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Contents

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Front cover illustration. *Lycognathophis seychellensis*. © Sara Rocha. See article on page 20.

NEW SPECIES OF HERPETOFAUNA FROM THE GREATER MEKONG REGION OF SOUTHEAST ASIA REPORTED BY WWF.

A remarkable 163 new species discoveries have been made in the past year in the jungles and rivers of the Greater Mekong region of Southeast Asia. The new finds in 2008 comprise 100 plants, 28 fish, 18 reptiles, 14 amphibians, 2 mammals and 1 bird species, highlighting the biological importance of this unique and diverse land. Among the new herpetofauna (Table 1) is a rare and endangered leopard gecko. The Cat Ba Leopard Gecko (*Goniurosaurus catbaensis*) (Fig. 1) is a beautiful technicoloured gecko known only from Cat Ba Island (a National Park) in northern Vietnam (Ziegler et al., 2008). It has a mesmerizing pattern adorning the entire length of its body. Relatively large, orange-brown, cat-like eyes are accompanied by a head pattern consisting of a dark marbling; this leads to leopard stripes on the body and five immaculate contrasting black and white bands on the tail. A creature that certainly appears to be from another world, the lizard's long and thin legs, digits and claws add to its fantastical appearance. The scientific name emphasizes the importance of Cat Ba Island, the largest of 366 islands in the 285 km^2 Cat Ba Archipelago. The primary habitat within the National Park is tropical moist forest on limestone, which houses a number of endemic and rare species, foremost amongst which is the Cat Ba Langur (*Trachypithecus p. poliocephalus*). Scientists believe the high level of endemism may be due to the long separation of the island from continental Vietnam. The island was formed 7,000-8,000 years ago during glacial ice melting. Unfortunately, the other eleven known species of *Goniurosaurus* have become valuable commodities in the herpetocultural trade and the limited distribution of the new species *G. catbaensis* makes it susceptible to over-collecting. Scientists believe that the species should be classified as rare and endangered, proposing its listing in the Red Data Book for Vietnam. They are also recommending that the Vietnamese government put sanctions on the collection of *Goniurosaurus* species in order to protect populations and the habitats in which they occur.

Figure 1. *Goniurosaurus catbaensis.*© Thomas Ziegler.

Figure 2. *Limnonectes megastomias.*© David Mcleod.

A voracious "bird eating", fanged frog is among the new anuran species for Thailand. *Limnonectes megastomias* (Fig. 2) is an opportunistic predator, lying in wait for its prey in streams (McLeod, 2008). The species has a diverse diet which includes frogs and insects. According to scientists, the species is also known

Species	Scientist(s)	Distribution in Greater Mekong
AMPHIBIA		
Bufo luchunnicus	Yang & Rao	Yunnan
Bufo menglianus	Yang	Yunnan
Hylarana hekouensis	Fei, Ye, Jiang & Xie	Yunnan
Hylarana menglaensis	Fei, Ye, Jiang & Xie	Yunnan
Limnonectes megastomias	McLeod	Thailand
Odorrana macrotympana	Yang	Yunnan
Odorrana rotodora	Yang & Rao	Yunnan
Odorrana yentuensis	Tran, Orlov & Nguyen	Vietnam
Philautus quyeti	Nguyen, Hendrix, Böhme, Vu & Ziegler	Vietnam
Polypedates impresus	Yang	Yunnan
Polypedates spinus	Yang	Yunnan
Rana cangyuanensis	Yang	Yunnan
Rhacophorus chuyangsinensis	Orlov, Nguyen & Ho	Vietnam
Rhacophorus marmoridorsum	Orlov	Vietnam
REPTILIA		
Cnemaspis biocellata	Grismer, Onn, Nasir & Sumontha	Thailand
Cryptelytrops honsonensis	Grismer, Ngo & Grismer	Vietnam
Cyrtodactylus eisenmani	Ngo	Vietnam
Cyrtodactylus grismeri	Ngo	Vietnam
Cyrtodactylus hontreensis	Grismer, Ngo & Grismer	Vietnam
Cyrtodactylus huynhi	Ngo & Bauer	Vietnam
Cyrtodactylus pseudoquadrivirgatus	Rösler et al	Vietnam
Cyrtodactylus takouensis	Ngo & Bauer	Vietnam
Cyrtodactylus ziegleri	Nazarov et al	Vietnam
Fimbrios smithi	Ziegler, David, Miralles, van Kien & Quang Truong	Vietnam
Gekko nutaphandi	Bauer, Sumontha & Pauwels	Thailand
Goniurosaurus catbaensis	Ziegler, Truong, Schmitz, Stenke & Rosler	Vietnam
Oligodon deuvei	David, Vogel & van Rooijen	Vietnam/Lao PDR Cambodia/Thailand
Oligodon moricei	David, Vogel & van Rooijen	Vietnam
Oligodon pseudotaeniatus	David, Vogel & van Rooijen	Thailand
Oligodon saintgironsi	David, Vogel & Pauwels	Vietnam/Cambodia Lao PDR /Thailand
Opisthotropis tamdaoensis	Ziegler, David & Vu	Vietnam
Pseudocalotes khaonanensis	Chanard, Cota, Makchai & Laoteow	Thailand

Table 1. New herpetofauna of the Greater Mekong Region.

to eat birds, as feathers were discovered in the frog's faeces. The species has a greatly enlarged head and enlarged 'fangs' within its mouth. These are actually growths that protrude from the jawbone. Males of the species use the 'fangs' in combat and scientists have observed frogs with missing limbs and multiple scars. There are a number of differences between the males and females of this species. Unlike many other frogs, the males are larger than the females and have exceptionally large mouths and powerful jaws that appear out of proportion to the rest of the body. The frog has been found in three isolated and remote protected areas in eastern Thailand: at medium-high altitudes (600-1,500 m) at Sakaerat Environmental Research Station (SERS); in Pang Si Da National Park and in the Phu Luang Wildlife Sanctuary. Remarkably, the SERS area has been the subject of scientific study for more than 40 years, but this frog had escaped detection until now. Scientists state that much remains unknown about this and many other species in terms of their natural history, reproductive biology and ecology. For example, it is still unclear whether populations of these frogs are stable or in decline.

Among new snakes encountered is a tiger-striped Pit-viper (*Cryptelytrops honsonensis*). It was found on a tiny island off the coast of Vietnam (Grismer et al., 2008a). Named after the Hon Son Island in Rach Gia Bay in the Kien Giang Province of southern Vietnam on which the endemic species was discovered, the new half-metre-long snake has a straw yellow body colour with approximately 92 zig-zag 'tiger stripes'. The species is the latest of 45 Pit-vipers to have been discovered in Southeast Asia belonging to the genus *Trimeresurus* sensu lato, the largest Asian Pit-viper genus. This genus is generally nocturnal, terrestrial or arboreal and inhabits a wide variety of environments ranging from meadows to plantations, open bushy areas, secondary lowland forests and primary cloud forests. Hon Son is a very small island (ca. 22 km^2) composed of large granitic boulders that extend from the shoreline to its peaks with little to no primary vegetation remaining. At half-metre-long and orange-eyed, *Cryptelytrops honsonensis* was encountered along trails, where the species was first discovered moving over small branches of Bamboo that were lying across a small pile of rocks. The species is considered potentially endemic to the island.

Another unique frog species found was a new Rough-coated Treefrog (*Philautus quyeti*). It was discovered in Vietnam's Truong Son mountain range (Nguyen et al., 2008). Its head and body have a rough skin texture. The frog was found in the montane evergreen and karst forests within Quang Binh Province. The new species is relatively small among Rhacophorid treefrogs. It has reduced finger webbing and a unique head that is longer than it is wide. This species joins the *Philautus* genus which includes approximately 150 species. The discovery is the latest in a long line of new fascinating finds from the Truong Son range, the most celebrated being the Saola or Vu Quang Ox (*Pseudoryx nghetinhensis*).

A secretive new snake also revealed itself for the first time. The half-metre-long snake, *Oligodon deuvei*, is elusive and mostly encountered lurking among vegetation and in gardens of small subsistence farms. The species has two strongly enlarged and blade-like fangs and a unique stripe that extends the length of the snake which varies in colour between males and females. Males display an orange or rusty brown vertebral stripe; females, a more subdued yellowish brown stripe with darker dots. The snake also has a dark brown heart-shaped arrow pattern on its head pointing forward. Due to its elusive nature, the distribution of the species is still unknown but has so far been recorded in southern Vietnam, Vientiane and near Lao PDR (Peoples Democratic Republic) and Pursat Province in Cambodia. Scientists expect the species to also occur in Thailand. The species is among four new snakes from the *Oligodon* genus discovered in the last year (David et al., 2008). During surveys in the isolated karsts of the Nakawan Range that span the Thai-Malaysian

Figure 3. *Oligodon deuvei.* © L. Lee Grismer.

border, a Painted Lizard (*Cnemaspis biocellata*) was discovered (Grismer et al. 2008b). This new gecko is one of the most brightly coloured of the new species. The lizard displays five yellow, butterfly-shaped blotches extending from the shoulder region to the base of the tail. Males have a ground colour of dull yellow which is overlain by grey areas that highlight the yellow markings and shoulder patches. Females have a base colour of light brown and lack shoulder markings. The species is generally nocturnal but was also seen by day on the shaded surfaces of large rocks and tree trunks. When encountered by scientists, the lizards were amazingly quick and agile. The name of the species, *biocellata*, refers to the two small 'eyes' on the 'face' pattern that is displayed on the back of the gecko's head.

The Greater Mekong spans the countries of Cambodia, Lao PDR, Myanmar, Thailand, Vietnam and Yunnan Province of China, through which the mighty Mekong River flows. The region boasts 16 global eco-regions, critical landscapes of international biological importance, more than anywhere else on mainland Asia. The new species are the latest additions to an already impressive list found in this globally-unique landscape, that is home to Indochinese tigers, Javan Rhinos, rare primates and ungulates, Irrawaddy River Dolphins and the Mekong Giant Catfish. More than 1,000 new species have been discovered here over the past decade. However, the diverse species and habitats of the Greater Mekong region continue to face a wave of ever-growing threats, including habitat loss, infrastructure development, and unsustainable, illegal, natural resource use (Tordoff et al., 2007). As a consequence as little as 5% of the region's natural habitats remain intact today.

Climate change is compounding these threats. WWF is working to conserve 600,000 km^2 of the Mekong Region by seeking to reduce pressures such as unsustainable resource use, unsustainable infrastructure development and habitat loss so that species are more able to cope with climate pressures. They also aim to help protect key features of the region's ecosystems such as free-flowing rivers and trans-boundary forests that will allow species to adapt to changes in climate. WWF also supports the formulation of Asia's first regional climate change adaptation agreement to provide a legal framework for regional cooperation and coordination on climate change. The full report *Close Encounters: Greater Mekong Species Discoveries 2008* is found at: www.wwf.org.uk.

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Ziegler, T., Nguyen, Q.T., Schmitz, A., Stenke, R. & Rösler, H. (2008). A new species of *Goniurosaurus* from Cat Ba Island, Hai Phong, northern Vietnam (Squamata: Eublepharidae). *Zootaxa* **1771**, 16-30.

Adapted from material kindly supplied by WWF.
Submitted by: TODD R. LEWIS (EDITOR).

Research Abstracts

A NATURAL HISTORY OF RANAVIRUS IN AN EASTERN BOX TURTLE POPULATION.

Ranavirus is a genus in the family of Iridoviridae. Amphibians and fish had previously been recognized victims of this highly virulent pathogen. In 2003 this virus struck one of two translocated Eastern Box turtle (*Terrapene carolina carolina*) populations that were monitored in adjacent, northwestern Pennsylvania counties. The unaffected habitat, an 80 ha tract in Mercer County, Pennsylvania (PA) and the affected population's habitat was only 20 km away, to the NE in Venango County, PA. Eastern Box turtles have been telemetrically monitored in the Venango County sanctuary for a decade. It is the only chelonian population that has been intensively monitored before, during, and after a Ranavirus outbreak in natural habitat. In 2003-2006 several sudden death events occurred.

On 24 August 2003, one of the Venango County turtles (that had been seen three days earlier to be alert and in apparent good health) was seen near death. The turtle was in poor condition, devoid of muscle tone and had a clear exudate from the mouth. The turtle was brought to an infirmary and began a therapeutic regimen that had been used successfully for respiratory infection. The turtle died 30 h later, on 25 August. The speed with which the turtle died was astonishing. During the 8 weeks spanning late-August to late-October of 2003 this rapid-death scenario repeated 12 times. In all, fifteen turtles (23 % of our population) were apparent victims of the rapid-death syndrome during the 2003 season. All of the turtles that were alive and under soil for winter brumation at the end of 2003 were alive and emerged from the soil at the start (April-May) of the 2004 season. No deaths occurred during the first three months of the 2004 season but on 28 July the first turtle of 2004 died of this syndrome. The disease killed five animals during the latter half of our 2004 season. 2005 repeated the pattern of rapid-deaths starting only after the season's first several disease-free months. The first 2005 case was found on 23 July, five days earlier than the first one in 2004. Three unambiguous cases of the rapid-death disease occurred during the latter half of the 2005 season. Including, in a 2005 census, the year's addition of displaced adults and head-started juveniles to the habitat, these three deaths represented a 4 % population loss for 2005 and a continuation of the declining trend in annual mortality. 2006 suffered only one unambiguous rapid-death (10 July), a juvenile female on the edge of a swamp. This was the earliest of all sudden deaths during the four affected years (2003-2006). A second 2006 sudden-death was an adult male found (2 August) lying at the base of a 10 m cliff. To date (1 October 2009) no sudden-death has occurred since the 10 July 2006 case at our study site. With the annual additions of adults and head-started juveniles since 2006, as part of our long-term repatriation study, the site's population for 2007 was 42 adults and 46 head-started sub-adults; for 2008, 44 adults and 51 head-started sub-adults; for 2009, 51 adults and 55 head-started sub-adults. Of the 24 rapid-death victims, while the disease ran its course from August 2003 to July 2006, 18 (75 %) were on the edge of water (pond, swamp, or seep) when found dead or moribund. Sudden-deaths occurred equally (12 each) between the sexes; 16 victims were juveniles and 8 were adults. When we count all the different adults and juveniles that had lived in this habitat for at least six months during the four year span of 2003-2006, the proportioned mortality rates were 28 % of all juveniles, and 20 % of all adults, exposed to the habitat during this epidemic. Because of our ignorance of the pathogen's means of transmission, contact that each turtle may have had with an infected vector, and other factors that might affect exposure, our simple analysis, suggesting that age-class is not statistically associated ($p = 0.62$) with dying from the pathogen, is not conclusive.

After the first two rapid-death cases in 2003, it was realized that the disease was unfamiliar to the turtle population and so a carcass was sent to various Government and University veterinary diagnostic laboratories in Pennsylvania. The necropsy reports all came back with descriptions of extensive pathology: "severe fibrinonecrotic esophagitis, pneumonitis, acute hepatocellular necrosis, enteritis", "severe acute multifocal ulcerative enteritis and necrotizing splenitis", "congested lungs with acute hemorrhagic foci", "severe acute necrotizing splenitis, severe suppurative oropharyngitis", "acute pulmonary hemorrhagia and hepatic inflammation". No parasites nor Salmonella were recovered from the moribund or dead turtles. The bacteria that were grown (e.g., *Morganella morganii*; *Streptococcus non-entero* group D; *Streptococcus alpha* hemolytic-L, *Providencia rettgeri*; *Chryseobacterium meningosepticum*-L, *Citrobacter* sp., *Clostridium perfringens*, *Fusobacterium russi*; *Aeromonas hydrophila*, *Stentrophomonas maltophilia*-L, *Vertivillium* sp.-S) varied from turtle to turtle and were evidently opportunists that were secondary to the unknown infection that caused the massive tissue destruction. Toxicology screens of the turtles' organs were all negative.

