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The herpetofauna of the Babuyan Islands, northern Philippines

By

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ABSTRACT We document 52 species of amphibians and reptiles from the Babuyan Islands in the northern Philippines. Among these records, 12 species are endemic to the Babuyan Islands and another 18 are endemic to the Philippines. Prevalence of endemic forms in the island group is high, with 1–3 island-endemic species present in each of the major islands. The present-day assemblage of herpetofauna in the island group is attributed to dispersal from Luzon and subsequent diversification. No evidence of successful southward colonization of species from Taiwan is found. Based on data from our own surveys, and to enable future work, we provide an updated list of the species from the Babuyan and Batanes Island groups. Molecular phylogenetic studies are recommended to gain more insights into the evolutionary history of the island-endemic forms and the biogeography of the small islands between Luzon and Taiwan.

KEY WORDS: Batanes; endemism; Lanyu; Luzon; similarity index; small island; species list; Taiwan.

INTRODUCTION

The Philippine archipelago is known for its high proportion of endemic fauna. Roughly 60% of its 938 land vertebrates occur nowhere else in the world (Catibog-Sinha and Heaney, 2006). Some Philippine endemics are known only from tiny (< 300 km²) oceanic islands. Although poorly studied, island endemics are known from the islands of Camiguin Sur (north of Mindanao), South Gigante (northeast of Panay), and the Batanes Islands at the northern tip of the country (Brown and Alcalá, 1970, 1978; Heaney and Tabaranza, 2006; Lazell, 1992; Ota and Crombie, 1989; Ota and Ross, 1994). Thus, although studies are few, it is generally acknowledged that small islands make an important contribution to the diversity of Philippine fauna.

One of the least studied groups of small oceanic islands in the Philippines is the Babuyan chain north of Luzon (Fig. 1). This island group consists of five main islands – Camiguin Norte (not to be confused with Camiguin Sur north of Mindanao), Babuyan Claro, Calayan, Dalupiri, and Fuga – and seven smaller islets – Pamoctan, Didicas, Dilayag (or Guinapao), Panuitan (or Dipari), Irao, Barit, and Mabag. With the possible exception of Fuga, Barit, and Mabag, these islands are volcanic in origin and have not been connected to Luzon or the Asian mainland since their emergence (Defant et al., 1989; Yang et al., 1996). The deep waters of the Babuyan Channel separate these islands from Luzon by at least 25 km. North of the Babuyan Islands, 75 km across the Balintang Channel, lie the Batanes Islands, whose major islands include Batan, Sabtang, and Itbayat. Further north, the continental island of Taiwan and the small island of Lanyu (Taiwan) are situated 130 km from the Batanes Islands. It follows from the geologic history (Defant et al., 1989; Yang et al., 1996) and geographic setting of the Babuyan Islands that their fauna was assembled from over-water dispersers (Brown et al., 2009; Lazell, 1992).

Very little is known about the herpetofauna and biogeography of the typhoon-swept islands of the Babuyan group because their isolation meant that basic inventories were few and often cursory. Nonetheless, three reptile species that are known only from the area have been described: the gekkonid lizard *Luperosaurus macgregori*, and the colubrid snakes *Lycodon bibonius* and *Lycodon chryso-prateros* (Ota and Ross, 1994). Very recently two island-endemic geckos were described indicating substantial levels of endemism in these islands (Brown et al., 2008; Brown et al., 2009). Various workers have surmised that the Babuyan Islands may harbor additional endemic species (Brown et al. 2009; Lazell, 1992; Ota and Ross, 1994). Lazell (1992) even predicted that each island bank might support an endemic, undiscovered species of flying liz-

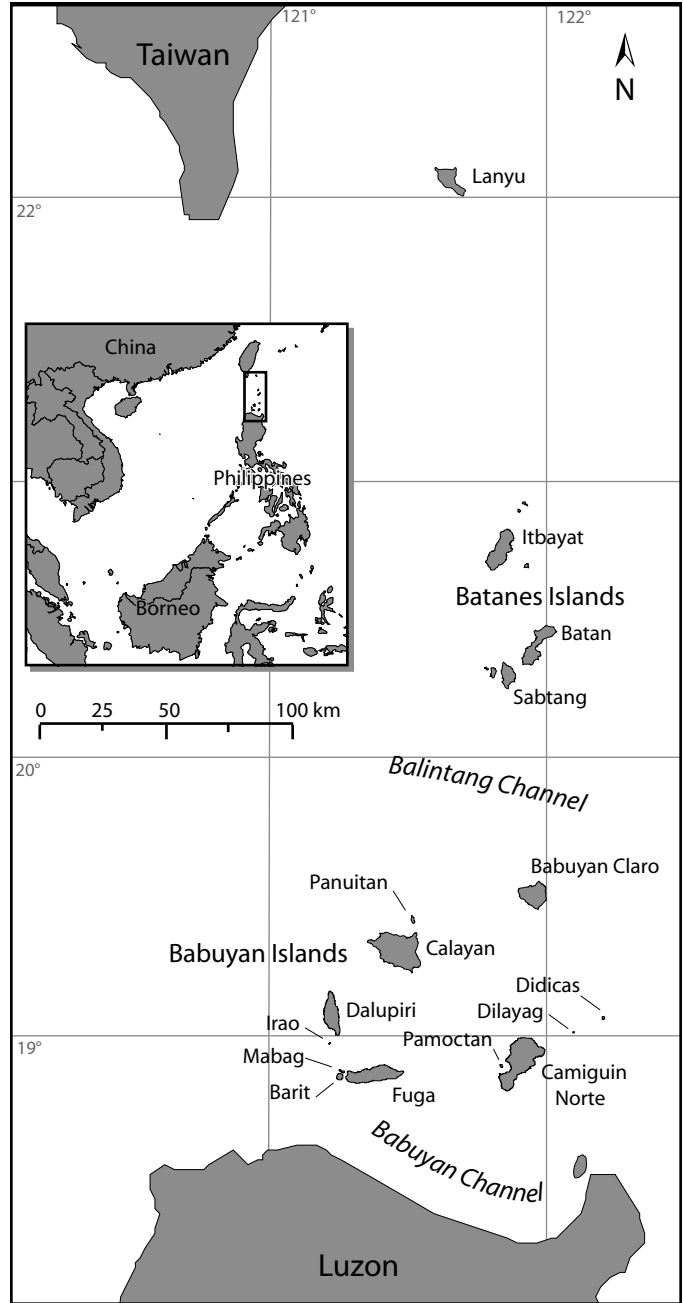


Fig. 1. Map showing location of islands between Luzon and Taiwan.

ard. In comparison, the neighboring Batanes Islands hold five endemic reptiles, along with ten other species of amphibians and reptiles (Ota and Ross, 1994).

Over the last two decades, major collection efforts have been undertaken in the Babuyan Islands covering all of the major landmasses. A few species descriptions have resulted (Ota and Ross, 1994; Brown et al., 2008, 2009) and a preliminary species list has been published

from only one trip (Broad and Oliveros, 2005). However, to date, no comprehensive faunistic account is available for this small but important archipelago. In this paper, we present species accounts for all currently documented amphibian and reptile species in the Babuyan Islands. In some groups we note taxonomic issues that require further work, most of which is beyond the scope of this paper. In addition, we examine zoogeographic affinities of the herpetofauna of the islands between Luzon and Taiwan using records obtained from this study as well as those from published literature.

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MATERIALS AND METHODS

Multiple faunal inventories were conducted in the Babuyan Islands from 1989–2007. First, a team from the Smithsonian Institution and affiliated researchers (including HO and RIC) visited Camiguin Norte on May 17–22, 1989, stopping briefly on a nearby islet, Pamoctan, on May 22. A year later, another team from the Smithsonian Institution (including RIC and C. A. Ross) collected on Mabag, Barit, and Fuga on March 2–13, making a brief stop on Irao on March 14, then continuing on to Dalupiri on March 14–21 and Calayan on March 23–29. In 2004, CO and G. Broad co-led vertebrate faunal surveys on Camiguin Norte (April 1–14, May 31–June 4), Pamoctan (April 11–12, 15, May 31–June 2), Babuyan Claro (April 16–May 3), Calayan (May 3–17), and Dalupiri (May 20–28). More recently, under the Comparative Biogeography and Conservation of Philippine Vertebrates Project, RMB and CO conducted field studies on Camiguin Norte on March 3–11, 2006, Pamoctan on March 11, Babuyan Claro on March 12–14, and Calayan on March 15–22. CO made subsequent visits to Dalupiri on September 10–17 of the same year and Camiguin Norte on February 6–15 in the following year. Table 1 lists details of localities visited on each island and provides a key to site numbers used in the Species Accounts.

RMB and CO made detailed examinations of specimens in three museums that house specimens from the field surveys above: the University of Kansas Natural History Museum (KU), the National Museum of the Philippines (PNM), and the U.S. National Museum of Natural History (USNM).

Table 1. Localities visited between 1989 and 2007, listed by site number.

Site	Locality	Coordinates
1a	Camiguin Norte Island, Barangay Balatubat, Limandok	18.929° N, 121.899° E
1b	Camiguin Norte Island, Barangay Balatubat, Kauringan	18.902° N, 121.909° E
1c	Camiguin Norte Island, Barangay Balatubat, Mambit	18.908° N, 121.865° E
1d	Camiguin Norte Island, Barangay Balatubat, Cabuaan	-
1e	Camiguin Norte Island, Barangay Naguillian, Magas-asok	18.872° N, 121.831° E
2	Pamoctan Island	18.901° N, 121.837° E
3a	Babuyan Claro Island, Asked	19.513° N, 121.912° E
3b	Babuyan Claro Island, Ayumit	19.545° N, 121.958° E
3c	Babuyan Claro Island, Centro	19.489° N, 121.948° E
3d	Babuyan Claro Island, Rakwaranom	19.561° N, 121.953° E
4a	Calayan Island, Barangay Magsidel, Macarra	19.294° N, 121.409° E
4b	Calayan Island, Barangay Magsidel, Longog a Bassit	19.331° N, 121.439° E
4c	Calayan Island, Barangay Magsidel, Longog a Dakkel	19.325° N, 121.448° E
4d	Calayan Island, Barangay Centro	19.263° N, 121.473° E
4e	Calayan Island, Barangay Dadao	19.259° N, 121.480° E
5a	Dalupiri Island, Visita	19.064° N, 121.245° E
5b	Dalupiri Island, Nipa Creek	19.102° N, 121.223° E
5d	Dalupiri Island, Manolong Creek	19.085° N, 121.241° E
6a	Fuga Island, Villa Vicenta	18.873° N, 121.283° E
6b	Fuga Island, Barrio Naguillian	18.846° N, 121.350° E
7	Barit Island	18.872° N, 121.255° E
8	Mabag Island	18.881° N, 121.261° E
9	Irao Island	18.982° N, 121.218° E

We followed the taxonomy of Alcalá and Brown (1998) and Frost (2010) for amphibians, Alcalá (1986) and Diesmos et al. (2008), for turtles, Brown and Alcalá (1978) as modified by Brown et al. (2007, 2008) and Zug et al. (2007) for gekkonid lizards, Brown and Alcalá (1980) and Mausefeld et al. (2002) for scincid lizards, and Koch et al. (2007) for varanid lizards. We used McGuire and Alcalá (2000) for identification of lizards belonging to the genus *Draco*. Taxonomy of snakes followed Leviton (1964a; 1964b; 1967; 1968; 1970a; 1970b), Malhotra and Thorpe (2004), Ota and Ross (1994), Taylor (1922) and Utiger et al. (2005).

