

Research Article

**The land and mangrove snail fauna of the islands of Banggi and Balambangan (Mollusca: Gastropoda)**

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**ABSTRACT.** We studied land and mangrove snails at four sites (three of which were limestone outcrops) on the islands of Balambangan and Banggi, within the proposed Tun Mustapha Marine Park. Both locations have island faunas with a moderate number of species: we found a total of 56 true land snail species, plus 11 intertidal Ellobiidae and Truncatellidae. Of the 56 land snails, at least six are short-range endemics of the Kudat-Banggi-Balambangan-Balabac-Palawan region. In addition, several other species that occur here are rare or threatened. We conclude that the limestone outcrops of Banggi and Balambangan are essential to the survival of at least 12 Malaysian land snail species. In view of uncontrolled logging and possibility of planned mining of limestone, we highly recommend conserving limestone outcrops of both Banggi and Balambangan as part of land-based degradation prevention at the proposed Tun Mustapha Marine Park.

**Keywords:** Borneo, Pulmonata, endemism, limestone, karst, biogeography.

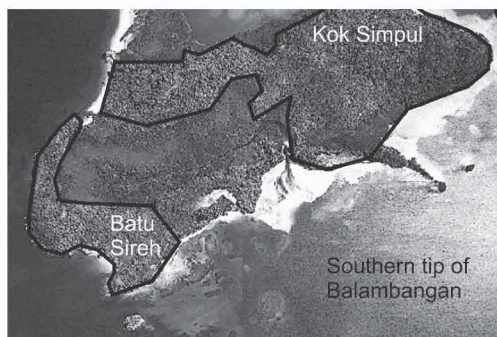
**INTRODUCTION**

In this paper, we report on a malacological survey of sites on the islands of Banggi and Balambangan (Sabah, Malaysian Borneo). Banggi and Balambangan are two relatively large islands (the former, measuring 440 km<sup>2</sup>, is Malaysia's largest island) off the north coast of Borneo. Both are linked to Borneo by a 40-m contour, and hence must have been connected with the mainland during recent glacial regressions. On the other hand, they are geographically close to Balabac and Palawan, and share faunal elements with these islands as well. In addition, the islands' limestone deposits are attractive from a malacological point of view, as calcareous soils are known to support dense land snail populations (Schilthuizen *et al.*, 2003; Liew *et al.*, 2008).

On Banggi, the limestone is restricted to a few low outcrops at the southern tip of the island, south of the village of Karakit. It is presumably this locality that was visited by Mr. A. Everett in the 1890s, and is the type-locality of some of the snails described by Mr. E. A. Smith from "Banguay" (=Banggi), e.g.,

*Everettia bangueyensis*, *Georissa bangueyensis* and *Lagochilus bangueyensis* (Smith, 1895). Today, the vegetation is very degraded. A strip of dry primary coastal forest exists on the cliffs at the seaside, but most vegetation elsewhere on the hill (including the lower parts of the Karakit Virgin Jungle Reserve) has disappeared due to fire and encroachment brought on by shifting cultivation (see also Sabah Forestry Department, 2002); only at the summit of the hill (the upper part of the VJR) the limestone rocks and boulders are still under some canopy cover.

The limestone on Balambangan is more extensive, occurring in two localities (Figure 1; Ali *et al.*, 2008) on the southern peninsula, inside the Balambangan Class I Forest Reserve (Sabah Forestry Department, 2002): (1) coastal limestone cliffs with caves on the west, named "Siburungei" in Francis (1987) and "Tanjung Kalutan" in Lim & Kiew (1997), but referred to below as "Batu Sireh" and (2) the cliffs on a promontory known as "Kok Simpul" on the northeast of the peninsula. Another large limestone area is said to occur at "Tanjung Timohing" (7°17'30"N; 116°54'30"E) on the northwestern coast of Balambangan (Yin, 1985; Lim & Kiew, 1997), but was not visited for the present report. It was also not mentioned in a recent paper on Balambangan's geoheritage (Ali *et al.*, 2008).



**Figure 1.** Aerial photograph (undated; several decades old) of the limestone outcrops (outlined in black) of Batu Sireh and Kok Simpul on the southern portion of the island of Balambangan.

