

The Herpetofauna of Nusa Penida, Indonesia

SAMI ASAD¹, J. LINDLEY MCKAY^{2,4} AND AGUS PRADANA PUTRA³

¹28 Forshaws Lane, Burtonwood, Warrington WA5 4ES, England.

²1/4 O'Connor St, Blackrock 3193, Australia.

³Jalan Keboiwa, Br:Pagutan, Gapura:1 No:1, Denpasar barat, Indonesia.

⁴corresponding author: baliherpetofauna@yahoo.com.au

ABSTRACT - The Nusa Penida group, three islands lying offshore of Bali, Indonesia, were systematically surveyed for the first time on behalf of the Friends of the National Parks Foundation, using timed searches in representative habitats. Ten species were newly recorded for the islands. In combination with previous data we record a total of 3 anurans, 11 lizards and 14 snakes. The herpetofauna is very strongly related to that of Bali, sharing only one species exclusively with Lombok and islands further east, the fossorial lizard *Dibamus taylori*. Richest habitats from a herpetological standpoint are remnant tropical rainforest and semi-deciduous forest, and these are priorities for conservation efforts.

The Nusa Penida group (herein referred to as NP) lie at -8.7389° , 115.5402° , 14 km SE of Bali, Indonesia, and are administered as a branch of Bali's Klungkung regency. The largest of the group is Nusa Penida island, around 207 sq km, comprised mostly of rolling hills, with a highest point of Gunung Mundi at 529 m asl, a narrow northern low coastal strip and cliffs to the south. Nusa Ceningan and Nusa Lembongan, nestled against their sibling's north-east corner, are a fraction of the size and have a similar geography on a smaller scale. Despite their proximity to volcanic Bali, the group are coralline islands. Their calcareous geology, coupled with comparatively low annual rainfall, make the soils very dry and the habitats relatively barren (Giambelli, 1999), and the semi-deciduous forests which once covered most of the islands (Whitten et al., 1996) have largely been cleared for agriculture. Tree-felling began 400+ years ago, by exiled convicts supplying timber to the mainland (Giambelli, 1999). Surviving mature forest is confined to valleys and ravines which have proved too difficult or costly to exploit (McKay, 2006a).

The known flora and fauna are Wallacean transitional assemblages with the majority of taxa being of the South East Asian Assemblage and secondarily species of Lesser Sundanese affinity.

Bali and neighboring Lombok represent the eastern range limit of many Asian species and the western limit of a number of Lesser Sundanese organisms (Jonsson et al., 2008). Smaller size and limited mature habitat suggests NP harbours a small subset of the Bali-Lombok taxa. To date the wildlife of NP has been poorly documented and there is no definitive species database, an essential tool for future studies and the implementation of conservation programs. Previous herpetological research (McKay, 2006a) provides some information on species presence in a handful of areas. With the assistance of the Friends of National Parks Foundation, a conservation NGO recently lauded for success in re-establishing a wild population of the Bali Starling, *Leucopsar rothschildi*, and establishing an island-wide protected bird sanctuary under traditional law on Nusa Penida island, we aimed to conduct a more comprehensive assessment of the herpetofauna richness and habitat associations on NP, the overall objective being to not only create a herpetofauna database, but provide a better understanding of the islands' biodiversity.

METHODS

Seventeen vehicle-accessible sites were established across Nusa Penida island, each comprising a