We examined similarities in terrestrial herpetofaunal

assemblages of the major islands in the Babuyan group as well as the islands of Lanyu and Batan with those of their nearest potential sources of colonizers, Taiwan and Luzon. We computed Simpson similarity indices (S) using the formula $S = C/N$, where C is the number of species common to both islands and N is the number of species on the island of interest (Cheatham and Lazell, 1969). Species lists were based on Brown, Crombie and Diesmos (unpublished data) for Luzon; Zhao and Adler (1993) and Shang et al. (2009) for mainland Taiwan; Ota (1991b), Toda et al. (1998), Ota and Huang (2000) and Matsui et al. (2007) for Lanyu; and Ota and Ross (1994) for Batan.

RESULTS

We provide records of five species of amphibians and 47 species of reptiles, including one turtle, 25 lizards, 20 snakes, and one crocodile (Table 2). Of the 52 species identified, 12 are endemic to the Babuyan Islands and another 18 endemic to the Philippines. Among the major islands in the Babuyan group, the highest number of reptile and amphibian species was recorded on Camiguin Norte (33), while the lowest species richness was observed on Babuyan Claro (17). At least one endemic species is found in each of the five main landmasses of the Babuyan Islands, with Camiguin Norte supporting the highest number (3).

The similarity indices of the islands of the Batanes and Babuyan groups are higher with Luzon than with Taiwan (Table 3). Although Fuga holds the highest similarity in-

dex with Luzon at 90%, Camiguin Norte has more species in common with it (26 compared with Fuga's 18). On the other hand, Lanyu's herpetofauna was more similar to Taiwan than to Luzon.

Table 3. Indices of herpetofaunal similarity with Taiwan and Luzon.

	Simpson Similarity Index (%)	
	Taiwan	Luzon
Lanyu	76%	33%
Batan	24%	65%
Babuyan Claro	12%	65%
Calayan	12%	80%
Dalupiri	18%	86%
Camiguin Norte	9%	79%
Fuga	25%	90%

Table 2. Checklist of terrestrial herpetofauna of the Babuyan Islands, Batan, Lanyu, Luzon and Taiwan. Species lists from islets in the Babuyan Islands and those from Sabtang and Itbayat in the Batanes Islands are not shown. Luzon and Taiwan checklists include only those species they share with the small islands shown in the table.

Species	Taiwan	Lanyu	Batan	Camiguin Norte	Babuyan Claro	Calayan	Dalupiri	Fuga	Luzon
Class Amphibia									
Order Anura									
Family Bufonidae									
<i>Duttaphrynus melanostictus</i>	X	X	-	-	-	-	-	-	-
<i>Rhinella marina</i>	-	-	-	X	X	X	X	X	X
Family Microhylidae									
<i>Kaloula picta</i>	-	-	-	-	-	X	X	X	X
Family Dicroglossidae									
<i>Fejervarya cf. sakishimensis</i>	X	X	-	-	-	-	-	-	-
<i>Limnonectes cf. woodworthi</i>	-	-	-	X	-	-	-	X	X
Family Ceratobatrachidae									
<i>Platymantis</i> sp.*	-	-	-	X	-	-	-	X	-
Family Rhacophoridae									
<i>Polypedates leucomystax</i>	-	-	X	X	-	-	-	X	X
Class Reptilia									
Order Testudines									
Family Geoemydidae									
<i>Cuora amboinensis</i>	-	-	-	X	-	-	-	X	X

Table 2. Con't.

Species	Taiwan	Lanyu	Batan	Camiguin Norte	Babuyan Claro	Calayan	Dalupiri	Fuga	Luzon
Order Squamata									
Family Agamidae									
<i>Draco jarecki</i> *	-	-	X	-	-	-	-	-	-
<i>Draco</i> sp. 1*	-	-	-	X	-	-	-	-	-
<i>Draco</i> sp. 2*	-	-	-	-	X	-	-	-	-
<i>Japalura swinhonis</i>	X	X	-	-	-	-	-	-	-
Family Gekkonidae									
<i>Cyrtodactylus philippinicus</i> †	-	-	-	X	X	-	-	-	X
<i>Gehyra mutilata</i>	X	-	X	X	-	X	X	X	X
<i>Gekko crombota</i> *	-	-	-	-	X	-	-	-	-
<i>Gekko hokouensis</i>	X	X	-	-	-	-	-	-	-
<i>Gekko kikuchii</i> *	-	X	-	-	-	-	-	-	-
<i>Gekko porosus</i> *	-	-	X	-	-	-	-	-	-
<i>Gekko rossi</i> *	-	-	-	-	-	X	-	-	-
<i>Gekko</i> sp. 1*	-	-	-	-	-	-	-	X	-
<i>Gekko</i> sp. 2*	-	-	-	-	-	-	X	-	-
<i>Gekko</i> sp. 3*	-	-	-	X	-	-	-	-	-
<i>Hemidactylus frenatus</i>	X	X	X	X	X	X	X	X	X
<i>Hemidactylus platyurus</i>	-	-	-	X	-	-	-	-	X
<i>Hemiphyllodactylus typus</i>	X	X	-	-	-	-	-	-	X
<i>Lepidodactylus balioburius</i> *	-	-	X	-	-	-	-	-	-
<i>Lepidodactylus yami</i> *	-	X	-	-	-	-	-	-	-
<i>Lepidodactylus</i> sp.†	-	-	-	X	X	X	X	-	-
<i>Luperosaurus macgregori</i> †	-	-	X	-	X	X	-	-	-
<i>Luperosaurus</i> sp.†	-	-	-	X	-	-	-	-	X
Family Lacertidae									
<i>Takydromus sauteri</i>	X	X	-	-	-	-	-	-	-
Family Scincidae									
<i>Brachymeles</i> cf. <i>bonitae</i> †	-	-	-	X	-	-	-	-	X
<i>Brachymeles</i> sp.†	-	-	-	X	-	X	-	X	X
<i>Emoia atrocostata</i>	X	X	-	-	X	X	X	X	X
<i>Eutropis bontocensis</i> †	-	-	X	-	-	X	X	X	X
<i>Eutropis cumingi</i>	-	X	-	X	X	X	X	X	X
<i>Eutropis</i> cf. <i>indeprensus</i>	-	-	-	X	-	X	-	-	-
<i>Eutropis longicaudata</i>	X	X	-	-	-	-	-	-	-
<i>Eutropis multicarinata borealis</i>	-	X	X	X	X	X	-	X	X
<i>Eutropis multifasciata</i>	X	-	-	X	-	-	-	X	X
<i>Lamprolepis smaragdina philippinica</i>	-	-	-	X	X	X	X	X	X
<i>Sphenomorphus abdictus</i> cf. <i>aquilonius</i>	-	-	-	X	X	X	X	X	X
<i>Sphenomorphus incognitus</i>	X	X	-	-	-	-	-	-	-
Family Varanidae									
<i>Varanus marmoratus</i> †	-	-	X	X	X	X	X	X	X
Family Boidae									
<i>Python reticulatus</i>	-	-	X	-	-	-	X	-	X
Family Colubridae‡									
<i>Amphiesma stolatum</i>	X	X	-	-	-	-	-	-	-
<i>Ahaetulla prasina preocularis</i>	-	-	-	X	-	-	-	-	X
<i>Boiga cymodon</i>	-	-	-	X	-	-	-	-	X
<i>Boiga dendrophila divergens</i> †	-	-	-	-	-	X	-	-	X
<i>Boiga philippina</i> †	-	-	-	-	X	-	X	-	X
<i>Calamaria geroaisi</i> †	-	-	-	X	-	-	-	-	X
<i>Calamaria pavimentata</i>	X	X	-	-	-	-	-	-	-
<i>Chrysopelea paradisi</i>	-	-	-	-	-	X	X	-	X
<i>Coelognathus erythrura manillensis</i>	-	-	-	-	-	X	X	-	X

Table 2. Con't.

Species	Taiwan	Lanyu	Batan	Camiguin Norte	Babuyan Claro	Calayan	Dalupiri	Fuga	Luzon
<i>Cyclocorus lineatus lineatus</i> †	-	-	-	X	-	X	-	-	X
<i>Dendrelaphis caudolineatus luzonensis</i>	-	-	-	X	-	X	X	X	X
<i>Elaphe carinata</i>	X	X	-	-	-	-	-	-	-
<i>Gonyosoma oxycephalum</i>	-	-	X	X	-	X	-	-	X
<i>Lycodon cf. alcalai</i> †	-	-	X	X§	X§	X§	-	-	-
<i>Lycodon biboniust</i> †	-	-	-	X	X	-	-	-	-
<i>Lycodon chrysoprateros</i> *	-	-	-	-	-	-	X	-	-
<i>Oligodon formosanus</i>	X	X	-	-	-	-	-	-	-
<i>Oxyrhabdium leporinum leporinum</i> †	-	-	-	-	-	X	-	-	X
<i>Psammodynastes pulverulentus</i>	X	X	X	-	-	-	-	-	X
<i>Rhabdophis spilogaster</i> †	-	-	(?)¶	X	-	-	-	-	X
Family Typhlopidae									
<i>Ramphotyphlops braminus</i>	X	X	X	-	-	-	X	X	X
<i>Typhlops luzonensis</i> †	-	-	-	X	-	-	X	-	X
Family Viperidae									
<i>Parias flavomaculatus</i> †	-	-	-	X	X	X	X	-	X
<i>Parias mcgregori</i> *	-	-	X	-	-	-	-	-	-
<i>Viridovipera stejnegeri</i>	X	X	-	-	-	-	-	-	-
Order Crocodylia									
Family Crocodylidae									
<i>Crocodylus mindorensis</i>	-	-	-	-	-	-	X	-	X
Total number of species		21	17	33	17	25	22	20	
Total number of island endemics		2	5	3	2	1	2	1	
Percentage of island endemics		10%	29%	9%	12%	4%	9%	5%	

* - island endemics; † - Philippine endemics; ‡ - Karns et al. (2010) provided a photograph of *Enhydryis plumbea* as being from Lanyu (see their Fig. 1A). However, this is an error and the snake was actually found in Taipei (Harold K. Voris, private communication). To the present, *E. plumbea* has never been recorded from Lanyu.; §- *Lycodon cf. alcalai*; ¶ - unidentified *Rhabdophis* or *Amphiesma* (Ota and Ross, 1994).