## MATERIALS AND METHODS

The material reported in this paper was collected at four sites (two on each island) during eight separate visits, as follows:

A. Pulau Banggi, limestone hills south of Karakit, covered with very dry primary and secondary forest (GPS-derived coordinates: 7°06'32"N; 117°05'07"E):

- 1) 19 April 1987, *leg.* J.J. Vermeulen,
- 2) February 2001, *leg.* Mustafa Abd. Rahman (reconnaissance trip for May 2001 Universiti Malaysia Sarawak Pulau Balambangan expedition), and
- 3) 12 April 2002, *leg.* J.J. Vermeulen & M. Schilthuizen.

B. Pulau Banggi, foot of Bukit Sinambung, primary forest (GPS-derived coordinates: 7°18.043'N 117°5.016'E), Pulau Banggi Scientific Expedition:

- 4) 25 July - 2 August 2003, *leg.* Noraini Nasaruddin (Universiti Malaysia Sabah), and
- 5) 24 July - 1 August 2003, *leg.* Maklarin Lakim (Sabah Parks).

C. Pulau Balambangan, Batu Sireh, near-coast limestone crest with old coastal woodland with large cycads (Fig. 1; GPS-derived coordinates: 7°12'29"N; 116°51'30"E):

- 6) 13 April 2002, *leg.* J.J. Vermeulen & M. Schilthuizen, and
- 7) 20-29 May 2003, *leg.* Paul Imbun (Sabah Parks).

D. Pulau Balambangan, Kok Simpul, near-coast limestone crest with very dry primary forest (Fig. 1; GPS-derived coordinates: 7°13'03"N; 116°53'14"E):

- 8) 13 April 2002, *leg.* J.J. Vermeulen & M. Schilthuizen.

Sampling was carried out by closely searching the soil, leaves and branches of trees, rocks and logs for living snails and empty shells, as described in Schilthuizen (2003). We also took several litres of forest litter and soil, which were sieved, flotated and further searched under a dissection microscope in a

laboratory. During visits 3 and 6, we also collected debris from the shoreline, which yielded shells of intertidal snails probably living in nearby mangroves.

All collected material was cleaned and stored dry (in the case of empty shells) or in 70% ethanol (in the case of individuals that were collected alive). Species identifications were carried out on the basis of Vermeulen *et al.* (in prep.), the UMS *BORNEENSIS* land snail collection, and the private collection of J.J. Vermeulen. Undescribed or unrevised species were given several types of provisional names. "Sp. BO-##" refers to a recognised and known species of a genus that has not been revised yet; it may or may not have been described already. "V####" refers to a presumably undescribed species of which a reference sample is kept in the collection of J.J. Vermeulen; the number is the Vermeulen collection number. Finally, species of unrevised genera that have yet to be given any of the above provisional names are referred to with "sp. #" and/or a particular shell characteristic in quotation marks. All material has been deposited in collections of Sabah Parks (reference numbers SP 12276-12310), *BORNEENSIS*, and J.J. Vermeulen (Leiden).

## RESULTS

We identified 67 species, but the genus *Microcystina* (which in most areas contains 2 - 5 species) has not yet been completely sorted to species level; the total will thus be close to 70 species. In the list of collected material (Table 1), we have combined all localities into just two categories: Banggi and Balambangan. In addition, we present an indication of the degree of endemism, ranging from "1" for short-range endemics, to "5" for species with wide (global or pantropical) distribution. Finally, some biogeographic detail is given as follows: w, a widespread Southeast-Asian species; b, a species from Borneo; p, a species from the Philippines; c, a widespread coastal species; e, a species endemic to the Kudat-Banggi-Balambangan-Balabac-Palawan area; s, a species endemic to the western Sulu archipelago; and i, an introduced species.

## DISCUSSION

When we exclude the 11 intertidal ellobiids and truncatellids, we are left with a total of 56 true land snails. Compared with calcareous areas of the same size that have been surveyed with a similar collecting effort (Vermeulen & Schilthuisen, unpublished data), this diversity is moderate, and typical for island faunas in general. The lack of species appears to be particularly concentrated in the "prosobranch" families Diplommatinidae and Hydrocenidae, which could be due to the fact that prosobranchs are less tolerant of dry and disturbed coastal conditions than pulmonates (see Schilthuisen *et al.*, 2002, 2005).

