last Glacial Maximum (e.g. Zhang & Li, 2002). The question of when the uplift of the Tibetan Plateau reached altitudes hostile to snakes that did not live near hot springs is still in dispute. Rowley and Currie (2006) give a late Eocene to Miocene age of altitudes more than 4000 m since the last 35 million years for the central Tibetan highlands, whereas Spicer *et al.* (2003) give 15 million years for altitudes of 4600m in southern Tibet. In contrast, Xu (1981) provides evidence of a very young uplift after 0.5 million years.

We hypothesise that the ancestor of *T. baileyi* managed to survive such a relatively rapid geological uplift of the plateau by retreating into hot spring areas, and that its evolution in this habitat continued through many periods of climate change. As yet there are only very few data available on the morphological and taxonomic evolution of *T. baileyi*; thus one can only speculate about its phylogenetic history. The hemipenial structure might be interpreted as evidence of a relationship with the genus *Elaphe* (Malnate, 1953). Our further studies will be focussing on more detailed mapping of distribution in this species, and will also include molecular phylogenetic analyses.

Because of its apparently very restricted distribution and unique habitat preferences *T. baileyi* should be considered as a species of particular conservation concern. The populations face numerous threats by the increasing commercial use of the few hot springs and are likely to undergo a substantial decline in the near future. The development of infrastructural facilities around the hot springs does not only reduce the snakes' habitat but also directly diminishes the number of individuals since they are trapped as a source of food ((S. Hofmann, pers. data). Field research to further elucidate their distribution and habitat preferences is urgently required with a view to determining their conservation status and the potential impact of habitat changes.

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# Mountain wolf snake (*Lycodon r. ruhstrati*) predation on an exotic lizard, *Anolis sagrei*, in Chiayi County, Taiwan

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**ABSTRACT** – The Mountain wolf snake (*Lycodon ruhstrati ruhstrati*) is a common snake species at low elevations all over Taiwan. Still, it appears to be poorly studied in Taiwan and adjacent areas since little has been reported about this species. On 26<sup>th</sup> August 2002 ten *L. r. ruhstrati* eggs were obtained from an adult female, one of two that were caught a day before, and eight of the eggs hatched successfully on 14<sup>th</sup> October 2002. While in captivity all the adults preyed upon *Anolis sagrei*, which were given to them as prey, while two neonates accepted *A. sagrei* hatchlings offered to them as food. On February 18<sup>th</sup>, 2006, a DOR Mountain wolf snake, with an *A. sagrei* in its stomach, was found on a tarred road in Santzepu, Sheishan District, Chiayi County. This appears to be the first report from Taiwan of the Mountain wolf snake (*L. r. ruhstrati*) preying on the exotic introduced lizard *A. sagrei*.

**T**HE common name ‘wolf snake’ refers to members of the genera *Cryptolycus* – 1 species, from Mozambique; *Lycodon* – 26 species, distributed over Asia; and *Lycophidion* – 15 species, inhabiting tropical and southern Africa (Coborn, 1991; Mattison, 1999). Their common name derives from their enlarged curved teeth, which are used for capturing lizards such as skinks (Greene, 1997).

The Mountain wolf snake (*Lycodon ruhstrati*), formerly classified as *Dinodon septentrionale* and *Ophites ruhstrati* (Ota, 1988), can be found in Indo-China, central to southwestern China, as well as Hong Kong and Ryukyu Island, and *Lycodon ruhstrati ruhstrati* is the only member of these peculiar snakes that naturally occur in Taiwan, where they tend to inhabit mountainous areas below 2000 m, as well as gardens, rice paddies and other agricultural areas, and secondary forests all over Taiwan (Kuntz, 1963; Lazell, 1999; Lue *et al.*, 2002). Although this is a fairly common species (Kuntz, 1963; Maki, 1931), apart from its distribution and possible prey, it seems that very little has been reported about this snake and its natural history is thus most likely poorly understood.

Introduced populations of the Brown anole (*Anolis sagrei*), also known as *Norops sagrei* (Köhler, 2000; Lee, 2000), have been recorded in Jamaica (Roughgarden, 1995, Landwer *et al.*, 1995) (Note: It is not definite that *A. sagrei* was introduced into Jamaica by anthropogenic activities as opposed to getting there by natural dispersal (J.B. Losos, *personal communication*)), Grand Cayman (Roughgarden, 1995), Arkansas (McAllister *et al.*, 2003), Texas (Conant & Collins, 1991), Louisiana (Steven & Lance 1994), Georgia, northeastern Florida and all Florida counties southeast of the Suwannee River (Campbell, 1996; Campbell, 2003), México to Belize (Calderon *et al.*, 2003; Rodriguez Schettino 1999; Schwartz & Henderson, 1991), Granada, West Indies (Greene *et al.*, 2002), Hawaii (Goldberg & Bursey, 2000) and Taiwan (Norval *et al.*, 2002). Here we report what appears to be the first reported case of a Mountain wolf snake (*L. r. ruhstrati*) predation on the exotic introduced lizard *A. sagrei* in the wild.

## MATERIALS AND METHODS

On 25<sup>th</sup> August 2002, two adult *L. r. ruhstrati* females were captured in the shower of the administration building of the Taiwan Flower

Biotechnology (TFB) nursery in Santzepu, Sheishan District, Chiayi County (23°25'51"N, 120°28'30"E). The snakes were given to Norval for examination. Due to time constraints, he decided to leave the snakes in their containers until the following morning. When the snakes were removed for examination the following morning, it was found that the largest of the two females (female-A) had laid 10 eggs. Since the eggs had not whitened completely and were still soft it is believed that oviposition most likely took place earlier that morning. On 14<sup>th</sup> October 2002 eight eggs hatched, but only six of the neonates survived.

As part of an investigation whether *L. r. ruhstrati* would prey on the introduced brown anole (*Anolis sagrei*, also known as *Norops sagrei*) (Norval *et al.*, 2002), which also occur in the area surrounding the nursery, live *A. sagrei* were collected from the wild and offered as prey items to the adult and neonate snakes. The sex, SVL, TL (measured to the nearest mm with a ruler) and mass (measured to the nearest 0.1g with an electronic scale) of the lizards were recorded before placing them in the containers containing the snakes. If predation did not take place within 48h, the lizard was removed and the trial was scored as failed to predate. The date on which predation took place was noted if it took place. Upon completion of the study, the snakes were released (the adult females on 9<sup>th</sup> October 2002 and the neonates on 18<sup>th</sup> November 2002) back into the wild in the vicinity where the adult females were collected.

On February 18<sup>th</sup>, 2006, at 10:38 h, a DOR (dead on road) Mountain wolf snake was found on a tarred road in Santzepu, Sheishan District, Chiayi County (23°25'41"N, 120°29'20"E; datum: WGS84). The road is bordered on the eastern side by a betelnut palm plantation (*Areca catechu*), and on the western side by a temple and some residences. Vegetation such as *Ampelopsis brevipedunculata* var. *hancei*, *Bidens pilosa*, *Cardiospermum halicacabum*, *Ipomoea cairica*, *Ipomoea obscura*, *Melastoma candidum*, *Mikania micrantha*, and *Panicum maximum* make up the under-story vegetation of the betelnut palm plantation. Brown anoles (*A. sagrei*), *Eumeces*

*elegans*, *Hemidactylus frenatus*, *Japalura swinhonis*, *Mabuya longicaudata*, *Sphenomorphus indicus*, and *Takydromus formosanus* were the only lizard species observed in this area, and the only other snake species observed were *Amphiesma stolatum*, *Bungarus multicinctus multicinctus*, *Dinodon rufozonatum rufozonatum*, *Elaphe carinata carinata*, *E. taeniura friesei*, *Naja atra*, *Oligodon formosanus*, *Ptyas korros*, and *Xenochrophis piscator*.

The snout-vent length (SVL) and tail-length (TL) of the two adult females were measured to the nearest millimeter and they were weighed to the nearest 0.1g with an electronic scale. To avoid injury to the neonates, they were not sexed and were measured by being placed next to a small ruler for scaling under a white sheet, which was on an EPSON PROFESSIONAL 1650 scanner set to scan at 400 dpi, and scanned at 100% (Mao *et al.*, in preparation). All the neonate measurements were then recorded from these scanned images. The neonates were also weighed to the nearest 0.1g with an electronic scale.

The SVL and TL of the DOR snake was measured to the nearest millimeter, using a transparent plastic ruler, and the body mass was weighed to the nearest 0.1g with a PROSCALE BEB-250 digital scale. It was then dissected by making a mid-ventral incision with a surgical scissor. The stomach appeared to be containing a prey item, and an incision was therefore made in the stomach wall to remove the stomach contents. The snake and stomach content were fixed and preserved in 75% alcohol.

Using a transparent plastic ruler, the stomach contents – the remains of a lizard – was measured to the nearest millimeter, after which it was identified to the lowest possible taxonomic category based on the scales of the tail, limbs, and digits.