In frustration of the etiology and biology of the pathogen, late-2003 field precautions were intensified in the hope of minimizing risk of spreading the disease. For example, two volunteers (who had previously helped with tracking) were excluded from the sanctuary so that only two workers would enter the habitat and approach turtles. Clothing and equipment was disinfected with bleach after a session in the habitat. In October 2003, Bob Wagner (University of Pittsburgh's Division of Laboratory Animal Resources) suggested that the laboratory of Elliot Jacobson in Gainesville, at the University of Florida's College of Veterinary Medicine, a leader in uncovering emerging and cryptic reptile pathogens, might be able to shed light on what was decimating our population. After listening to the description of the disease's signs and rapid lethalness, and of local climatic conditions, Elliott speculated that Ranavirus may be the etiologic pathogen. Dead specimens were requested for necropsy and PCR-tests. April Johnson, working in his laboratory, had recently identified Ranavirus-like particles using transmission electron microscopy in archived tissue from unexplained box turtle mass mortality events in Georgia during 1991 and in Texas in 1998. Evidence suggested that this virus was the causative pathogen for those die-offs. Testing our specimens by PCR and virus isolation, she confirmed their suspicion that Ranavirus was killing the box turtles.

In May 2004, April Johnson and April Childress from Jacobson's lab travelled to northwestern Pennsylvania and collected blood samples from almost all turtles living at the affected site. They also collected dead frogs and tadpoles. PCR and virus isolation revealed that the dead anurans had also been infected with Ranavirus. Restriction enzyme analysis of whole genomes of the turtle and frog isolates showed identical restriction patterns, suggesting they were infected with the same virus and so frogs might represent the disease vector for our outbreak. The turtle serology, however, showed that one individual (an aged female) had antibodies against the virus. Our interpretation of their turtle-serology findings is that this virus kills so quickly there is too little time for most victims to launch an effective immune response; but the authors point out other possible explanations for the serology findings, such as short-lived antibody production by sensitized leukocytes, or a slowly developing immune response that might take many months. Amphibians are known to carry Ranavirus, and the virus was identified in dead frogs from our habitat. This study site experienced record-setting rainfall during summer 2003. Elliot Jacobson (University of Florida College of Veterinary Medicine, 29 October 2003) noted that exceptionally wet summers, particularly after summers of drought (exactly the climate circumstance in our habitat in 2003), might generate unusually robust amphibian populations.

Despite the insights provided to us by the laboratory studies of this newly-recognized chelonian disease, we do not yet know how the virus entered and spread through our population, nor why the turtle death toll steadily declined and finally ended. Belzer speculated that perhaps surviving turtles were genetically protected by virally-incompatible cell receptors; or perhaps that vector populations, or the viral abundance in them, steadily declined. Given the long-term monitoring planned for this population, we may be able to gain further insight into the natural history of the disease should it ever return to this habitat.

Beltzer, W. & Seibert, S. (2010). A natural history of Ranavirus in an eastern box turtle population. Turtle and Tortoise Newsletter. In Press.

PCBS IN SEA TURTLES IN THE CANARIES.

Polychlorinated biphenyls (PCBs) are dangerous manufactured pollutants that can be sequestered by a range of animals. PCBs 28, 31, 52, 101, 138, 153, 180 and 209 were measured in tissue from 30 Loggerhead Turtles *Caretta caretta*, 1 Green Turtle *Chelonia mydas* and 1 Leatherback *Dermochelys coriacea* stranded on the Canary Islands to investigate relations between PCBs, lesions and causes of death. Tissues contained higher levels of PCBs than reported from other geographical regions. Sigma PCB concentrations (1980+/-5320 ng g (-1) wet wt.) in the liver of Loggerheads were higher than in the adipose tissue (450+/-1700 ng g (-1) wet wt.). Concentrations of PCB 209 in the liver (1200+/-3120 ng g (-1) wet wt.) of Loggerheads and in the liver (530 ng g (-1) wet wt.) and adipose tissue (500 ng g (-1) wet wt.) of the leatherback were remarkable. Frequency of PCB 209 in the liver (15.5%) and adipose tissue (31%) were equally high. Cachexia was detected in 7 turtles (22%) and septicemia diagnosed in 10 turtles (31%). Statistically, a positive correlation was detected between Sigma PCBs and cachexia. Poor physical condition, cachexia and/or septicaemia could explain the high levels of PCBs detected. However, no histological lesions were exclusively attributed to the effects of PCBs. The most prevalent infections found in the turtle tissue lesions were ulcerative and purulent oesophagitis, purulent dermatitis, necrotizing enteritis and granulomatous pneumonia. The most frequent bacteria found in tissue were *Escherichia coli*, *Staphylococcus* sp. and *Aeromonas* sp. Although immunosupression as a result of PCB pollution is known, among other factors, such as fishing, poor nutritional status and exposure to micro-organisms to cause turtle death, obscure correlates between PCBs and these factors make determination of analysis of exact cause of death difficult. Often analysis of synergistic effects of pollution related stressors is required.

Orós, J., González-Díaz, O.M. & Monagas, P. (2009). High levels of Polychlorinated Biphenyls in tissues of Atlantic turtles stranded in The Canary Islands, Spain. *Chemosphere* **74** (3), 473-478.

GLOBAL AMPHIBIAN EXTINCTION RISK ASSESSMENT FOR THE PANZOOTIC CHYTRID FUNGUS.

Emerging infectious disease has been shown to increase amphibian species loss and any attempts to reduce extinction rates need to squarely confront this challenge. In this report a procedure is developed for identifying amphibian species that are most at risk from the effects of Chytridiomycosis by combining spatial analyses of key host life-history variables with the pathogen's predicted distribution. The technique is applied to the known global diversity of amphibians in order to prioritize species that are most at risk of loss from disease emergence. This risk assessment shows where limited conservation funds are best deployed in order to prevent further loss of species by enabling ex situ amphibian salvage operations and focusing any potential disease mitigation projects. A map of Worldwide potential distribution of areas where Chytrid fungus could develop is drawn.

Approximately one sixth of all known amphibian species fall with their total distributions into regions potentially suitable to Chytrid. The results identify 379 species in which the entire geographic range is, in terms of climate, of high suitability to Chytrid. So far though, little is known about the current infection or population status of most of the 'Top 379'. Perhaps due to the circumstance that many of them occur in regions from where Chytrid has not been recorded only seven of these species are reported to be infected with Chytrid in nature. The report also suggests that this is the result of limited surveillance for disease rather than the occurrence of healthy populations, as at least 42 species of the 'Top 379' have undergone so called 'rapid enigmatic declines' likely caused by the spread of Chytrid and the effect of chytridiomycosis. The report concludes with a discussion on the limitations of the methodology used and how corrective measures could aid better results.

Rödder, D., Kielgast, J., Bielby, J., Schmidtlein, S., Bosch, J., Garner, T.W.J., Veith, M., Walker, S., Fisher, M.C. & Lötters, S. (2009). Global Amphibian Extinction Risk Assessment for the Panzootic Chytrid Fungus. *Diversity* **1**, 52-66.

Research Articles

Grassland snake assemblages in central and western Pennsylvania and northeastern Ohio, USA

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ABSTRACT - Surveys of snake assemblages during 2001-2009 from 15 grasslands in central and western Pennsylvania and northeastern Ohio found that in smaller sites (4.6 ha) the Common Garter Snake (*Thamnophis sirtalis*) was nearly always the dominant snake out of as many as eight species found under cover boards, and generally followed by smaller, fossorial species that were considerably less abundant. At the single large site (101 ha), large individuals (> 105 cm SVL) of the Midland Rat Snake (*Scotophis spiloides*) and the Eastern Racer (*Coluber constrictor*) greatly outnumbered other species and no Common Garter Snakes were captured. Although not confirmed, the small size and isolated nature of the smaller grassland sites may have been the reason for the absence of the Eastern Racer. However, in domino effect, the absence of this large-bodied ophiophage may have allowed the Common Garter Snake to dominate, which in turn may have been a superior competitor for earthworms and also a possible predator of its competitors. Habitat structure of these sites appeared to be responsible for the status of some of the species as well as non-competitive, larger species at these sites. Thus, whereas conservation of the Eastern Racer is tied, in part, to large parcels of early successional grasslands, somewhat predictable responses by northeastern grassland snakes to successional changes within the grassland must also be taken into account when formulating conservation plans for disappearing habitat in the northeastern United States.

GRASSLANDS in the eastern United States have declined by 80% since the mid-1800s (Brennan & Kuvlesky, 2005). In the Northeast, succession of grasslands to forest has been the main source of grassland loss (Brennan & Kuvlesky, 2005). In a review of Pennsylvania grassland habitats, Duncan (2005) noted the occurrence of grasslands in Pennsylvania since the glacial retreat 11,000 years ago. These post-glacial grasslands were maintained by large herbivores, burning by Native Americans, and more recently by land clearing by European settlers. Land clearing associated with European settlement reduced forest cover to approximately 25% of its pre-Columbian coverage. In the last 200 years succession of agricultural land back to eastern deciduous forest has resulted in a net loss of previously predominant grassland habitats. Presently, approximately 25% of Pennsylvania's habitats are open. In neighboring Ohio, only 0.5% of the original 2,591 km^2 native tallgrass prairie remains and secondary grassland habitat, such as pastures and hayfields have declined 61% and 46% respectively, since 1950 (Swanson, 1996).

Recent interest has focused on secondary (i.e., anthropogenic) grasslands for conservation efforts. For example, the importance of large tracts has been shown to be important for a variety of grassland birds (Davis, 2004), such as the Grasshopper

Sparrow (Balent & Norment, 2003) and Henslow's Sparrows (Bajema & Lima, 2001). Research has revealed that small grasslands can become a sink for grassland species populations (Balent & Norment, 2003) or may be avoided altogether (Peterjohn, 2006). Community structure and dynamics of Midwestern grassland herpetofaunal communities have received attention (e.g., Fitch, 1999; Cavitt, 2000; Wilgers & Horne, 2006) as well as the loss of grassland habitat to succession (e.g., Fitch, 1999, 2005, 2006). Significantly, grassland habitats, whether primary or secondary, were found to have supported larger and more diverse herpetofaunal assemblages than forest habitats. In the northeast, less attention has been devoted to grassland herpetofaunas and often only in association with multi-habitat surveys of an area (e.g., Yahner et al., 2001; Tiebout III, 2003; Brotherton et al., 2005). However, a study in Connecticut that examined snake assemblages in relation to patch size found an effect of patch size on assemblage diversity and body size of snakes (Kjoss & Litvaitis, 2001).

The importance of rare and shrinking grassland habitats in Pennsylvania is evident in 37 vertebrate species identified by the Pennsylvania Wildlife Action Plan as worthy of conservation efforts (Duncan, 2005). Among terrestrial invertebrates in south-central Pennsylvania, butterflies were found to be more numerous in open habitat than in forest (Keller & Yahner, 2002). Appearing effectively as islands in an ocean of forest, grasslands provide us with an opportunity to examine responses of snakes to this habitat as well as responses to the assemblage structure to patch size of these grasslands at sites in Pennsylvania and northeastern Ohio.

METHODS AND MATERIALS

Powdermill Nature Reserve (PNR)

This 856.2 ha reserve is privately owned and operated by the Carnegie Museum of Natural History and is located in Rector, Westmoreland County, Pennsylvania, USA. Founded in 1957, tracts which had been farmed were allowed to reforest such that today 89.5 % of PNR is covered in mixed forest. Once each month we visited up to eight sites during May-September 2003-2009, depending on the site. Exceptionally, in 2003 visits did not commence until June instead of May. Cover boards were constructed of 1 x 3 m corrugated galvanized steel.

1. Crisp Meadow is a 1.0 ha site of mixed rangeland located near the station's bird-banding lab. It is convex in topography and is mowed each fall. Eight cover boards encircled most of the field and were monitored during 2003-2009.
2. Barn is a 0.9 ha site of mixed rangeland located along Rt 381 and southwest of Powdermill Run. It is convex in topography and very wet on its eastern side. The Barn site is mown each fall. Three cover boards were monitored during 2003-2009.
3. Friedline Left Entrance is a 3.1 ha site of rolling mixed rangeland that borders Rt. 381 and is located north of the Pennsylvania Turnpike. This site is irregularly mown during the fall. Seven cover boards were monitored during 2004-2009.
4. Friedline Right Entrance is a 2.2 ha site of rolling mixed rangeland that borders Rt. 381 and is located north of the Pennsylvania Turnpike. This site is irregularly mown during the fall. Seven cover boards were monitored during 2008-2009.
5. Friedline Original is a 0.6 ha site of mixed rangeland on a slope found southeast of Rt. 381 and north of the Pennsylvania Turnpike. This site is irregularly mown during the fall. Six cover boards partially encircled the field and were monitored during 2003-2009.
6. Friedline Foundation is a 2.1 ha site of mixed rangeland on a slope found southeast of Rt. 381 and north of the Pennsylvania Turnpike. This site is irregularly mown during the fall. One cover board was monitored during 2008-2009.
7. Friedline Corners is a 14.6 ha site of rolling fallow field that is located along the corner of Rt. 381 and the Pennsylvania Turnpike. This site is irregularly mown during the fall. Three cover boards were monitored during 2006-2009.
8. Friedline Turnpike is a 4.9 ha site of a rolling fallow field that is located east of Rt. 381 and faces the Pennsylvania Turnpike. This site is irregularly mown during the fall. Eight cover boards were monitored during 2004-2005 and

subsequently one cover board was monitored during 2006-2009.

Fort Indiantown Gap National Guard Training Center (FITG)
This 7500 ha military training ground is located in Dauphin and Lebanon counties, Pennsylvania, USA. Established in 1931, approximately 101 ha of grassland have been set aside for the protection of the Eastern Regal Fritillary Butterfly (*Speyeria idalia idalia*) (Ferster et al., 2008). The grassland is maintained by periodic disturbance by tanks, or "iron bison" (Ferster et al., 2008). At opposite ends of FITG, a single 3 x 1 m corrugated galvanized steel was monitored in section B-12, and a mix of eight 1 x 1 m plywood boards and 3 x 1 m corrugated galvanized steel were monitored at section D-3 during May-September 2005. The data were combined for one area. Ferster et al. (2008) provided a map of FITG.

Wildwood Park (WP)
This 96.3 ha county park is located in Harrisburg, Dauphin County, Pennsylvania, USA. WP is an urban park isolated from other semi-natural habitats by highways. WP is centred around an artificial lake that comprises over 60 % of an otherwise heavily forested park of mixed deciduous trees. The single 0.4 ha grassland site was created by clearing forest for an aborted road and is situated on a gentle slope. This site is mown each fall. Six 1 x 1 m untreated plywood boards were monitored during May-September (2004-2007).

James H. Barrow Field Station (JHBFS)
This 121.4 ha reserve is privately owned and operated by Hiram College and is located in Hiram Township, Portage County, Ohio, USA Founded in 1960, JHBFS habitats range from various stages of oldfield succession to 67% forest coverage of a primarily Beech-Maple community. Monthly visits occurred at five sites during May-September (2001-2004). Exceptionally, boards were monitored daily for one week each September. Cover boards were constructed of 1 x 1 m untreated plywood. Ten cover boards were set 2 m apart from each other.

1. Front Road is a 1.6 ha early successional oldfield site that borders agricultural crop land. This site was monitored in 2004.
2. Mulch Pile is a 1.20 ha mid-successional oldfield site with scattered shrubs and small deciduous trees. This site was monitored during 2002-2004.
3. Oil Well is a 0.2 ha early successional Oldfield site that is surrounded by forest on 3 sides and by field on one side. This site was monitored during 2001-2004.
4. Old Field is a 2.8 ha mid-successional oldfield site that is scattered with shrubs and small deciduous trees. This site was monitored during 2001-2004.
5. Wet Site is a 1.3 ha late successional oldfield site. Shrubs and trees are extensive. The site borders a wetland and was monitored during 2001-2004.