Several species were found that clearly represent Philippine elements, as their main area of distribution is there; *i.e.*, *Aphanoconia trichroa*, *Amphidromus adamsi adamsi*, and *Videna repanda*. Other species are narrowly endemic to the island region of Palawan, Balabac, Banggi, Balambangan, and the northern tip of the Kudat peninsula, namely: *Japonia* sp. 1, *Japonia* sp. 2 "flat", *Japonia balabacensis*, *Platyraphe bongaoensis*, *Arinia boreoborneensis*, and *Cochlostyla trailii*. The latter species (Figure 2) is a new record for Malaysia, although the related *C. satyrus*, recorded for Banggi by Smith (1895) may well refer to this species. Overall, we have the impression that while the land snail fauna of Banggi is very similar to that of mainland north Borneo, the malacofauna of Balambangan shows signs of a stronger influence from the Philippines. However, this will need further substantiation.

Apart from these narrowly-endemic elements, the Banggi and Balambangan fauna included several species that are rarely seen, such as *Opisthostoma telestoma*, for which the only other known locality is the limestone hill of Pun Batu in Sabah's interior province. Another example is *Diaphera wilfordi wilfordi*, which elsewhere in Sabah only occurs on a limestone outcrop at the Tabin Wildlife Reserve (Schilthuisen & Vermeulen, 2003).

**Table 1.** A list of land and mangrove species found on Banggi and Balambangan. Range size classes are as follows: "1" site endemics; "2", local endemic (range size less than one third of Borneo); "3" endemic to Borneo, but with a range size larger than one-third of the island; "4" widespread Southeast Asian species; "5" species with global or pantropical distribution. Biogeographic categories are as follows: w, a widespread Southeast-Asian species; b, a species from Borneo; p, a species from the Philippines; c, a widespread coastal species; e, a species endemic to the Kudat-Banggi-Balambangan-Balabac-Palawan area; s, a species endemic to the western Sulu archipelago; and i, an introduced species.

No.	Pulm./Proso.	Family	Genus	Species	Author and year	Range	Banggi	Bal-amb.	Bio-geogr.
1	Prosobranchia	Assimineidae	<i>Assiminea</i>	<i>nitida</i>	(Pease 1868)	4	+		w
2	Prosobranchia	Cyclophoridae	<i>Alycaeus</i>	<i>jagori</i>	Martens 1859	4		+	w
3	Prosobranchia	Cyclophoridae	<i>Japonia</i>	sp.2 "flat"		1	+		e
4	Prosobranchia	Cyclophoridae	<i>Japonia</i>	<i>balabacensis</i>	(Smith 1895)	2	+	+	e
5	Prosobranchia	Cyclophoridae	<i>Japonia</i>	sp.1		1		+	e
6	Prosobranchia	Cyclophoridae	<i>Japonia</i>	<i>jucunda</i>	(Smith 1893)	3	+	+	b
7	Prosobranchia	Cyclophoridae	<i>Japonia</i>	<i>borneensis</i>	(Smith 1893)	3	+		b
8	Prosobranchia	Cyclophoridae	<i>Leptopoma</i>	<i>sericatum</i>	(Pfeiffer 1851)	4		+	w
9	Prosobranchia	Cyclophoridae	<i>Leptopoma</i>	<i>pelucidum</i>	Grateloup 1840	4	+	+	w
10	Prosobranchia	Cyclophoridae	<i>Platyrhapha</i>	<i>bongaensis</i>	(Smith 1894)	2		+	s
11	Prosobranchia	Cyclophoridae	<i>Pterocyclos</i>	<i>tenuilabatus</i>	(Metcalfe 1851)	3	+	+	b
12	Prosobranchia	Cyclophoridae	<i>Pterocyclos</i>	<i>trusanensis</i>	(Godwin Austen 1889)	3	+	+	b
13	Prosobranchia	Cyclophoridae	<i>Arinia</i>	<i>stenotrochus</i>	Vermeulen 1996	3	+		b
14	Prosobranchia	Diplommatinidae	<i>Arinia</i>	<i>boreoborneensis</i>	Vermeulen 1996	2		+	e
15	Prosobranchia	Diplommatinidae	<i>Diplommatina</i>	<i>recta</i>	Smith 1895	3		+	b
16	Prosobranchia	Diplommatinidae	<i>Opisthostoma</i>	<i>cf. obliquedentatum</i>	Vermeulen 1994	2		+	b
17	Prosobranchia	Diplommatinidae	<i>Opisthostoma</i>	<i>concinnum</i>	Fulton 1901	2	+		b
18	Prosobranchia	Diplommatinidae	<i>Opisthostoma</i>	<i>telestoma</i>	Vermeulen 1991	2	+		b
19	Prosobranchia	Helicinidae	<i>Aphanocoma</i>	<i>trichroa</i>	(Wagner 1905)	3	+	+	p
20	Prosobranchia	Hydrocenidae	<i>Georissa</i>	<i>bangueyensis</i>	Smith 1895	2	+	+	b
21	Prosobranchia	Truncatellidae	<i>Truncatella</i>	<i>guerinii</i>	Villa 1841	4	+	+	c
22	Pulmonata	Achatinellidae	<i>Elasmias</i>	<i>globulosum</i>	Quadrass & v. Möll.	4		+	w
23	Pulmonata	Achatinidae	<i>Achatina</i>	<i>fulica</i>	(Bowdich)	5	+	+	i
24	Pulmonata	Ariophantidae	<i>Macrochlamys</i>	<i>tersa</i>	(Issel 1874)	4		+	w
25	Pulmonata	Ariophantidae	<i>Macrochlamys</i>	sp.	(Lea 1841)	3		+	b
26	Pulmonata	Ariophantidae	<i>Hemiplecta</i>	<i>humphreysiana</i>		4	+	+	w
27	Pulmonata	Ariophantidae	<i>Quantula</i>	sp.		?		+	?
28	Pulmonata	Ariophantidae	<i>Everettia</i>	sp.4		3	+		B
29	Pulmonata	Ariophantidae	<i>Microcystina</i>	sp. BO-01		?	+		?