## RESULTS

The mean SVL, TL and body mass of the adult *L. r. ruhstrati* were 585 mm (SD = ±42.43), 75.5 mm (SD = ±21.92), and 20.35g (SD = ±6.29), respectively. On 14<sup>th</sup> October 2002 the six live neonates had a mean SVL, TL and body mass of 156.8 mm (SD = ±22.53), 56.9 mm (SD = ±5.98), and 2.2g (SD = ±0.46), respectively. Exactly a



Snake species (as predator)	<i>Anolis sagrei</i> (as prey)				Trial	
	Sex	SVL (mm)	TL (mm)	Mass (g)	Date	Result
<i>Lycodon r. ruhstrati</i> (female A)	F	31	62	1	09-09-2002	P 09-09-2002
	F	31	61	1	17-09-2002	P 17-09-2002
	F	30	54	2.3	26-09-2002	P 26-09-2002
<i>Lycodon r. ruhstrati</i> (female B)	M	30	66	1.4	09-09-2002	P 09-09-2002
	M	55	55	5	17-09-2002	P 17-09-2002
	F	45	92	0.5	26-09-2002	P 26-09-2002
<i>Lycodon r. ruhstrati</i> (neonate A)	M	19	32	0.2	15-11-2002	F
<i>Lycodon r. ruhstrati</i> (neonate B)	F	19	30	0.1	15-11-2002	P 16-11-2002
<i>Lycodon r. ruhstrati</i> (neonate C)	F	20	15	0.2	15-11-2002	F
<i>Lycodon r. ruhstrati</i> (neonate D)	F	23	41	0.3	15-11-2002	F
<i>Lycodon r. ruhstrati</i> (neonate E)	M	17	30	0.1	15-11-2002	P 16-11-2002
<i>Lycodon r. ruhstrati</i> (neonate F)	M	19	32	0.2	15-11-2002	F
<i>Dinodon r. rufozonatum</i> (Male; SVL-630, TL-150, 43.5g) obtained 08-08-2003	F	45	59	2.6	15-08-2003	P 15-08-2003
	M	51	101	4.3	27-08-2003	P 27-08-2003
	M	55	120	4.9	05-09-2003	P 05-09-2003
	F	41	77	2.0	05-09-2003	P 05-09-2003
	M	50	104	3.9	17-09-2003	P 17-09-2003
<i>Elaphe c. carinata</i> (Female; SVL-378, TL-108, 20.6g) obtained 11-09-2003	M	47	85	3.4	17-09-2003	P 17-09-2003

month later, the six neonates had an average SVL, TL and body mass of 172.4 mm (SD =  $\pm 22.22$ ), 61.7 mm (SD =  $\pm 6.57$ ), and 1.9 g (SD =  $\pm 0.45$ ), respectively.

Both the adult *L. r. ruhstrati* accepted the *A. sagrei* that were offered to them as prey, while only two neonates preyed on the *A. sagrei* hatchlings offered to them (Table 1).

The DOR *L. r. ruhstrati* had a SVL, TL, and pre-dissection mass of 626 mm, 153 mm, and 46.3g, respectively. A partly digested male *A. sagrei* (TL = 120 mm) was retrieved from the stomach. From the scalation of the tail, it was determined that this individual had never experienced tail-loss.

**Table 1.** *Lycodon r. ruhstrati* individuals used in *A. sagrei* predation trials, as well as the outcome of each trial (P - Predation took place, F - Predation failed to take place). For snake species other than *L. r. ruhstrati*, dimensions are provided - measured on the day the animal was obtained.

## DISCUSSION

Even though the Mountain wolf snake is a common snake species in Taiwan, its small size and nocturnal nature may make it an unsuitable study subject, which may explain why so little has been reported about this species. This may also be the case for many other *Lycodon* species. Mattison (1999), for example, stated that the taxonomy of this

genus is not clear and that the number of species may be exaggerated. In India, where six *Lycodon* species occur, nothing is known of the diet and reproductive behaviour of *L. flavomaculatus* and *L. travancoricus* (Das, 2002). For that reason chance observations, like the ones described in this paper, should be reported not only to develop a better understanding of the natural history of the species in question, but also to highlight the aspects that require more research.

The feeding behaviour and dietary preference of the Mountain wolf snake is very poorly reported. Pope (1929) stated that this species is saurophagus, although, according to Lue *et al.* (2002) they might also be insectivorous. Ota and Azuma (2006) reported feeding *L. r. multifasciatus*, a related subspecies from Okinawa (Goris & Maeda, 2004), in captivity tropical house geckos (*Hemidactylus frenatus*). Under captive conditions, in the predation trials we also noted that the adults, as well as the two largest neonates of *L. r. ruhstrati* preyed on *A. sagrei* that were offered to them as prey. Although one should be cautious when interpreting predation under captive conditions, the predation trials, as well as the stomach content of the DOR *L. r. ruhstrati*, confirms that these snakes are indeed saurophagus, and even more importantly, they are natural predators of the exotic lizards. The fact that the adults so readily accepted the exotic Brown anole as food items may indicate towards a possible important ecological role for *L. r. ruhstrati* in the biological control of the brown anole in this region. The question remains, however, why didn't the other neonates prey on the *A. sagrei* offered to them? Were they simply too big to handle, or do very small *L. r. ruhstrati* neonates prey on another type of prey, and if so, what prey? This also raises the question about how these snakes capture their prey. While conducting fieldwork, between the 1<sup>st</sup> of September 2005 and 1<sup>st</sup> of November 2006, on three occasions, *L. r. ruhstrati* were encountered in the study area

on vegetation. In addition to that, another four *L. r. ruhstrati* were captured in traps set in the study area to collect terrestrial reptiles, and from this, it can be deduced that these snakes are semi-arboreal. But it is still not clear how these snakes locate and capture their prey. Like all the other biological aspects of this snake species, the feeding behaviour requires more in depth study.

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# Colour and pattern polymorphism in *Pristimantis shrevei* and *Eleutherodactylus johnstonei* (Leptodactylidae) on St. Vincent, West Indies

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THE genus *Eleutherodactylus*, with more than 700 species, had been considered to be the most speciose vertebrate genus (Pough *et al.*, 2004). A recent revision (Heinicke *et al.*, 2007), however, revealed three major clades, two of which are represented in the West Indies. A “Caribbean clade” (*Eleutherodactylus*) contains four subgenera and 170 currently recognised species, including all but two West Indian forms. A “South American clade” (*Pristimantis*) contains nearly 400 species, two of which occur on the St. Vincent and Grenada island banks. All of these frogs lay eggs in humid places outside of water and exhibit direct development, with froglets emerging as small replicas of adults (Rivero, 1998). They often exhibit colours and patterns that render them cryptic (Pough *et al.*, 2004), although many species exhibit considerable polymorphism (e.g., Savage & Emerson, 1970; Sifers *et al.*, 2001, Sander *et al.*, 2003). Schwartz & Henderson (1991) used phrases such as “... dorsal pattern variable ...” and “... frequently present”, and Kaiser & Hardy (1994) noted “... a great variety of dorsal patterns”.

Two eleutherodactylines, *Pristimantis shrevei* and *Eleutherodactylus johnstonei* (Figure 1), occur on St. Vincent. *Pristimantis shrevei* is endemic and occurs primarily at higher elevations (> 350 m), whereas *E. johnstonei* presumably is introduced (Kaiser & Hardy, 1994), albeit well-established, and occurs at low and high elevations. The former is most abundant in relatively natural habitats, where *E. johnstonei* often is less commonly encountered (C. A. Rodríguez Gómez, pers. comm.). However, in heavily altered situations, especially at lower elevations, ecologically

versatile *E. johnstonei* dominates and *P. shrevei* is absent (Mallery *et al.*, 2007).

As in many eleutherodactylines (e.g., Schwartz & Henderson, 1991; Sifers *et al.*, 2001), both Vincentian species are extremely variable in colour and pattern. Sander *et al.* (2003) documented considerable variation in *E. johnstonei* from Grenada, identifying colour and pattern elements that occurred in varying frequencies in populations at different locations. We examined colour, patterns, and sizes of frogs taken from sites on St. Vincent at high to moderate elevations, where both species were present, and at low elevation, where we found only *E. johnstonei*, to determine if variability was influenced by elevation.

From 1<sup>st</sup>–20<sup>th</sup> June 2006, we captured 25 *P. shrevei* and 43 *E. johnstonei* from five sites on St. Vincent (Fig. 2): (1) La Soufriere Volcano trail (elevation 961 m), (2) Vermont Nature Trail natural forest (411 m), (3) Hermitage Forest Reserve (342 m), (4) Vermont Nature Trail plantation forest (297 m), and (5) Bambareux Beach Resort (< 10 m). Frogs were kept individually at ambient temperatures (ca. 27°C) for no more than six days before release at the original site of capture. We measured snout-vent length (SVL) to the nearest 0.1 mm using a Vernier caliper and mass to the nearest 0.1 g with a Pesola spring scale (Pesola AG, Baar, Switzerland). Each individual was photographed with a digital camera (Nikon Cool Pix 5600; Nikon USA, Melville, New York) to record colour and pattern. Photographs were taken in a darkened room, as individuals often are much darker when exposed to daylight. We specifically noted the following



**Figure 1.** Adult male *Pristimantis shrevei* (left) and adult female *Eleutherodactylus johnstonei* from the Hermitage Nature Trail (342 m), St. Vincent. All photographs © R. Powell.

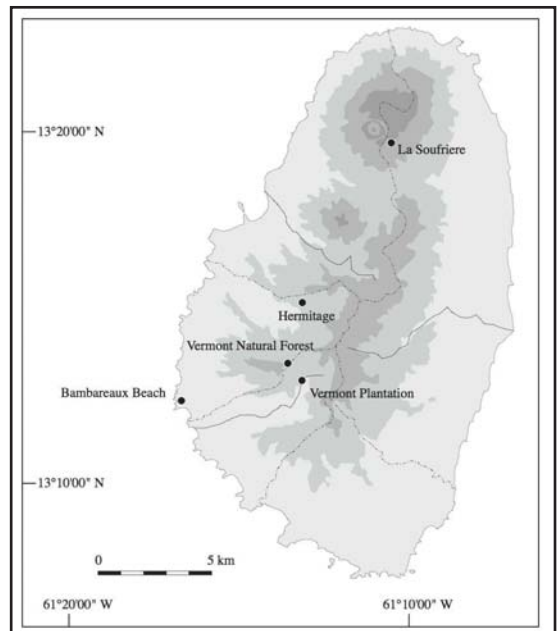
characteristics: dorsal, lateral, and ventral ground colour, colour of iris, snout, and toe pads, and presence/absence, extent, and colour of dorsal mottling, middorsal line, dorsolateral lines, dorsal chevrons, interorbital line, canthal lines, supratympanic, tympanic, and subtympenic lines, post-anal triangle, and vertical bars on fore- and hindlimbs. For statistical tests, we used Statview 5.0 (SAS Institute, Cary, North Carolina). All means are presented  $\pm$  one standard error;  $\alpha = 0.05$ .