SPECIES ACCOUNTS

Class Amphibia Order Anura Family Bufonidae

Rhinella marina (Linnaeus, 1758)

This species is non-native to the Philippines but has become widespread throughout the country (Alcala, 1986; Diesmos et al., 2006). Although specimens collected are from Calayan only, it was also observed in residential and agricultural areas on Babuyan Claro, Camiguin Norte, Dalupiri, Fuga, and Pamoctan. The species has not colonized the Batanes Islands, possibly due to the absence of irrigated rice fields, where they have been introduced in other parts of the country to control insect pests. Specimens: KU 304868 (Site 4a); USNM 314153–58 (Site 4d); USNM 314152 (Site 4e).

Family Microhylidae

Kaloula picta (Duméril and Bibron, 1841)

We collected this Philippine endemic on Calayan, Dalupiri, Fuga, and Barit. It appears to be absent from

Camiguin Norte, Babuyan Claro, and the Batanes Islands, making Calayan the northernmost island in its range. These frogs were seen under trash, rotting coconut logs, stumps, rock and debris in and around residential areas, near puddles in grassland, near ponds at forest edge, and in puddles and streams in selectively logged forest, and ricefields. Specimens: KU 304856, 304858–67, 304869, 304895 (Site 4a); KU 304910, 304925–26, 304932 (Site 4b); USNM 508325–31, 508397 (Site 5a); KU 307021 (Site 5b); USNM 508395, 512456–687 (Site 6a); USNM 508198–237, 508396 (Site 7).

Family Dicroglossidae

Limnonectes cf. woodworthi (Taylor, 1923) (Fig. 2A)

We collected the species in puddles, streams, and on rocks in second growth forest on Camiguin Norte and Fuga. Vocalizations of this Philippine endemic were recorded by RMB. Records of *Limnonectes macrocephalus* from Camiguin Norte (Broad and Oliveros, 2005) are doubtful and need to be verified with voucher specimens. The same species has been reported from Batan (Lazell

and O'Shea 2000 in Oliver et al. [2007]) but no specimens are known from either island. We suspect all past records of *Limnonectes macrocephalus* from the Babuyan and Batanes Islands are in error and based on misidentifications of *Limnonectes* cf. *woodworthi*. The taxonomic status of the northern Luzon and Camiguin Norte populations of *Limnonectes* cf. *woodworthi* need to be evaluated with molecular and acoustic data; at present *Limnonectes woodworthi* is otherwise known from extreme southern Luzon and Polillo. We suspect that the isolated northern Philippine populations of this apparent species may be taxonomically distinct (RMB and A. Diesmos, unpublished data). Specimens: KU 304191, 304594, 304597, 304613–16, 304640, 304648–53, 304674–80 (Site 1a); KU 307961–62, 307964, 307979, 308005 (Site 1b); KU 304550–52 (Site 1d); USNM several specimens uncatalogued (Site 6).

Family Ceratobatrachidae

Platymantis sp. (Fig. 2B)

Frogs belonging to the genus *Platymantis* were collected near banks of streams on or under leaf litter in second

growth forest on Camiguin Norte and Fuga. The frogs from Camiguin Norte likely represent an undescribed taxon endemic to the island but, at present, its taxonomic affinities remain unknown. The taxonomic status of this species as well as other frogs in the genus is currently under review by RMB, A. Diesmos, and A. Alcala. Close inspection of specimens from the same island reported by Broad and Oliveros (2005) as possibly representing two species of *Platymantis* frogs reveal that they belong to the same taxon (some specimens of the suspected undescribed species superficially resemble *P. dorsalis*, and others somewhat resemble *P. corrugatus*). Frogs of the genus *Platymantis* appear to be absent from Babuyan Claro, Calayan, Dalupiri, and the Batanes Islands. More material and call recordings of *Platymantis* frogs from Fuga are needed to help diagnose two uncatalogued specimens from USNM. Specimens: KU 304578–80, 304590–92, 304601–02, 304644–45, 304660–64, USNM uncatalogued (Site 1a); KU 308021–22, 308026, USNM uncatalogued (Site 1b); KU 304553–54 (Site 1d); USNM 2 specimens uncatalogued (Site 6).

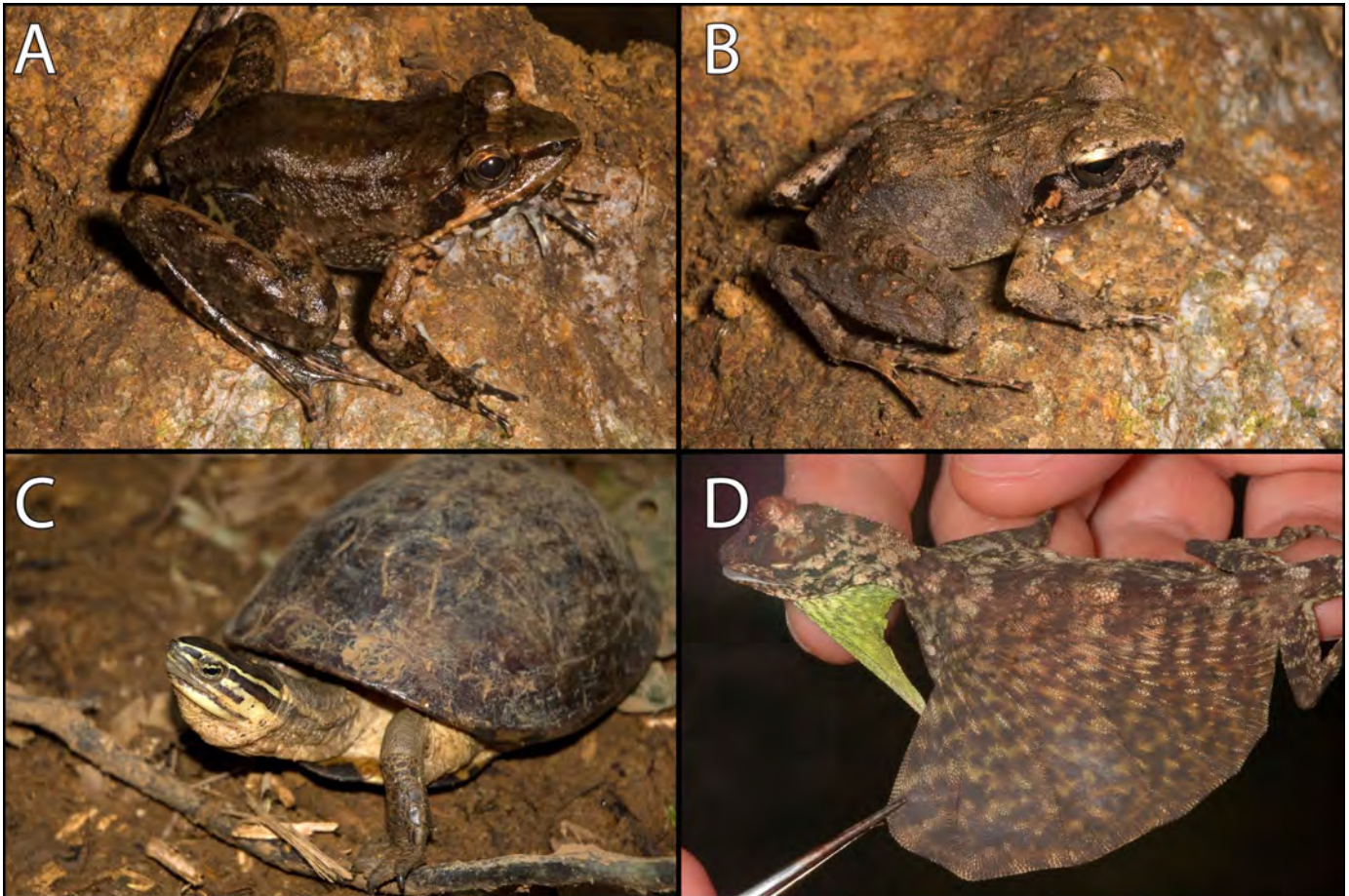


Fig. 2. Amphibians and reptiles from Camiguin Norte. A. *Limnonectes* cf. *woodworthi*. B. *Platymantis* sp. C. *Cuora amboinensis*. D. *Draco* sp. 1.

Family Rhacophoridae

Polypedates leucomystax (Gravenhorst, 1829)

We recorded this widespread species from Camiguin Norte, Fuga, and Barit. They were captured on stems and leaves of woody and herbaceous plants near streams in second growth forest, in puddles in patches of grassland, active on the ground or dormant in a hole in a wall of an old bunker. The species is known farther north from the islands of Batan and Sabtang (Oliver et al., 2007; Ota and Ross, 1994; CHO and RMB, unpublished data, specimens deposited at KU), but was not encountered on Itbayat (Oliver et al., 2007). It is likely that *P. leucomystax* is a recent introduction to the Babuyan and Batanes Islands. The species is a highly invasive human commensal (Diesmos et al., 2006; Brown et al., 2010); populations as far away as the Ryukyu Archipelago appear to have been introduced (by humans) from the Philippines (Kuraishi et al., 2009). Specimens: KU 304581, 304596, 304600, 304612 (Site 1a); KU 307956–60, 308024–25 (Site 1b); KU 304739–41 (Site 1c); USNM 508391–94 (Site 6a); USNM 508238–39 (Site 7).

Class Reptilia
Order Testudines
Family Geoemydidae

Cuora amboinensis (Daudin, 1802) (Fig. 2C)

We collected this species from ponds and small streams on Camiguin Norte, Pamoctan, Fuga, and Barit. It is apparently absent from Babuyan Claro, Calayan, Dalupiri, and the Batanes Islands. Specimens: KU 304656–59 (Site 1a); KU 304778–79, USNM 507774–88 (Site 1c); KU 304773–74 (Site 2); USNM 507793–95 (Site 6b); USNM 507789–92 (Site 7).