Site	Site name	Altitude (m) asl	Location	Habitat Type	Vegetation composition	Vegetation diversity	Anthropogenic disturbance	Soil quality
1	Penangkidan	203	S 080 44' 27. 8" E 1150 28' 39. 3"	Scrub	Acacias, palms, grasses	Moderate	Moderate	Low - moderate
2	Penida	19	S 080 42' 59. 1" E 1150 27' 43. 1"	Wetland	Predominately aquatic vegetation, lillies, mangrove trees, palms	High	Low	High
3	Sebunibus	147	S 080 42' 28. 9" E 1150 29' 17. 7"	Tropical semi-deciduous forest/ scrub	Deciduous trees, vines, ferns, palms, Acacias	Moderate - High	Moderate	Moderate
4	Toya Pakeh	13	S 080 40' 58. 8" E 1150 29' 16. 2"	Plantation	Palms	Low	High	Low
5	Ped	7	S 080 40' 47. 8" E 1150 31' 05. 0"	Plantation/Scrub	Acacias, palms	Moderate	Moderate	Moderate
6	Pilah	182	S 080 41' 50. 1" E 1150 32' 36. 0"	Plantation/ Tropical semi-deciduous forest	Deciduous trees, palms, Acacias	Moderate	Moderate	Moderate
7	Batumulapan	6	S 08040' 43. 2" E 1150 34' 20. 7"	Plantation	Palms	Low	High	Low
8	Karangsari	35	S 080 42' 35. 5" E 1150 34' 58. 5"	Tropical semi-deciduous forest	Deciduous/Evergreen trees, Acacias, ferns, vines	High	Low	High
9	Sumaya	8	S 080 43' 44. 0" E 1150 36' 03. 7"	Scrub /Plantation	Acacias, palms, grasses	Moderate	Moderate	Poor
10	Pejukutan	245	S 080 44' 52. 1" E 1150 35' 17. 0"	Tropical semi-deciduous forest	Deciduous/Evergreen trees, Acacias, vines, ferns	High	Low	High
11	Tanglad	442	S 080 46' 00. 8" E 1150 34' 53. 7"	Savannah	Predominantly grasses, Acacias, palms	Low	Moderate	Low
12	Sukartaji	234	S 080 47' 50. 3" E 1150 33' 45. 8"	Scrub/Plantation	Acacias, palms, grasses	Moderate - High	High	Moderate
13	Sebuluh	195	S 080 45' 19. 5" E 1150 29' 32. 8"	Scrub/Tropical semi-deciduous forest	Deciduous/Evergreen trees, ferns, vines, Acacias	High	Low	High
14	Tembeling	259	S 080 45' 38. 6" E 1150 30' 13. 2"	Tropical rain forest	Predominately evergreen trees, deciduous trees, ferns, vines, palms, Acacias	High	Low	High
15	Mundi	530	S 080 43' 56.1" E 1150 31' 28.2"	Tropical semi-deciduous forest	Deciduous/Evergreen trees, ferns, vines, Acacias	High	Low	High
16	Pangalan	288	S 080 43' 19. 2" E 1150 33' 53. 9"	Plantation/ Tropical semi-deciduous forest	Deciduous trees, palms, Acacias	Moderate-High	Moderate	Moderate
17	Soyo	444	S 080 46' 06. 3" E 1150 34' 02. 6"	Savannah	Predominately grasses, Acacias, palms	Low	High	Low

Table 1. Location and habitat details of the sites surveyed on NP in 2011.

transect of approximately 500 m. Coordinates and elevation were logged with a Garmin Etrex GPS 12 Channel unit. Sites were distributed across six major habitats: scrubland, with a high diversity of *Acacia* spp, other shrubs and small deciduous trees; savannah, characterized by large quantities of grasses with little other vegetation except some *Acacias* and palms, and no 3+ m trees; plantation, areas of active agricultural activity with crops including bananas, palms, cassavas, corn and chillies, most often in monocultures; tropical semi-deciduous forest, comprising mostly deciduous trees, some intermittent evergreens and thick fern and shrub ground layers; tropical rainforest, diverse communities of primarily evergreen trees, deciduous trees, shrubs, ferns and epiphytes; and wetland, a freshwater spring with diverse aquatic plants. At each of these sites anthropogenic disturbance was scored in three categories: further than 150 m from an anthropogenically disturbed area - low; within 150 m of an anthropogenically disturbed area - moderate; site positioned within an anthropogenically disturbed area - high. Soil quality was also scored in three classes: less than 3 cm/little or no organic matter - low; 3-5 cm/intermittent organic matter - moderate; > 5 cm/predominantly organic matter - high. During August - September 2011 each site was visited three times (morning/afternoon/night), and walked for a duration of approx. 2 hrs, followed by searches of specific micro-habitats, recording any herpetofauna encountered. This method may not discriminate smaller or more agile species glimpsed momentarily by the observer who may not be experienced in differentiating between sibling species, in such case genus/species group was recorded.