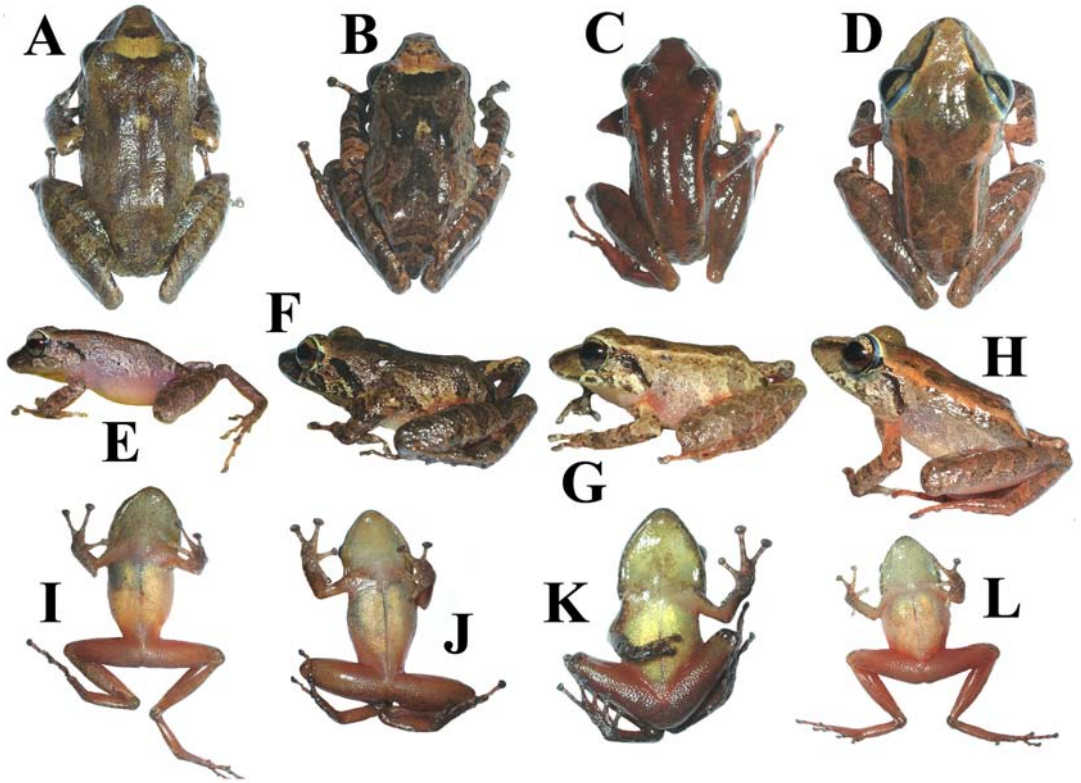
Female and male *P. shrevei* from sites 1 and 2 did not differ significantly in SVL (Mann-Whitney U,  $Z = -0.28$ ,  $P = 0.78$ ;  $Z = -0.94$ ,  $P = 0.35$ ; respectively) or body mass (males,  $Z = -0.23$ ,  $P = 0.82$ ; females,  $Z = -1.17$ ,  $P = 0.24$ ), allowing us to pool our samples from those sites (Table 1). Females were significantly longer and heavier than males (SVL,  $Z = -3.35$ ,  $P = 0.0008$ ; weight,  $Z = -3.48$ ,  $P = 0.0005$ ). Size and body mass were significantly correlated in both sexes (Kendall correlation, females,  $Z = 2.21$ ,  $P = 0.03$ ; males,  $Z = 4.58$ ,  $P < 0.0001$ ).

Results were essentially similar for *E. johnstonei* (Table 1). No significant differences existed in SVL between females or males from high and low elevations (Mann-Whitney U,  $Z = -1.64$ ,  $P = 0.10$ ;  $Z = -0.44$ ,  $P = 0.66$ ; respectively), nor did either males or females from different elevations differ significantly in body mass (males,  $Z = -0.76$ ,  $P = 0.45$ ; females,  $Z = -0.22$ ,  $P = 0.83$ ). Female *E. johnstonei* were significantly larger and heavier than males (SVL,  $Z = -3.47$ ,  $P = 0.0005$ ; weight,  $Z = -3.70$ ,  $P = 0.0002$ ). As expected, SVL and body mass were significantly correlated in both males (Kendall correlation,  $Z = 3.239$ ,  $P = 0.0012$ ) and females ( $Z = 3.97$ ,  $P < 0.0001$ ).

*Pristimantis shrevei* from both of the sites where we found these frogs (Table 2) was extremely variable in colouration and pattern (Fig. 3). We found no consistent differences between either of our sites, nor were any traits found exclusively in either males or females. Characteristics common to most frogs

**Figure 2.** Map of St. Vincent showing collecting localities: (1) La Soufrière Volcano trail (elevation 961 m), (2) Vermont Nature Trail natural forest (411 m), (3) Hermitage Forest Reserve (342 m), (4) Vermont Nature Trail plantation forest (297 m), and (5) Bambareaux Beach Resort (< 10 m).



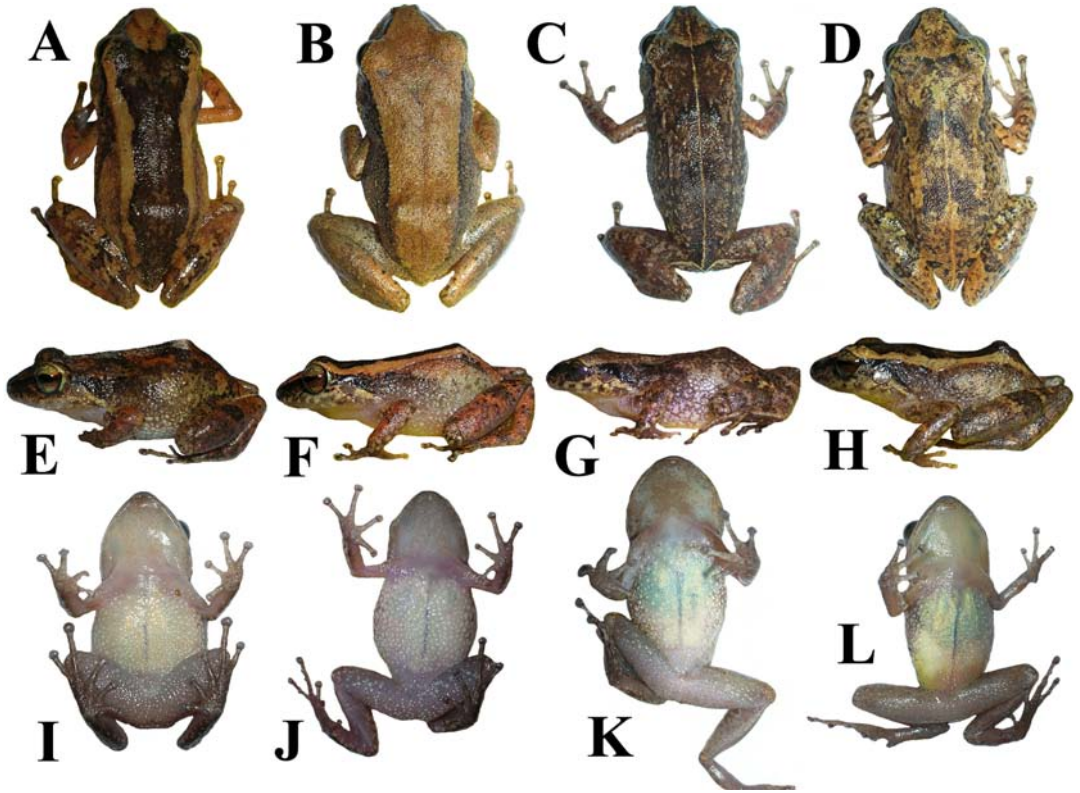


**Figure 3.** Representative colour and pattern polymorphism in *Pristimantis shrevei* from St. Vincent (note that individuals are not figured in the same scale): **A.** Gravid female (SVL 29.0 mm) from site 2 with a complete interorbital bar and a light bar on the top of the snout, two dorsal chevrons, and distinct bars on hindlimbs; **B.** Male (SVL 13.0 mm) from site 2 with a line on the top of the snout and interorbital bar present, distinct bars on hind- and forelimbs; **C.** Male (SVL 20.0 mm) from site 2 with dorsolateral lines, toe pads darker than toes, interorbital line absent; **D.** Male (SVL 19.0 mm) from site 2 with distinct bars on hindlimbs, inverted chevrons on dorsum, and full interorbital and canthal lines; **E.** Male (SVL 29.0 mm) from site 2 with broken bars on forelimbs, ivory coloration of the iris, and a strong supratympanic line; **F.** Male (SVL 18.5 mm) from site 2 with a supratympanic line, distinct bars on lips and hindlimbs; **G.** Male (SVL 18.0 mm) from site 2 with distinct bars on lips and supratympanic line followed by a lighter line; **H.** Male (SVL 19.0 mm) from site 2 with a weak bars on lips, distinct bars on fore- and hindlimbs, and distinct canthal and dorsolateral lines; **I.** Gravid female (SVL 24.0 mm) from site 1 with heavy mottling on grey throat and reddish colour on hind- and forelimbs; **J.** Male (SVL 19.0 mm) from site 1 with weak mottling on green throat and dark red on hindlimbs; **K.** Male (SVL 18.5 mm) from site 2 with a yellowish belly and mottling limited to the centre of the throat; **L.** Male (SVL 18.0 mm) from site 2 with a reddish belly and white throat.

included predominately yellow venters, and a greenish throat with a distinct yellowish cast; some individuals had white, grey, or yellow throats, but always with a yellowish tinge. Varying degrees of brown stippling on the throat were universally present, albeit sometimes reduced to margins and few scattered specks. The ground colour of the iris above and below a dark horizontal line running through the pupil ranged from near white through ivory to pale brown, often with a slightly golden tinge. Areas above and below the line were

essentially similar in colour. The horizontal line itself was dark brown, frequently with a reddish cast.