Order Squamata (Lizards)
Family Agamidae

Draco sp. 1 (Fig. 2D)

We caught specimens of lizards of the genus *Draco* from Camiguin Norte on tree trunks and on young saplings in mango and coconut plantations and in second growth forest. The species is quite common at the edge of forests and in selectively logged and second growth stands, but is apparently less abundant in interior areas of mature forest. These lizards are morphologically distinct from any described forms (McGuire and Alcalá, 2000) as also noted by (Lazell, 1992) based on 2 specimens collected by the Smithsonian Institution team in 1989. This undescribed species is currently being studied (RMB et al. unpublished data.). It is possible that the same species also occurs on nearby Pamoctan. Specimens: KU 304582,

304681–87, PNM 9085 (Site 1a); KU 307968, 307971, 307992–95, 308034–41 (Site 1b); KU 304715–26, 304734–38, 304763–66, 304768, 304770–72, USNM uncatalogued (Site 1c); KU 304780–81 (Site 3a).

Draco sp. 2 (Fig. 3A)

Another distinct flying lizard of the genus *Draco* was encountered in residential areas and second growth forest on Babuyan Claro. This undescribed taxon is likewise being described (RMB et al., unpublished data). Flying lizards are absent from Calayan, Dalupiri, and Fuga in the Babuyan Islands (CHO, pers. obs.) and on Sabtang (CHO, pers. obs.) and Itbayat (J. Lazell, pers. comm.) in the Batanes Islands despite the presence of suitable habitat. It is interesting to note that the western banks of the Batanes and Babuyan Islands lack flying lizards. Specimens: KU 304799, 304806, 304838–43 (Site 3a); PNM 9081–83 (Site 3b); PNM 9080 (Site 3c); PNM 9084 (Site 3d).

Family Gekkonidae

Cyrtodactylus philippinus (Steindachner, 1867) (Fig. 3B)

This Philippine endemic was encountered on rocks along stream banks and under bark of trees in second growth and gulley forest on Camiguin Norte and Babuyan Claro. Haplotypes from these islands appear minimally divergent and closely related to Luzon populations from the Caraballo Mountains (Nueva Vizcaya Province) and central Sierra Madre (Aurora Province) (Siler et al., 2010). Specimens: KU 304587, 304604, 304631–37, 304671–72, 304690, PNM 9086–87 (Site 1a); KU 307963, 307991, 308044 (Site 1b); KU 304784–86, 304808, 304848 (Site 3a); PNM 9088 (Site 3b).

Gehyra mutilata (Wiegmann, 1834)

Specimens of this species, which widely occurs across Asia, were obtained from Camiguin Norte, Calayan, Dalupiri, and Fuga. This lizard has previously been recorded from Batan (Ota and Ross, 1994). Specimens: USNM uncatalogued (Site 1); PNM 9106 (Site 4d); USNM 508332–33 (Site 5a); USNM uncatalogued (Site 6).

Gekko crombota Brown, Oliveros, Siler and Diesmos, 2008 (Fig. 3C)

These lizards were found on tree trunks of secondary and primary growth forest on Babuyan Claro. This species appears to be common from interior forest to the coast, owing to the intact status of the forest on the south coast of Babuyan Claro (Brown et al., 2008). Specimens: KU 304807, 304809, 304814, 304821, 304825–26, 304829–30, 304832–33, 304836, 304845, 304847, 304849 (Site 3a); PNM 9095–97 (Site 3b); PNM 9098 (Site 3c); PNM 9090 (Site 3d).

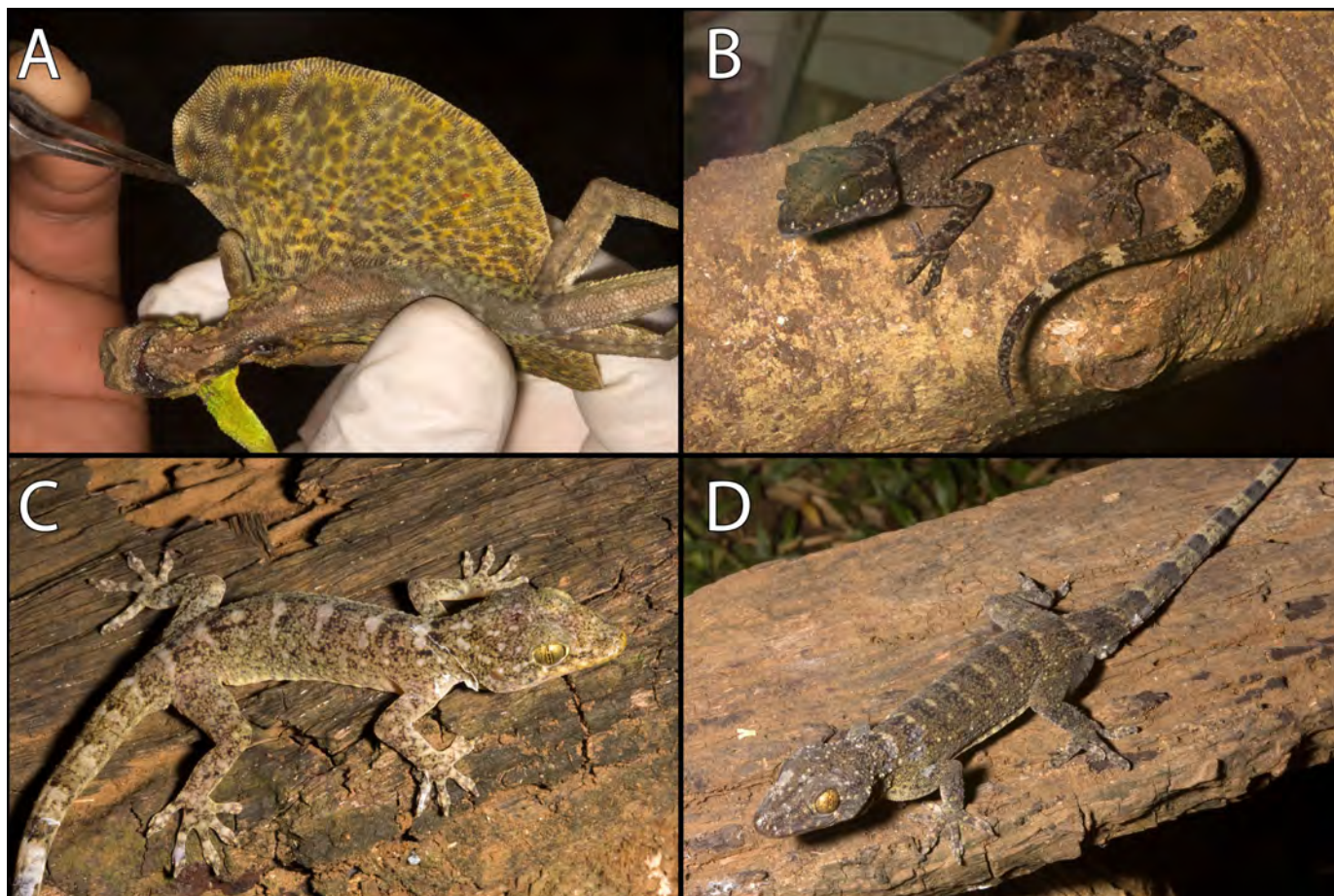


Fig. 3. Reptiles from the Babuyan Islands. A. *Draco* sp. 2 (Babuyan Claro). B. *Cyrtodactylus philippinicus* (Camiguin Norte). C. *Gekko crombota* (Babuyan Claro). D. *Gekko rossi* (Calayan).

Gekko rossi Brown, Oliveros, Siler and Diesmos, 2009
(Fig. 3D)

This gecko species was found on trunks of trees in selectively logged forest and on walls of the entrance of limestone caves on Calayan. This species appears to have been first collected on Calayan by R. McGregor as early as 1904 (Stejneger, 1907; USNM 36184–85) then referred to *G. monarchus*, but no references to these specimens have been made until now (Brown and Alcala, 1978). Specimens: KU 304876–77, 304885 (Site 4a); KU 304916–19, 304923–24, 304927, 304931, 304934–39 (Site 4b); PNM 9091 (Site 4c); USNM 340375 (Site 4e).

Gekko sp. 1

Geckos were collected from trunks of trees in scrubby woods and in the grassy central plateau of Barit; from walls of an old church and an old Japanese bunker and from rocks behind a small village on Fuga; and from trees in scrubby woods on Mabag. They represent a distinct species endemic to these three islands. HO and RIC (unpublished data) are in the process of describing this

species. Specimens: USNM 340452–65 (Site 6a); USNM 340466–77 (Site 6b); USNM 340422–24 (Site 7); USNM 340425–51 (Site 8).

Gekko sp. 2 (Fig. 4A)

Specimens of a second species of *Gekko* from the Babuyan Islands were collected on Dalupiri. They were taken from caves, large trees, large boulders, an old hut in gallery forest along Manolong and Nipa Creeks. This island-endemic is also found in caves near the settlements of Caucauyan and Visita. HO and RIC (unpublished data) are describing this species. Specimens: KU 307022–39, PNM 9093, USNM 340325–68, 340374 (Site 5a); KU 307040–52, 307054–55 (Site 5b); PNM 9089, 9092, 9094 (Site 5c); KU 307053, 307056–57, USNM 340369–73 (Site 5d).

Gekko sp. 3 (Fig. 4B)

A third distinct species belonging to the genus *Gekko* was encountered on Camiguin Norte and nearby Pamoc-tan, where they are thought to be endemic. The speci-