At sites except JHBFS, snakes were captured, and immediately sexed, measured for snout-vent length (SVL) and either fitted with an AVID Passive Integrated Transponder (PIT) tag for individual recognition or a ventral scale clip to note that the animal was marked. Snakes were released immediately afterwards. At JHBFS, individual marking by use of AVID chips only, was restricted to a subset of snakes. For this reason, only total captures were examined for JHBFS. All other protocols were followed at JHBFS. Means are followed by + 2 standard deviations. Common names follow the arrangement by Collins & Taggart (2009).

RESULTS

Powdermill Nature Reserve
We recorded 1056 captures of 669 marked snakes of eight species at PNR during 2002-2007. For all sites, the Common Garter Snake (*Thamnophis sirtalis*) was the most abundant species accounting for 71.6% of all snake captures and 64.3% of all new snakes captured during the study (Fig. 1). The Redbelly Snake (*Storeria occipitomaculata*) was second in abundance for all sites as measured by all captures (11.6%) and all new snakes (17.2%), both of whose abundance values only slightly exceeded those of the Ringneck Snake (Fig. 1).

Overwhelming dominance of the Common Garter Snake on PNR grasslands was evident at

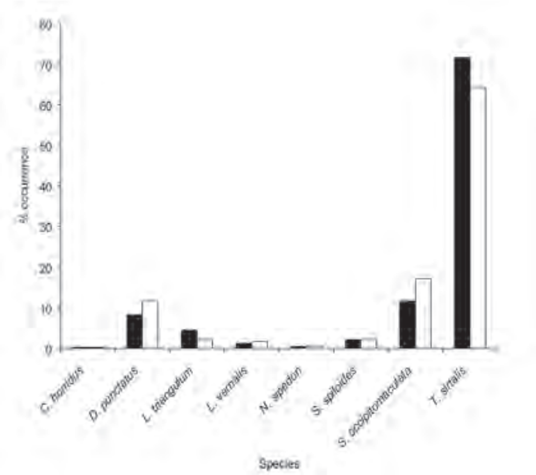

Figure 1. Relative abundance of snakes at all eight grassland sites combined from Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2003-2009. Solid bars denote the percent of all captures (n = 1056). Open bars denote the percent of all new captures (n = 669).

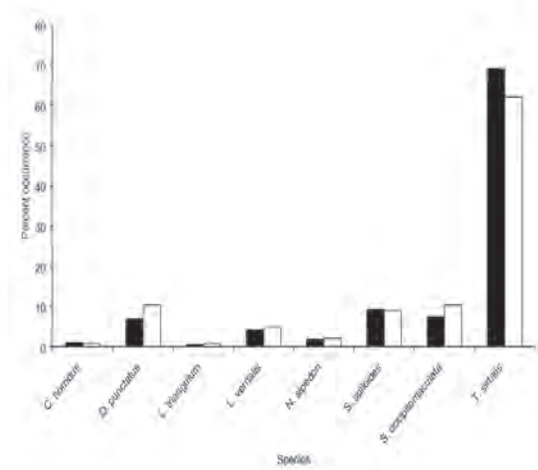

Figure 2. Relative abundance of snakes at the Crisp Meadow site at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2003-2009. Solid bars denote the percent of all captures (n = 217). Open bars denote the percent of all new captures (n = 145).

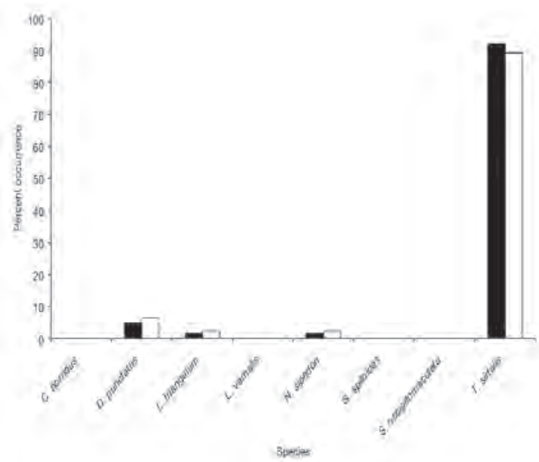

Figure 3. Relative abundance of snakes at the Barn site at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2003-2009. Solid bars denote the percent of all captures (n = 63). Open bars denote the percent of all new captures (n = 47).

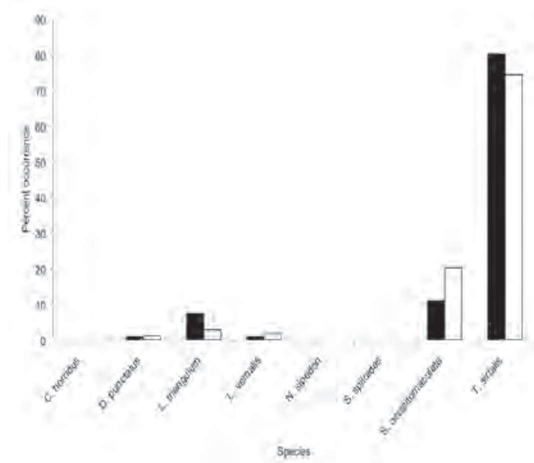

Figure 4. Relative abundance of snakes at the Friedline Left Entrance site at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2004-2009. Solid bars denote the percent of all captures (n = 367). Open bars denote the percent of all new captures (n = 183).

seven sites (Figs. 2-9) and similar to that of the Redbelly Snake at one site (Fig. 5). However, the distribution and composition varied greatly among the remaining species. Likewise, the overall abundance of snakes, as measured by numbers of snakes/cover board, varied extensively among sites (Fig. 10). Three species co-occurred at four sites (Figs. 5, 7, 8, 9), four species co-occurred at one site (Fig. 3), five species co-occurred at two sites (Figs. 4, 6), and eight species co-occurred at one site (Fig. 2). With one exception, Friedline Right Entrance (Fig. 5), snake species that co-occurred with the Common Garter Snake were generally much lower in abundance than the Common Garter

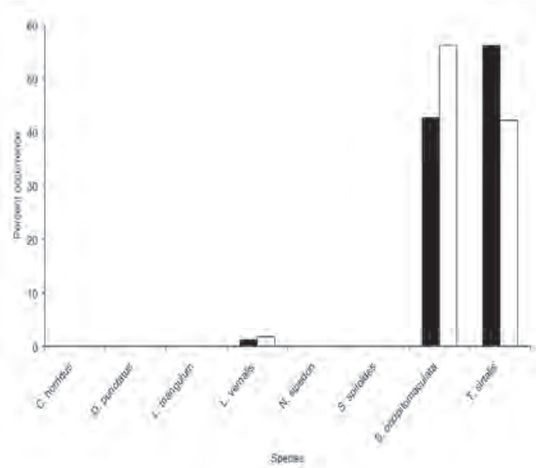

Figure 5. Relative abundance of snakes at the Friedline Right Entrance site at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2008-2009. Solid bars denote the percent of all captures (n = 82). Open bars denote the percent of all new captures (n = 57).

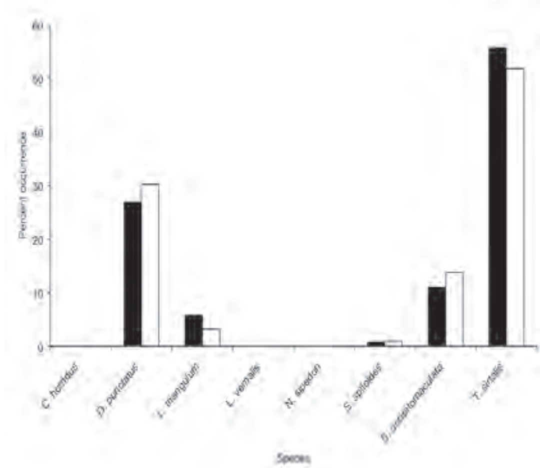

Figure 6. Relative abundance of snakes at the Friedline Original site at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2003-2009. Solid bars denote the percent of all captures (n = 246). Open bars denote the percent of all new captures (n = 189).

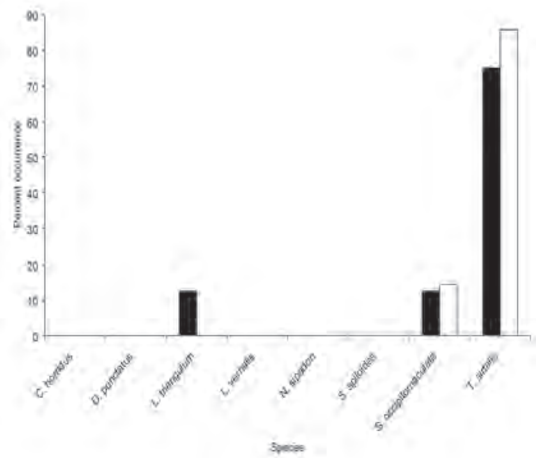

Figure 7. Relative abundance of snakes at the Friedline Foundation site at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2008-2009. Solid bars denote the percent of all captures (n = 8). Open bars denote the percent of all new captures (n = 7).

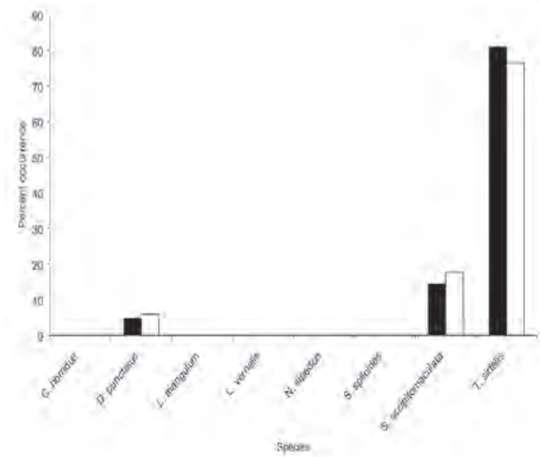

Figure 8. Relative abundance of snakes at the Friedline Corners site at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2006-2009. Solid bars denote the percent of all captures (n = 21). Open bars denote the percent of all new captures (n = 17).

Snake. The Ringneck Snake (*Diadophis punctatus*) or Redbelly Snake comprised the second most abundant snake at four sites (Figs. 3, 4, 6, 8). Along the edge of Crisp Meadow (Fig. 2), the Midland Rat Snake (*Scotophis spiloides*) was more numerous with respect to total number of captures than either the Ringneck Snake or Redbelly Snake. With a very small sample size, the Milk Snake and Redbelly Snake were similar in total Numbers of captures at Friedline Foundation (Fig. 7), and at Friedline Turnpike (Fig. 9) the Milk Snake (*Lampropeltis triangulum*) was more numerous in both total and new captures than was the Redbelly Snake. Number of snakes captured/cover board

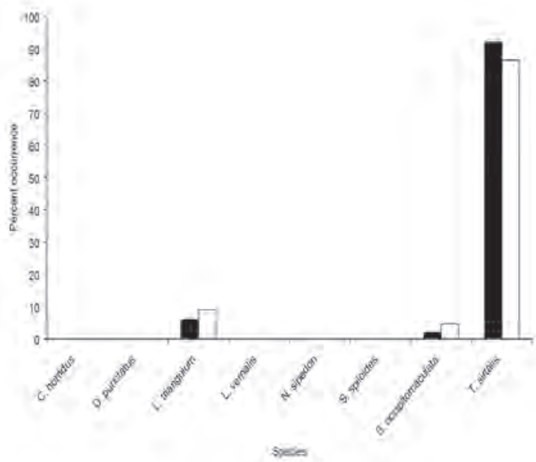

Figure 9. Relative abundance of snakes at the Friedline Turnpike site at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2006-2009. Solid bars denote the percent of all captures (n = 50). Open bars denote the percent of all new captures (n = 22).

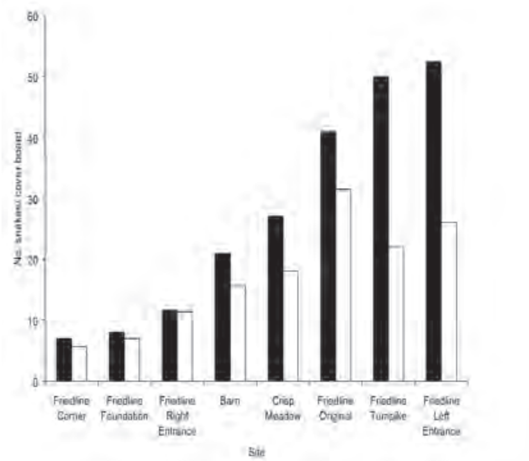

Figure 10. Number of snakes/ cover board at all eight grassland sites at Powdermill Nature Reserve, Westmoreland County, Pennsylvania, USA, during 2003-2009. Solid bars denote the percent of all captures (n = 1056). Open bars denote the percent of all new captures (n = 669).

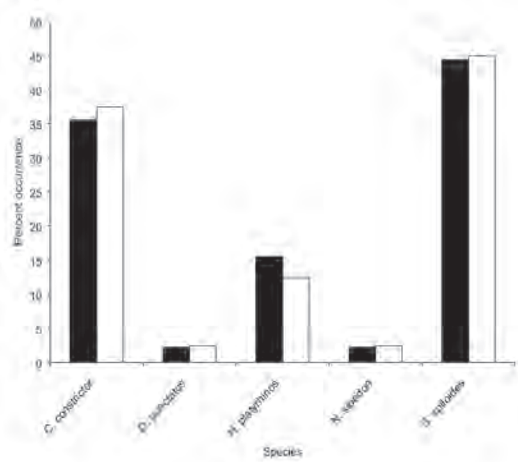

Figure 11. Relative abundance of snakes from grassland habitat at Fort Indiantown Gap National Guard Training Center, Dauphin and Lebanon counties, Pennsylvania, USA, in 2005. Solid bars denote the percent of all captures (n = 45). Open bars denote the percent of all new captures (n = 40).

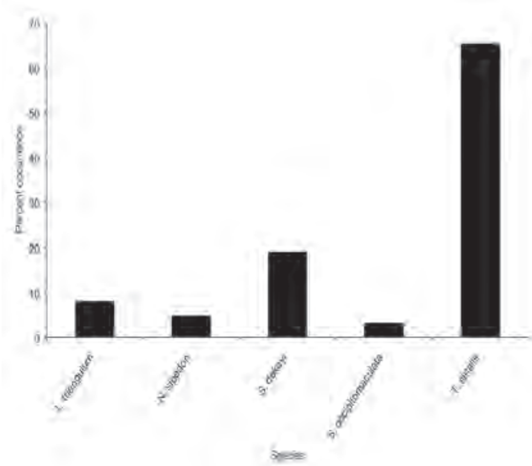

Figure 12. Relative abundance of snakes at all of the five grassland sites combined from the James H. Barrow Field Station, Portage County, Ohio, USA, during 2001-2004. Solid bars denote the percent of all captures (n = 566).

ranged 7.0-52.4 for total captures and 5.7-31.5 for new captures, the values of which appeared to have little to do with patch size (Fig. 10). No other reptilian species was captured under the cover boards. However, a trail that passes through Crisp Meadow was used as a nesting site by the Painted Turtle (*Chrysemys picta*), Wood Turtle (*Glyptemys insculpta*), and Box Turtle (*Terrapene carolina*). A hepetofaunal list recorded 21 amphibians and 18 reptiles for PNR (Meshaka et al., 2008a).