Pattern elements that were almost universally present, albeit less well defined in some individuals, included: (1) a dark brown to black canthal line continuous with the line through the orbit and continuing as a comparably dark supratympanic line set off by a lighter line passing through the tympanum; (2) interorbital bars (complete or broken) were present in all but two of the females (one each from sites 1 and 2) and three of the males (all from



**Figure 4.** Representative colour and pattern polymorphism in *Eleutherodactylus johnstonei* from St. Vincent (note that individuals are not figured in the same scale): **A.** Male (SVL 22.0 mm) from site 4 with distinct dorsolateral lines, dorsum darker than sides, and bars on hindlimbs broken; **B.** Female (SVL 30.0 mm) from site 3 with dorsum lighter than sides and no interorbital bar or middorsal line; **C.** Gravid female (SVL 27.0 mm) from site 5 with a light middorsal line, broken interorbital bar, and top of the snout lighter than dorsum; **D.** Male (SVL 20.0 mm) from site 5 with heavy mottling on the dorsum, dorsal chevrons, and middorsal line; **E.** Male (SVL 21.0 mm) from site 5 with no bars on lips and light tympanic above a faint subtympanic line; **F.** Male (SVL 21.0 mm) from site 4 with distinct bars on lips, broken bars on fore- and hindlimbs and dorsolateral lines; **G.** Male (SVL 21.5 mm) from site 4 with a supratympanic line, light tympanic line, and strong bars on the lips; **H.** Gravid female (SVL 22.0 mm) from site 4 with dorsolateral lines and distinct bars on hindlimbs; **I.** Male (SVL 19.9 mm) from site 5 with faint mottling on the throat and white belly; **J.** Male (SVL 19 mm) from site 5 with brown mottling on grey throat; **K.** Female (SVL 30.0 mm) from site 3 with mottling limited to margins and centre of throat; **L.** Gravid female (SVL 19.0 mm) from site 4 with a slightly yellowish belly.

site 2). Post-anal triangles occurred in all frogs. No individuals in our samples had middorsal lines. Most individuals had strong to indistinct vertical bars on the upper lips; three individuals that did not have bars on the upper lips instead had varying numbers and sizes of brown specks. Most frogs had two dark chevrons on the dorsum, but four had one chevron and six had none.

The ground colour of the dorsal and lateral fields, the top of the snout in front of the interorbital bar, and limbs ranged from grey and

light brown to very dark brown, often with a yellowish, orange, or reddish cast. Dorsal ground colour was usually the same as the lateral colour, but was occasionally darker or lighter. The top of the snout was usually lighter, but infrequently the same as the dorsum. Dorsolateral lines were in most cases absent, but when present, they were usually lighter than the dorsum; in only one individual were the dorsolateral lines darker than the dorsum. Toe pads varied in colour from very light brown through dark brown, sometimes with a

<i>Pristimantis shrevei</i>			
Female SVL	Female Body Mass	Male SVL	Male Body Mass
Site 1: La Soufrière Volcano Trail			
25.9 ± 1.9	1.6 ± 0.2	18.0 ± 0.6	0.6 ± 1.7
24.0-27.9	1.4-1.8	17.0-19.0	0.6-0.7
N = 2	N = 2	N = 3	N = 3
Site 2: Vermont Nature Trail Natural Forest			
28.5 ± 1.0	2.1 ± 0.3	17.8 ± 1.0	0.6 ± 0.1
27.0-31.0	1.4-2.5	13.0-29.0	0.2-1.8
N = 4	N = 4	N = 16	N = 16
<i>Eleutherodactylus johnstonei</i>			
Site 2: Vermont Nature Trail Natural Forest			
27.0 ± 0.0	2.6 ± 0.0	21.5 ± 0.5	0.7 ± 0.1
27.0	2.6	21.0-22.0	0.6-0.8
N = 1	N = 1	N = 2	N = 2
Site 3: Hermitage Nature Trail			
29.5 ± 0.5	2.1 ± 0.2		
29.0-30.0	1.9-2.2		
N = 2	N = 2		
Site 4: Vermont Nature Trail Plantation Forest			
22.2 ± 1.2	1.0 ± 0.1	20.2 ± 0.4	0.7 ± 0.1
19.0-25.0	0.5-1.4	18.2-22.0	0.5-1.1
N = 5	N = 5	N = 13	N = 13
Site 5: Bambareux Beach Resort			
24.0 ± 1.7	1.2 ± 0.2	19.5 ± 0.2	0.7 ± 2.9
17.5-27.0	0.6-1.4	18.0-21.0	0.4-0.8
N = 5	N = 5	N = 15	N = 15

**Table 1.** Sizes (mm) and body masses (g) of *Pristimantis shrevei* and *Eleutherodactylus johnstonei* from various sites on St. Vincent. Each entry includes the mean ± 1 SE, range, and sample size.

distinct greyish cast; colour in all but one frog from site 1 was darker than the toe itself. Eight individuals from site 2 had a light bar on the snout, with bars ranging from wide and complete to narrow and broken; one individual had a light spot on the snout.

Although *E. johnstonei* is at least equally polymorphic (Table 3, Fig. 4), we found no consistent differences between sites, nor were any traits found exclusively in either males or females.

Nearly all *E. johnstonei* have essentially white venters with varying degrees of brown stippling on the throat. Venters of a few individuals had a slight yellowish tinge, and throat stippling was sometimes reduced to margins and few scattered, medial flecks.

The ground colour of the iris above and below a horizontal line running through the pupil ranged from yellowish-white and gold through brown, the latter often with a golden tinge. Sometimes the area below the line was darker or lighter than that above the line. The horizontal line itself was dark brown, frequently with a reddish cast.

Pattern elements that were almost universally present, albeit less well defined in some individuals, included a dark brown to black canthal line continuous with the line through the orbit and continuing as comparably dark supratympanic line set off by a lighter line passing through the tympanum. In most (34 of 43) individuals, an additional complete or broken dark subtympanic line was present under the lighter one. The ground colour of the dorsal and lateral fields, the top of the snout in front of the interorbital bar, and limbs ranged from grey and light brown to very dark brown, often with a yellowish, orange, or reddish cast. Dorsal ground colour was in most cases

the same as the lateral colour, but was occasionally darker or lighter. The top of the snout was usually lighter than the dorsum. Nine individuals from site 5 had middorsal lines, all of which were narrow, lighter than the dorsum, and split posteriorly to continue laterally onto the backs of the thighs. Dorsal chevrons, when present, were darker than the ground colour. Limbs varied in relation to dorsal and lateral colour and were variously marked with bars that were sometimes broken into stippling or dots. Toe pad colour was set off by a light (proximal) and dark band from the colour of the toe. Pads varied in colour from nearly white and light brown through dark brown, sometimes with a distinct reddish tinge. In most cases, colour was essentially similar to the colour of the toes. Most individuals had weak vertical bars on the upper lips, seven had distinct bars, whereas 12 had only specks or no dark markings whatsoever.



Females and males, respectively, of both species and from all sites were essentially equal in size and weight. As is common in frogs (Duellman & Trueb, 1986), females of both species and from all sites were significantly larger than males. Our samples of both species essentially corresponded to previously published descriptions (e.g., Schwartz & Henderson, 1991), although we found greater variation in dorsal ground colours and noted some previously undescribed variations and combinations of colour and pattern elements (e.g., yellow/orange dorsal and lateral colouration and transverse bars on the snout in *P. shrevei*, and variable light tympanic lines above dark subtympnic lines that may or may not be present, variation in extent and distinction of labial bars, and variability in the colour of toe pads in both species).

Despite belonging to deeply divergent clades, both *P. shrevei* and *E. johnstonei* share many similar characteristics and are both exceedingly variable in colour and pattern, often rendering the distinction between them superficially difficult. The easiest way to distinguish one species from the other is by means of the consistently present reddish coloration on the ventral side of the hindlimbs in *P. shrevei* (Schwartz & Henderson, 1991).

Both species remain abundant, although the distribution of *P. shrevei* was restricted to higher elevations, where *E. johnstonei* was less frequently encountered (C. A. Rodríguez Gómez, pers. comm.). The former may once have been found in forests throughout the island, only to have been displaced to at least some extent from the lowlands by deforestation for agricultural purposes during the colonial era, with the subsequent introduction of *E. johnstonei* facilitating that process. Specimens of closely related *P. euphronides* on Grenada were collected historically from areas where the species is no longer found (e.g., Schwartz & Henderson, 1991; Kaiser *et al.*, 1994); this may provide some support for the contention that both *P. euphronides* and *P. shrevei* were once more widely distributed on their respective islands. However, suspect locality data may render that evidence inconclusive (many specimens originating on islands prior to the onset of the 20<sup>th</sup> century were attributed to the major ports from which they were shipped; e.g., Dixon, 1981).