30	Pulmonata	Ariophantidae	<i>Microcystina</i>	sp.	(v.Möllendorff 1885)	?	+	?
31	Pulmonata	Ariophantidae	<i>Microcystina</i>	<i>sinica</i>	Ferussac 1821	4	+	w
31	Pulmonata	Bradybaenidae	<i>Bradybaena</i>	<i>similaris</i>	(Pfeiffer 1855)	5	+	i
32	Pulmonata	Bradybaenidae	<i>Cochlostyla</i>	<i>trilii</i>	(Reeve 1848)	2	+	e
33	Pulmonata	Camaenidae	<i>Anphidromus</i>	<i>adamsi</i>	(Smith 1894)	3	+	p
34	Pulmonata	Camaenidae	<i>Chloritis</i>	<i>sibutuensis</i>	(v.Möllendorff 1888)	4	+	s
35	Pulmonata	Charopidae	<i>Discocharopa</i>	<i>aperta</i>	(Aldrich 1889)	4	+	w
37	Pulmonata	Endodontidae	<i>Philalanka</i>	<i>kusana</i>	(Mousson 1865)	4	+	w
38	Pulmonata	Euconulidae	<i>Kaliella</i>	<i>microconus</i>	(Cox 1872)	4	+	w
39	Pulmonata	Euconulidae	<i>Kaliella</i>	<i>scandens</i>	(Pfeiffer 1846)	5	+	w
41	Pulmonata	Euconulidae	<i>Kaliella</i>	<i>doliolum</i>	(Smith 1894)	2	+	c
41	Pulmonata	Helicarionidae	<i>Geotrochus</i>	<i>bongaoensis</i>	(v.Möllendorff 1894)	4	+	s
42	Pulmonata	Helicodiscidae	<i>Stenopylis</i>	<i>coarctata</i>		4	+	c
43	Pulmonata	Rhytididae	<i>Macrocycloides</i>	sp. "V2877"		3	+	b
44	Pulmonata	Rhytididae	<i>Macrocycloides</i>	<i>densesculpta</i>	Rensch 1932	4	+	c
45	Pulmonata	Streptaxidae	<i>Gulella</i>	<i>bicolor</i>	(Hutton 1834)	5	+	i
46	Pulmonata	Streptaxidae	<i>Diaphera</i>	<i>wilfordi</i>	(Dance 1970)	3	+	b
47	Pulmonata	Subulinidae	<i>Allopeas</i>	<i>gracile</i>	(Hutton 1834)	5	+	i
48	Pulmonata	Subulinidae	<i>Subulina</i>	<i>octona</i>	(Bruguère 1789)	5	+	i
49	Pulmonata	Trochomorphidae	<i>Videna</i>	<i>metcalfei</i>	(Pfeiffer 1845)	4	+	w
50	Pulmonata	Trochomorphidae	<i>Videna</i>	<i>bicolor</i>	(Martens 1864)	4	+	w
51	Pulmonata	Trochomorphidae	<i>Videna</i>	<i>repanda</i>	(v.Möllendorff 1890)	3	+	p
52	Pulmonata	Vertiginidae	<i>Gastrocopta</i>	<i>avanica</i>	(Benson 1863)	4	+	c
53	Pulmonata	Vertiginidae	<i>Nesopupa</i>	<i>moreleti</i>	(Brown 1870)	4	+	c
54	Pulmonata	Vertiginidae	<i>Nesopupa</i>	<i>malayana</i>	(Issell 1874)	4	+	w
55	Pulmonata	Vertiginidae	<i>Pychopatula</i>	<i>orcula</i>	(Benson 1850)	4	+	b
56	Pulmonata	Vertiginidae	<i>Acinolaemus</i>	sp.		2	+	b
57	Pulmonata	Vertiginidae	<i>Systemostoma</i>	sp. BO-01		2	+	c
58	Pulmonata	Ellobiidae	<i>Cassidula</i>	<i>multiplicata</i>	(Martens 1865)	4	+	c
59	Pulmonata	Ellobiidae	<i>Microtralia</i>	<i>alba</i>	(Gassies 1865)	4	+	c
60	Pulmonata	Ellobiidae	<i>Laemodonta</i>	<i>typica</i>	(H. & A. Adams 1853)	4	+	c
61	Pulmonata	Ellobiidae	<i>Laemodonta</i>	<i>monilifera</i>	(H. & A. Adams 1853)	4	+	c
62	Pulmonata	Ellobiidae	<i>Coilostele</i>	<i>inquirenda</i>	Rensch 1935	4	+	c
63	Pulmonata	Ellobiidae	<i>Ellobium</i>	<i>aurisjudae</i>	(Linnaeus 1758)	4	+	c
64	Pulmonata	Ellobiidae	<i>Pythia</i>	<i>scarabeus</i>	Linnaeus 1758	4	+	c
65	Pulmonata	Ellobiidae	<i>Blauneria</i>	<i>quadrasi</i>	v.Möllendorff 1895	4	+	c
66	Pulmonata	Ellobiidae	<i>Melampus</i>	<i>pulchellus</i>	(Petit 1842)	4	+	c
67	Pulmonata	Ellobiidae	<i>Melampus</i>	<i>lividus</i>	(Deshayes)	4	+	c