The data was combined with records collected by JLM in 2002, 2007 and 2010, the results of opportunistic day/night searching on foot and vehicle, mostly in preparation for subsequent field guides (McKay 2006a, 2006b). We then comment on species richness in comparison to the known Balinese-Lombok fauna, and draw inferences for the significance of NP's herpetofauna and remaining habitat to conservation efforts on the islands.



Figure 1. Site 14, "Tembeling", a tropical rainforest gully, from which the greatest herpetofauna diversity was recorded. Photo by JL McKay.

RESULTS

The visual transects yielded three amphibian and 22 reptile species. Ten species were newly recorded for the NP group (two frogs, one lizard and 7 snakes). The maximum number of taxa recorded in a site was 10, from site 14, a relatively undisturbed tropical rainforest gully. Tropical semi-deciduous forests, and tropical semi-deciduous forest associated with scrub, yielded the next highest richness of taxa, between 9 and 7 taxa per site. Other habitats yielded a moderate number of species; the lowest diversity was from the savannah and wetland sites with zero or a single species. As would be expected, sites with greatest species richness had correspondingly high organic soil content and low anthropogenic disturbance.

Of the amphibia, *Duttaphrynus melanostictus* was by far the most prevalent, not only detected in the study areas but also observed throughout the island between sites. *Polypedates leucomystax* was found at only two sites, in tropical semi-deciduous forest/scrub, and tropical rainforest. *Fejervarya cancrivora* occurred only in the wetland.

With the exception of *Varanus salvator bivittatus*, all the lizards on NP are small insectivores, with four Gekkonidae, three Scincidae species and one Dibamid. The three most widespread and abundant are *Gecko gecko*, *Cyrtodactylus fumosus* and *Eutropis multifasciata*, which all inhabited a wide range of habitats throughout the island. *C. fumosus* appeared to be the most abundant of these, and was highly

Order : Sub order	Family	Species	Site																	Total		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17			
Anura	Bufonidae	<i>Duttaphrynus melanostictus</i>	X	X	X	X	-	-	-	-	-	-	-	-	-	X	X	-	-	6		
	Dicroglossidae	<i>Fejervarya cancrivora</i>	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
	Rhacophoridae	<i>Polypedates leucomystax</i>	-	-	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	2	
Squamata: Lacertilia	Dibamidae	<i>Dibamus taylori</i>	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	2		
	Gekkonidae	<i>Cryptodactylus fumosus</i>	X	X	X	X	-	X	X	X	X	X	-	X	X	X	X	X	-	-	14	
		<i>Gekko gecko</i>	X	X	X	X	X	X	X	X	X	X	-	X	X	X	X	X	-	-	15	
		<i>Hemidactylus frenatus</i>	X	-	X	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	4	
		<i>Hemidactylus platyurus</i>	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	2	
	Scincidae	<i>Eutropis multifasciata</i>	X	-	X	-	X	X	-	X	X	X	X	X	X	X	X	X	-	-	13	
		<i>Eutropis rugifera</i>	-	-	-	-	X	-	X	-	-	-	-	-	X	-	-	-	-	-	3	
		<i>Lygosoma bowringii</i>	-	-	-	-	-	-	-	-	-	X	-	X	-	-	X	-	-	-	3	
	Varanidae	<i>Varanus salvator</i>	X	X	-	-	-	-	-	-	-	-	-	-	X	X	X	X	-	-	6	
	Squamata: Serpentes	Colubridae	<i>Ahaetulla prasina</i>	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
<i>Boiga multomaculata</i>			-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	1	
<i>Coelognathus radiates</i>			-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
<i>Dendrelaphis pictus</i>			-	-	X	-	X	-	-	X	-	-	-	X	-	X	-	-	-	-	5	
<i>Lycodon aulicus capucinus</i>			-	-	-	-	-	-	-	X	-	-	-	-	-	X	X	-	-	-	3	
<i>Lycodon subcinctus</i>			-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	2	
<i>Pareas carinatus</i>			-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	1	
<i>Psammodynastes pulverulentus</i>			-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	1	
<i>Ptyas korros</i>			-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Rhabdophis chrysargos</i>			-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Crotalidae			<i>Cryptelytrops insularis</i>	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-	-	2
Elapidae			<i>Naja sputatrix</i>	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	2
Typhlopidae	<i>Ramphotyphlops braminus</i>	-	-	-	-	X	-	X	-	X	X	-	-	-	-	-	-	-	-	4		
Total			6	6	9	4	7	4	5	8	5	8	1	5	7	10	7	4	0			