Pattern Element	Site (Sample Size)		
	1 (5)	2 (20)	Total (25)
Dorsal Colour			
Darker than side	0	8	8
Lighter than side	1	3	4
Same as side	4	9	13
Colour Top of Snout			
Lighter than dorsum	4	17	21
Same as dorsum	1	3	4
Colour of Toe Pads			
Darker than toes	4	16	20
Lighter than toe	1	0	1
Same as toe	0	4	4
Dorsolateral Lines			
Darker than dorsum	0	1	1
Lighter than dorsum	0	7	7
Absent	5	12	17
Dorsum			
Mottled	1	1	2
Uniform	4	19	23
Dorsal Chevrons			
Two	2	13	15
One	1	3	4
Absent	2	4	6
Bars on Hindlimbs			
Distinct	2	15	17
Broken	2	5	7
Absent	1	0	1
Bars on Forelimbs			
Distinct	2	12	14
Broken	2	7	9
Absent	1	1	2
Subtympnic Line			
Present	0	2	2
Broken	0	1	1
Weak	0	2	2
Absent	5	16	21
Bars on Lips			
Present	3	12	15
Weak	1	7	8
Specks	1	2	3

**Table 2.** Frequencies of pattern elements in *Pristimantis shrevei* from two sites on St. Vincent. Site 1 = La Soufrière Volcano Trail (961 m); 2 = "Upper" Vermont Nature Trail (natural forest, 411 m).

*Eleutherodactylus johnstonei* has effectively colonised the island, and is phenomenally abundant in many areas, especially in more dramatically altered lowland habitats. During the 20 days we spent on St. Vincent, we were never out of earshot of calling *E. johnstonei* at night, although the relatively few

Pattern Element	Site and Sample Size				
	2 (3)	3 (2)	4 (18)	5 (20)	Total (43)
Dorsal Colour					
Darker than sides	0	0	4	3	7
Lighter than sides	2	2	4	3	11
Same as sides	1	0	10	14	25
Colour Top of Snout					
Darker than dorsum	1	0	2	1	4
Lighter than dorsum	1	0	10	12	23
Same as dorsum	1	2	6	7	16
Colour of Toe Pads					
Darker than toes	1	0	3	4	8
Lighter than toes	1	0	6	7	14
Same as toes	1	2	9	9	21
Dorsolateral Lines					
Lighter than dorsum	0	0	8	1	9
Absent	3	2	10	19	34
Dorsum					
Mottled	3	0	6	8	17
Uniform	0	2	12	12	26
Dorsal Chevrons					
Two	1	0	2	12	15
One	1	0	11	6	18
Absent	1	2	5	2	10
Bars on Hindlimbs					
Distinct	1	0	9	5	15
Broken	2	1	8	10	21
Absent	0	1	1	5	7
Bars on Forelimbs					
Distinct	0	0	6	7	13
Broken	2	1	9	7	19
Absent	1	1	3	6	11
Interorbital Bar					
Full	2	0	13	8	23
Broken	1	0	2	6	9
Absent	0	2	3	6	11
Subtympanic Line					
Present	0	0	3	8	11
Broken	0	2	11	10	23
Absent	3	0	4	2	9
Bars on Lips					
Present	1	0	4	2	7
Weak	2	1	12	10	24
Specks	0	0	2	4	6
Absent	0	1	1	4	6

**Table 3.** Frequencies of pattern elements in *Eleutherodactylus johnstonei* from four sites on St. Vincent. Site 2 = "Upper" Vermont Nature Trail (natural forest, 411 m); site 3 = Hermitage (natural forest, 342 m); site 4 = "lower" Vermont Nature Trail (plantation forest, 297 m); site 5 = Bambareaux Beach (lowland forest, < 10 m).

individuals at the higher elevations on La Soufrière were inconspicuous among the much more numerous *P. shrevei*. We also frequently heard *E. johnstonei* singing by day in sheltered locations in dense forest, streambeds, leaf litter, and even in urban alleys. In contrast, we heard calling *P. shrevei* only in the evenings (18:00–21:30 h).

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## Notes on the poorly known colubrid snake *Rhadinaea anachoreta* Smith & Campbell

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SMITH & Campbell (1994) described *Rhadinaea anachoreta* from two localities in the Sierra de Caral and Sierra de Santa Cruz of northeastern Guatemala. That description was based on two adult males and one adult female, one of which was “badly mutilated.” Campbell (1998) reported the species from Tikal, in the northern Petén of Guatemala, but did not mention the number or sex of the specimens from that locality. Campbell (1998) increased the known range of ventrals from 139 to 151 from over that of 139 to 147 given by Smith & Campbell (1994), but all of his other data were the same as that given by Smith & Campbell. Campbell’s (1998) colour description appears to

be taken from a preserved specimen, as was the colour description provided by Smith & Campbell (1994). Townsend *et al.* (2005) recorded the species from the department of Cortés in northwestern Honduras, based on one “desiccated” unsexed adult. All data provided by Townsend *et al.* (2005) are in agreement with the previously published data for the species. The only colour description of the Honduran specimen provided by Townsend *et al.* (2005) was also taken in preservative.

On 10<sup>th</sup> October 2006, I collected a specimen of *Rhadinaea anachoreta* in the top portion of a rotten tree stump about 0.5 m above the ground in a shade-tolerant coffee farm at Cerro Negro,



**Figure 1.** Adult female (USNM 563606) of *Rhadinaea anachoreta*. The only previously published illustrations of this species are drawings of the head and midbody showing colour and scale pattern. © J. R. McCranie.

Santa Bárbara, Honduras. That locality lies at 900 m elevation along the border with Guatemala less than 0.5 km from the type locality of the species. The original vegetation at the site was Premontane Wet Forest in the Holdridge (1967) system, but the forests in the area were cleared more than 30 years ago. The small coffee farm where the specimen was collected is bordered above and on both sides by completely denuded and eroded pastures. There is no forest remaining in that area of Honduras, but there are numerous other shade-tolerant coffee farms in the area.

The new specimen of *Rhadinaea anachoreta* (USNM 563606) is an adult female with a total length of 216 mm and a tail length of 55 mm. Pertinent scale data are: ventrals 151; anal plate divided; subcaudals 68; supralabials 8–8, with fourth and fifth bordering eye; loreals 1–1; preoculars 1–1; postoculars 1–1; temporals 1+1–1+1; infralabials 8–8, with first pair in contact behind mental and first four on one side and first five on other side in contact with anterior pair of chinshields; dorsal scale rows 17–17–17, smooth, without apical pits. Thus, the specimen agrees in most aspects with the previously published data for the species, except that it has six fewer subcaudal scales than previously reported.

Colour in life for the new specimen (Figure 1; colour and codes from Smithe, 1975–1981): dorsal ground color Cinnamon (39) with Dark

Grayish Brown (20) stripes on upper and lower edges of scale rows 3 and 4, respectively, and on vertebral row and adjacent edges of paravertebral rows; Olive-Brown (28) supplemental stripes present on lower and upper edges of scale row 1 and lower edge of scale row 2; incomplete Buff (24) nuchal collar; dorsal surface of head Dusky Brown (19) with Buff mottling; supralabials anterior to eye Dusky Brown, supralabials 3–4 also with pale cream anterior edges; pale cream, incomplete postocular stripe present; ventral surface of body pale grayish brown, except for Olive-Brown lateral edges; subcaudal surface pale gray, except for Olive-Brown lateral edges; iris Dusky Brown.

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# A rare and little known lizard, *Otocryptis beddomi*, from the *Myristica* swamps of southern Kerala, India

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**ABSTRACT** – We present new data on the occurrence, behaviour, life history and ecology of the little known Indian kangaroo lizard, *Otocryptis beddomi* from the *Myristica* swamps of southern Kerala, a highly endangered, fragmented and restricted fresh water swamp forest in the Western Ghats. The result of our study conducted for two years from November 2004 to November 2006, also indicates that *Myristica* swamp forests provide an optimum habitat for this lizard which has disappeared from its earlier habitats, and calls for the conservation of these unique forests.

*MYRISTICA* swamps were first described by Krishnamoorthy (1960) and classified by Champion & Seth (1968) in the sub-group of tropical fresh water forests (4c/FS1). These fresh water swamp forests are highly fragmented and restricted in distribution due to systematic destruction (Rodgers & Panwar, 1988), and also special abiotic conditions required for their survival. These swamps have been reported from the flat-bottomed, ill-drained valleys of Anchal and Kulathupuzha Forest Ranges and Shendureney Wildlife Sanctuary of Southern Kerala, and from Uttara Kannara in Karnataka and Satari regions in Goa. These swamps are usually surrounded by low elevation evergreen forests at altitudes ranging from 180–200 ASL. The dominant vegetation is trees belonging to *Myristicaceae* family which show adaptations such as (breathing roots) knee roots and stilt roots (for anchoring the tree in damp soil) (Varghese, 1992).

During our field trips for the ongoing research project, “Mapping Biodiversity of *Myristica* swamps in southern Kerala”, we sighted *Otocryptis beddomi* in the drier regions of many *Myristica* swamps and from the forests adjacent to these swamps, both in Kulathupuzha Forest Range and Shendureney Wildlife Sanctuary. The IUCN Red list (2006) at the IUCN website does not list this lizard but the C.A.M.P Workshop for Reptiles (1998) reported this as endemic and vulnerable under IUCN criteria (B1, 2c; D2). Little is known about the life history or ecology of this species (Daniels, 1991). Till 2005, the only other species in the genus was

*Otocryptis weigmanni* which is endemic to Sri Lanka. The presence of a new species, *Otocryptis nigristigma* also from Sri Lanka, was reported by Mohamed & Silva (2005).

## STUDY AREA AND METHODOLOGY

The field study was conducted for two years from November 2004 to November 2006 in and around the *Myristica* swamps of Anchal and Kulathupuzha Forest range and Shendureney Wildlife Sanctuary. This area lies between 8°75'N and 9° N and 76°75' E and 77°25' E. Of the 60 individual swamp patches identified at present, most were less than 0.05 km<sup>2</sup>. The cumulative area of all *Myristica* swamp patches in this area is less than 2 km<sup>2</sup> (Roby & Nair, 2006). All sightings of *Otocryptis beddomi* were recorded along with the date, time, location and microhabitat and the details were tabulated and analyzed. When a lizard was sighted, it was observed for 10 minutes without disturbing it. It was photographed using a JVC Handycam and a Canon EOS300 digital camera. The lizards were captured by hand, measured and released at the site of capture. Identification was done following Smith (1935).