In view of the fact that limestone on the Kudat peninsula seems to have disappeared due to quarrying (Schilthuizen, unpublished observations), Banggi and Balambangan form the only remaining localities in Malaysia for at least nine land snail species (*viz.*, *Amphidromus adamsi adamsi*, *Videna repanda*, *Japonia* sp. 1, *Japonia* sp. 2 “flat”, *Japonia balabacensis*, *Platyraphe bongaoensis*, *Arinia boreoborneensis*, and *Cochlostyla trailii*). Three more species occur at only one other Malaysian locality (*viz.*, *Aphanoconia trichroa*--also found at the Mantanani islands, *Opisthostoma telestoma*, and *Diaphera wilfordi wilfordi*). It may thus be concluded that the limestone outcrops of Banggi and Balambangan are essential for the survival of at least 11 Malaysian land snail species.

We have shown elsewhere (Schilthuizen *et al.*, 2005) that a thick vegetation cover is essential for the stability of malacofauna at limestone outcrops in Sabah. During our 2002 visit to Banggi and Balambangan, we encountered severely degraded vegetation in a number of places. Encroachment due to shifting cultivation and small-scale logging had damaged the vegetation of the Virgin Jungle Reserve on the Banggi outcrop, whereas

large-scale and presumably illegal logging had taken place around Kok Simpul. In addition, rumours have been circulating for several years of planned limestone quarrying on Balambangan (Ali *et al.*, 2008). We wish to conclude by pronouncing the hope that, as part of measures to prevent land-based degradation of the proposed Tun Mustapha Marine Park, quarrying will be forbidden and the ban on logging in the forest reserves will be enforced.

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**Figure 2.** *Cochlostyla trailii*, a remarkable species of Balambangan (shell height c. 3 cm), and new to Malaysia (photo: Liew Thor-Hui).

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