Table 2. Herpetofauna recorded at the 17 sites surveyed on NP in 2011 (data collected on behalf of the Friends of the National Park Foundation).

detectable as a result of its active terrestrial lifestyle. *Hemidactylus frenatus* and *H. platyurus* were found predominately around human

habitation, hunting invertebrates around artificial lights. *Lygosoma bowringii* and *Eutropis rugifera* were found at various sites throughout the island



Figure 2. An unusual red-nosed variant of *E. multifasciata* found on Nusa Penida. Photo taken at site 14 by J.L. McKay.



Figure 3. *Dibamus taylori* from Lombok. Photo by J.L. McKay.

where deep leaf litter had accumulated. *Dibamus taylori* was found at only two sites (both tropical semi-deciduous forest) in subterranean microhabitats. *D. taylori* presents an interesting case as it was the only specimen found during the study which is not a part of the south-east Asian assemblage. *D. taylori* is a lesser Sundanese species, inhabiting the seasonally drier areas of eastern Indonesia and New Guinea (Hallerman, 1998). Our *D. taylori* specimens conformed with anatomical characteristics of other populations in their range.

Thirteen species within four families of snake were recorded. Despite this high diversity, few species were recorded regularly, with the majority of observations made of single individuals. Three species measuring over a metre were found during the study: *Naja sputatrix*, *Pythas korros* and a large

unidentified colubrid. Snake records came almost entirely within tropical semi-deciduous and rain forests and their adjacent habitats. The most abundant and widespread species were: *Dendrelaphis pictus*, *Ramphotyphlops braminus*, *Lycodon aulicus capucinus* and *Lycodon subcinctus*. These, with the exception of *R. braminus*, are active foragers, which no doubt increases their detectability. *R. braminus* is the most ecologically distinct of NP's snakes, its ecology and morphology more closely resemble that of *D. taylori* than any of the other snake species. Specimens of this fossorial nocturnal snake were only found via microhabitat searches.

DISCUSSION

The results of this study form the most definitive herpetofauna list for the Nusa Penida group. Our recent fieldwork increases the known number of species present by 55%, and to date four anurans, 11 lizards and 14 snakes are known from NP. Indonesian herpetofauna in general is very poorly known and even the most intensively studied areas, such as Bali, are still underestimated in terms of diversity (McKay & Lilley, 2012). We expect future work to uncover the presence of more taxa on NP, and the use of traps and surveys in varying seasons would likely to be fruitful.

From our data we infer the composition of NP's herpetofauna to essentially be frogs adapted to xeric habitats, and close-canopy forest squamates. None of the taxa associated with relictual drier open woodland were recorded, such as *Python molurus* or *Psammophis condanarus*. This fits with our understanding of modern pre-agricultural NP as receiving low and highly seasonal rainfall, and being covered with tropical semi-deciduous and evergreen forest. In comparison with its close and grander neighbour Bali, NP is predictably a smaller subset with (one exception) the same fauna. Approximately half of Bali's squamates are known from NP (11 vs 21 lizards, 14 vs 32 snakes); and only a third of Bali's frogs (four vs 13 species). Amphibian diversity on NP is likely to have been historically depauperate, as the island receives significantly lower rainfall than mainland Bali, coupled with calcareous soil of little to no water holding ability, meaning streams run only for a



Figure 4. *D. pictus* consuming a *Polypedates leucomystax*, site 3. Photo by S Asad.