The movements and behaviour of the lizards after release were also recorded. Environmental parameters such as rainfall data, water level (above and below soil and inundation), canopy cover, temperature, humidity, altitude, slope, leaf litter depth, leaf litter cover, undergrowth and regeneration were recorded using standard methods. But only those environmental parameters



**Figure 1.** *Otocryptis beddomi* (normal colour variant). © J. Jose.

which affected the number of sightings of *Otocryptis beddomi* have been mentioned in this report for the sake of brevity. Procedures involving animal killing or excessive handling and habitat destruction were avoided in the interests of conservation.

## RESULTS

### Morphology

All the lizards sighted by us confirmed to the description by Smith (1935) (Figure 1) with two exceptions. Colour variations were evident in two cases. In the first case the pale vertebral stripe was closer to grey than buff and the darker flanks were closer to black than brown. In the second case the pale vertebral stripe was not distinct and the general body colour was a darker shade of brown than usual. The snout to tail measurement of adults varied from 78–125 mm.

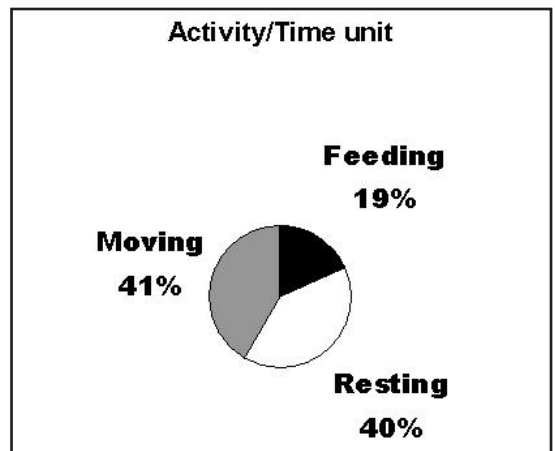
During the months of October and November we observed seventeen young ones of the species. The morphological characters differed slightly from that of the adult. The snout to tail length varied from 30 mm to 60 mm. Scales on the head and trunk were not clearly visible to the naked eye but those on the tail and limbs were quite clear. The head and body were dark brown. The tail, where it joined the body was cream coloured but the distal end of the tail was buff. The extremities of the limbs were also cream coloured. The pale vertebral region was indistinct but the series of brown transverse vertebral spots was visible.

### Behaviour, Distribution and Ecology

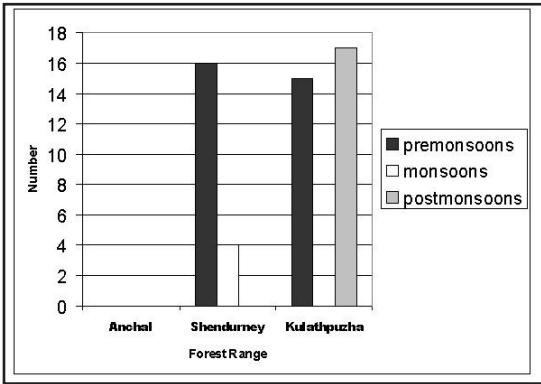
Some of these lizards were observed feeding on ants, termites and on small dipterans. When disturbed they fled on hind legs with the prey clutched in the mouth. Of the approximately 920 minutes spent observing the 92 individuals of *Otocryptis beddomi*, the animals 19% of this time was spent for feeding while 40% and 41% of the time was spent for resting and moving respectively (Fig. 2).

The number of sightings across three seasonal units – premonsoon, monsoon and post monsoon and across the three forest ranges where *Myristica* swamps are found in southern Kerala is shown in Figures 3 and 4. During the rainy season the number of sightings in the swamps declined but increased in the forests adjacent to the swamps and vice versa for dry season. All sightings during rainy season were between 09:30 h and 15:30 h. During the dry season time of sighting varied between 08:30 h and 17:00 h. A single nocturnal sighting was made during the dry season inside a swamp at 20:30 h.

This lizard preferred the peripheral areas of completely inundated swamps whereas it was found in both core and peripheral areas in periodically



**Figure 2.** Activities/Time units spent.



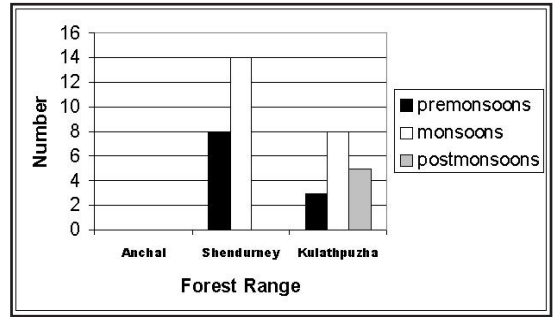
**Figure 3.** Sightings of *Otocryptis beddomi* inside *Myristica* swamps.

inundated swamps. The lizard was seen less in inundated areas, and areas where the forest floor litter had been washed away due to flooding (Fig. 5). Areas with high canopy cover were preferred over areas with low canopy cover. It is also evident from Figure 5 that litter cover and inundation were more decisive factors than canopy cover in determining the number of *Otocryptis beddomi* sightings.

Kulathupuzha and adjacent areas get heavy rain in the post monsoon period leading to high level of inundation in the swamps, but the number of sightings increased during the months of October and November due to the juveniles sighted in the peripheral areas of the swamp. Of the nineteen individuals sighted during these two months, seventeen were juveniles. The total number of juveniles sighted from all the other months combined is less than this figure. All the sightings during these two months were from the drier areas of the swamp, where the forest floor litter deposited by natural leaf fall was supplemented by litter deposited during rain water run off.

### DISCUSSION

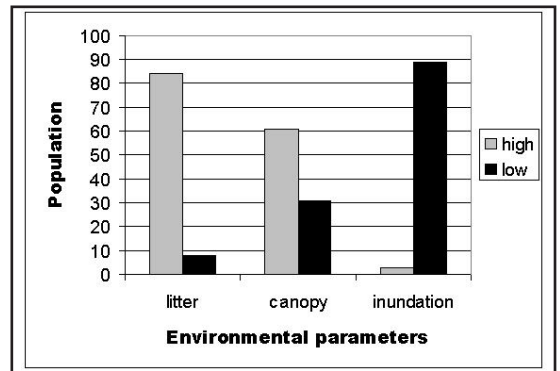
Mohomed & Silva (2005) quote Deraniyagala's study which reports the peak breeding season for *Otocryptis wiegmanni* as October–January, and observed egg laying in July–October from the wet zones of Sri Lanka. They also report egg laying by *O. weigmanni* during May 2004, with a clutch size of five eggs and *insitu* hatching period of forty nine days. There are no reports on the breeding habits of *Otocryptis beddomi*. The general assumption is that tropical lizards breed continuously. But increase in the number of juvenile sightings of *O. beddomi* by



**Figure 4.** Sightings of *Otocryptis beddomi* in forests adjacent to *Myristica* swamps.

us during the months of October and November, suggest an egg laying peak in the immediately preceding months which is similar to its Sri Lankan counterpart. Further studies on the natural history of *O. beddomi* is needed to validate the assumption that as the egg-laying peak seems to be similar in the Indian and Sri Lankan species the breeding peak will also be similar.

Daniels (1991) has described *O. beddomi* as one of the least known lizards of the Western Ghats. He wrote that although he had seen this lizard many times in the 1960's in the forests of Balamore, Kanyakumari district, Tamil Nadu State, he had never seen this species elsewhere in the Western Ghats in spite of his intensive field work. As his last sighting of this species was in the early 1970's in Maramalai Hills south of Balamore he suggested that the species could be possibly extinct in its restricted range and hypothesized canopy cover destruction as a possible reason for this. Our perusal of literature make us conclude that there have been sporadic reports of this



**Figure 5.** Comparison of number of sightings in littered and non littered, inundated and non -inundated, low and high canopy covered areas.

species after Daniel's paper and different authors (Easa *et al.*, 2004; Ajith Kumar *et al.*, 2002; Murthy, 1985; Inger *et al.*, 1984) have included it in their list of lizards for Western Ghats. Ajith Kumar *et al.*, (2002) reported it from Rosemala and Palaruvi forests of Thenmala division, Kerala and suggested that the absence of the same from Tamil Nadu could be due to destruction of low elevation rainforests in that state. Rosemala and Palaruvi are within the 25 km radius from our study area but at a higher altitude. The findings of our study concur with these opinions. We sighted *O. beddomi* in the *Myristica* swamps and in the forests near the swamps in Shendureney Wildlife Sanctuary and also in Kulathupuzha forest range but did not have even one sighting of the species from Anchal forest range. The swamps in Anchal range are highly degraded and the surrounding vegetation is almost always disturbed forests, man-made grasslands or plantations. The absence of leeches in the Anchal part of our study area is another indicator of the desiccation of this area. The non-perennial and degraded status of many *Myristica* swamps in Anchal could be due to the destruction of the surrounding evergreen forests which has reduced the year long water seepage into the swamps. This combined with anthropogenic disturbance are sounding the death knell for the swamps in Anchal range. Conversion of evergreen patches into moist deciduous forests, monotypic plantations and grasslands have led to reduced canopy and litter cover which in turn may have affected habitat specialists like *O. beddomi*. In Shendureney Wildlife Sanctuary there were no sightings of *O. beddomi* during the post monsoon period either in swamps or in the adjacent forests. The absence of *O. beddomi* in the swamps is due to high inundation caused by heavy rains but the adjacent forests are also devoid of *O. beddomi*. We attribute this to the clearing of fire-lines surrounding almost all the swamps in Shendureney Wildlife Sanctuary. The presence of fire-lines has drastically reduced the litter cover in the peripheral areas of the swamps which are contiguous to the adjacent forests.