Fort Indiantown Gap Training Center

We recorded 45 total captures of 40 marked snakes of five species at FITG in 2005. Using

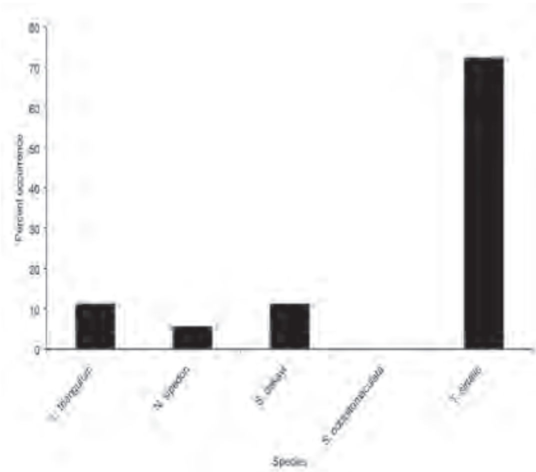

Figure 13. Relative abundance of snakes at the Front Road site at James H. Barrow Field Station, Portage County, Ohio, USA, in 2004. Solid bars denote the percent of all captures (n = 18).

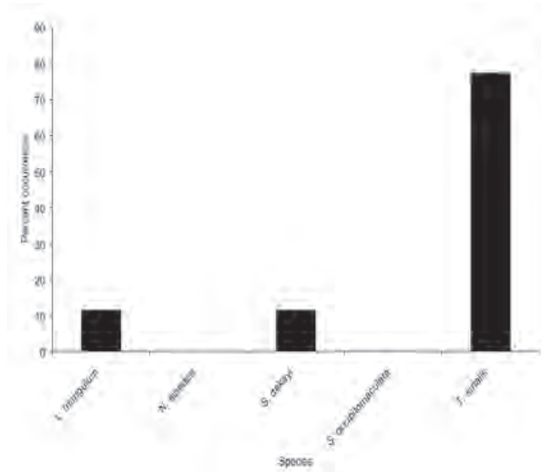

Figure 14. Relative abundance of snakes at the Mulch site at James H. Barrow Field Station, Portage County, Ohio, USA, during 2002-2004. Solid bars denote the percent of all captures (n = 44).

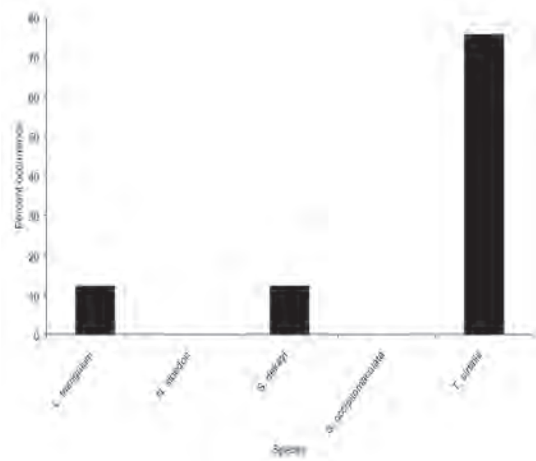

Figure 15. Relative abundance of snakes at the Oil Well site at James H. Barrow Field Station, Portage County, Ohio, USA, during 2001-2004. Solid bars denote the percent of all captures (n = 90).

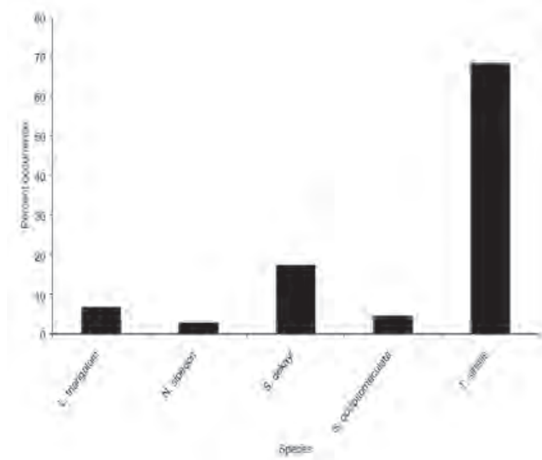

Figure 16. Relative abundance of snakes at the Old Field site at James H. Barrow Field Station, Portage County, Ohio, USA, during 2001-2004. Solid bars denote the percent of all captures (n = 281).

either measure of abundance, the Midland Rat Snake and Eastern Racer (*Coluber constrictor*) were the two dominant species and were followed distantly in numbers of captures of other species (Fig. 11). Numbers of snakes/cover board were relatively low for all captures (5.8 snakes/ cover board) and all new captures (4.4 snakes/ cover board). Mean body sizes of nine Eastern Racers (mean = 107.2 + 13.5 cm SVL; range = 83-123) and 11 Midland Rat Snakes (mean = 108.4 + 13.5 cm SVL; range = 96.5-135). Body sizes of two Eastern Hognose Snakes (*Heterodon platirhinos*) were also large in body size (77, 64 cm SVL). Seven Timber Rattlesnake (*Crotalus horridus*) sightings in the study areas in 2005 were of adults > 1.5 m TL.

A Five-lined Skink (*Plestiodon fasciatus*) was captured under cover boards on 8 June and on 2 August in parts of the grassland. The following additional species were seen at FITG

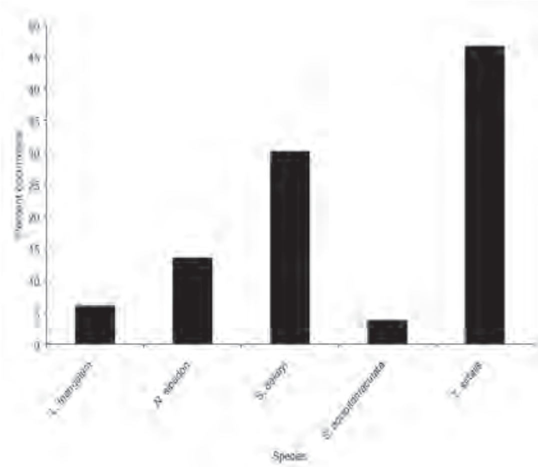

Figure 17. Relative abundance of snakes at the Wet site at James H. Barrow Field Station, Portage County, Ohio, USA, during 2001-2004. Solid bars denote the percent of all captures (n = 133).

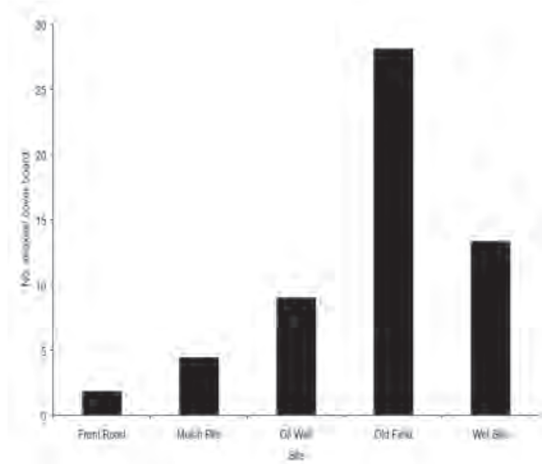

Figure 18. Number of snakes/cover board at all five grassland sites combined at James H. Barrow Field Station, Portage County, Ohio, USA, 2001-2004. Solid bars denote percent of all captures (n = 566).

during the study: Common Snapping Turtle (*Chelydra serpentina*), Painted Turtle, and Box Turtle.

Wildwood Park

We recorded 92 total captures of 71 marked Common Garter Snakes at WP during 2001-2004. Numbers of snakes/cover board were intermediate for all captures (15.3 captures) and all new captures (8.8 captures). A single Spotted Salamander (*Ambystoma maculatum*) was found beneath one of the cover boards on 9 September 2005. A trail that passes through this site is used as nest sites by the Painted Turtle and Box Turtle. The following species were seen at WP during the study: American Toad (*Anaxyrus americanus*), Fowler's Toad (*A. fowleri*), Spring Peeper (*Pseudacris crucifer*), Bullfrog (*Lithobates catesbeianus*), Bronze Frog (*L. clamitans*), Pickerel Frog (*L. palustris*), Northern Dusky Salamander (*Desmognathus fuscus*), Northern Two-lined Salamander (*Eurycea bislineata*), Northern Redback Salamander (*Plethodon cinereus*), Common Snapping turtle, and Brown Snake (*Storeria dekayi*). WEM was told of reports of the Wood Turtle (*Glyptemys insculpta*) and a single sighting of the Midland Rat Snake (*Scotophis spiloides*).

James H. Barrow Field Station

We recorded 565 total captures of five species that were caught during 2001-2004. For all sites combined, the Common Garter Snake was the most abundant species accounting for 65.2% of all snake captures during the study (Fig. 12). The Brown Snake was second in abundance for all sites combined when measured by all captures (18.9%) (Fig. 12). Overwhelming dominance of the Common Garter Snake on the station's grasslands was evident at each of the five sites (Figs. 13-17). However, the distribution and composition varied greatly among the remaining species. Likewise, the overall abundance of snakes, as measured by total numbers of snakes/cover board, varied extensively among sites (Fig. 18). Three snake species co-occurred at two sites (Figs. 14, 15), four species co-occurred at one site (Fig. 13), and five species co-occurred at two sites (Figs. 16, 17). Snakes co-occurring with the Common Garter Snake were generally low in abundance. Exceptionally, the Brown Snake, which co-occurred at all five sites, was clearly the second most frequently encountered species at Old Field (Fig. 16) and the Wet Depression site (Fig. 17). At remaining sites, the Brown Snake occurred at abundances equal to or exceeding those of synoptic species (Figs. 13-15). With respect to number of snakes captured/cover board, Front Road was the least productive

Figure 19. *Thamnophis sirtalis* at PNR. Photograph by Robert S. Mulvihill. ◄

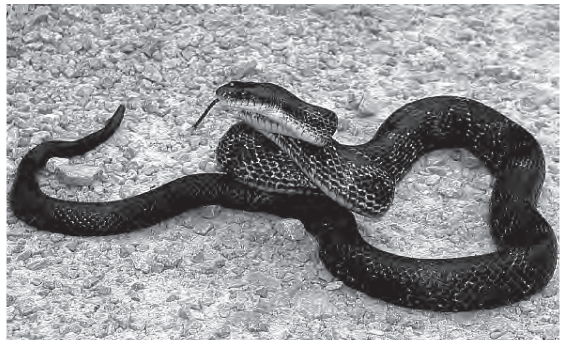

Figure 20. *Scotophis spiloides* at PNR. Photograph by Robert S. Mulvihill. ▲

Figure 21. *Coluber constrictor* at FITG. Photograph by Dave Zapotok. ◄

(1.8 snakes/cover board), and Old Field was the most productive (28.1 snakes/cover board) (Fig. 18). No other reptiles or amphibians were found under the cover boards; however, the following species were seen on the station during the study: Northern Dusky Salamander, Eastern Newt (*Notophthalmus viridescens*), Redback Salamander, Spring Peeper, Bullfrog, Bronze Frog, Pickerel Frog and Midland Rat Snake.

DISCUSSION

Common to 13 of the 15 sites, in three of the four main study areas, the Common Garter Snake (Fig. 19) was consistently the most frequently encountered snake. The second most frequently observed species was nearly always a small fossorial species, such as the Brown Snake, Redbelly Snake, or Ringneck Snake. In sharp contrast, large individuals of the Midland Rat Snake (Fig. 20) and the Eastern Racer (Fig. 21) were most abundant in a large grassland. At that same study area, other species were large in body size, only one Ringneck Snake was captured and the Common Garter Snake was not encountered.

Isolation and small size of the grassland patches were associated with the absence of the Eastern Racer, a large-bodied and wide-ranging species, in our study and another study (< 10 ha) (Kjoss & Litvaitis, 2001) in the northeastern United States. In this regard, the Eastern Racer, once common in the more open habitat of PNR, was subsequently found to have been rare in connection with forest encroachment (Meshaka et al., 2008a). Its absence from smaller grasslands could have been a response to the need for increased home range size by this large snake.

Kjoss & Litvaitis (2001) found that fewer small species of snakes, and larger individuals of those species, were found in areas intensively used by the Eastern Racer. They attributed those results to predation by the Eastern Racer. Similarly, we found large individuals only of large-bodied (e.g., Eastern Racer and Midland Rat Snake) and stout-bodied (Eastern Hognose Snake and Timber Rattlesnake) species, and only one individual of a small-bodied snake (Northern Ringneck Snake) at the 101-ha site at FITG. We suggest that predation by the Eastern Racer, whose diet includes a wide range of snakes (Palmer & Braswell, 1985; Klemens, 1993; Hulse et al., 2001) was responsible for these findings. In the absence of the Eastern Racer, small species and juveniles were encountered among the snakes found at PNR (Meshaka, 2009a) and JHBFS (Meshaka et al., 2008b), and juvenile Common Garter snakes were encountered at WP (Meshaka, 2009b).

Like Kjoss & Litvaitis (2001) who found only the Common Garter Snake in the smallest patches (< 1.5 ha), we found only the Common Garter Snake in one of our smallest patches. Kjoss & Litvaitis (2001) attributed the absence of other species in the smallest patches to insufficient soil moisture because of frequent mowing. In support of this explanation in our study, at two of the four main study sites in which the Brown Snake had been recorded, it was the annually mown site at WP that did not have this species in the grassland. On the other hand, JHBFS also had very small patches of grassland but were in various stages of oldfield succession. For example, Oil Well was even smaller (0.2 ha) than the site at WP, but was inhabited by three snake species. Thus, the Common Garter Snake patches were small, but not restricted to the Common Garter Snake.

Dominance of the Common Garter Snake with varying combinations and frequencies of other small-bodied species was found in larger patches studied by Kjoss & Litvaitis (2001). Regarding Common Garter Snake dominance, in our study this finding was generally but not exclusively the case. For instance, at one of eight sites at PNR total captures of the Common Garter Snake exceeded those of the Redbelly Snake and the opposite was true concerning new captures. One testable explanation of this departure is the short duration, 2008-2009, of study at this site. On the other hand, as yet unknown features of the habitat may have inhibited the success of the Common Garter Snake at this site. Among the syntopic snakes in Common Garter Snake dominated sites, second place in captures by small-bodied earthworm or slug-eating species was the general pattern. That they did not occur in greater abundance than they did, we attribute to competition for a shared food resource with, and to some extent predation by, the Common Garter Snake as testable explanations. In this connection, the Common Garter Snake was reported to have fed primarily on earthworms in Pennsylvania (Hulse et al., 2001) and on earthworms and amphibians in Indiana (Minton, 2001) and New York (Hamilton, 1951). In the latter study, snakes were also eaten in low frequencies. Habitat quality is also a testable explanation. Highest numbers of PNR Ringneck Snakes were found along the two pasture edges of an infrequently mowed site and less so along the edges of an annually mowed site. To this end, the Ringneck Snake was sensitive to the successional changes in grassland whereby population sizes increased shortly after the removal of cattle and growth of dense ground cover or tall grass, and began to diminish at varying points in which open habitat was lost to canopy and eventual forest (Fitch, 1991). In this same study, the Brown Snake and the Common Garter Snake were least affected by the successional changes, such that their initial population increases were followed by relatively stable population sizes. In the case of the Common Garter Snake, temporal variation in its abundance was found to have been affected more by annual changes in weather than by the succession (Fitch, 1999).

In remaining cases, larger-bodied vertebrate-eating snakes, such as the Midland Rat Snake and Milk Snake, occurred at similar or greater abundances than their earthworm and slug-eating counterparts in Common Garter Snake dominated sites. Variation in their abundance may have been related not only to the size of the patch, but, also adjoining habitat, succession of the site, its isolation from other patches, and sample size. For instance, nearby ponds, thicket and buildings, including a shed which contained two recaptured individuals from Crisp Meadow, enhanced the habitat for the Midland Rat Snake. Also at this site and Friedline Original, cover boards were set along the edge that might have been analogous to the presence of tree and shrub cover that was interspersed in the openness at FITG where this species was also captured.

