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Community-driven survey of land snails in three communal conservation areas in East Kwaio, Malaita, Solomon Islands

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Abstract. In collaboration with the Kwainaa'isi Cultural Centre and Baru Conservation Alliance, we undertook a survey of the land snails of East Kwaio, Malaita, Solomon Islands with emphasis on the species inventory of land snails in three communal conservation reserves. This report is based on three visits to the region in April 2019 and November 2023. We conducted collective visual searches at five main survey sites recording 36 species of land snails based on morphological examinations. We collected 186 sample vouchers that are deposited in the malacological collection of the Australian Museum as resource for on-going taxonomic research aimed at an enhanced documentation of the land snail fauna of Malaita. Considering an inevitable sampling bias, we conclude that the land snail faunas of all three conservation sites are rather similar and that collectively the three reserves contain a representative fraction of the overall land snail diversity in central Malaita. Therefore, the reserves fulfil their intended role of preserving Malaita's land snail species for the future.

Introduction

The Solomon Islands consist of six large (>500 km^2) and more than 900 smaller islands to the southeast of Papua New Guinea. The land snail fauna of this archipelago has only recently been catalogued more comprehensively by Delsaerdt (2010; 2012; 2016) in a small series of books, which summarize the taxonomic accounts and descriptions of taxa that are scattered through the taxonomic literature published over the course of nearly two centuries. Owing to the lack of modern study, however, our concepts of many species are largely hypothetical as they are frequently known from historical shell-based accounts only, which often were

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based on specimens of vague or uncertain provenance.

The land snails of Malaita have received particularly little attention due to a substantial lack of survey effort in the past. Only few reports have dealt with more systematic collections of specimens on Malaita, such as the work of Clapp (1923) based on collections undertaken by Mann in 1916 as well as Clench (1941), whose studies were largely based on collections undertaken between 1920 and 1941 by the Whitney South Sea Expedition of the American Museum.

According to Clench (1941), Mann collected in Auki (8° 52' S, 160° 48' 30" E), Fourati (8° 35' S, 160° 50'E), and Atta [Ata] (8° 31' S, 160° 55' E) while participants of the Whitney South Sea Expedition collected in Auki, Aurola [Arorla] (8° 58' S, 161° 05' E), Kwarambara (8° 57' S, 161° 06' E), Maramasiki (8° 30' S, 161° 30' E), Su'u (9° 13' S, 161° 02' E) and Ulimburi (8° 57' S, 161° 06' E) [all coordinates approximate]. Some of these historical localities, such as Aurola, Kwarambara, and Ulimburi, are in proximity of the current study area (Fig. 1).

Neither Clapp (1923) nor Clench (1941) provided systematically comprehensive accounts of all land snails, however. Clench (1941) focused only on three families reporting nine species of 'placostylids' (now family Bothriembryontidae) from Malaita. However, this high number of species may be e result of taxonomic over-splitting that is fueled by the conchological variation typical for the species in this family. Additional, opportunistic species records from Malaita were subsequently published by Clench (1965, 1966).

The comparatively poor knowledge of biodiversity patterns in Malaita more generally (refer to Callaghan *et al*., 2019 for the avifauna; Alabai *et al*., 2020 for frogs; Lavery *et al*., 2020 for mammals) stands in sharp contrast to the growing anthropogenic pressures the island is facing. Supporting the highest human population density in the Solomon Islands, most primary forest had been replaced by rotating subsistence gardens and secondary growth that occupies vast swathes of land even in the island's interior (Callaghan *et al*., 2019). In some locations these gardens may be several hundred years old, as recorded by the Whitney expedition (Mayr, 1931). Substantial loss of the remaining forest is currently occurring due to timber harvesting, which has resulted in rapid deforestation. In addition to the impact that deforestation is having on natural ecosystems, there is ongoing pressure from timber harvesting and urban development (Callaghan *et al*., 2019). These threats are particularly worrying for people who seek to maintain their traditional culture. To support sustainable land use practices, several groups have established cultural centers as an initiative to maintain traditional practices (Esau & Kekubata, 2018). One of these cultural centers in Malaita is the Kwainaa'isi Cultural Centre, which is teaching traditional activities, establishing sustainable conservation-based income streams and restoring peace amongst groups that have experienced conflict in the past (Esau, 2018).