short period after heavy rainfall (McTaggart, 1989). Penida was the only wetland habitat found on the island, with other bodies of water being significantly smaller and of lesser quality. As such, the habitat is also unsuitable for freshwater turtles and none of the three turtles known from Bali are recorded on NP. We observe that many large forest snakes are notably absent on NP, species such as *Ptyas mucosa*, *Gonyosoma oxycephalum* and *Bungarus candidus*, and postulate that the size of NP is not great enough to support a richer assemblage of high-ranked predators. Scrutinising the fauna of Lombok absent from NP we find that taxa associated with the Lesser Sundas, including *Lamprolepis smaragdina*, *Cyrtodactylus darmandvillei*, *Ramphotyphlops polygrammicus* and *Coelognathus subradiatus* (de Lang, 2011; Mertens, 1930) have not colonised NP. The only exception is *D. taylori*, known from Lombok and further east, but not Bali. Biogeographic barriers in the faunal transition zone termed Wallacea have been much discussed (e.g. How et al., 1996b; Kitchener & Suyanto, 1996), and the effects of changes in sea level, sea beds, and land masses in the Sundas is complex and far from precisely known (see Auffenberg, 1980). That some taxa, including large mammals such as pygmy stegodonts, dispersed eastwards into the Lesser Sundas, yet reptiles of Lesser Sunda affiliation have almost entirely failed to disperse west beyond Lombok suggests climatic factors are more

important and/or these taxa have evolved in recent times, when the Lombok Strait has been an effective barrier (e.g. How et al., 1996a). The presence of *D. taylori* on NP is yet another demonstration of the region's complexity of biogeographic evolution.

Evidently the majority of areas on NP have been altered by past and present anthropogenic activity. Most habitats are secondary growth, few if any support primary vegetation. This lack of forest is attributed to felling activity initiated by convicts exiled to the island by the king of Bali more than four centuries ago, after which regrowth has been severely hindered by further felling, agricultural activity and the islanders' "slash and burn" farming practices (Giambelli, 1999). The result has been fragmentation of the island's former forests, with the remaining areas serving as biodiversity "islands" for NP's wildlife and housing the greatest remaining reptile and amphibian species richness. It is likely that they also harbour the richest caches of mammals and other vertebrate families. Therefore these reservoirs of diversity, in particular the sites at Karangari, Tembling, Pejукutan and Mundi, are of high value for conservation. However, quantifying species richness is only one way of calculating biodiversity, for example Schmidt et al. (2000) found NP populations of *E. multifasciata* to be the most genetically divergent within the Lesser Sundas. Generalist species occupying a wide range of habitats, such as *E. multifasciata*, *G. gekko* and *Cryptodactylus fumosus*, are a notable biomass and their management should not be ignored, as can be seen in the recent many-fold increase in *G. gekko* harvest for the medicine trade, a trend which easily results in local extinction (Caillabet, 2011).

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APPENDIX

A comprehensive list of herpetofauna species found on the Nusa Penida group. Compiled from field surveys and secondary research. *denotes taxa newly recorded by the 2011 survey.

Amphibia

Anura:

Bufonidae:

Duttaphrynus melanostictus

Microhylidae:

Kaloula baleata

Dicroglossidae:

*Fejervarya cancrivora**

Rhacophoridae:

*Polypedates leucomystax**

Reptilia

Squamata: Lacertilla

Dibamidae:

*Dibamus taylori**

Gekkonidae:

Cryptodactylus fumous

Gekko gecko

Gehyra mutilata

Hemidactylus frenatus

Hemidactylus platyurus

Scincidae:

Cryptoblepharus renschi

Eutropis multifasciata

*Eutropis rugifera**

Lygosoma bowringii

Varanidae:

Varanus salvator bivittatus

Squamata: Serpentes

Colubridae:

Ahaetulla prasina

*Boiga multomaculata**

*Coelognathus radiatus**

Dendrelaphis pictus

Lycodon aulicus capucinus

*Lycodon subcinctus**

*Pareas carinatus**

*Psammodynastes pulverulentus**

*Pytas korros**

Rhabdophis chrysargos

Crotalidae:

*Cryptelytrops albolabris**

Elapidae:

Naja sputatrix

Pythonidae:

Broghammerus reticulatus

Typhlopidae:

*Ramphotyphlops braminus**