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Results of a Herpetological Survey in Ghana and a New Country Record

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The West African country of Ghana has a diverse herpetofaunal assemblage of more than 220 species (Hughes 1988). Ghana is environmentally heterogeneous (Lawson 1968). Although some species have broad distributions, others occur in more specialized vegetative zones (e.g., semi-deciduous forest, coastal thicket, or savannah woodland), offering great potential for studying geographic diversity at varying spatial scales. Myers et al. (2000) identified the Upper Guinean Forest that stretches into Ghana (excluding the Dahomey Gap, an area of savannah woodlands that interrupt the forest) as one of the 25 biodiversity hotspots and conservation priorities on the planet. Thus, it is surprising that Ghana has received so little attention in terms of herpetological research.

Methods

I conducted a herpetological survey of three study sites in Ghana during the dry season from 6–29 March 2003. These survey sites represent savannah woodland, semi-deciduous forest, and coastal thicket vegetative zones as defined by Lawson (1968; Fig. 1). Locality information and habitat descriptions of each survey site are provided in the following sections.

Specimens were found by visual encounter surveys (Heyer et. al. 1994) supplemented with acoustic searching, turning rocks and logs, peeling bark, digging through leaf litter, and excavating burrows. Surveys were conducted during the day and night. Specimens were collected by hand or blowgun (using blunt, plastic plugs as ammunition), and snake tongs were used to capture poisonous snakes. Sex, SVL, tail length, tail condition (complete, regenerated, or broken), weight, date, time, and reproductive condition and habitat (qualitative assessments) were recorded for each specimen. Up to ten individuals of each species were collected at a survey site, and all species encountered are recorded in Table 1. Tissue samples (liver) were flash frozen in liquid nitrogen for future genetic studies. Geographic coordinates for each survey site were determined in the field with a Garmin GPS 72 receiver. Coordinates were recorded as latitude and longitude in decimal degrees, and referenced to the WGS84 (World Geodetic System of 1984) datum. The number series of field tags associated with specimens is ADL 504–825 (Adam D. Leaché, personal field series). Voucher specimens and tissue samples are deposited at the Louisiana State University Museum of Natural Science (voucher specimen catalog series LSUMZ 86813–87134, frozen tissue collection series H20026–H20347).

Survey Sites

Savannah Woodland Site—The savannah woodland site was located in the Northern Region, 2.5 km SW of Buipe by dirt road (08.76877 °N, 001.47732 °W, 102 m elevation) and surveyed during 6–15 March. Most amphibians collected from this site were found on the margins of one small pond located 1 km N of camp, and the rest were collected along the northern edge of the Black Volta River, 0.5 km S of camp.