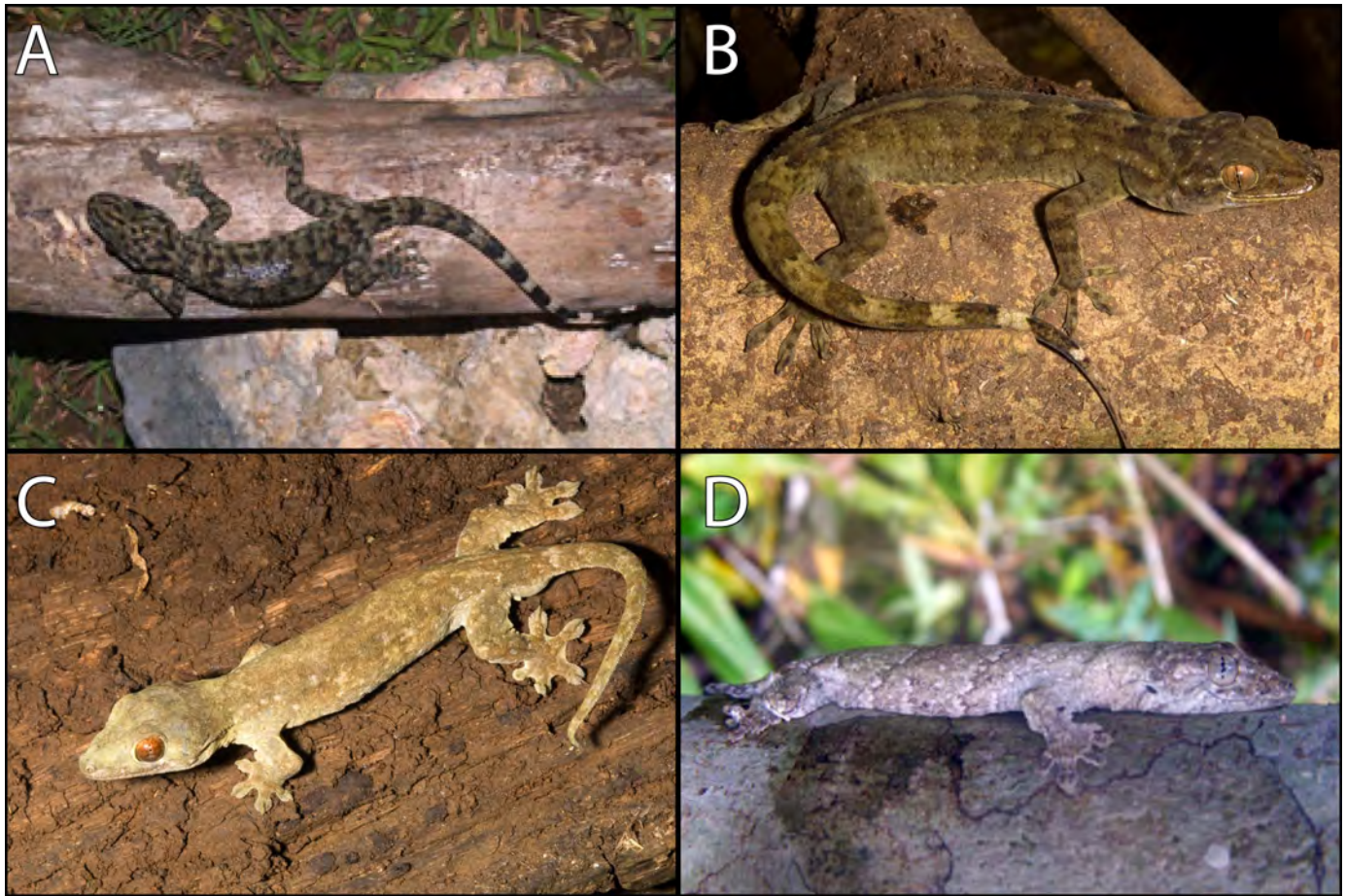


Fig. 4. Reptiles from the Babuyan Islands. A. *Gekko* sp. 2 (Dalupiri). B. *Gekko* sp. 3 (Camiguin Norte). C. *Luperosaurus macgregori* (Babuyan Claro). D. *Luperosaurus* sp. (Camiguin Norte).

mens were captured on trunks of trees, rock faces, under the bark of stumps and under fallen logs. This form is being described by HO and RIC (unpublished data). Specimens: KU 304583, 304585–86, 304588, 304605–11, 304617, 304638, 304673, PNM 9101 (Site 1a); KU 308043, 307990 (Site 1b); KU 304728–33, USNM 340313–23 (Site 1c); PNM 9099 (Site 1e); USNM 340324, PNM 9100 (Site 2).

Hemidactylus frenatus (Schlegel in Duméril and Bibron, 1836)

We collected this widespread species from all islands visited, under bark of trees, under logs, on dead coconut stumps, on rocks, on a fence, inside huts, in and near residential areas and in scrubby woods. The Smithsonian Institution team collected eggs under limestone rocks on the northern end of a plateau on the islet of Irao. R. McGregor collected this species from Fuga (USNM 36190) in 1903 and later from Calayan in 1904 (USNM 36186–88; Stejneger, 1907). The species has also been recorded from Batan, Ivojos (Ota and Ross, 1994) and Sabtang (Oliver et al., 2007) of the Batanes Islands. Specimens: KU 304742–

44, USNM 498956, 508389–90 (Site 1c); PNM 9103 (Site 1e); PNM 9105 (Site 2); KU 304782, 304818–20, 304831 (Site 3a); PNM 9102, 9104 (Site 3c); USNM uncatalogued (Site 4); USNM 508334–508356, 508400–02 (Site 5a); KU 306751–54 (Site 5b); USNM uncatalogued (Site 6); USNM 508240–305, 508399 (Site 7); USNM 508147–92 (Site 8); USNM 508143–46 (Site 9).

Hemidactylus platyurus (Schneider, 1792)

A single uncatalogued specimen of this widespread species was collected from Camiguin Norte. This species was not previously recorded from any islands north of Luzon (Ota, 1989). Specimens: USNM uncatalogued (Site 1).

Lepidodactylus sp.

Lizards belonging to the genus *Lepidodactylus* were captured under the bark of dead trees, along rocks and on trees along the banks of Nipa Creek and Manolong Creek, Dalupiri, and under the bark of trees near human residences at Mambit, Camiguin Norte. They were also

collected from Babuyan Claro and Calayan. These specimens may possibly belong to one or more undescribed species. We do not assign species names to these lizards until more specimens from each island are available, allowing a more convincing diagnosis. Specimens: KU 304603, 304713 (Site 1a); USNM uncatalogued (Site 1c); PNM 9107–08 (Site 3c); USNM uncatalogued (Site 4e); KU 306610 (Site 5b); PNM 9109 (Site 5c); KU 306755 (Site 5d).

Luperosaurus macgregori Stejneger, 1907 (Fig. 4C)

Until recently, this species was known only from the type specimen from Calayan that was collected by R. McGregor in 1904 (Stejneger, 1907). Brown and Alcala (1978) tentatively assigned embryonic specimens from Polillo to this species. This record probably represents misidentifications of hatchling of another, undescribed species of *Luperosaurus* (see below; Brown and Diesmos, 2000; Brown et al., 2000; Gaulke et al., 2007; Brown et al., in press). Three specimens were collected from small saplings on the central plateau on Barit and many individuals were taken from twigs and leaves of trees in primary and secondary growth forest on Babuyan Claro. A specimen tentatively referred to this species was recently collected on Batan (KU 314021). A re-description of the taxon is ongoing (RMB and CO, unpublished data) and a phenotypically similar new species was described from the Sierra Madre mountain range of northern Luzon (Brown, et al., 2007). Specimens: KU 304796–98, 304800–05, 304810–13, 304815–16, 304822–24, 304828, 304834–35, 304846, 304850–51 (Site 3a); USNM 508306–08 (Site 7).

Luperosaurus sp. Brown, Oliveros and Diesmos, in press (Fig. 4D)

A single specimen of a new species referred to the genus *Luperosaurus* was caught on a leaf 4 m above ground on Camiguin Norte. The specimen is similar in size to *L. macgregori*, and smaller than *Luperosaurus cumingii*, a species known from Luzon. However, it lacks the ventral transverse markings found in *L. cumingii* (Gaulke et al., 2007) and also differs by several other morphological characters. It is morphologically similar to two specimens of *Luperosaurus* collected from Aurora Province; these three specimens represent a distinct taxon (Brown, et al., in press). The Philippine endemic *L. cumingii* has been previously reported only from Luzon and Negros Island in the central Philippines. Recently, Gaulke et al. (2007) described the Visayan Negros population as a new species (*L. corfieldi* Gaulke, Roesler and Brown, 2007) and convincingly argued that the name *L. cumingii* should be restricted to populations from Luzon. All Visayan populations (Negros and Panay) are now considered to be *L. corfieldi* (Dolino et al., 2009). Specimens: KU 308023 (Site 1b).

Family Scincidae

Brachymeles cf. *bonitae* Duméril and Bibron, 1839 (Fig. 5A)

We collected this Philippine endemic under leaf litter and decaying logs in second growth forest of Camiguin Norte. It was previously known only from Luzon and some of the islands that surround it. A taxonomic review of the *bonitae* group of *Brachymeles* is currently underway (Siler and Brown, unpublished data). Specimens: KU 304566–67 (Site 1a); KU 307967, 308004, 308019–20, 308027, 308030 (Site 1b).

Brachymeles sp. Siler and Brown, in press (Fig. 5B)

Specimens of this undescribed species were captured in pitfall traps and under decaying logs and stumps in second growth forest on Camiguin Norte, Calayan, and Fuga. This undescribed species also occurs on Luzon. These populations were previously identified as *B. talinis*, a species actually restricted to the Visayan islands of the central Philippines (Siler and Brown, in press). Specimens: KU 304562–65, 304569, 304571–75, 304593, 304627–30, 304643, 304647, 304696–99, 304704–12, 304714, 304753–59 (Site 1a); KU 307965–66, 307984–86, 307996–8003, 308006–15, 308017–18 (Site 1b); KU 304558–59 (Site 1d); KU 304875 (Site 4a); KU 304897, 304899–900, 304902–03, 304905–09, 304915, 304921, 304929, 304941 (Site 4b); USNM uncatalogued (Site 6).

Emoia atrocostata (Lesson, 1826)

We collected this species on rocks: along Dakkel a Danom River on Babuyan Claro, in a coconut grove along the coast of Calayan, and along the coasts of Dalupiri and Mabag. The specimen collected by R. McGregor referred to as from the “Babuyan Islands” in Brown and Alcala (1980) is from Fuga (USNM 36136; Stejneger, 1907). Specimens: PNM 9110 (Site 3d); KU 304896 (Site 4a); USNM 508357–58 (Site 5a); USNM 508193 (Site 8).

Eutropis bontocensis (Taylor, 1923) (Fig. 5C)

The species is known only from high elevation areas in the central Cordillera mountain range of Luzon. We collected specimens in bamboo leaf litter in second growth forest and forest edge on Calayan. Specimens closely resembling this species were also taken from Dalupiri, Fuga, Barit, and Mabag. Similar specimens have also recently been collected on Batan (KU 314025) and Sabtang (KU 314026–32). Specimens: KU 304873–74, 304878, 304881–83, 304886–92 (Site 4a); USNM uncatalogued (Sites 4, 5, 6, 7, 8).

Eutropis cumingi (Brown and Alcala, 1980)

Specimens were captured on the ground in leaf litter in second growth forest on Camiguin Norte, Babuyan

Claro, Calayan, Dalupiri, and Fuga. Similar lizards were observed on Pamoctan but not captured. This species is known only from Luzon but phenotypically similar populations have been recorded from Fuga (USNM 36139–48; Stejneger, 1907; then referred to as *Mabuya multicarinata*) and as far north as Lanyu in Taiwan (Ota and Huang, 2000). Specimens: KU 304745–46, 304751 (Site 1c); PNM 9113 (Site 3c); PNM 9115 (Site 4c); PNM 9114 (Site 5a); several uncatalogued (Site 6).