Ophiophagous as a juvenile and primarily a mammal-eater as an adult in Pennsylvania (Hulse et al., 2001), the Milk Snake would have existed as a predator of the Common Garter Snake for part of its life and apart from potential competition for prey with that species throughout its life where it maintained some presence in larger fields at PNR. The heavily canopied deciduous forest surrounding the smaller patches would have enforced the rarity of this species in small patches. Not surprisingly, this species was unknown in the heavily wooded WP. On the other hand, the small grassland sites at JHBFS were separated by thicket that would not have hindered its movements among oldfield patches of our study and would themselves have served as habitat for this species. In this regard, after initial increases in population sizes following cattle removal, the Eastern Racer, the Milk Snake and the Northern Water Snake were negatively impacted by forest encroachment. The Midland Rat Snake and the Brown Snake were least affected by the successional changes, such that their initial population increases were followed by relatively stable population sizes (Fitch, 1999). Sample size also could have played a role in the observed frequencies of the Milk Snake. For example, it was expected but not captured during a single season of trapping in the expansive grassland of FITG. Likewise sample size was too small for us to determine if the similarity of total numbers of the Milk Snake and the Redbelly Snake at Friedline Foundation was the norm for this site. Snake diversity was a correlate of large patch size in the study by Kjoss & Litvaitis (2001). At a macro-level, large overall area of three study areas was associated with high numbers of snake species. Connections among patches and proximity to human disturbance were present in all but WP whose grassland snake assemblage was comprised of only the Common Garter Snake. Possibly, the connections were sufficient to support a rich snake assemblage but not large enough to include the Eastern Racer.

Our findings corroborate the role of patch size in grassland snake assemblage structure. Large patches could support more species including the Eastern Racer, an ophiophage in part, whose presence affected the composition, evenness and population structure of the assemblage. In its absence, the Common Garter Snake, a prey species of the Eastern Racer, was found to have been a dominant component of otherwise highly uneven assemblages. Whereas competition for food and perhaps predation are potential explanations for the variation in abundances of some of the species, for other species structural composition of the habitat appeared to have played a role (e.g., Ringneck Snake, Brown Snake) or primary role (Midland Rat Snake, Milk Snake) in determining abundances in these latter sites. Consequently, whereas large parcels of early successional and shrub-dominated habitats are necessary for the conservation of the Eastern Racer in the northeastern United States (Kjoss & Litvaitis, 2001), attention should also be paid to responses of ecological succession in grasslands regardless of size by individuals snakes species in this region of North America.

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Recent data on the distribution of lizards and snakes of the Seychelles

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THE Seychelles comprise 155 islands scattered across the western Indian Ocean at 4-11º S and 45-56º E. Traditionally divided into two main groups, the northern, granitic islands and the southern, coralline islands, they can in fact be differentiated into three geological categories: the inner (granitic islands), the low coralline islands and the raised coralline islands (Baker, 1963; Braithwaite, 1984a) (Fig. 1).

The granitic islands consist of a group of about 40, clustered together on an undersea shelf of granite, the Seychelles bank, and are remnants of the Seychelles microcontinent which was isolated following Gondwana breakup, roughly 65 million years ago (Plummer & Bell, 1995). These comprise the islands of North, Silhouette, Fregate, Mahé, Praslin, La Digue, Curieuse and several smaller islands encircling these (Fig. 1). The islands are generally high, some very mountainous, reaching 914 m above sea level (Morne Seychellois, Mahé). Such height results in great habitat diversity and rainfall. In periods of low sea levels during the Pleistocene and Pre-Pleistocene ice ages (Colonna et al., 1996; Rohling et al., 1998; Siddall et al., 2003; Camoin et al., 2004; Miller et al., 2005) most of the Seychelles Bank would have been exposed as a single large island, but even when global sea level was at its highest, most of the granitic islands remained above sea level, allowing the survival of unique endemic species (Stoddart, 1971; Geyth et al., 1979; Braithwaite, 1984a; Montaggioni & Hoang, 1988; reviewed in Gardner, 1986).

The low coralline islands (Bird, Denis, Coëtivity and Platte, the Amirantes and the Farquhar groups) were formed very recently, probably less than 6,000 years ago, from marine sediments sometimes cemented by deposits of guano. Almost all are less than 3 m above sea level (Braithwaite, 1984b).

All of the Aldabra group (Aldabra, Cosmoledo and Astove atolls and Assumption island) are raised coralline islands. Like the low coralline islands, they are oceanic in origin, formed by reef-building corals acting on submerged volcanic seamounts that may have formed some 20 million years ago (Plummer, 1995) and have thus been submerged and emerged several times since their formation. Aldabra's last full submergence dates back to 125,000 years ago (Thomson & Walton, 1972). Remaining islands in the group, lower than Aldabra itself, were probably submerged during the last interglacial when sea level was 10 m higher than present, re-emerging slightly later than Aldabra (Taylor et. al., 1979). In general the coralline islands have limited habitat variation and correspondingly lower species diversity. Aldabra is an exception, possibly due to its slightly older age and proximity to both continental Africa and Madagascar. As currently recognized, the native reptiles of the Seychelles

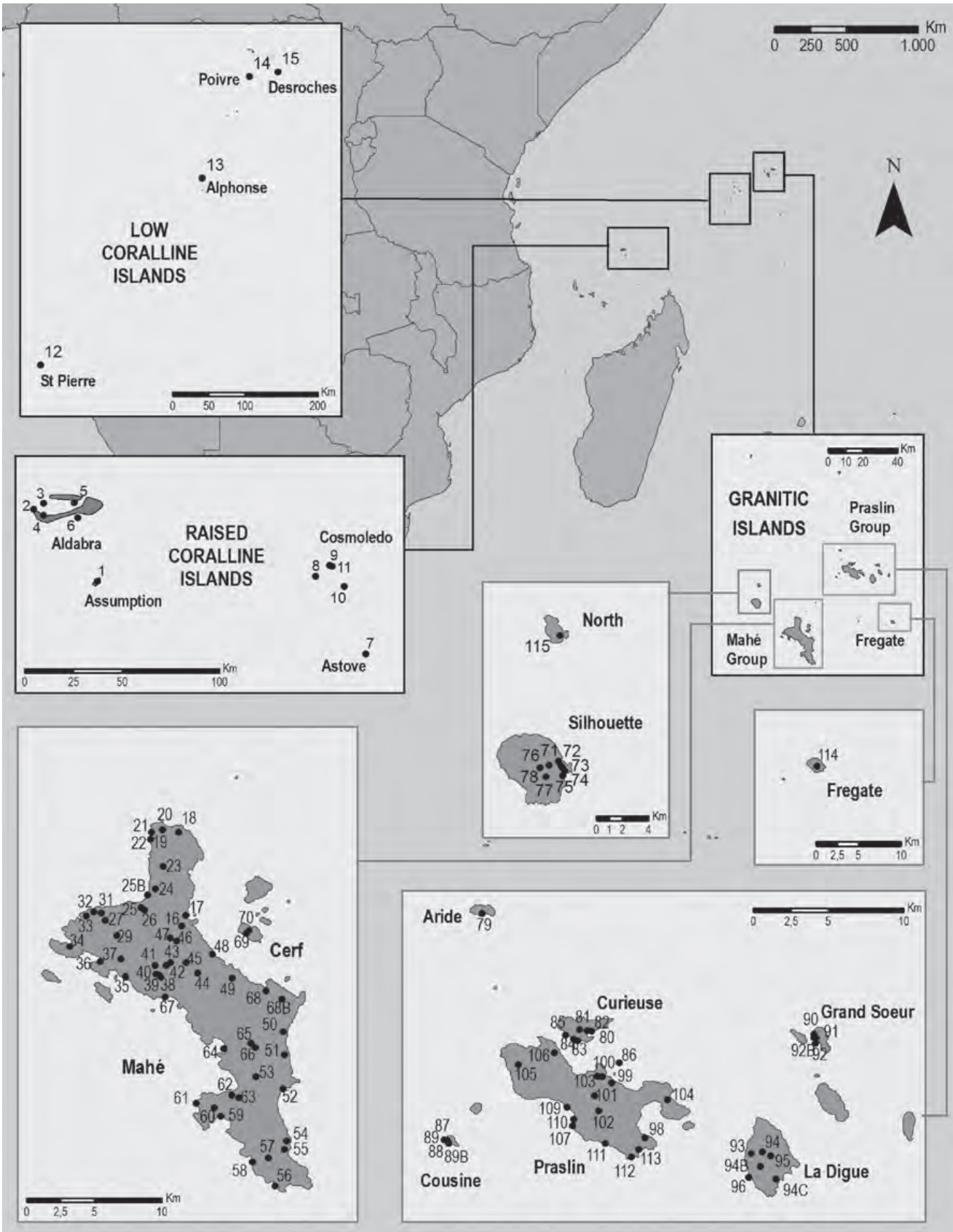

Figure 1. General map of the study area and the principal island groups sampled in this study.

comprise around 30 species, 70% of which are endemic (Gerlach, 2007). Systematic studies on vertebrate fauna at the Seychelles dates back from the late 1880s, but despite this and even after two very recent publications covering species accounts and tentative distributions (Bowler, 2006; Gerlach, 2007), precise distribution records are still lacking and many distributions are incomplete. Here we report data obtained during roughly 12 weeks of fieldwork between 2005 and 2008 that together, with the surveys undertaken as part of the Indian Ocean Biodiversity Assessment 2000-2005, and previous records, provide the most up-to-date distribution record of the lizards and snakes in the Seychelles. A total of 121 localities were sampled (Fig. 1 and Table 1 [Appendix]), covering a wide range of the coralline and granitic islands, resulting in approximately 900 observations. Specimens observed were located with GPS and identified to species level following the most recent taxonomic revisions in each case. Biogeographic and taxonomic remarks in respect of ongoing molecular work are also discussed.

REPTILIA

GEKKONIDAE

Phelsuma

The most conspicuous reptile group of the Seychelles, *Phelsuma* are brightly coloured, generally diurnal geckos, occurring in a wide range of habitats from high mountain forest to banana and coconut plantations. There are clearly two species in the granitic islands (*Phelsuma sundbergi* and *Phelsuma astriata*) and another one present on the southern atolls (*Phelsuma abbotti*). Alpha-taxonomy is still not clear for the group, mainly due to the highly variable nature of dorsal coloration patterns across the islands. A third form is sometimes recognised as a full species (*Phelsuma longinsulae*) and as many as three to four subspecies are sometimes recognized within *P. astriata* and *P. sundbergi* respectively. In this report only two subspecies within *P. sundbergi* (*P. sundbergi* and *P. longinsulae*) are provisionally used, and no subspecific divisions within *P. astriata*, recognizing only the forms that are easily distinguishable in the field. *Phelsuma sundbergi* and *P. astriata* are endemic to the Seychelles and sister-taxa, having originated within the Seychelles. However, *P. abbotti* from Aldabra and Assumption are closely related to other *P. abbotti* subspecies from Northwestern Madagascar, resulting from an independent colonisation of the southern atolls (Rocha et al., 2009a). Ongoing molecular work should clarify the structure within these species.

Phelsuma sundbergi sundbergi (Fig. 2)
Localities: Grand Soeur 90; Poivre 14; Praslin 99, 102, 110; Curieuse 81; La Digue 93, 94B, 95, 96. Easily distinguished from its conspecific by being the largest species and predominantly green, with small, widespread, red freckles. It is abundant and widespread across its distribution. The individuals from La Digue (and Felicite, Cocos, Grand Soeur, Petite Soeur and Mariane) are often refered to as *Phelsuma sundbergi ladiguensis*. As they are not different from *P. sundbergi sundbergi* individuals in the field (except for the geographic criteria), we do not consider it as a different subspecies for now.

Phelsuma sundbergi longinsulae (Fig. 14)
Localities: Fregate 114; Mahé 16-18, 20, 22, 24-26, 25B, 29, 31, 34-36, 39, 40, 44, 45, 47-52, 55, 59, 62, 64-68, 68B; Cosmoledo 8; Cerf 69, 70; Silhouette 71, 75, 76; North Island 115. In Mahé, where it co-exists with *P. astriata*, *P. sundbergi* seems to be much more abundant (at least it is much more frequently observed), with *P. astriata* being much less conspicuous and predominantly found at higher altitudes in the canopy.

Phelsuma astriata (Fig. 11)
Localities: Mahé 29, 33, 39, 45, 53, 55, 59; Praslin 99, 100, 102, 103, 104, 105, 107, 109, 110, 113; La Digue 93, 94, 95, 99; Curieuse 80, 81, 82; Cerf 70; Cousine 87, 89; Grand Soeur 92; Fregate 114; Silhouette 74, 75; Aride 79; Astove 7; Alphonse 13. Cheke (1984) described *P. astriata* from Fregate (« Fregate form ») as an intermediate form between *P. a. astriata* (Mahé group, Silhouette, Astove and Alphonse) and *P. a. semicarinata* (Praslin group, D'Arros and St. Joseph). Ongoing studies with molecular markers should reveal patterns of genetic variation within this group and provide useful information for future taxonomic reappraisals.

Phelsuma abbotti (Fig. 1)
Localities: Aldabra 2, 3, 6; Assumption 1. A nortwestern Malagasy species. Traditionally two endemic subspecies are recognized as inhabiting the southern atolls of the Seychelles: *P. a. abbotti*, in Aldabra and *P. a. sumptio*, in Assumption. Both seem to exist at high densities but are presently considered as "Vulnerable" due to their restricted range (Gerlach, 2007). This species is usually observed on trunks, perching at low heights within tropical dry forest.

Ailuronyx
The genus is endemic to the Seychelles. The previous Malagasy record of *Ailuronyx trachygaster* (1981) is probably erroneous (Bauer, 1990). The species is believed to have a pre-quaternary age in the islands (Cheke, 1984) and their phylogenetic affinities are unknown. Currently they are placed basal to a big Afro-Malagasy clade of geckos (A. Bauer, pers. comm.). Today, they are common only in palm forests on Praslin or rat-free islands like Aride, Cousine or Fregate. This may indicate that rats do have a major influence on their present distribution. Three species are recognized (Gerlach, 2002) although they can be difficult to distinguish. Of them, *Ailuronyx trachygaster* is rarely observed and known only from a few sightings from Praslin and Silhouette where it is usually found high in the forest canopy. Ongoing molecular work should shed further light on species differentiation levels and patterns. No specimens were observed that could clearly be assigned to *A. trachygaster* during the surveys herein.

Ailuronyx seychellensis (Fig. 4)
Localities: Praslin 102, 107; Cousine 88; Fregate 114; Silhouette 76; Aride 79.

Ailuronyx tachyscopaeus (Fig. 18)
Localities: Mahé 55; Cerf 70; Silhouette 75; Praslin 102; La Digue 96; Curieuse 81; Grand Soeur 92B. Previous records from Cerf were identified to genus as *Ailuronyx* sp. The species is tentatively suggested as *A. tachyscopaeus* in this report and is awaiting further, more rigorous morphological identification and more precise molecular investigation to clarify its identity.

Hemidactylus
At least two *Hemidactylus* species occur in the Seychelles: *Hemidactylus mercatorius* (sensu Kluge 2001) and *Hemidactylus frenatus*. Records for a third species, *Hemidactylus brookii*, exist for Desroches (Amirantes) but were not confirmed by surveys in this report. The relationship between the Seychelles populations of *H. mercatorius* with both East African and Malagasy specimens, and with East African *Hemidactylus mabouia* was recently studied using molecular data (Rocha et al., in press).