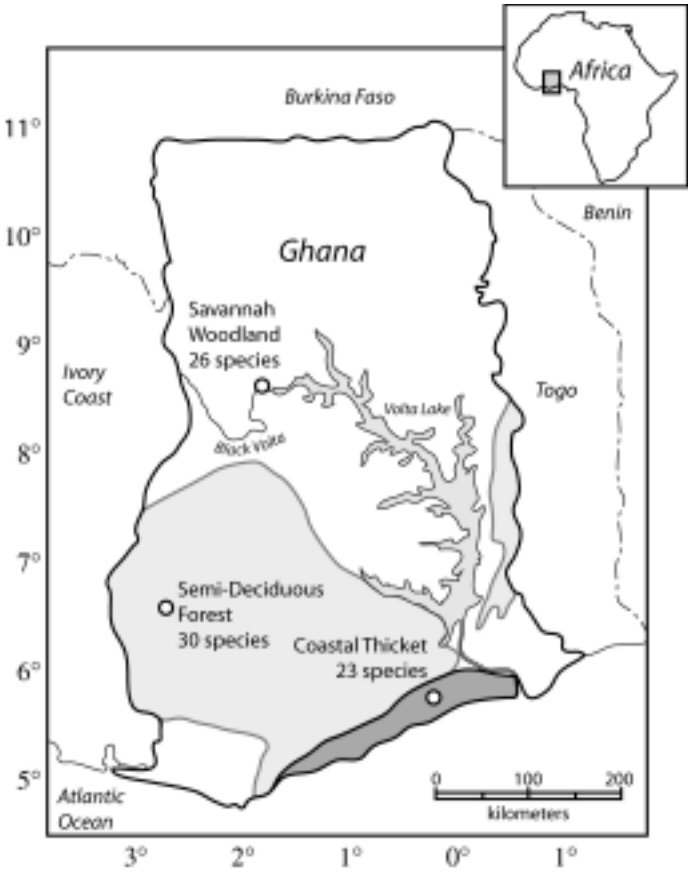

FIG. 1. Maps of Africa (inset) and Ghana (including neighboring countries) illustrating the vegetative zones (Lawson 1968), survey sites (indicated by open circles), and number of species recorded for each survey site.

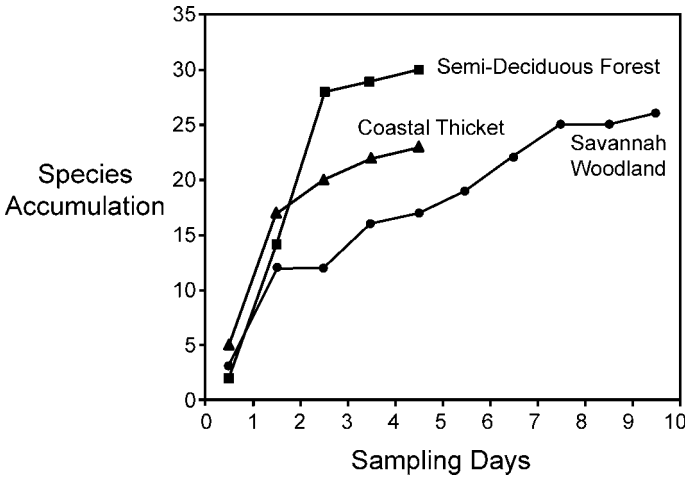

FIG. 2. Species accumulation curves of reptiles and amphibians sampled at the savannah woodland, semi-deciduous forest, and coastal thicket survey sites.

Semi-Deciduous Forest Site—The semi-deciduous forest site was located in the Brong-Ahafo Region, 26 km SW of Goaso (by road to Asumura), along the boundary line between Subim and Ayum Forest Reserves (06.70149°N, 002.07614°W, 101 m elevation) and surveyed during 17–21 March. The site included a mixture of cocoa plantations, urbanized area, and semi-deciduous forest. Although small ponds were present on the margins of the cocoa plantation and urbanized area, forest streams were dry during the survey. The site received a brief rain shower on the evening of 19 March, but it did not result in any water accumulation. Most amphibians were found in disturbed habitats along the margins of the cocoa plantations, but a few were restricted to the semi-deciduous forest

Coastal Thicket Site—The coastal thicket site represents three geographically proximate collecting areas in the Greater Accra Region, 26 km N of Accra, near Amrahia (05.76308°N, 000.10797°W, 87 m elevation), 34 km N of Accra (05.83910°N, 000.10850°W, 62 m elevation), and 55 km NE of Accra, near Nyibena (05.85287°N, 000.25972°E, 44 m elevation). These sites were surveyed during 23–29 March. Small ponds were present at the sites 26 km and 34 km N of Accra and were surveyed during the day and night. These sites received substantial rain on the night of 25 March. The site 55 km NE of Accra was devoid of any water and was only surveyed during the day.

Results

I found relatively equal numbers of species at the survey sites and recorded 26 species in the savannah woodland, 30 in the semi-deciduous forest, and 23 in the coastal thicket. Relatively more anurans were recorded in the semi-deciduous forest and coastal thicket compared to the savannah woodland, and the savannah woodland contained more snakes and turtles (Table 2).

The following LSUMZ specimen represents a new record for Ghana, based on the checklist of the reptiles and amphibians of Ghana (Hughes 1988). Jeff Boundy (Louisiana Department of Wildlife and Fisheries) verified the specimen identification.