Eutropis cf. indepressus (Brown and Alcala, 1980)

This species is currently known from central and southern Philippines and northern Borneo. We collected this species in residential areas and second growth on Camiguin Norte, Pamoctan, and Calayan. The interparietal scales were in contact in some specimens and separate in others. We suspect that this species is a complex of multiple independent evolutionary lineages that will eventually warrant separate taxonomic status. Specimens: KU 304767, 308074, USNM 499012, uncatalogued (Site 1c); USNM uncatalogued (Site 2); KU 304872 (Site 4a); KU 304940 (Site 4b).

Eutropis multicarinata borealis (Brown and Alcala, 1980)

We collected this species in leaf litter in second growth forest on Camiguin Norte and Calayan. The species occurs on Lanyu through northern and central Philippines and east to the islands of Palau. Records from Batan, Sabtang, and Itbayat in the Batanes Islands are reported by Oliver et al. (2007). Specimens from Batan are also housed at KU. Specimens: KU 304618, 304620, 304641–42, 304688–89, PNM 9112 (Site 1a); KU 304750, 304727 (Site 1c); KU 304837 (Site 3a); KU 304871 (Site 4a); USNM uncatalogued (Site 6).

Eutropis multifasciata (Kuhl, 1820)

We encountered this widespread species along trails and in cleared patches of forest on Camiguin Norte and Fuga. It also occurs in mainland Taiwan as a result of recent accidental introduction (Shang et al., 2009). Specimens: KU 304654 (Site 1a); KU 304557 (Site 1d); KU 304747–48, PNM 9116 (Site 1c); USNM uncatalogued (Site 6).

Lamprolepis smaragdina philippinica (Mertens, 1929) (Fig. 5D)

Specimens were collected from trunks of coconut trees and large trees in second growth forest on Camiguin Norte, in residential areas on Babuyan Claro, in selectively logged forest on Calayan, in gallery forest along Manolong Creek on Dalupiri, and in residential areas on Fuga. A specimen was collected by R. McGregor on Fuga in 1903 (USNM 36134; Stejneger, 1907). Specimens: KU 304584 (Site 1a); KU 304749, 304769 (Site 1c); KU 304783, 304791–95 (Site 3a); PNM 9111 (Site 3c); KU 304857,

304893–94 (Site 4a); USNM 497566, 508359–61 (Site 5a); USNM 508362–66 (Site 5d); USNM uncatalogued (Site 6).

Sphenomorphus abdictus aquilonius Brown and Alcala, 1980

This Philippine endemic was previously known only from Luzon and Polillo. We captured specimens in pitfall traps and under leaf litter in secondary forest on Camiguin Norte, Babuyan Claro, Calayan, and Fuga, and along the banks of Nipa Creek and Manolong Creek on Dalupiri. The genus was recently reviewed and some populations in the Babuyan Islands may represent distinct taxa (Linkem et al., 2010). Oliver et al. (2007) report the presence of *Sphenomorphus jagori* and *S. abdictus* from Batan and Itbayat but we are unable to verify these identifications because of the lack of voucher specimens. Stejneger (1907) also report *S. jagori* from Calayan and Fuga but no specimens of this species were found at USNM. We suspect reports of *Sphenomorphus jagori* from the Batanes and Babuyan Islands resulted from misidentifications and that all *Sphenomorphus* skinks from the area belong to the *S. abdictus aquilonius* group. Specimens: KU 304560–61, 304568, 304570, 304576–77, 304621–26, 304639, 304646, 304691–95, 304700–03, 304760–62 (Site 1a); KU 307969–70, 307977, 307987–89, 308016, 308028–29 (Site 1b); KU 304790 (Site 1c); KU 304555–56 (Site 1d); KU 304787–89 (Site 3a); PNM 9117 (Site 3c); PNM 9124 (Site 3d); KU 304898, 304901, 304904, 304911–14, 304922, 304928, 304930, 304933 (Site 4b); PNM 9118–19 (Site 4c); KU 307068, 307009 (Site 5b); KU 307010–20, 307066, PNM 9120–23 (Site 5d); USNM uncatalogued (Site 6).

Family Varanidae

Varanus marmoratus (Wiegmann, 1834)

We salvaged specimens from local residents of Camiguin Norte, Babuyan Claro, Calayan, Dalupiri, and Fuga. We also collected specimens from a small stream on Babuyan Claro and one individual was encountered asleep in a small side pool of a river on Calayan. This taxon is currently known from the western and northern Philippines, including Sabtang and Batan (Oliver et al., 2007; Ota and Ross, 1994) in the Batanes Islands. Specimens: KU 304595 (Site 1a); USNM 505713 (Site 1c); KU 304853 (Site 3a); PNM 9125 (Site 3d); KU 304879–80 (Site 4a); USNM 505719 (Site 4e); USNM 505716–18 (Site 5a); USNM 505714–15 (Site 6a).

Family Boidae

Python reticulatus (Schneider, 1801)

We collected a specimen that was killed by a local resident inside his chicken coop at the main village of Visita

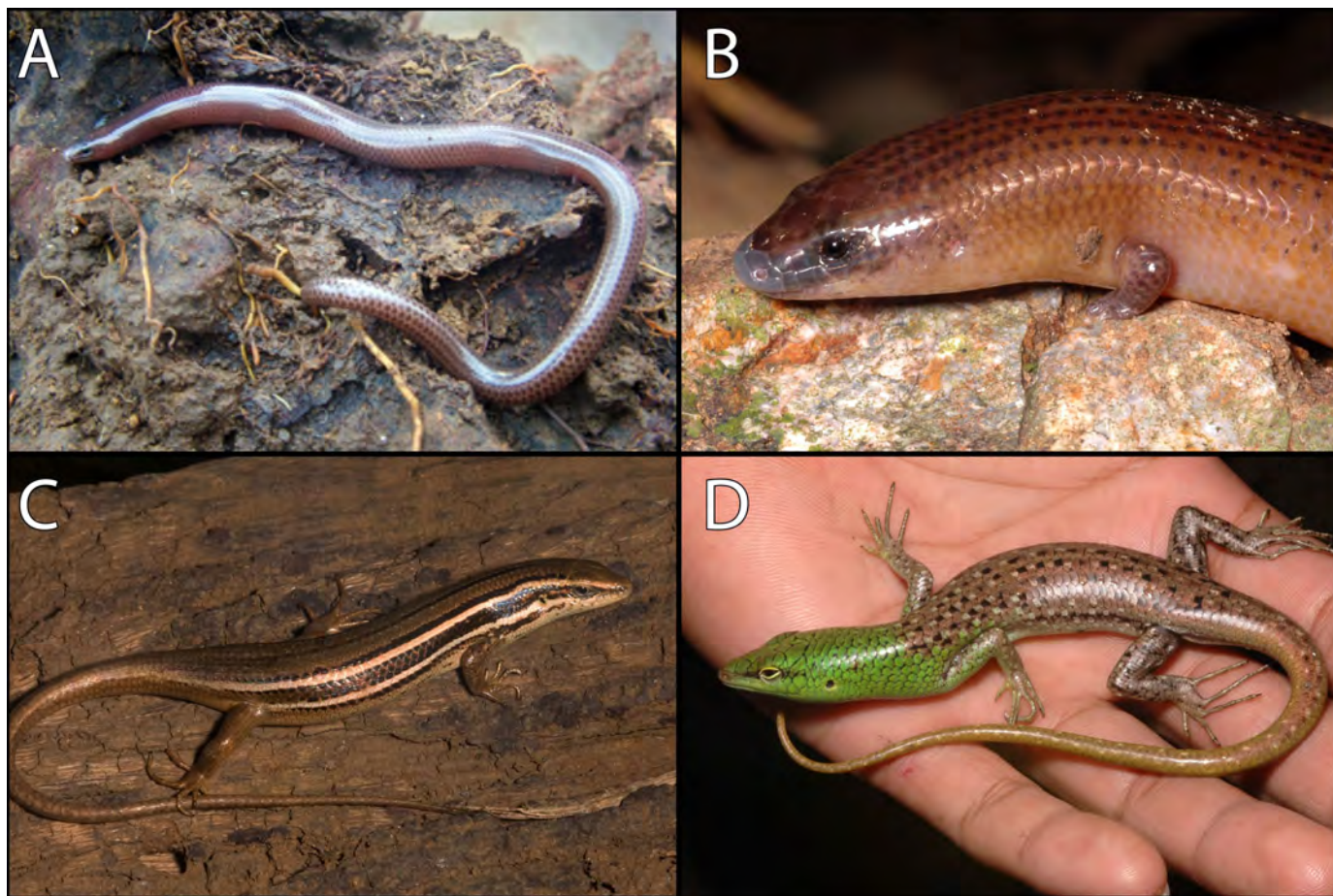


Fig. 5. Skins from the Babuyan Islands. A. *Brachymeles* cf. *bonitae* (Camiguin Norte). B. *Brachymeles* sp. (Camiguin Norte). C. *Eutropis bon-tocensis* (Calayan). D. *Lamprolepis smaragdina philippinica* (Camiguin Norte).

on Dalupiri. Another individual was captured on the same island by mist net - presumably trying to prey on captured bats on the net set along the banks of Manolong Creek. The species is widespread throughout Southeast Asia and in the Philippines as far north as Itbayat (Oliver et al., 2007), Batan (Oliver et al., 2007; Ota and Ross, 1994), and Sabtang (RIC, unpublished data) in the Batanes Islands. Specimens: KU 323932 (Site 5a); KU 307714 (Site 5d).

Family Colubridae

Ahaetulla prasina preocularis (Taylor, 1922) (Fig. 6A, 6B)

This species was found in vines and trees in second growth forest on Camiguin Norte. We encountered two color morphs of the species on the island: bright yellow and green. This taxon is known throughout the Philippines except for the Palawan region where the nominate form, *Ahaetulla prasina prasina*, occurs. Oliver et al. (2007) reported this species from the islands of Batan and Sabtang in the Batanes Islands. Specimens: KU 304598–

99, 304655, 304666, PNM 9126 (Site 1a); KU 307972–76, PNM 9127–28 (Site 1b).

Boiga angulata (Peters, 1861)

One individual was caught in a mist net while trying to eat a bat on Barit. This Philippine endemic species is known from records scattered throughout the country with the exception of the Palawan region. Specimen: USNM 508309 (Site 7).

Boiga cynodon (Boie, 1927) (Fig. 6C, 6D)

We collected two specimens from saplings in second growth forest on Camiguin Norte. This species occurs throughout Southeast Asia including the Philippines. A specimen in the KU collection (KU 304665) is unusual because it keys out to *Boiga cynodon* from scale count data but it does not show crossbars on its dorsum, which is typical of the species. More study is needed on the variation of this species throughout its range. Specimens: KU 304665, 304667–68 (Site 1a).