One important initiative of the Kwainaa'isi Cultural Centre was to initiate the creation of conservation reserves by customary landowners to protect mammalian species which had been seen in the highlands of Malaita, but which had previously been thought to be extinct (Lavery *et al*., 2020). Customary landowners from four adjacent tribes then formed the 'Baru Conservation Alliance' to coordinate conservation activities which utilize both traditional knowledge and western science. With philanthropic support, the Kwainaa'isi Cultural Centre and Baru Conservation Alliance facilitated collaborative work of local landholders and visiting scientists from the Australian Museum to document faunistic values of these local reserves. The Australian Museum Ornithology group was the first to partner with Kwainaa'isi Cultural Centre in conducting an avifaunal survey in Kwaio Customary land (Callaghan *et al*., 2019), which was followed by a herpetological survey (Alabai *et al*., 2021) and a first survey of terrestrial invertebrates, which was conducted in 2019, whose malacological results are documented herein.

The partnership of the Australian Museum, the Kwainaa'isi Cultural Centre and Baru Conservation Alliance presented an outstanding opportunity to determine how effective the newly established Baru Conservation Alliance conservation reserves are in preserving faunistic habitats that harbor a representative fraction of the native fauna of Malaita. The aims of the study were (1) to document the land snail assemblages present in each of three conservation reserves designated by local communities and (2) to assess their complementarity.

Material and methods

Terrestrial snails were visually searched at selected survey sites by a group of people (teams of between 10-20) for about two hours each, who inspected lower parts of the tree canopy, the surface of tree trunks, undergrowth, and leaf litter for

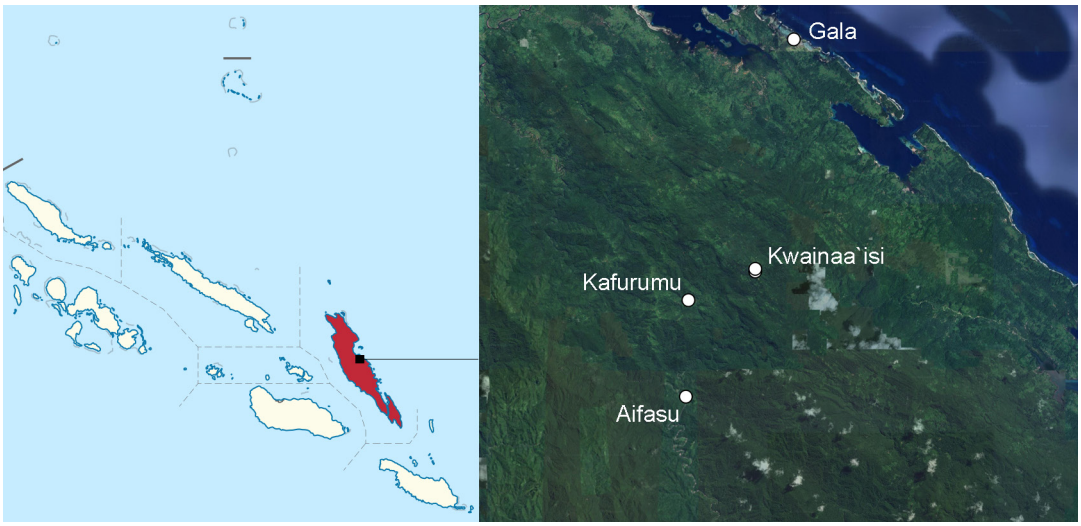

Figure 1. Map showing location of survey sites.

snails. All collected specimens have been deposited in the malacological collection of the Australian Museum, Sydney (AM) as a resource for taxonomic research.

These searches focused on five survey sites (Fig. 1):

1. Gala Island, near Atoifi. Centre of plot: 8.8581 S, 161.026 E. Littoral rainforest patch and adjacent mangroves; close to gardens. Visited: 13 April 2019.
2. Kwainaa`isi communal conservation area. Centre plot: 8.947 S, 161.011 E. Secondary rainforest, abandoned gardens; elevation approx. 950 m. Visited: 15 April 2019, 5 November 2023.
3. Kwainaa`isi cultural village, path to Kafurumu. Centre of plot: 8.946 S, 161.011 E. Secondary rainforest on flood plain, abandoned gardens; elevation approx. 930 m. Visited: 17 April 2019.
4. Kafurumu communal conservation area. Centre of plot: 8.958 S, 160.985 E, Secondary riparian rainforest. Visited 2019 and 2023; elevation approx. 470 m. Visited: 18 April 2019.
5. Aifasu communal conservation area. Centre of plot: 8.995 S, 160.984 E. Primary rainforest along river; elevation approx. 320 m. Visited: 19 April 2019.