Panaspis nimbaensis (Mt. Nimba Snake-Eyed Skink). Brong-Ahafo Region, 26 km SW of Goaso (by road to Asumura), along the boundary line between Subim and Ayum Forest Reserves (06.70149°N, 002.07614°W, 101 m elevation). 18 Mar 2003. LSUMZ 86975, tissue number H-20188, ADL 666. 68 mm SVL, 54 mm tail length (regenerated), 3.7 g. Found in a cocoa plantation adjacent to semi-deciduous forest. Captured by hand under a rotting log surrounded by leaf litter at 1000 h.

Discussion

Only a few surveys have focused on the reptile and amphibian diversity of Ghana. Schiøtz (1964), Leston and Hughes (1968), Raxworthy and Attuquayefio (2000), and Rödel and Agyei (2003) provided detailed information for particular localities and/or taxa, and Hughes (1988) presented a comprehensive checklist for the country. These authors concluded that the herpetological diversity of Ghana is underestimated. Raxworthy and Attuquayefio (2000) surveyed the herpetofaunal community at Muni Lagoon during the peak of the rainy sea-

Table 1. Summary of species collected and cumulative species count for each survey site. Numbers refer to specific habitat types and collection localities within the three survey sites (described in the text) and are defined as follows: 1. Savannah woodland, 2. Small pond, 3. Edge of Black Volta River, 4. Semi-deciduous forest, 5. Cocoa plantation, 6. Urbanized area, 7. Small ponds in disturbed areas, 8. Coastal thicket 26 km N of Accra, 9. Coastal thicket 34 km N of Accra, 10. Coastal thicket 55 km NE of Accra. Species collected from new vegetative regions (but not necessarily new habitat types) compared to Hughes (1988) are denoted with an asterisk symbol (*). *Phrynobatrachus* sp. 1 appears to belong to an undescribed species in Rödel (2000).

	Savannah Woodland	Semi-Deciduous Forest	Coastal Thicket
ANURA			
ARTHROLEPTIDAE			
Arthroleptis variabilis		4*	
Arthroleptis sp.		4	
BUFONIDAE			
Bufo maculatus		7	8, 9
B. regularis	2, 3	7	8, 9
HEMISIDAE			
Hemisus sp. (aff. *guineensis*)		7	9
HYPEROLIIDAE			
Hyperolius concolor		7	
H. nitidulus			9
Kassina senegalensis			8, 9
Leptopelis viridis		4*	8, 9
MICROHYLIDAE			
Phrynomantis microps			9
PIPIDAE			
Silurana tropicalis		7	
RANIDAE			
Amnirana galamensis	2, 3		9
Hoplobatrachus occipitalis	2, 3	7	8, 9
Phrynobatrachus accraensis		7	
P. francisci	3		
P. latifrons	3		
P. natalensis			9
P. sp. 1		4, 7	
P. sp.		4	
Ptychadena bibroni	2, 3		9
P. mascareniensis		7	8
P. oxyrhynchus	3	7*	8
P. tellini	2, 3		9
P. sp.	3	7	
LACERTILIA			
AGAMIDAE			
Agama agama	1	5, 6	8
GEKKONIDAE			
Cnemaspis spinicollis		4	
Hemidactylus brooki	1	6	
H. fasciatus		4, 5	
H. muriceus		5*	
H. mabouia			9
Hemitheconyx caudicinctus	1		
Lygodactylus conraui		5	
L. guttaralis	1*		
Tarentola ephippiata	1		
SCINCIDAE			
Mabuya affinis		5	9
M. albilabris	1*		