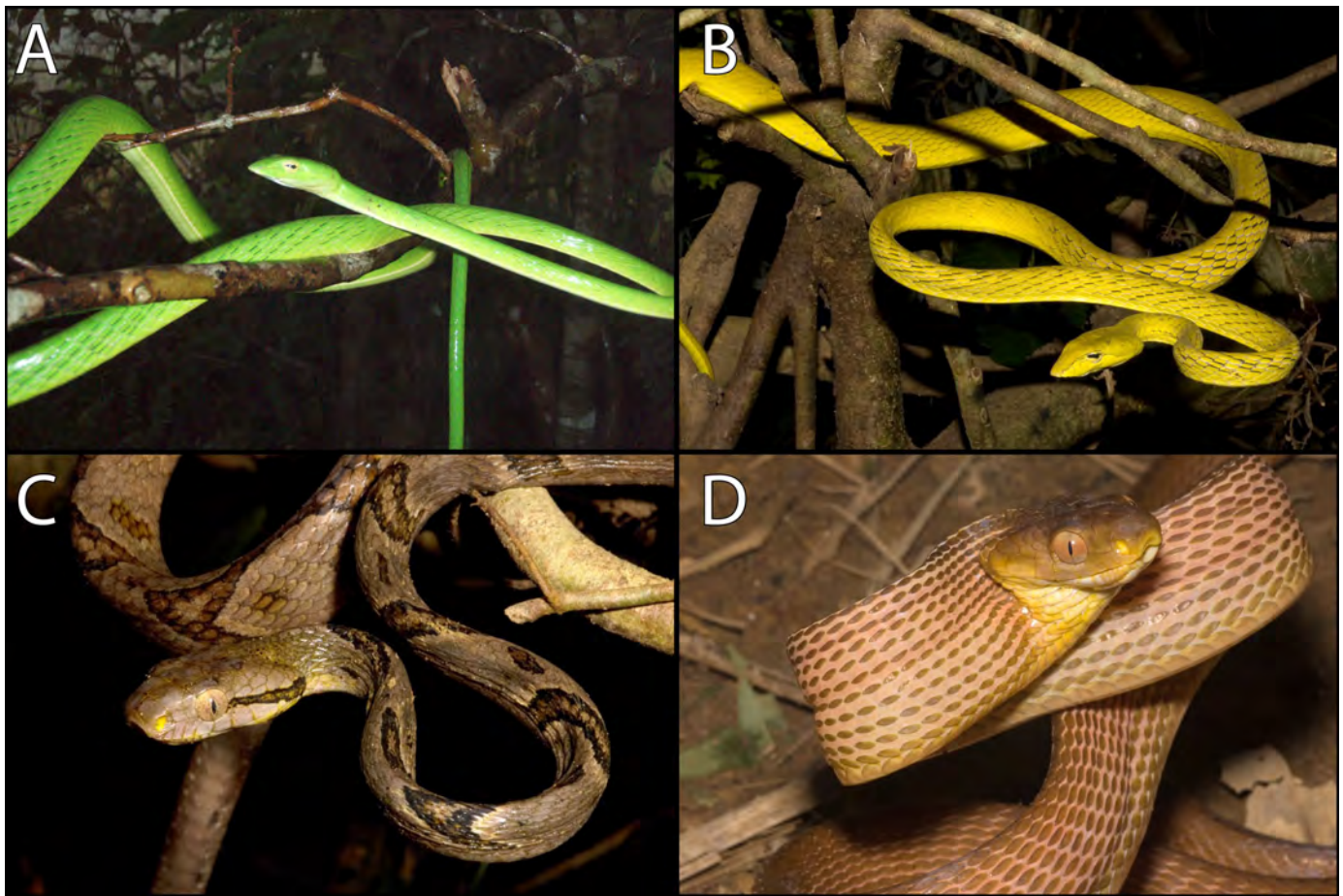


Fig. 6. Snakes from Camiguin Norte. A. *Ahaetulla prasina preocularis* green morph. B. *Ahaetulla prasina preocularis* yellow morph. C. *Boiga cynodon* banded morph. D. *Boiga cynodon* pale morph.

Boiga dendrophila divergens Taylor, 1922 (Fig. 7A)

We encountered this species along a trail in an agricultural clearing and in primary and second growth forest on Calayan. This Philippine endemic is known from Luzon and Polillo (Leviton, 1970a), and has also been reported from Batan (Oliver et al., 2007). Specimens: KU 304884 (Site 4a); PNM 9142–43 (Site 4c).

Boiga philippina (Peters, 1867) (Fig. 7B)

Specimens were collected from twigs of woody plants in primary growth forest on Babuyan Claro. This species is endemic to the Philippines and was previously reported only from Luzon and Marinduque. Specimens: KU 304855 (Site 3a); PNM 9135–36 (Site 3c); PNM 9129 (Site 5a).

Calamaria gervaisi Duméril, Bibron and Duméril, 1854

This Philippine endemic occurs throughout most of the archipelago, with the exception of the Palawan region. We caught individuals inside decaying stumps in second growth forest on Camiguin Norte. Specimens: KU 307982–93, 308031–33, 308042 (Site 1b).

Chrysopelea paradisi H. Boie in F. Boie, 1828

Specimens were collected in viny tangles in large trees west of the residential areas on Dalupiri and an individual was photographed on Calayan. This species occurs widely throughout the Philippines and many other parts of Southeast Asia. Specimens: USNM 497563, 508367 (Site 5a).

Coelognathus erythrura manillensis (Jan, 1863)

We collected specimens along trails in second growth forest on Calayan, from the edge of grassland on the plateau and at the mouth of a stream on Dalupiri, and from inside a rotting coconut palm stump on Barit. Oliver et al. (2007) recorded *C. erythrura* from Batan in the Batanes Islands. Specimens: USNM 512771–72 (Site 4e); USNM 497561, 508376 (Site 5a); USNM 497562 (Site 5d); USNM 508310 (Site 7).

Cyclocorus lineatus lineatus (Reinhardt, 1843)

We collected a specimen inside a decaying tree stump in second growth forest on Camiguin Norte and a sec-

ond specimen from Calayan. This Philippine endemic is known from Luzon and some surrounding islands (Leviton, 1967). Specimens: KU 307981 (Site 1b); USNM uncatalogued (Site 4).

Dendrelaphis caudolineatus luzonensis Leviton, 1961

We encountered this species on saplings in gallery forest along Nipa Creek and Manolong Creek, in scrubby woods near Visita on Dalupiri, and from the islands of Camiguin Norte and Calayan. Specimens: USNM uncatalogued (Site 1); PNM 9144 (Site 4e); USNM 508368–70, 508372–75, 508387–88, PNM 9130 (Site 5a); KU 307719 (Site 5b); KU 307706, USNM 508371 (Site 5d); USNM uncatalogued (Site 6).

Gonyosoma oxycephalum (Reinwardt in F. Boie, 1827)

We collected a specimen from a tree branch in second growth forest on Camiguin Norte and an individual was photographed on Calayan. This widespread species has previously been recorded from Batan, Sabtang (Ota and Ross, 1994), and Itbayat (Oliver et al., 2007) in the Batanes

Islands. Specimens: KU 307980 (Site 1b).

Lycodon bibonius Ota and Ross, 1994 (Fig. 7C)

This species was previously known only from Camiguin Norte. We collected another specimen along a dirt road in a residential area on this island. A specimen captured in primary forest on Babuyan Claro is referred to this species following the key in Ota and Ross (1994). Specimens: PNM 9131 (Site 1c); KU 304852 (Site 3a).

Lycodon chrysoprateros Ota and Ross, 1994

This species is known only from Dalupiri. We collected another specimen in gallery forest along Manolong Creek on Dalupiri. Specimen: KU 307720 (Site 5d).

Lycodon cf. alcalai Ota and Ross, 1994 (Fig. 7D)

We captured specimens from saplings and trunks of large trees in primary forest on Babuyan Claro, along a muddy trail in selectively logged forest and in second growth forest on Calayan, and along the banks of a stream in second growth forest on Camiguin Norte. This



Fig. 7. Snakes from the Babuyan Islands. A. *Boiga dendrophila divergens* (Calayan). B. *Boiga philippina* (Babuyan Claro). C. *Lycodon bibonius* (Babuyan Claro). D. *Lycodon cf. alcalai* (Camiguin Norte).

species was previously known only from Batan (Ota and Ross 1994). Specimens from Babuyan Claro, Calayan and the Batanes Islands require further study to determine whether some populations are distinct taxa. Specimens: KU 304589 (Site 1a); KU 304817, 304827, 304844 (Site 3a); KU 304870 (Site 4a); PNM 9147–48 (Site 4c).

Oxyrhabdium leporinum leporinum (Günther, 1858)

We collected a single specimen in second growth forest on Calayan. This Philippine endemic is known only from the northern Philippines. Specimens: PNM 9149 (Site 4c).

Rhabdophis spilogaster (Boie, 1827)

We encountered this Philippine endemic species along trails in second growth forest on Camiguin Norte. Specimens: PNM 9132 (Site 1b); KU 304752 (Site 1c).

Family Elapidae

Laticauda colubrina (Schneider, 1799)

This species was captured in holes in beach rocks, inside caves along the coasts, and in tide pools in reefs on Babuyan Claro, Calayan, Dalupiri, Barit, and Mabag. See also *L. laticaudata*. Specimens: PNM 9137 (Site 3d); PNM 9145 (Site 4e); USNM 497553–54, 508377–81 (Site 5a); USNM 497555–57 (Site 5d); USNM 497558–59, 507823–24, 508311–19 (Site 7); USNM 497560, 507819–22, 508194–95 (Site 8).

Laticauda laticaudata (Linnaeus, 1758)

We collected a specimen inside a cave along the coast of Calayan. There were about one dozen snakes of this species and *L. colubrina* inside this cave. Specimens: PNM 9146 (Site 4e).

Laticauda semifasciata (Reinwardt, 1837)

We obtained a specimen from a local resident who captured the snake along the northern coast of Babuyan Claro. Specimens: PNM 9138 (Site 3d).

Family Typhlopidae

Ramphotyphlops braminus (Daudin, 1803)

This species was encountered under a rock at the edge of the beach and under trash in the residential area on Dalupiri, under a dead palm stump on Barit, under logs near abandoned barracks on Mabag, and on the island of Fuga. The species was previously reported from Batan and Ivojos in the Batanes Islands (Ota and Ross, 1994). Specimens: USNM 508382–85 (Site 5a); USNM uncatalogued (Site 6); USNM 508320–24 (Site 7); USNM 508196–97 (Site 8).

Typhlops luzonensis Taylor, 1919 (Fig. 8A)

We collected a specimen of this Philippine endemic species inside a rotten log in second growth on Camiguin Norte and another under a decaying stump in gallery forest along Nipa Creek on Dalupiri. Specimens: KU 304619 (Site 1a); KU 323931 (Site 5b).