Hemidactylus mercatorius (Fig. 9)
Localities: Mahé 59, 68; Assumption 1; Aldabra 2, 3, 5, 6; Astove 7; Cosmoledo 8-11. Abundant and widespread in the southern atolls, there are some observations also in the granitics. This species is closely related to East African *H. mabouia*, and while individuals found in Mahé may be introductions from the East African mainland or the Comoros, the Aldabra group harbours a distinct, apparently autochtonous clade (Rocha et al., in press). Nevertheless, the taxonomy of this group remains controversial.

Hemidactylus frenatus
Localities: Mahé 16, 18, 25, 25B, 59, 62; Poivre 14; Desroches 15. This species is present throughout Indian Ocean islands without any signs of geographic structure and its presence in the region is possibly recent (Vences et al., 2004; Rocha et al., 2005).

Urocotyledon inexpectata (Fig. 6)
Localities: Praslin 99, 101, 110, 111, 112; Mahé 19, 27, 29, 32, 37, 41, 45, 46, 58, 60, 61; La Digue 94, 95; Curieuse 80; Grand Soeur 90, 92 ; Fregate 114; Silhouette 72, 73, 75, 76, 77; Aride 79; Cousine 89B. Particularly interesting from a biogeographic point of view, this species is rarely encountered and remains among the most poorly known gecko species. The few records in the literature suggested this was a rare species. However, its rarity may be due to its particular habitat and ecology; mainly nocturnal, hardly emerging from shelters (usually very small cracks in granitic boulders) and moving only a short distance from them. In the Seychelles

Figure 1. *Phelsuma abbotti.* ►

Figure 2. *Phelsuma sundbergi sundbergi* (spotted venter with a V shape on chin). ► ►

Figure 3. *Zonosaurus madagascariensis.* ▼

Figure 4. *Ailuronyx seychellensis.* ▼

Figure 5. *Lamprophis geometricus.* ► ►

Figure 6. *Urocotyledon inexpectata* (clutch, in the interior of wasp nests and; distinctive sucker structure on tip of tail). ▲

Figure 7. *Calumma tigris.* ▲

Figure 8. *Pamelascincus gardineri.* ▲ ▲

Figure 9. *Hemidactylus mercatorius.* ►

Figure 10. *Mabuya wrightii.* ▲

Figure 11. *Phelsuma astriata* (with characteristic pale white venter). ▲

Figure 12. *Janetaescincus* sp. ◄

Figure 13. *Ramphotyphlops braminus.* ▲

Figure 14. *Phelsuma sundbergi longinsulae* (spotted/V shape chin). ▲

Figure 15. *Gehyra mutilata*.

Figure 16. *Mabuya sechellensis*.

it can frequently be found in granitic boulders around empty wasp nests in which it frequently lays its eggs. Our recent records do not add new localities to the known distribution for this species, but it is now clear that it is more frequently encountered than previously thought. The species is rather inconspicuous and probably abundant, at least in many of the granitic islands, but sometimes difficult to detect.

Gehyra mutilata (Fig. 15)
Localities: Mahé 16, 19, 21, 23-25, 32, 34, 37, 57-59, 62, 66, 67; Aldabra 2; Alphonse 13; Praslin 103, 109; La Digue 93; Curieuse 80; Fregate 114; Silhouette 71. This species is native to southern Asia. Cryptic variation occurs in this species and possibly at least two species exist under *G. mutilata* designation (Rocha et al., 2009b). The species recently spread across several Indian Ocean islands where it is mostly associated with housing and buildings. It has also been observed in more "pristine" habitat at Morne Seychellois mountains at Mahé and sometimes in syntopy with the endemic *Urocotyledon inexpectata*, suggesting that the species may be spreading fast into non-anthropogenic habitats.

SCINCIDAE
Mabuya (=*Trachylepis*)
The genus *Mabuya* comprises more than 100 species widespread acroos Asia, Africa and the Neotropics (Greer et al., 2000), and it is the only circumtropical skink genus (Mausfeld et al., 2002). The two endemic species from the Seychelles, *Mabuya wrightii* and *Mabuya sechellensis*, are apparently closely related to the African and Comoroan

Figure 17. *Cryptoblepharus boutonii aldabrae.* ◄

Figure 18. *Ailuronyx tachyscopaeus*. ▼

species *Mabuya maculilabris*, which is probably a species complex (Jesus et al., 2005), and basal to most of remaining Afro-Malagasy representatives of the genus (Carranza et al., 2001; Mausfeld et al., 2002; Carranza & Arnold, 2003, Jesus et al., 2005). Based on arguments outlined in Jesus et al. (2005) we still use the generic designation of *Mabuya* instead of the recently proposed genus, *Trachylepis* (Mausfeld et al., 2002; Bauer, 2003).

Mabuya wrightii (Fig. 10)
Localities: Saint Pierre 86; Cousine 87; Fregate 114; Aride 79. Easily recognizable from *M. sechellensis* by its size, this large, heavy bodied skink can reach up to 138 mm snout-vent length (Gerlach, 2005). It is endemic to the granitic islands occurring only in rat-free areas, possibly due to pressure from this introduced predator. Higher population densities are reached in islands with large seabird colonies and may take advantage of higher food availability associated to them.

Mabuya sechellensis (Fig. 16)
Localities: Mahé 16-18, 20-24, 25B, 27, 29-32, 34, 35, 38-41, 43-50, 54-60, 62-64, 66-68, 68B; Praslin 98, 99, 102, 104, 106, 107, 109; La Digue 93, 94B, 94C, 95, 96; Curieuse 80-84; Cerf 69; Grand Soeur 91, 92; Fregate 114; Silhouette 73, 75-77; Aride 79; North Island 115. This species is endemic and extremely widespread across all the granitic islands. It has also been introduced in some coralline islands such as Denis, Bird and some of the Amirantes (Gerlach, 2007). They are extremely common and can be found in virtually all kinds of habitats from woodland, plantations, gardens and housing from sea level to mid-altitudes. Ongoing studies using molecular tools are attempting to clarify interspecific relationships and inter-island variation across both species.

Pamelaescincus
Pamelaescincus is a monospecific genus endemic to the Seychelles. It is also a sister-taxa to another possibly monospecific genus from the Seychelles (*Janetaescincus*). Both seem to be basal to all remaining Afro-Malagasy scincines (Brandley et al., 2005) and are of significant biogeographic interest.

Pamelaescincus gardineri (Fig. 8)
Localities: La Digue 93, 95; Mahé 42, 46, 47, 58, 66; Praslin 102, 105; Grand Soeur 91; Fregate 114; Silhouette 73, 76,77; Aride 79.

Janetaescincus (Fig. 12)
Localities: Mahé 65; Praslin 102; La Digue 93, 95; Curieuse 85; Fregate 114; Silhouette 76, 77, 78. Two species are sometimes recognized (*Janetaescincus braueri* and *Janetaescincus veseyfitzgeraldi*) but they are often synonymised [Bowler, 2006]). Both species are very similar in body shape and limb size, and (eventual) taxonomic differences are found in the arrangement of head scales and coloration, both very difficult to determine in the field. This report considers only the generic identification but further molecular results may unveil patterns of variation within this group. Both *Janetaescincus* and *Pamelaescincus* are burrowing skinks with reduced limbs, always found among leaf litter, in more humid and darker places. *Janetaescincus* is much smaller, longer, slender, with a more elongate snout and usually darker than *Pamelaescincus*, which is generally a larger, stouter skink. *Pamelaescincus* has five toes in all limbs while *Janetaescincus* has four toes in the forelimbs. *Pamelaescincus* seems to be crepuscular, at least in some islands, and is more active at dawn. In the field, both species are easily recognized by their rapid, serpentiform movement among the leaf-litter. They are not usually confused with *Mabuya* spp., which are ground dwellers that consistently bask in sunlight.

Cryptoblepharus boutonii aldabrae (Fig. 17)
Localities: Assumption 1; Aldabra 2-6; Astove 7; Cosmoledo 8-11; Saint Pierre 12. A small, slender skink, frequently found under trunks or rocks. It has a disjunct Indo-Pacific distribution with Western Indian Ocean populations that are a result of an ancient colonization from the Australian region (Rocha et al., 2006). The origins of the Seychelles populations remain unknown. Conversely to other islands in the Western Indian Ocean and the African coast, these skinks have been observed not only in the intertidal area but also in open habitats inland, where they are found on trunks and plant debris.

CHAMAELEONIDAE

Calumma tigris (Fig. 7)

Localities: Mahé 37, 46, 47. All the other members of this genus occur in Madagascar, from where the ancestor of this species presumably originated. This species is a very difficult lizard to observe in the field and is possibly more abundant than currently realised from our surveys. Two of the observations reported to us were road kills.

CORDYLIDAE

Zonosaurus madagascariensis (Fig. 3)

Localities: Cosmoledo 9. This species is wide-spread in Madagascar. In the Seychelles it inhabits only Cosmoledo. Ongoing genetic studies reveal no significative differentiation between Malagasy and Cosmoledo individuals (A. Raselimanana, pers. comm.).

COLUBRIDAE

Lamprophis geometricus (Fig. 5)

Localities: Fregate 114; Praslin 102. *Lamprophis* is an African genus, with isolated populations in Arabia and the Seychelles. *L. geometricus* is nocturnal and was rarely seen, except on Fregate Island, where very high densities were observed. Gerlach (2007) states maximum sizes of 91.4 cm but individuals little over 1.0 m were observed on Fregate Island. Its evolutionary relationships are currently unknown, but it is not particularly distinct from some of its African congeners being possibly introduced (Nussbaum, 1984; Dowling, 1990).

Lycognathophis seychellensis (Edition cover)

Localities: Mahé 29; La Digue 95, 96; Fregate 114; Silhouette 76; Praslin 102. This monotypic genus is apparently related to Ethiopian and Oriental natricines (Dowling, 1990; Vidal et al., 2008). Our observations extend previous records to La Digue, where it seems to be abundant.

TYPHLOPIDAE

Ramphotyphlops braminus (Fig. 13)

Localities: Assumption 1; Mahé 66, 67; La Digue 93; Curieuse 85; Cerf 69; Cousine 87. This fossorial and parthenogenetic snake is widely distributed in the tropics and many Carribbean, Indian and Pacific Ocean islands where it is easily introduced. It has been recently reported around the Gulf of Guinea and the Comoro islands (Jesus et al., 2003; Carretero et al., 2005). It has also been introduced in recent times in the Seychelles (Nussbaum, 1984).The observations herein extend distribution records to Alphonse, Curieuse and Cerf.

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APPENDIX

Table 1. Localities sampled (WGS84 Coordinate System). Due to the large number of localities sampled, records very close together were grouped. More detailed individual records can be obtained from the authors.

No.	Locality	Island	Longitude	Latitude
1	Assumption	Assumption	46,500333	-9,734167
2	Picard	Picard, Aldabra	46,206000	-9,401056
3	Polymnie Island	Polymnie Island, Aldabra	46,251369	-9,372633
4	Ile Esprit	Ile Esprit, Aldabra	46,250650	-9,427336
5	Malabar	Malabar, Aldabra	46,394119	-9,369458
6	Grand Terre	Grand Terre, Aldabra	46,410275	-9,439361

7	Astove Island	Astove Island	47,739000 -0,070194
8	Menai Island	Menai Island, Cosmoledo	47,507889 -9,709972
9	NorthWest Island	NorthWest Island, Cosmoledo	47,572597 -9,660986
10	Wizard Island	Wizard Island, Cosmoledo	47,640819 -9,758050
11	NorthEast Island	NorthEast Island, Cosmoledo	47,584583 -9,664536
12	Saint Pierre	Saint Pierre, Amirantes	50,725719 -9,328497
13	Alphonse	Alphonse, Amirantes	52,730667 -7,008861
14	Poivre	Poivre, Amirantes	53,310336 -5,746003
15	Desroches	Desroches, Amirantes	53,666194 -5,692111
16	Mont Fleuri, Victoria	Mahé	55,454756 -4,628367
17	Port, Victoria	Mahé	55,457414 -4,621339
18	NorthEast Point	Mahé	55,452650 -4,565878
19	North 1	Mahé	55,441961 -4,564258
20	North 2	Mahé	55,441961 -4,564475
21	Glacis 2	Mahé	55,434467 -4,565919
22	Glacis 1	Mahé	55,434050 -4,570619
23	Reservoir, La Gogue	Mahé	55,442239 -4,588675
24	Mare Anglaise	Mahé	55,437264 -4,603708
25	Beau Vallon (beach) 1	Mahé	55,427656 -4,616028
25B	Beau Vallon (beach) 2	Mahé	55,431878 -4,607639
26	Beau Vallon 3	Mahé	55,429961 -4,617803
27	Danzil 3	Mahé	55,404036 -4,624647
29	Mare aux Cochons	Mahé	55,411584 -4,634866
30	Danzil 4	Mahé	55,407980 -4,630331
31	Danzil 1	Mahé	55,401178 -4,619889
32	Danzil 2	Mahé	55,396097 -4,619050
33	Anse Major	Mahé	55,391142 -4,621767
34	Cap Ternay	Mahé	55,380247 -4,642239
35	Port Glaud 1	Mahé	55,417342 -4,662019
36	Port Glaud 2	Mahé	55,400403 -4,651961
37	Port Glaud 3	Mahé	55,414219 -4,650506
38	Tea factory	Mahé	55,440425 -4,662481
39	Tea plantation	Mahé	55,439539 -4,661169
40	Morne Blanc	Mahé	55,437692 -4,660319
41	Casse Dent	Mahé	55,436964 -4,654786
42	Mission	Mahé	55,444411 -4,654869
43	Salazie	Mahé	55,447375 -4,652661
44	Fairview	Mahé	55,465178 -4,659708
45	Copolia	Mahé	55,457617 -4,652894
46	Trois Frères 1	Mahé	55,451158 -4,638611
47	Trois Frères 2	Mahé	55,446989 -4,636489
48	Brilliant	Mahé	55,474800 -4,646967
49	Cascade	Mahé	55,488308 -4,663222
50	Anse aux Pins 1	Mahé	55,522139 -4,698908
51	Anse aux Pins 2	Mahé	55,522889 -4,714061
52	Anse Royalle	Mahé	55,522092 -4,736867
53	Anse Louis	Mahé	55,503958 -4,728744
54	Anse aux Forbans 2	Mahé	55,524428 -4,771742
55	Anse aux Forbans 1	Mahé	55,523133 -4,777383
56	Ptit Police	Mahé	55,516714 -4,801739
57	Quatre Bornes	Mahé	55,512339 -4,782778
58	Anse Intendance	Mahé	55,501625 -4,785728
59	Baie Lazare	Mahé	55,480728 -4,755383
60	road to Anse Soleil	Mahé	55,476269 -4,749483
61	Anse Soleil	Mahé	55,464217 -4,746544
62	Anse a la Mouche 1	Mahé	55,487914 -4,741072