TABLE 1. *Continued.*

M. maculilabris		6*	
M. perrotetii	1		10
M. quinquetaeniata	1		
Panaspis nimbaensis		5*	
P. togoensis		5	
VARANIDAE			
Varanus exanthematicus			8, 10
SERPENTES			
ATRACTASPIDAE			
Atractaspis dahomeyensis			8
COLUBRIDAE			
Boiga blandingii		4	
Dasypeltis scabra			9
Gastropyxis smaragdina		5	
Lycophidion laterale		5	
Philothamnus irregularis	1		
Psammophis elegans	1		
P. phillipsii	1		
P. rukwae	1*		
ELAPIDAE			
Naja nigricollis			9
LEPTOTYPHLOPIDAE			
Leptotyphlops bicolor	1		
L. macrorhynchus	1*		
PYTHONIDAE			
Python regius	1		
VIPERIDAE			
Causus maculatus		5	
TESTUDINES			
PELOMEDUSIDAE			
Pelomedusa subrufa	2		8, 9
Pelusios castaneus	1		
TESTUDINIDAE			
Kinixys erosa		5	

son and found a maximum of 26 species at a site. Rödel and Agyei (2003) surveyed the amphibians of the Togo-Volta highlands in eastern Ghana and recorded 31 species. Both studies predicted higher species abundance at their study sites based on non-level species accumulation curves and prior collection records. In the present study of the savannah woodland, semi-deciduous forest, and coastal thicket sites, species accumulation curves failed to reach a plateau indicating that additional species remained to be recorded (Fig. 2).

Hughes (1988) provided a checklist of the herpetofauna of Ghana that included undiscovered species, which were inferred to be likely inhabitants of the country. This list included *Panaspis nimbaensis*. This species is distributed throughout Gambia, Guinea, and Ivory Coast, and may have a broader distribution throughout the Upper Guinean Forest. It is likely that surveys of additional rain forest sites in Ghana will further extend the range of this species.

There has not been a rigorous study of the geographic diversity (molecular or morphological) of the widely distributed reptiles and amphibians of Ghana. Candidates for detailed studies of species that potentially occur in high abundance in Ghana include: *Bufo maculatus, B. regularis, Hoplobatrachus occipitalis, Phrynobatrachus accraensis, Ptychadena mascareniensis, P. oxyrhynchus, Agama agama, Hemidactylus brooki,* and *Mabuya affinis.* Additional candidate species occur throughout Ghana, but their low abundance (e.g., snakes) or seasonality (e.g., some anurans and *Chamaeleo gracilis*) make their collection more difficult. In addition, many widely distributed species are able to colonize degraded forest habitats and may be good indicators of habitat degradation (Rödel and Branch 2002; Branch and Rödel 2003). The new collection reported herein provides opportunities for pilot studies on the geographic variation and biodiversity sampling of the Ghanaian herpetofauna.

TABLE 2. Summary of the number of species caught at the savannah woodland, semi-deciduous forest, and coastal thicket survey sites.

	Savannah Woodland	Semi-Deciduous Forest	Coastal Thicket
Frogs	9	15	14
Lizards	8	10	5
Snakes	7	4	3
Turtles	2	1	1
Total	26	30	23

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Nest Switching in the Brown Toadlet (*Pseudophryne bibroni*): Do Males Use Chemical Signals?

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The view that vocalizations are the dominant form of communication in anuran amphibians has recently been challenged by papers reporting the existence of sexually attractive pheromones in aquatic breeding frogs (Pearl et al. 2000; Wabnitz et al. 1999). Pheromones in fecal pellets deposited on terrestrial substrates serve important roles in territorial defense and courtship in plethodontid salamanders (e.g., Jaeger and Gergits 1979), and in neighbor recognition in the voiceless, archaic frog *Leiopelma hamiltoni* (Lee and Waldman 2002). These and other studies have demonstrated that chemical communication is the most significant factor affecting social behaviors in voiceless amphibians. However, the function of chemosignals in anurans that also communicate acoustically remains enigmatic. Here I report observations of nest switching in a terrestrial breeding anuran, the Australian brown toadlet (*Pseudophryne bibroni*), and speculate that chemical cues may be involved in this behavior.

Pseudophryne toadlets are small, cryptic, terrestrial-breeding anurans characterized by aposematic ventral markings that warn potential predators of their toxicity (Williams et al. 2000; Fig. 1a). Male toadlets call from terrestrial sites that subsequently become flooded by seasonal rains, and mating occurs in subtle soil depressions constructed below leaf litter (e.g., Fig. 1b), or among grass roots or under rocks or logs. Occasionally, males call from discrete burrows, but nest sites are generally difficult to detect unless occupied by a frog or eggs.