*Myristica* swamp forests are low elevation evergreen forests, the existence of which depends on the presence of healthy evergreen forests in the vicinity. The presence of evergreen forests is a sure indicator for high canopy cover and high forest floor litter which are essential component of

the *O. beddomi* microhabitat. Even though high levels of inundation inside the *Myristica* swamps may not be conducive for *Otocryptis beddomi* populations, the drier peripheral areas of the swamps and the adjoining evergreen forests provide a habitat for this rare and little known lizard. In this context our sightings of *O. beddomi* in and around of *Myristica* swamps assumes a two pronged importance. Firstly, the fact that at least a small population of this little known lizard is still intact is a matter of significance and all efforts should be taken to maintain this population. Secondly the importance of the *Myristica* swamps, an endangered, restricted and fragmented ecosystem, in Southern Kerala, as a habitat and home range for rare animals is highlighted.

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## Bicephaly in *Salamandra salamandra* larvae

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**A**BNORMALITIES occur frequently in wild populations of amphibian and reptiles (e.g., Matz, 1998; Meyer-Rochow & Asahima, 1988; Worthington, 1974). Polymelia (presence of supernumerary limbs) or polydactyly (presence of supernumerary digits) are the most common alterations and have been reported frequently in the herpetological literature (e.g., Johnson *et al.*, 2001; Recuero & Campos Asenjo, 2003; Sealander, 1944). Reports on bicephaly are, however, more scarce.

Bicephaly, in general terms, refers to the presence of two heads in a single individual. It has been documented occurring naturally in mammals, including humans (e.g., Wu, 2002), and reptiles (e.g., lizards [e.g., Pleticha, 1968], turtles [Diong *et al.*, 2003], geckos [Holfert, 1999]), being specially frequent in snakes (e.g., Belluomini, 1959; Da Cunha, 1968; De Lema, 1982, 1994; Hoser & Gibbons, 2003; Khaire & Khaire, 1984;

Maryan, 2001; Mitchell & Fieg, 1996; Oros *et al.*, 1997). Bicephaly, however, is not very common in amphibians. To our knowledge, it has only been documented in three anuran larvae (Dragoiu & Busnitza 1927; Lebedinsky, 1921; Loyez 1897) and in the Golden-striped salamander (Pereira & Rocha, 2004).

The term 'bicephaly' is used to describe a broad spectrum of developmental alterations. Different abnormalities, from the duplication of some structures of the head to the occurrence of Siamese or co-joined twins, give rise to bicephalic individuals. Bicephaly may be the consequence of the incomplete separation of the zygote of identical twins (co-joined twins). Bicephalia may also occur by the terminal bifurcation of the axis of development of the embryo, the notochord, during the neurulation process. The notochord gets divided or forked, leading to two distinct axes and the formation of two neural plates and their neural



**Figure 1.** Craniofacial duplicated larva in *S. salamandra bejarae*. © D. Buckley.



**Figure 2.** Bicephalic co-joined twins in *S. salamandra gallaica*. © G. Velo-Antón.

crest cell derivatives (Machin, 1993). Craniofacial duplication, is an unusual variant of bicephalia (e.g., Wu *et al.*, 2002). In this case, cranial structures like eyes, mandibles and mouths get duplicated but the individual does not present two distinct heads or axis of development. In this note, we report one case of co-joined twins and one case of craniofacial duplication, in larvae from two different subspecies of the Fire salamander *Salamandra salamandra*.

The craniofacial duplicated larva was born from a *S. salamandra bejarae* female from the Central Iberian Peninsula. The female gave birth to 45 larvae, one of them presenting the abnormality (Figure 1). The larval body was fully developed, but presenting a duplication of the craniofacial structures (Fig. 1). All the structures were functional apparently, although the larva could not feed and died after two weeks in the laboratory.

The bicephalic co-joined twins were found in *S. salamandra gallaica* (Figure 2). A female from one of the Galician coast population (NW Iberian Peninsula) gave birth to 2 larvae, one of them presenting the abnormality. The bifurcation of the axis was manifest; one of the heads presented no eyes, although the gills and the two limbs were functional. The larva could not move easily, and fed normally through one of the head, presenting, however, a slower rate of development than its siblings.

It has been shown that polydactyly and polymelia are related, in some cases, to the presence of parasites within the individuals (e.g., Johnson *et al.*, 2001; Sessions & Ruth, 1990). In the cases we present, however, the abnormalities presumably involve the disruption of the genetic and developmental pathways during the early development of the individual and during the neurulation process. The genetic cascades involved in the development of the head and craniofacial structures begin now to be well understood (e.g., Glinka *et al.*, 1998; Nie, 2005) and the report of such examples of malformations can shed some light on the developmental process underlying them, and may also help to explain why this kind of abnormalities seems to be more frequent in some taxa (e.g., snakes) than in others.

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## NATURAL HISTORY NOTES

**LIOLAEMUS ELEODORI (San Guillermo's lizard): REPRODUCTION.** *Liolaemus eleodori* is a small-medium (75 mm in snout-vent length) iguanid lizard, endemic to the high-Andean San Guillermo National Park in western Argentina (Cei *et al.*, 1983; Chébez *et al.*, 2005). Virtually nothing is known about the natural history of this steppe-dwelling lizard (Cei, 1986). Although viviparity in high-elevation lizards may be reasonably expected for the advantages that it bears (Fitch, 1970; Pianka & Vitt, 2003), the condition remains unknown in many species of the genus *Liolaemus*. Here we report the first account on litter size, and provide confirmation of viviparity, *sensu* Blackburn (1993), in *L. eleodori*.

At 13:00 h on 19<sup>th</sup> November 2003, during authorised fieldwork for the project "Herpetological Inventory of National Parks of Central Region", JCM captured a gravid female *Liolaemus eleodori* in the western section of the San Guillermo National Park (29°20'12"S, 69°24'19"W; 3650 m of altitude), Iglesia Department, San Juan Province, Argentina. There, *L. eleodori* was abundant, living associated with the extensive rodent burrows of *Ctenomys fulvus*. At the time of capture, many lizards of both sexes were active.

Once in the laboratory, it was housed alone in a glass vivarium with sand as a substrate, under the natural light/dark cycle of the austral summer, and

**Figure 1.** Three-day old neonates of *Liolaemus eleodori*, born in captivity from a lizard collected in the San Guillermo National Park, western Argentina. © M. R. Cabrera.



fed on larval and adult insects *ad libitum*. On the evening of 26<sup>th</sup> December 2003, the lizard adopted a motionless posture, and with her hindlegs spread gave birth to four young. The first neonate was born at 19:10 h, and the second one was born within the next 10 minutes. A third lizard was born at 19:40 h, this delay likely provoked by our move of the vivarium into conditions of better lighting for photographic purposes. The fourth lizard was born nine minutes later. Following the last birth, a blood-red chord was expelled through the maternal cloaca. All neonates were born headfirst, each one wrapped in a transparent membrane that the female immediately attempted to tear with her hindlegs, a task she succeeded in completing within 1–2 minutes for each newborn. Until liberated, the neonates remained immobile within the membrane, which was then discarded.

The four neonates were similar in appearance (Figure 1). Dorsally, they were similar in colour to the female, only grayer but with traces of an orange taint as is typical of adults. However, they lacked any trace of the yellow colour on the belly that adults bear. We measured only one neonate (30 mm in snout-vent length, plus 30 mm in tail length), but no obvious difference existed in size among the four young. Soon after parturition the mother ignored the neonates, displaying neither obvious parental care nor aggression towards them. The female died while hibernating in May 2004, and could not be properly conserved. Two neonates (AC 460a, and 460b) died later in the season, and were deposited in the collection of Comparative Anatomy Laboratory (Universidad Nacional de Córdoba, Argentina).

In January 2005, other two pregnant females of *Liolaemus eleodori*, captured at Vega de los Salineros, NE section of the San Guillermo National Park (29°08'06"S, 69°18'14"W; 3355 m of altitude), were transported to our laboratory in Córdoba. One of them gave birth to three young on 8<sup>th</sup> January 2005, at dawn, and the other gave birth to two lizards five days later. All these newborns were alike in size and pattern to those of the 2003 parturition. The body mass of three of them, two days after birth, ranged between 0.740 g and 0.788 g

(mean = 0.758 g). In the vivarium, the five neonates coexisted without any evident conflict between them, or between the two females and one adult male, and willingly fed on small insects. Days after, both females and young were returned alive to the site where the adults had been captured.

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**VARANUS SALVATOR (Water monitor): INTRA-SPECIFIC AGGRESSION.** Intra-specific aggression in lizards is well known, particularly in males. In monitor lizards (*Varanus* spp.) it is believed to occur for a variety of reasons, usually over resources - food, shelters and access to females for males (Horn *et al.*, 1994). Here we describe a brief observation of intra-specific conflict in *V. salvator* at Hettipola, Central Province, Sri Lanka. The observations were in made during July 2005 at the locality described in a recent note (Jolley & Meek, 2006). Each morning, from around 7am local time, we regularly observed up to at least six large *V. salvator* foraging or basking in a canalised waterway of less than 0.5 km. All individuals observed were approximately 2 metres in total length, indicating mature animals (e.g. Andrews, 1995; Bennett, 1998). Basking was common at this time of day (dry season) with daily operative temperatures usually above 40°C and although we never measured water temperature, we estimate this was around 20–25°C at the time.