Pairwise community similarity among sites was calculated using the Sørensen–Dice index (Sørensen, 1948) based on presence–absence data by implementing the Bray–Curtis dissimilarity (Legendre & Legendre, 2012) in the R script 'vegan' (Oksanen *et al*., 2024).

To account for differences in species richness among sites, Sørensen dissimilarity was partitioned into turnover and nestedness components following Baselga (2010), allowing separation of species replacement from richness-driven differences.

Results

The collection site 1 (Gala Island) was a garden near the coast just below sea level. Samples were only opportunistically collected at this site. Two species of terrestrial snail were found, *Pythia scarabaeus* (Linnaeus, 1758) and *Omphalotropis nebulosa* Pease, 1872. However, the main emphasis of the project was to survey sites in each of the three communal reserves, which are referred to as Kwainaa'isi (site 2), Kafurumu (site 4), and Aifasu (site 5) in the following (Fig. 1, Table 1). Another site that was sampled only opportunistically was site 3. The species inventory of this site was therefore not analysed.

The reserve in Kwainaa'isi was visited twice in 2019 and 2023 whereas the reserves in Kafurumu and Aifasu were each visited only once in 2019. Overall, we found 36 species representing 14 families in all three reserves. The number of recorded species per reserve varied only slightly between 22 (Aifasu) and 20 (Kwainaa`isi).

Species similarity among sites was quantified using the Sørensen–Dice index based on presence–absence data. Pairwise similarities ranged from 0.51 to 0.59, indicating moderate overlap in species composition (Table 2). Partitioning of Sørensen dissimilarity following Baselga (2010) showed that turnover accounted for more than 94% of total β-diversity in all pairwise comparisons, indicating that sites host distinct faunal assemblages rather than richness-driven subsets (Table 2).

In the following systematic comments are provided on a family-by-family basis, where necessary or useful.

Order Hypsogastropoda

Family Assimineidae

Terrestrial assimineids of the subfamily Omphalotropidinae are represented by four species (Fig. 2B-E). One is *Nesopoma eyerdami* Clench, 1958, a species originally described from Su'u, Malaita (Clench, 1958). The second one is *Setaepoma hoodi* Clench, 1965, a species originally described from Guadalcanal (Clench, 1965). This is the first record of this taxon from Malaita. In addition, we found *Omphalotropis nebulosa* and a presumably undescribed species of *Omphalotropis* that is distinguished from the former by its larger size. *Omphalotropis nebulosa* was found near the coast as well as in Aifasu. A presumably undescribed species of *Omphalotropis* was also found in Aifasu (Fig. 2E).

Order Architaenioglossa

Family Cyclophoridae

A single species, *Leptopoma perlucidum* (Grateloup, 1840), has been recorded in all three reserves. The identification of this species is tentative following the currently accepted taxonomic classification. As presently delineated, this species is widespread through the Philippines, Borneo, and northern Australia. It includes several nominal taxa that are treated as junior synonyms, such as *Cyclostoma pellucidum* Hombron & Jacquinot, 1848, originally described from the Solomon Islands (Hombron & Jacquinot, 1842-1854). The name *Leptopoma pellucidum* is available for populations from the Solomon Islands should these be found to represent a distinct species.

Family Diplommatinidae

Three presumably undescribed species of diplommatinids have been recorded during our surveys. These species found in Malaita are provisionally placed in the genera *Palaina* and *Diplommatina* consistent with the current classification of other species described from the Solomon Islands. However, molecular phylogenetic evidence suggests that at least two of these species may represent an undescribed genus (Köhler 2024). Generally, diplommatinids display high levels of endemism. While eight species have been recorded from the Solomon Islands so far, no species has yet been recorded from Malaita (Delsaerdt, 2016). This circumstance renders it likely that the species from Malaita are undescribed. Clarification of this matter requires further comparative examinations.