Family Viperidae

Parias cf. *flavomaculatus* (Gray, 1842) (Figs. 8B, 8C)

Specimens were captured along streams, near puddles in second growth on Camiguin Norte, on saplings in primary forest on Babuyan Claro, crawling on stream banks in second growth forest and along a trail in selectively logged forest on Calayan, and on a sapling in gallery forest along Manolong Creek on Dalupiri. We observed different color morphs of this Philippine endemic species: green on Camiguin Norte and Babuyan Claro; light grey, brownish yellow and dark grey on Calayan; and light cream on Dalupiri (Figs. 8B–8D). Further review of the taxonomy of the pit vipers from the area is recommended. Broad and Oliveros (2005) reported *Parias mcgregori* from Calayan based on the observation of a brownish yellow individual but we recommend that this record be discounted pending further review of the pit vipers in the area and until voucher specimens are available. Specimens: KU 304669–70, PNM 9133 (Site 1a); KU 307978, 308075, PNM 9134 (Site 1b); KU 304775–77 (Site 1c); PNM 9140–41 (Site 3b); PNM 9139 (Site 3c); KU 304854 (Site 4a); KU 304920 (Site 4b); KU 307711 (Site 5d).

Order Crocodylia

Family Crocodylidae

Crocodylus mindorensis (Schmidt, 1935)

Crocodiles were observed along Manolong Creek and Caucauyan Creek on Dalupiri in 1990 and 2004 (Ross, 2005; Broad and Oliveros, 2005), but in both cases, the identity of the crocodile/s was not ascertained. It was not until 2005 that the presence of *C. mindorensis* was confirmed along Caucauyan Creek, representing the northernmost record of this Philippine endemic species (Oliveros et al., 2005). A specimen of this critically endangered taxon has not been collected because of the extremely small population on the island. Subsequent visits to Dalupiri have been made to survey and monitor the local crocodile population and to gather support for their conservation among local residents (Oliveros et al., 2008).



Fig. 8. Snakes from the Babuyan Islands. A. *Typholops luzonensis* (Camiguin Norte). B. *Parias flavomaculatus* green morph (Camiguin Norte). C. *Parias flavomaculatus* grey morph (Calayan). D. *Parias flavomaculatus* light cream morph (Dalupiri).

DISCUSSION

This contribution fills in a large gap in our knowledge of the herpetofauna of the islands between Taiwan and the Philippines. We now know of at least 52 species that occur in the Babuyan Islands, compared to the previously known ten (Brown and Alcala, 1978; Brown and Alcala, 1980; Leviton, 1964; Leviton, 1970b; Ota and Ross, 1994; Stejneger, 1907). The differences in the number of species recorded from each island of the Babuyan group may largely be due to a combination of factors, including proximity to a large island like Luzon with a steady source of colonizers and island size (MacArthur and Wilson, 1967). Additionally, it is clear that the amount of survey work conducted on a given island directly impacts our understanding of its species diversity. Camiguin Norte, where the highest number of species was recorded, is closest to Luzon and was surveyed the most number of times, while Babuyan Claro, with the lowest species richness, is farthest from Luzon and received only cursory visits. These species lists are by no means complete. Much taxo-

nomic work is required in some groups (e.g. snakes of the genus *Boiga*) and in some cases is already in progress (e.g. frogs of the genus *Platymantis*, geckos of the genus *Gekko*, skinks of the genus *Brachymeles*, and flying lizards of the genus *Draco*). Further surveys are likely to yield new records, particularly on the islands of Fuga and Babuyan Claro, which have received the least amount of survey work. However, we believe our records provide a fair representation of the herpetofaunal diversity of each island.

The discovery of several new island-endemics and potentially endemic undescribed taxa in the Babuyan Islands highlights the high prevalence of herpetofaunal endemism in the area, where each major island, whose sizes vary from only 50–200 km², harbors an endemic land vertebrate. Lazell's (1992) prediction of a flying lizard on each island bank was not borne out by our studies. We did, however, find distinct species of *Draco* on islands where they were present (the eastern islands of the

Batanes and Babuyan Islands). In addition, unique forms of lizards of the genus *Gekko* were found on each major island. We predict that more endemic taxa in other genera will be discovered and described.

The high similarity of the herpetofaunal assemblage of the Babuyan Islands with that of Luzon and a low similarity with Taiwan's herpetofauna are expected because of the island group's proximity to Luzon, Luzon's greater size compared to Taiwan, and northward flows of the dominant surface current "Kuroshio" of this region (Nitani, 1972). Given that the volcanic history of the Babuyan Islands is fairly well known (Defant et al., 1989; Yang et al., 1996) oversea dispersals from Luzon and subsequent speciation seem to have been the dominant forces responsible for the present-day assemblage of reptiles and amphibians in the Babuyan Islands (Brown et al., 2009; Lazell, 1992).

While extinction rates might also play a role, the differential rates of colonization success from Luzon are evident from the nestedness of biotas in the Batanes and Babuyan Islands. For some groups, their northward invasion halts in the Babuyan Islands, including *Kaloula picta*, frogs of the genus *Platymantis*, *Cuora amboinensis*, skinks of the genus *Brachymeles*, snakes of the genus *Boiga*, and *Crocodylus mindorensis*. Yet for other taxa, their expansion reaches further north in the Batanes Islands, including flying lizards of the genus *Draco*, *Varanus marmoratus*, *Gonyosoma oxycephalum*, and pit vipers of the genus *Parias*.

Nine species of reptiles have populations on both sides of the 130 km stretch of ocean between Taiwan and the Batanes Islands – *Gehyra mutilata*, *Hemidactylus frenatus*, *Emoia atrocostata*, *Eutropis cumingi*, *Eutropis multicarinata borealis*, *Eutropis multifasciata*, *Ramphotyphlops braminus*, *Psammodynastes pulverulentus*, and *Hemiphyllodactylus typus*. Two of these, *Eutropis cumingi* and *Eutropis multicarinata borealis*, occur only on Lanyu north of this gap, and thus have been considered of Philippine origin (Ota, 1991b; Ota and Huang, 2000): they are likely to have dispersed northward to Lanyu by using the Batanes-Babuyan group as stepping stones. Two species, *Emoia atrocostata* and *Eutropis multifasciata*, occur on mainland Taiwan but are not known from eastern China, and are likely descendants from Philippine populations as well – the latter species considered to have reached Taiwan through recent artificial transportation (Ota et al., 1994). The other five species occur in eastern China thus making inferences about their origin based on taxonomy alone problematic. Wang (1962) suspected populations of *Psammodynastes pulverulentus* on Lanyu and the mainland Taiwan to have originated from the Philippines, but Rasmussen (1975), based on the analyses of morphological variation in the species throughout its range, negated this view: he suspected that all Taiwanese populations of this spe-

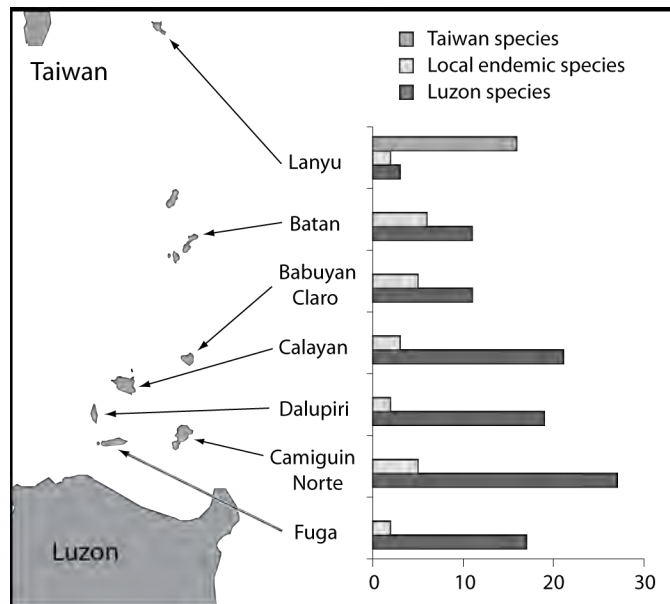


Fig. 9. Comparison of number of species on each major island that are endemic or shared with Taiwan and Luzon. Local endemic species include single island endemics and species endemic to the Batanes and Babuyan Islands.

cies (including the one on Lanyu) have dispersed from the continental stock. For the four other species (*Gehyra mutilata*, *Hemidactylus frenatus*, *Ramphotyphlops braminus*, and *Hemiphyllodactylus typus*) a continental origin of their Taiwan and Lanyu populations and a Philippine origin of their Batanes and Babuyan populations may well be the case as well if colonizations occurred from their nearest source. Thus, we do not find any evidence of herpetofaunal invasions of the Philippines' most northern islands from Taiwan based on taxonomic information. At least for amphibians and reptiles, the Batanes and Babuyan Island groups acted as a one-way filter of colonizers from Luzon to Taiwan (Fig. 9). Species from Taiwan do not occur south of Lanyu while Luzon species occur throughout the intervening islands with more species in islands closer to Luzon. However, colonization of these islands from the north has been shown in molecular studies for the case of the shrew *Crocidura tanakae*, which occurs on Batan and Sabtang (Esselstyn and Oliveros, 2010) and for the bulbul *Hypsipetes amaurotis*, a species common in the Batanes and Babuyan Islands and whose range stretches north to mainland Japan (Oliveros and Moyle, 2010).

Two genera of gekkonid lizards, *Gekko* and *Lepidodactylus*, occur throughout the islands between Taiwan and Luzon and have island-endemic forms. Ota (1991a) hypothesized that the ancestors of the Lanyu endemics *Lepidodactylus yami* and *Gekko kikuchii* originated from the Philippines. The phylogenetic study of Brown et al. (2009) of northern Philippine *Gekko* reveals a history of random island colonizations, but lacked a sample of *G.*

kikuchii. Snakes of the genus *Lycodon* are also diverse in this region with other distinct species in Taiwan and the Ryukyu archipelago. Molecular phylogenetic studies of taxa distributed across Taiwan, the Ryukyu archipelago and northern Philippines are recommended to gain more insights into the evolutionary history of these groups of taxa and the biogeography of this important region.

The islands of the Batanes and Babuyan groups are recognized as areas of very high priority for conservation of reptiles and amphibians because of the presence of small island endemics (Ong et al., 2002). While the

Batanes Islands form part of a national protected area, conservation efforts in the Babuyan Islands are community-based and focus on the Calayan-endemic flightless rail *Gallirallus calayanensis* and its forest habitat. The main threat to the local herpetofauna of the Babuyan Islands is the gradual conversion of forest into agricultural areas, a common practice in the rest of the Philippine archipelago. It is important that conservation initiatives in other islands of the Babuyan group, which support endemic species, are encouraged and supported.

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