During the course of a field experiment conducted in eucalyptus woodland in Watt's Gully Reserve, South Australia (see Mitchell 2001), six males occupied and called from nests that had previously been occupied by another male (Table 1). I was confident that the males that recolonized vacated nest sites were different individuals than the original male because toadlets are distinguishable by their unique ventral markings (Fig. 1a). None of the recolonized nests contained eggs, and the original occupant had vacated the nest up to two weeks before the second male occupied it. In particular, two features of the behavior were remarkable: first, some males moved up to 19 m to occupy a vacated nest (Table 1); and second, in most cases, males were calling from precisely the same location as the previous occupant (i.e., within 2–5 cm). Moreover, all nest sites were concealed beneath 5–15 cm of moist leaf litter, hence visual cues could not have been used to home in on the exact site.

In a separate case, a male toadlet called from a nest site used by another male in the previous breeding season (one year earlier). I was certain of the nest's location because the second occupant sat directly atop a 2 x 2 cm square of chromatography paper that I had inserted at the nest base the previous year during routine measures of nest water potential (the filter was still in place because I had been unable to relocate the nest). This nest was the third occupied by this particular male and was 55 m from the nest he occupied the previous year. The male moved a total of 46 m during the six-week breeding season, and the final nest he occupied was within 15 cm of another male's nest. Importantly, unlike other known cases of nest recycling (e.g., Kluge 1981; Mitchell 2002), nest sites were not obvious, nor were they a limiting resource: leaf litter piles were abundant and male densities were relatively low (between 1 male per $7m^2$ to 1 male per 76 m^2; Mitchell 2001).

While it is possible that males first identified a nest site while a satellite of a calling resident, and subsequently returned to the nest, it appears more likely that a chemical residue gave away the nest's

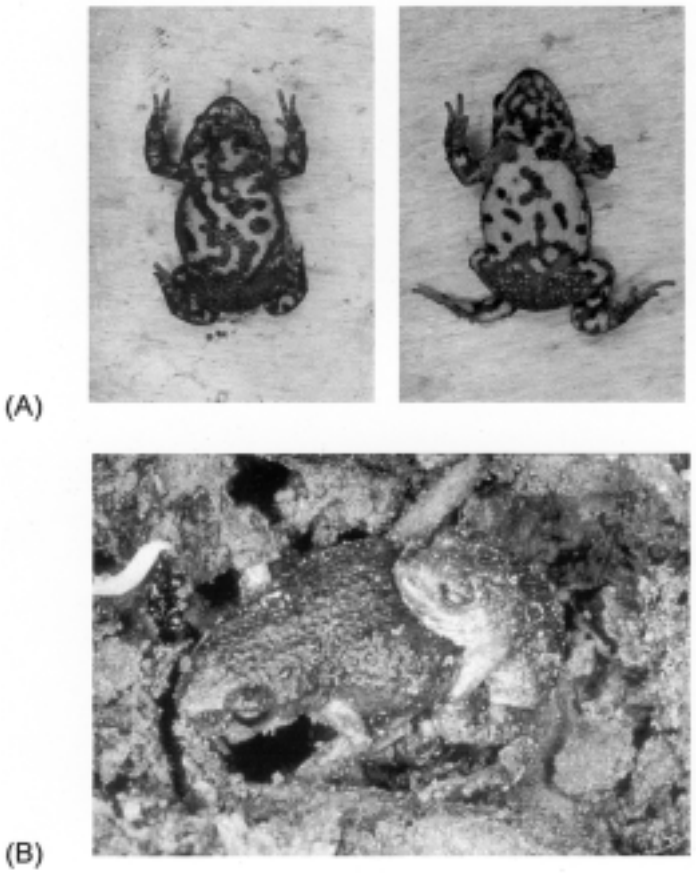

FIG. 1. A) Examples of the ventral markings of *P. bibroni* used for identification of individuals in the study; B) a *P. bibroni* pair in inguinal amplexus. The pair was buried beneath 15 cm of eucalyptus leaf litter, which was removed before the photograph was taken.