63	Anse a la Mouche 2	Mahé	55,492553 -4,743033
64	Anse Boileau	Mahé	55,482528 -4,710100
65	La Reserve 1	Mahé	55,500694 -4,706583
66	La Reserve 2	Mahé	55,503500 -4,709614
67	Grand Anse	Mahé	55,443744 -4,675850
68	Airport	Mahé	55,510811 -4,671667
68B	South Airport	Mahé	55,521192 -4,677047
69	Cerf Island 1	Cerf Island	55,497742 -4,633408
70	Cerf Island 2	Cerf Island	55,499175 -4,631353
71	La Passe 1	Silhouette	55,250833 -4,484694
72	La Passe 2	Silhouette	55,248983 -4,481867
73	La Passe 3	Silhouette	55,251897 -4,486283
74	road to Anse Lascars	Silhouette	55,253033 -4,488350
75	Anse Lascars	Silhouette	55,251931 -4,491681
76	around GB rock	Silhouette	55,242600 -4,484500
77	Gratte Fesse	Silhouette	55,240319 -4,492272
78	trail to Jardin Marron	Silhouette	55,236111 -4,486061
79	Aride Island	Aride Island	55,667958 -4,213183
80	Point1	Curieuse	55,733267 -4,283700
81	Turtle Pond	Curieuse	55,726294 -4,282981
82	Trail	Curieuse	55,730661 -4,283331
83	Doctor House	Curieuse	55,724883 -4,289472
84	Leper Colony 1	Curieuse	55,722572 -4,288703
85	Leper Colony 2	Curieuse	55,717700 -4,286222
86	Saint Pierre	Saint Pierre	55,749831 -4,302614
87	office	Cousine	55,647827 -4,351152
88	Plateau	Cousine	55,646894 -4,349383
89	To Cave	Cousine	55,644889 -4,348917
89B	East Cousine	Cousine	55,648214 -4,352300
90	Point 1	Grand Soeur	55,867578 -4,291023
91	North path 1	Grand Soeur	55,866485 -4,287730
92	North path 2	Grand Soeur	55,866503 -4,285678
92B	East path	Grand Soeur	55,867863 -4,287635
93	La Veuve Reserve 1	La Digue	55,828915 -4,357142
94	La Veuve Reserve 2	La Digue	55,835572 -4,356106
94B	To Grand Anse 1	La Digue	55,834464 -4,364803
94C	To Grand Anse 2	La Digue	55,843603 -4,372575
95	Belle Vue	La Digue	55,840623 -4,358718
96	Anse Source d'Argent	La Digue	55,827408 -4,371450
98	Baie Ste. Anne	Praslin	55,765086 -4,347797
99	Anse Volbert 1	Praslin	55,745347 -4,314867
100	Anse Volbert 2	Praslin	55,739703 -4,311256
101	Salazie	Praslin	55,735300 -4,322683
102	Vallé de Mai	Praslin	55,737617 -4,331433
103	Anse Volbert 3	Praslin	55,736650 -4,310825
104	Anse La Blague	Praslin	55,778797 -4,325111
105	Mont Plaisir	Praslin	55,689440 -4,303940
106	Anse Boudin	Praslin	55,710981 -4,296669
107	Anse Citron	Praslin	55,722047 -4,340547
109	Grand Anse	Praslin	55,718666 -4,329337
110	Fonde de L'Anse	Praslin	55,722460 -4,336602
111	Anse Bois de Rose	Praslin	55,741578 -4,351137
112	Anse Consolation	Praslin	55,757230 -4,359378
113	Anse Marie Louise	Praslin	55,761690 -4,354670
114	Fregate	Fregate	55,943872 -4,585808
115	North Island	North Island	55,249950 -4,395272

An undescribed gecko (Gekkonidae: *Cyrtodactylus)* from Deer Cave, Gunung Mulu National Park, Sarawak, with comments on the distribution of Bornean cave geckos

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GECKOS of the genus *Cyrtodactylus* are a speciose group in Southeast Asia, with at least nine species known from the island of Borneo (Das & Ismail, 2001; Das, 2006). Of these species, *Cyrtodactylus cavernicolus* has the smallest known range and is therefore the most vulnerable, a status that is reflected in the species having been designated a Totally Protected Species in Sarawak. Confirmed records of *C. cavernicolus* are known only from Niah Cave, located in an isolated limestone block known as the Gunung Subis massif, approximately 13 km^2 in extent. The Niah Cave Gecko is presumed to be dependent on the bat and swift guano ecosystems of the larger cave passages (c.f. Harrison, 1961), and its core habitat may be limited to Niah Great Cave which has some 1 x 10^5" m^2 of passages (data from survey by Wilford, 1964). The only published record of the species from outside the Niah massif is a single record from the Melinau Gorge of Gunung Mulu National Park (Hikida, 1990).

Chapman (1985) reported an observation of a single specimen of a gecko "resembling the Niah Cave Gecko" in Wonder Cave, Gunung Api, Gunung Mulu National Park. The specimen was not collected, and unfortunately is not diagnosable from the published photograph, so its true identity cannot now be established. The Grooved Bent-Toed Gecko, *Cyrtodactylus pubisulcus* is known from Bat Cave, a shallow cave system in the Deer Cave massif, Mulu (Chapman, 1985). More recently, Das et al. (2008) reported the collection of four specimens of an undescribed 'Mulu cave gecko' from Moonmilk Cave, Gunung Api massif, Mulu, and are preparing a formal description.

In July 2008, a gecko was observed and photographed in the dark zone of a high-level passage in Deer Cave (Gua Payau), Gunung Mulu National Park (Fig. 1). Photographic examination confirmed attribution to the genus *Cyrtodactylus* on the basis of slender toes (i.e., lacking distal dilation) and vertical pupils of the eyes. The specimen differs from *C. cavernicolus* and *C. pubisculus* in having a markedly longer tail (tail:body ratio, after correction for photographic angle, = 1.5; *C. cavernicolus* from O'Shea (1985) = 0.7; *C. pubisulcus* = 1.1), and more prominent unbroken, reticulate striping along the whole length of the body. Scale and tubercle counts are not available. Pending formal description of the Moonmilk Cave specimens by Das, we provisionally assign the Deer cave animal to his *Cyrtodactylus* sp. nov.

At the present time, the only published record of *C. cavernicolus* from anywhere other than the Niah Cave massif is that of Hikida (1990; summary of museum specimens, Appendix) based on a single specimen in the Department of Zoology Museum, Kyoto University, Japan (KUZ 12280). If we accept this specimen as *C. cavernicolus,* then it must be concluded that *C. cavernicolus* has a disjunct distribution separated by 100 km of lowland non-karst forest and the major drainage of the Baram River (Fig. 2). *C. cavernicolus* has never been reported from the well-studied caves of Gomantong (Sabah) or Bau (southwestern Sarawak) and can be considered to be genuinely absent at these sites. Karst outcrops at Beluru and Middle Baram have not been intensively studied,

Figure 1. *Cyrtodactylus* sp. nov, Deer Cave, Gunung Mulu National Park.

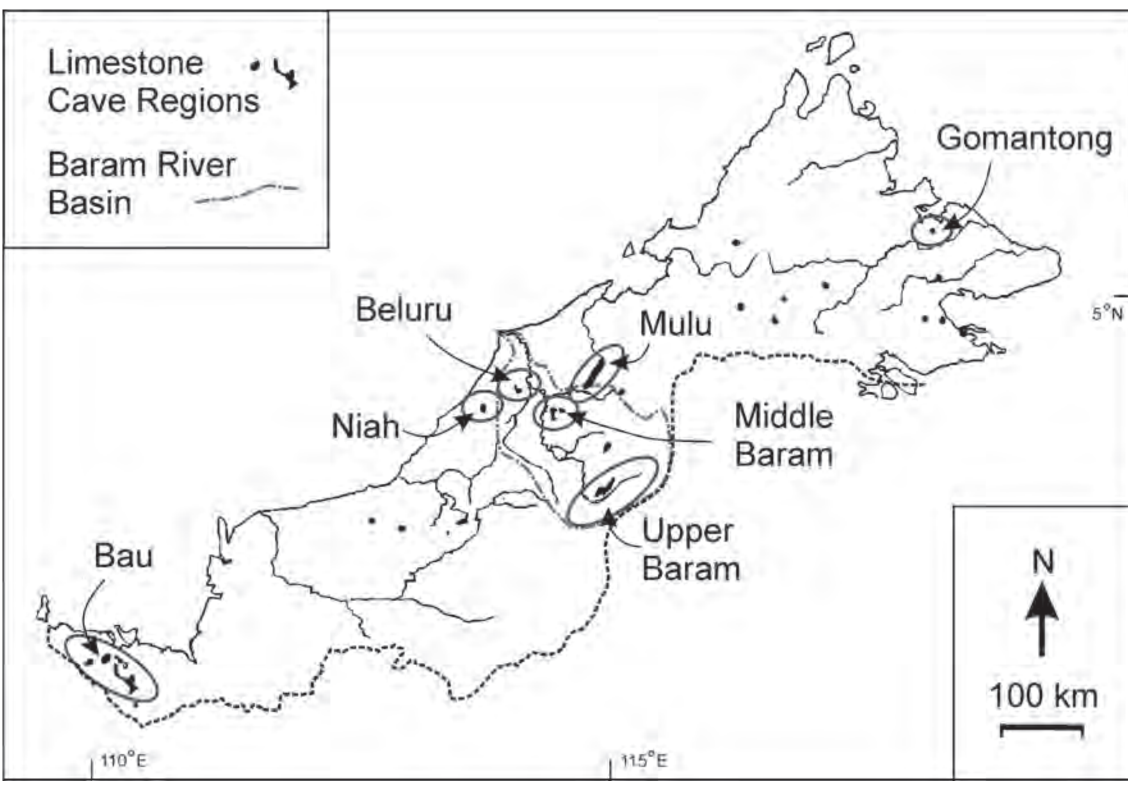

Figure 2. Map of conjectural distribution.

but lie between the Niah and Mulu massifs and would be expected to host *C. cavernicolus* if the species' distribution extended to Mulu. To date, *C. cavernicolus* has not been found in these areas. We therefore propose a more parsimonious hypothesis; that *C. cavernicolus*, the Niah Cave Gecko, is in fact truly endemic to Niah and that specimen KUZ 12280 has been misallocated. Under this scenario, the Mulu cave gecko *Cyrtodactylus* sp. nov Das is considered a Mulu endemic, and probably a sister taxon to *C. cavernicolus* and independently evolved to a troglophilic habit from a common ancestor, perhaps the widespread *C. pubisulcus* which is known to frequent the threshold zone of caves. Investigations of the cave-inhabiting geckonid fauna of the large karst massif at Upper Baram, as well as at Middle Baram and Beluru, can be expected to shed further light on this matter.

ACKNOWLEDGEMENTS

The observations reported here were made during geological research in the Mulu caves under Forest Department permit # NPW.907.4.2 (II)-34 and Park permit # 24/2008. We thank Mr Brian Clark for facilitating access to the caves, and Syria Lejau for assistance with fieldwork. Funding was providing by the National Geographic Society, grant # 8437-08 and Scripps College.

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APPENDIX

Type and voucher specimens of *Cyrtodactylus cavernicolus*. Known primarily from the type locality, Niah Great Cave, in northwest Sarawak (lat 3.8667 N, long 113.7333 E). Type specimen is FMNH 128388, paratypes 109955-60, 119904, 119915, 128387-89. CAS 23726 (paratype). Also Niah: BMNH 1984.705; FMNH 1311501-19. LSUHC 4055-56. ZRC 2.5227, 2.5775. Melinau Gorge, Gunung Mulu National Park; KUZ 12280. FMNH: Florida Museum of Natural History, Gainesville. CAS: California Academy of Sciences, San Francisco. LSUHC: La Sierra University, Riverside, California. BMNH: British Museum (Natural History), London. RC: National Museum Singapore, Raffles Museum of Biodiversity Research, Zoological Research Collection. KUZ: Zoological collections, University of Kyoto, Japan.

Conspicuous tail coloration in *Vipera berus*

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CAUDAL luring is a strategy used by snakes to entice potential prey through the movement of the distal portion of the tail (Parellada & Santos, 2002), which is often conspicuously coloured (Neill, 1960), resembling a vermiform invertebrate (Tiebout, 1997). Such behaviour is thought to be advantageous, in that it allows the snake to capture prey yet maintain the cryptic effect brought about by its pattern, coloration and relative immobility (Greene & Campbell, 1972).

Caudal luring is prevalent mostly in juvenile specimens (Neill, 1960) but also occurs in adult snakes (Greene & Campbell, 1972; Heatwole & Davison, 1976). It has been reported in many families, including Viperidae (Neill, 1960; Wharton, 1960; Greene & Campbell, 1972), Elapidae (Carpenter et al., 1978), Boidae (Mahendra, 1931; Murphy et al., 1978) and Colubridae (Tiebout, 1997). In the Viperidae caudal luring has been noted predominantly in the genus *Bothrops* (Greene & Campbell, 1972; Heatwole & Davison, 1976; Murphy & Mitchell, 1984), and *Agkistrodon* (Neill, 1960), with records also occurring in the genera *Cerastes* (Heatwole & Davison, 1976) and *Sistrurus* (Jackson & Martin, 1991).

Reports of caudal luring in the European genus *Vipera* are scarce (Parellada & Santos, 2002) although it has been observed in adults in Italian populations of *Vipera aspis* and *Vipera ammodytes* (Luiselli et al., unpublished data cited in Parellada & Santos, 2002). Further, more recent studies have reported observations of caudal luring in adult male and female *Vipera latasti* (Parellada & Santos, 2002). As far as the author is aware, caudal luring behaviour has not been recorded in the European Adder *Vipera berus*.

Many species of the genus *Vipera* have conspicuously coloured tails, including *V. berus*, *Vipera seoanei*, and *V. ammodytes* (Saint Girons, 1978), which has been suggested to be associated with caudal luring (Neill, 1960). During March, April and May of 2008 a large proportion of *V. berus* captured by the author in the Mendip Hills, Somerset exhibited a yellow or orange coloration to the underside of the distal portion of the tail. In most species, tails conspicuously marked in juveniles gradually become similarly coloured to the rest of the body before adulthood (Heatwole & Davison, 1976). Luring behaviour may cease in adulthood due to shifts in diet (Neill, 1960). In this instance conspicuous tail coloration was found in juvenile and adult female specimens (Fig. 1) although not in males. Yellow and green undersides to the tail have also been observed in neonate and immature Adders in Dorset, Surrey and Hampshire (T. Phelps, pers. comm.).

Some studies note that snakes that utilise caudal luring feed mostly on insectivorous foragers, such as lizards and frogs (Heatwole & Davison, 1976; Parellada & Santos, 2002) both of which occur within the diet of the Adder (Prestt, 1971; Andren & Nilson, 1983; Beebee & Griffiths, 2000). Thus caudal luring in the Adder should not be discounted. There may, nevertheless, be alternative functions associated with conspicuous tail coloration. Greene (1973) noted that tail displays can function defensively, either as a warning signal or to distract predators away from the head. Immature Adders have been observed with the distal portion of the tail raised from the ground and held in a horizontal plane, but no tail waving has been seen (T. Phelps, pers. comm.). The author suggests that studies on behaviour should focus on the feeding behaviour of neonates and immature specimens during the summer months following the dispersal of individuals from breeding sites. Due to the difficulty of observing behaviour in the field, observations from captive collections may also be useful.

ACKNOWLEDGEMENTS

The author wishes to thank Tony Phelps and the Members of the Reptiles and Amphibians of the

UK (RAUK) e-forum for contributions to the discussion of this topic.

Figure 1. Conspicuous orange coloration of the distal portion of the tail in two adult female Adders.

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Notes on the captive husbandry and breeding of the Shovel-footed Squeaker, *Arthroleptis stenodactylus* (Pfeffer 1893)

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ARTHROLEPTIS stenodactylus is a small robust frog with a blunt head and prominent eyes (Fig. 1). Adult female specimens measure up to 45 mm snout vent length (SVL) and males up to 35 mm. The colouration is highly variable. The ground colour of the dorsal surface is brown and most specimens have a marked dark stripe running from the snout which extends above the tympanum and terminates at the shoulder. The dorsum features a pair of dark spots on the sacrum, three lobed dorsal bands and sometimes a lighter vertebral line. The ventral surface may be speckled or unmarked. *A. stenodactylus* has large inner metatarsal tubercles on the hind feet at least as long as the first toe (Fig. 2).

This species is listed as Least Concern on the IUCN Red List due to its widespread distribution and tolerance of a range of habitats. It is notable, however, that it may represent a complex of cryptic species, and taxonomic revision of the complex is required (Channing & Howell, 2006). *Arthroleptis stenodactylus* is found throughout coastal Kenya, eastern and southern Tanzania, the island of Zanzibar, Mozambique, Zambia, the southern Democratic Republic of the Congo to western Angola, northern Botswana, Zimbabwe and north-eastern South Africa. It is found from 0-1,500 m a.s.l. (IUCN et al., 2006). *A. stenodactylus* is terrestrial and often associated with leaf-litter in a variety of habitats that include forest, savannah woodland and suburban gardens (IUCN et al., 2006). In the wild its diet includes arthropods, worms, snails and other frogs (Channing & Howell, 2006).