At approximately 07:30 h local time, a large *V. salvator* swimming along the waterway was seen to come into contact with another individual, almost as large, basking on the bank. The lizard in the water approached the basking lizard very slowly and at a distance of around a metre emerged and attacked the second lizard (Figure 1). Unfortunately, the actual speed at which the incident occurred made it difficult for detailed observations – we could not, for example, ascertain whether biting was involved, but the basking lizard quickly retreated into the water and submerged. The larger animal also returned to the water but remained swimming on the surface and appeared to be looking for the other animal, which we never saw resurface. Within 15 minutes or so of the incident another of our research group, John Drake, prompted by our observations, returned to the locality (less than 3 minutes walk from our base), and recorded and photographed combat behaviour between



**Figure 1.** Combat behaviour in *V. salvator*. Following a slow approach to the basking lizard, the animal in the water is just about to launch its attack. © R. Meek.

two large *V. salvator*. The lizards were in the water in a typical horizontal embrace but also reared up out of the water in a bipedal posture. However, we cannot be certain they were same lizards as those in the incident we observed.

The narrow waterway combined with high operative temperatures may have had a contributing effect to the incidents, making it difficult for the lizards to avoid contact. For example, our observations of foraging (dry season) indicated that this was generally an aquatic activity with brief excursions onto the bank, whereas in much cooler overcast weather during the rainy season at Kandy Lake, it was largely terrestrial, with entry into the water seemingly only to cross to the opposite bank. Conflict and/or combat behaviour is known in *V. salvator* but is usually a terrestrial activity,

with apparently no previous reports of its occurrence in water (review in Bennett, 1998). Additionally, monitor lizards are notoriously difficult to sex, even at close inspection, and so we cannot be sure of the sexes of the lizards involved. Defence of territory between males or conflict over basking sites (Bennet, 1998) are obvious suggestions, but female defence of a nesting area is a further possibility. This is known in females from several Varanids (Horn, 1999) and *V. salvator* is known to nest in water banks and can be aggressive just prior to egg laying (Bennet, 1998). Interestingly, in captivity, combat behaviour has been observed between both males and females as well as between females, usually over basking sites or nest boxes (Wicker *et al.*, 1999).

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## **PHILODRYAS PATAGONIENSIS (Parelheira): VENOMOUS SNAKE (CROTALID) AS PREY.**

*Philodryas patagoniensis* is found almost everywhere in South America. In Brazil, it can be found in the states of Pernambuco and Bahia (Northeast Region), Minas Gerais, Rio de Janeiro and São Paulo (Southeast Region) and in Parana and Rio Grande do Sul (South Region) (Peters & Orejas-Miranda, 1986) where it occurs primarily in open areas, but also woodland (Thomas, 1976). *Philodryas patagoniensis* is a medium-sized colubrid snake (Figure 1.) with predominantly terrestrial, diurnal habits (Marques *et al.*, 2001) that feeds on frogs, lizards, birds, mice, and other snakes (Duarte & Eterovic, 2003; Perroni, 2004; Hartmann & Marques, 2005). However, available reports limit it to the ingestion of colubrids, such as *Philodryas olfersii*, *Thamnodynastes strigatus*, *Clelia occipitolutea*, *Liophis poecilogyrus*, *Liophis jaegeri*, *Helicops carinicaudus*, *Lystrophis dorbignyi* (Lema *et al.*, 1983) and *Liophis poecilogyrus* and *Pseudablabes agassizii* (Hartmann & Marques, 2005). Perroni (2004) found dorsal and ventral scales of a non-identified colubrid on his analysis. According to Shine (1991) ophiophagus snakes can possibly show cannibalism. In the genus *Philodryas* this has been confirmed by Lema (1983) and by Hartmann & Marques (2005), with one report of cannibalism each. In captivity, a newborn *P. patagoniensis* was observed ingesting another conspecific newborn by attacking and ingesting it head-first. *Philodryas olfersii*, despite being a non-venomous snake, has enlarged maxillary fangs in addition to a Duvernoy's gland (which produces toxic substances), and is thus potentially bale to envenomate its prey (Silvia Cardoso, personal observation).

We analyzed gut contents from the digestive tract of one female *Philodryas patagoniensis* sent to us on April 24<sup>th</sup> 2003 from Santana de Parnaíba - SP (23° 26'S. 46° 56'W), measuring 525 mm in snout-vent length (SVL), 190 mm in tail length (TL), 14.2 mm in head length (HL) and weighing 35 g. After examining the faeces of this individual, we verified the presence of a grooved fang which belonged to a venomous snake, probably a young



**Figure 1.** *Philodryas patagoniensis* (adult female). © S. R. Travaglia-Cardoso.

one. By comparing it with the fangs of other venomous snakes born in captivity, in order to estimate the age group of the swallowed prey item, we found that it was from a species of pit viper (juvenile), probably of the genus *Bothrops*. The offspring of *Bothrops* spp. in Brazil are usually born between November and March (Almeida-Santos & Salomão, 2002), thus, predation on a newborn specimen by *Philodryas patagoniensis* in April could be possible. As far as we are aware there are no other such records available in the literature. Perhaps *P. patagoniensis* avoids this kind of prey because it is a venomous snake and can suffer some injury or even death. Alternatively, the snake may have been ingested when already dead. No cases of feeding on carrion have previously been reported for this species, but it is rare to observe this kind of behaviour in nature unless you see the snake directly encountering a dead animal (Lillywhite, 1982; Shine, 1986). We

seriously considered the possibility of secondary prey ingestion but conclude that for several reasons this seems unlikely. Firstly it is known that *P. patagoniensis* feeds primarily on mice and birds, and venomous snakes are not part of the general diet of these animals. In addition, only a large-sized bird could presumably have attacked a venomous snake, much larger than could have been ingested by a *Philodryas*.

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**AMPHIESMA STOLATUM (Striped keelback): PREDATION ON POLYPEDATES MEGACEPHALUS (Java treefrog).** Snakes have solved the problem of nourishing a heavy body, with a relatively small mouth, by infrequently consuming large prey items (Greene, 1997); made possible by the mobility of the jaw and mouth skeleton (Ernst & Zug, 1996). But preying on large prey comes at a cost. Snakes are not always capable of subduing such prey, and even when they do, risk losing it due to other predators, as well as being subjected to the risk of predation themselves. Another problem is that consuming a large prey item might result in injury or death to the snake due to the ingesting process or compromised mobility. It is thus crucial to note which prey items are consumed by which snake species, as well as the size of the prey in relation to the predator. Since the ability of snakes to swallow relatively large prey items is not equal throughout the snake kingdom (Mattison, 1995), it is important to note the prey/predator weight-ratio, and types of prey consumed by individuals of the same species to develop a better understanding of the energy budgets and foraging behaviour of the species in question.

Here we report predation by a Striped keelback (*Amphiesma stolatum*) on a Java treefrog (*Polypedates megacephalus*). At 11:52 h on 19<sup>th</sup> May 2006, a male *A. stolatum* (430 mm SVL, 7.72 mm HW, 18 mm HL, 144 mm tail length, 13.2 g) was observed moving along the fence on the inside of a 6m x 6m enclosure, constructed of 3 mm plastic mesh, erected in a Betelnut palm (*Areca catechu*) plantation in Santzepu, Sheishan District, Chiayi County, Taiwan (23°28'23"N, 120°29'15"E). The vegetation on the inside of the enclosure was very dense and consisted of *A. catechu*, *Bidens pilosa* var. *radiata*, *Ipomoea cairica*, *Mikania micrantha*, and *Panicum maximum*. The *A. stolatum* was captured and it was noted that the mid-body was greatly enlarged. After gentle palpation of the enlarged area of the mid-body, the snake regurgitated an anuran, along with a large number of eggs. The prey item was identified as a female *P. megacephalus* (ca. 55 mm SVL, 2.5 g). Since it was regurgitated head and fore limbs first, and the hind limbs folded forward, combined by the fact that the vent area and parts of

the hind limbs were already partly digested, it is believed it had been ingested vent first.

Colubrids prey commonly on creatures about 20% of their own mass (Greene, 1997), and in this case, although the prey item was already partly digested, the prey/predator weight-ratio was 18.93%. Based on the mass/SVL (0.119;  $n = 9$ ) index of live *P. megacephalus* encountered in the study area, it was estimated that the prey item had an approximate mass of 6g, i.e. an estimated prey/predator weight-ratio was 46%. With an approximate prey/predator weight-ratio of ca. 1:2, the prey size is out of the ordinary for a colubrid. However, it may not be unusual for this species. Norval *et al.* (2005) recorded a prey/predator weight-ratio of 39.5% for a specimen of *A. stolatum*, and on the 22<sup>nd</sup> October 2006, another male that preyed on a *Rana limnocharis* was collected in the same study area. The prey/predator weight-ratio of this latter prey item was 26.6%. In addition, since *A. stolatum* is primarily a diurnal terrestrial species, whereas *P. megacephalus* is nocturnal and arboreal, it is interesting to note that this snake species would prey on this anuran species. This was also not an isolated case; on the 11<sup>th</sup> of August 2006, at ca. 09:45 h, a female *A. stolatum* (458 mm SVL, 148 mm tail length, 42.5g) was collected from inside another enclosure (23°28'39"N, 120°29'23"E), with a similar habitat to the one described above. It too had the remains of a *P. megacephalus* in its stomach, but since the digestive process was fairly advanced, no further descriptions can be made.

The following other prey types have been reported for *A. stolatum*: insects (Acrididae), tadpoles, toads, frogs, fish (Lee & Lue, 1996), earthworms, geckos (Lue *et al.*, 2002), lizards and scorpions (Das, 2002). To date, however, the only other recorded prey of this species of snake in our study area are: *Bufo melanostictus* ( $n = 3$ ), *Microhyla ornata* ( $n = 1$ ), *Microhyletta heymonsi* ( $n = 2$ ), and *Rana limnocharis* ( $n = 2$ ). Because it has been shown that snakes of the same species, but from different localities, can have different prey preferences (Arnold, 1993), we would like to encourage authors to describe prey items and collection localities in greater detail. This would not only greatly contribute to the understanding of the foraging behaviour and energy budgets of

snakes, but also the ecosystem and food-chains they are part of. To our knowledge this appears to be the first description from Taiwan of *A. stolatum* predation on *P. megacephalus*.

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