Males have an elongated third finger (Fig. 3). This third finger is used in aggressive encounters when males drive other males away from their calling sites (Channing & Howell, 2006). The throat of the male is dark with loose vocal sack skin. Females have a pale throat which is speckled (Channing & Howell, 2006). When females are gravid the eggs become visible through the skin in the ventral and dorsolateral surfaces (Fig. 4).

Breeding commences in December at the start of the summer rains (Minter et al., 2004). Males call from the ground among leaf-litter throughout the day, with peak vocal activity after rainfall (Minter et al., 2004; Channing & Howell, 2006). The call is a short (0.05 secs.), high pitched (3.5 KHz) whistle which is repeated at half second intervals. Between 33-80 eggs are laid in hollows or burrows. Eggs are 2 mm in diameter and are creamy white. Males have been observed guarding eggs (Minter et al, 2004; Channing & Howell, 2006). The eggs undergo direct development where there is no free swimming tadpole stage. The frogs measure 2.0-2.8 mm SVL when they emerge (Harper & Vonesh, 2003). *Arthroleptis* sp. live between two to seven months once they have reached sexual maturity. Their short longevity is possibly due to predation pressures and difficulty in surviving the dry season (Barbault & Trefaut-Rodrigues, 1979; Wells, 2007). The maximum lifespan in captivity is unknown. In captivity sexual maturity can be reached in less than one year (pers. obs.).

CAPTIVE HUSBANDRY

Management

Durrell obtained two wild caught specimens in July 2006 which fortunately turned out to be a pair. The animals were seized by customs from illegal importation at Heathrow. The animals originated from an unknown location, but were probably from Tanzania. The pair were housed and bred in a converted plastic storage box, 400 x 2500 x 300 mm. The lid of this box was meshed for ventilation. For substrate, a 60 mm layer of *Sphagnum* sp. moss was used. Small rocks were placed in the enclosure. Artificial plants were provided for

Figure 1. Adult *Arthrolepis stenodactylus*.

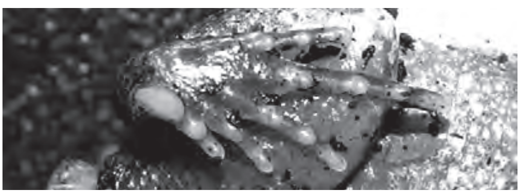

Figure 2. The large inner metatarsal tubercle of *A. stenodactylus*.

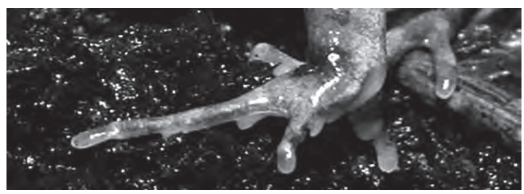

Figure 3. The fore foot of a male *A. stenodactylus*. Note the elongated third finger.

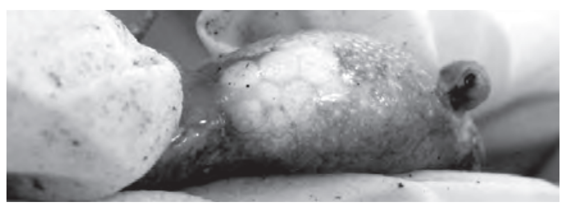

Figure 4. Eggs visible through the side and ventral surface of a female *A. stenodactylus*.

Figure 5. Captive housing.

Figure 6. Clutch of *A. stenodactylus* eggs.

refugia. The F1 specimens were housed in 400 x 250 x 200 mm converted plastic storage boxes (Fig. 5). Half of the lid was mesh to allow good ventilation. Mulch and Mix Organic Compost™ was used as a substrate (moist paper towel, for ease of servicing, was used temporarily and caused no problems). Moss covered one third of the area of the mulch and mix. Leaf-litter (Oak, *Quercus robur*), cork bark and artificial plants were also provided for refugia.

The original pair bred when they were housed in quarantine. The quarantine room was heated to 20-26˚C (night/day summer) and 20-24˚C (night/day winter) the hatchling frogs were kept there for one year. After one year the animals were moved from quarantine and kept in a room heated to 23-27˚C (night/day summer) and 20-25˚C (night/day winter). Initially, a ZooMed™ Reptisun 2.0 strip light was used for lighting, but this was later changed to a ZooMed™ Reptisun 5.0 strip light (see health section later on). A shallow (10 mm deep) water dish was provided at all times. The enclosure was lightly misted with tap water daily. Powder free latex gloves were used at all times when servicing the amphibians. All animals were visually inspected every seven days. The water bowl was wiped out with a paper towel daily. Chemical cleaners or disinfectants were not used when cleaning the water bowl or enclosure. The substrate and furnishings were changed when they became substantially soiled or waterlogged.

Arthroleptis stenodactylus were fed on live invertebrates, predominantly crickets (*Gryllus assimilis* and *Gryllus bimaculatus*) and occasionally the Cowpea Beetle (*Callosobruchus chinensis*). Hatchling frogs were fed on Springtails (miscellaneous *Collembolla* sp.). Juvenile animals were fed on live pin head crickets and *Drosophila melanogaster*. Food items (with the exception of spring tails) were dusted with Nutrobal® (dietary supplement) immediately prior to being fed to the frogs. Adults were fed every three to six days (depending on season and condition). Juveniles up to six weeks of age were fed daily.

Reproduction

In captivity, eggs were laid directly onto *Sphagnum* sp. moss and bark chip. Egg clutches consisted of 30-40 eggs which were usually clumped together but occasionally laid singly or in small groups of up to four eggs over an area 6 cm in diameter. Eggs measured 2.5-3.0 mm diameter (Fig. 6). The eggs were covered by up to 50 mm of moss or bark chip. Eggs were left in-situ and took approximately one month to hatch. If egg clutches were found they were kept humid and disturbance was minimised, so as not to perturb the male who was sometimes observed guarding the eggs.

The water dish in the enclosure was shallow enough for the tiny hatchling frogs to climb out of. Hatchling frogs measured 4.0 mm SVL. Hatchlings were carefully removed from the enclosure of the adults as they required slightly modified husbandry. The hatchlings were housed in small enclosures with humid *Sphagnum* sp. moss and leaf -litter as substrate. A small shallow water dish was provided. The water dish was small enough to enable the froglets to enter and exit easily. To reduce the risk of drowning gravel or submerged leaves were used to raise the water level in the dish.

Froglets were not housed in groups of more than ten for ease of servicing and monitoring. The hatchlings were raised at the same temperature as the adults (20-26˚C), and were also provided with a ZooMed™ Reptisun 5.0 strip light. Hatchlings were fed daily until about six weeks of age with Springtails. When large enough, pin head crickets and *Drosophila melanogaster* were added to their diet. Larger items were dusted with Nutrobal®. After six weeks, the feeding interval was gradually increased to once every three days. As the hatchlings grew they were sorted by size and larger frogs were housed together to avoid potential cannibalism (although cannibalism was not observed).

The males of the F1 generation were heard calling for the first time at 19 months of age (which may have indicated them reaching sexual maturity). The first egg clutches were successfully produced by females aged 22 months.

Health

Specimens were treated for parasites using Ivermectin. The frogs were bathed in dilute Ivermectin (10 mg/l) for one hour, once a week, for three weeks. No mortality of, or adverse effects on, specimens undergoing this treatment was observed. Even with food supplementation, this species seems to suffer from metabolic bone disease (including poor bone mineralisation with subsequent breaks and curved long bones) if UV light is not provided. X-rays before and after the provision of UV-B radiation (measured at 40µW/cm^2 at the level of the substrate) showed improved bone mineralisation after two months.

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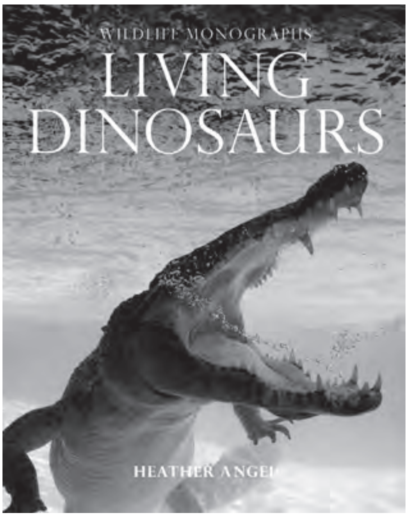
Wildlife Monographs: Living Dinosaurs & Other Reptiles

Heather Angel

2009, Evans Mitchell Books, Hertfordshire, 95 pp.



This book is richly endowed with a collection of wonderfully shot and beautifully clear photographs. From the outset, it reads as a good educational resource, providing a broad scope of information on its subjects ranging from distribution, anatomy and behavioural adaptations, in an informal but clear manner. Throughout, the author avoids overtly technical or scientific language and sticks to more fluid terminology. This makes the book easily accessible to a wide variety of audiences. With the title conceived by a nine-year-old boy, and the chapter titles following suit, it is probably correct to assume that the author intended this to be a book that anyone can enjoy.

The introduction provides a brief evolutionary synopsis, touching on the demise of the dinosaurs and leading up to the radiation of reptiles in modern ecosystems. The book does not cover all major groups in any depth, but by the author's own admission, focuses on those species or groups of species that have particularly remarkable behavioural traits.

The first chapter, 'Aquatic Snappers', centres on Crocodilia. It correctly defines the three major families, Crocodylidae, Alligatoridae and Gavialidae and notes the number of species contained in each. Its brief discussion on classification also highlights the False Gharial (*Tomistoma schlegelii*) and the current uncertainty as to which family it belongs.

The history of crocodilians, both anthropocentric and evolutionary is outlined. Reference is also made to the recent discovery of *Isisfordia duncani*, although it refers only to genus. Key morphological differences between Crocodylidae and Alligatoridae are noted before the chapter moves on to discuss the biology of crocodilians, referring to their digestion, both behavioural and enzymatic, thermoregulation, reproductive biology, behaviour and dietary ontogeny, using a variety of well chosen examples. The book focuses on two species, the Saltwater Crocodile (*Crocodylus porosus*) and the Gharial (*Gavialis gangeticus*), and neatly highlights their decline as a consequence of anthropogenic impact.

Chapter 2, 'An Ancient Lineage', describes the Tuatara (*Sphenodon* spp.) and begins by detailing the causes of its declines. The chapter progresses to describe the evolutionary uniqueness of these creatures, detailing the history of their lineage and the features that distinguish them from modern Squamate reptiles. Taxonomy of the extant species of Tuatara is touched on, as is the current translocation conservation programme. The author also gives a good anecdotal account of her experiences on Stephens Island, one of the few Tuatara strongholds. The habitat, diet and reproductive cycle of the Tuatara are outlined with several photographs. Their prey and natural habitat are also detailed. The reference to the Tuatara's extraordinarily fast molecular evolutionary rate, faster than any other animal studied, illustrates the author's use of recent scientific literature in research for this book.

Chapter 3, 'Mobile Homes', delves into the world of the Chelonians. As in previous chapters, their evolutionary history is skimmed over, with the mention of an appropriate prehistoric relative, *Archeleon ischyros*, which is unfortunately miss-spelt. Along with a brief account of their evolution, the text also outlines theories on shell evolution, utilising appropriate anatomical terminology and discussing the extent of radiation in the shells of modern chelonians.

The theme of anatomy is continued with a discussion of head withdrawal. Chelonia are classified into two distinct groups depending on the mechanism that they utilise to withdraw their head, hidden neck and side neck (*Cryptodira* and *Pleurodira*, respectively). The anatomical variance is displayed well noting shell adaptations of Box Turtles (*Cuora*, *Terrapene* or *Pyxidea* sp.) as well cutaneous adaptations utilised by some species to attract, or conceal, themselves from prey. It moves on to discuss chelonian decline and highlights marine turtles and the giant land tortoises of island archipelagos.

Chapter 4, 'Dragons & Monitors' covers varanids, (*Varanus* spp.). The wide distribution and morphological features common amongst varanids are noted briefly in the introduction to the section. The author then, rather boldly, states that, "They are the only lizards with a long, forked tongue", possibly overlooking the two extant members of the family Helodermatidae, the Gila Monster (*Heloderma suspectum*) and the Beaded Lizard (*Heloderma horridum*) which are discussed in the subsequent chapter. Nevertheless, it proceeds to explain the use of the forked tongue and the Jacobson's organ in chemoreception. In addition to this, it also observes other behavioural traits affiliated to this group, including tripoding. As with many popular texts on varanids, much attention is paid to the large and popular Komodo Dragon (*Varanus komodoensis*). The author briefly explains the process behind parthenogenesis (the growth and development of an embryo or seed without fertilisation by a male), a recently discovered phenomenon in Komodos. Her account of the process is explained well and avoids unnecessary jargon. A great inclusion in this chapter is a small piece on the Desert Monitor (*Varanus griseus*), a species rarely covered in similar publications. Two colour plates, depicting its natural habitat and beautifully striking markings, accompany notes on its distribution and life cycle. Concurrent with the previous chapter, the final paragraph of 'Dragons & Monitors' notes the species' vulnerability to human disturbance.

The fifth chapter, 'Notable Lizards', looks at species carefully selected for their physiological and behavioural traits such as the Texan Horned Lizard (*Phrynosoma cornutum*) with its ability to squirt a high pressured stream of blood from its eyes as a predator deterrent. The chapter discusses the unique herpetofauna of the Galapagos archipelago and the various species of Iguana, both marine (*Amblyrhynchus cristatus*, which incidentally was missed in the text) and terrestrial (*Conolophus* spp.). The author demonstrates further use of recent scientific material when noting the discovery of a new species of Galapagos terrestrial iguana, the Pink Iguana or Rosada, which has since been named *Conolophus marthae* (Gentile & Snell, 2009). It has also been noted to represent the earliest divergence of land animals on the Galapagos archipelago.

Many of the major groups of lizards are noted here, including the aforementioned Iguanidae along with Teiidae, Scincidae, Gekkonidae and Chamaeleonidae. The chapter then moves on to discuss the Helodermatidae, noting its two extant species "the only venomous lizards". The author exhibited some unfamiliarity with recent work which has revealed complex venom glands possessed by Komodo Dragons (Fry et al., 2009), although this work may not have been available prior to the book achieving press. Another discrepancy is that "Geckos have no eyelids", there are however the Eublepharidae, a subfamily of Gekkonidae whose name literally means 'true eyelid'. The penultimate section is entitled "Conservation", which rather than having continuous prose, has several photographic plates with detailed captions. The captions each explain the vulnerability of the species depicted. The final section has hints and tips for photographing reptiles, with a useful focus on aquatic specimens

Whilst this book contains beautiful photographic plates and macro shots, its textual content sometimes misses finer points. Some of the sentences do not always flow as smoothly as they could, giving some paragraphs a coarser read. Another inconsistency is the inclusion of scientific names. In most instances, a species is referred to by its common name, followed by its scientific name in brackets. There are a few occasions where the scientific name is omitted. Moreover, there is an erroneous length conversion in chapter 1, "5m (three feet)" in reference to the American Crocodile (*Crocodylus acutus*).

In summary, few academics and advanced students of herpetology would derive advanced knowledge from this text, however, the book is not solely intended for such an audience. The book would adequately provide many hobbyists and young herpetologists with an interest in the natural world with a wide variety of interesting examples of non serpentine reptiles. What is special about this book is the aesthetic, high quality of the photographic plates, a feature which pleasingly dominates this publication. Such good use of photographic compliment may alone merit the purchase of this book.

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