Family Pupinidae

Two species of pupinids, *Pupina keraudrenii* Vignard, 1829 and *P. huntingtoni* Clench, 1949, have been recorded during our surveys (Fig. 2A). These species are also known to occur on several other islands, such as Guadalcanal (Delsaerdt, 2016).

Order Cycloneritida

Family Helicinidae

Summarizing the taxonomic literature on helicinids, Delsaerdt (2016) concluded that helicinid species from the Solomon Islands are difficult to identify and plagued by an unstable taxonomy. We distinguished three potential

Table 1. Land snail inventory of the three communal conservation areas in Kwaio, Malaita.

Family	Species	Kwainaa'isi	Kafurumu	Aifasu
Assimineidae	*Omphalotropis nebulosa*	+	—	+
	Omphalotropis sp.	—	—	+
	Setaepoma hoodi	—	+	+
	Nesopoma eyerdami	—	—	+
Achatinidae	*Allopeas gracile*	+	+	—
	Subulina octona	—	—	+
Bothriembryontidae	*Eumecostylus macfarlandi*	+	—	—
	Eumecostylus malaitaensis	—	—	+
	Eumecostylus ophir	—	+	+
	Eumecostylus hargravesi	+	+	+
Camaenidae	*Chloritis eustoma*	+	+	—
	Crystallopsis balcombei	+	+	+
	Papuina motacilla	—	—	+
Cyclophoridae	*Leptopoma perlucidum*	+	+	+
Diplommatinidae	*Palaina* sp. A	—	—	+
	Palaina sp. B	—	+	—
	Diplommatina sp. C	—	+	+
Ellobiidae	*Pythia* sp.	—	+	
	Pythia pyramidata	—	—	+
Helicarionidae	*Sitalarion planospira*	+	+	+
Helicinidae	*Palaeohelicina egregia*	+	+	+
	Palaeohelicina sp. 'hairy'	+	+	+
Microcystidae	Microcystidae sp.	+	—	+
Pupinidae	*Pupina keraudrenii*	+	+	—
	Pupina huntingtoni	+	—	—
Rhytididae	*Ouagapia villandrei*	+	—	—
Succineidae	*Succinea simplex*	—	+	+
Trochomorphidae	*Orpiella* sp. 1	+	+	—
	Orpiella sp. 2	+	—	+
	Orpiella sp. 3	—	+	—
	Orpiella sp. 4	—	+	—
	Orpiella sp. 5	+	—	+
	Trochomorpha henschei makaensis	+	+	+
	Trochomorpha mcleani	+	—	+
	Trochmorpha sp.	+	+	—
	Dendrotrochus helicinoides	—	+	—

Table 2. Comparison of similarity, turnover (β-SIM), and nestedness (β-SNE) of species compositions between the three survey sites after Sørensen (1948) and Baselga (2010).

Comparison	Sørensen similarity	Turnover	Nestedness
Kwainaa'isi – Kafurumu	0.585	0.4	0.015
Kwainaa'isi – Aifasu	0.571	0.4	0.029
Kafurumu – Aifasu	0.512	0.476	0.012

species of *Palaeohelicina* Wagner, 1905 among the samples collected during our surveys. The identification of these samples is not easy for the lack of previous records of helicinids from this island. Clench (1958) described *Palaeohelicina mayri* Clench, 1958 from Auki for having a more depressed shell than other species in the genus, and for the lack of a spiral colour band.

However, it remains possible that *P. mayri* is a synonym of more widespread and similar taxa, such as *P. livida* (Hombron & Jacquinot, 1848) or *P. egregia* (Pfeiffer, 1855). One of the species collected here is consistent with the description of *P. mayri* (Fig. 3F). We also collected a species whose shell is covered with periostracal setae, which we cannot readily connect to any currently accepted name (*Palaeohelicina* sp. 'hairy'). The third species is characterized by being of smaller size (*Palaeohelicina* sp. 'small').

Order Stylommatophora

Family Bothriembryontidae

Species of this family were previously placed in Bulimulidae by Clench (1941) and in Placostylidae by Delsaerdt (2010). The classification of some Solomon Island taxa has recently been revised by Salvador *et al*. (2023). Accordingly, all species known from Malaita are now placed in the genus *Eumecostylus* (Bothriembryontidae). Among the samples

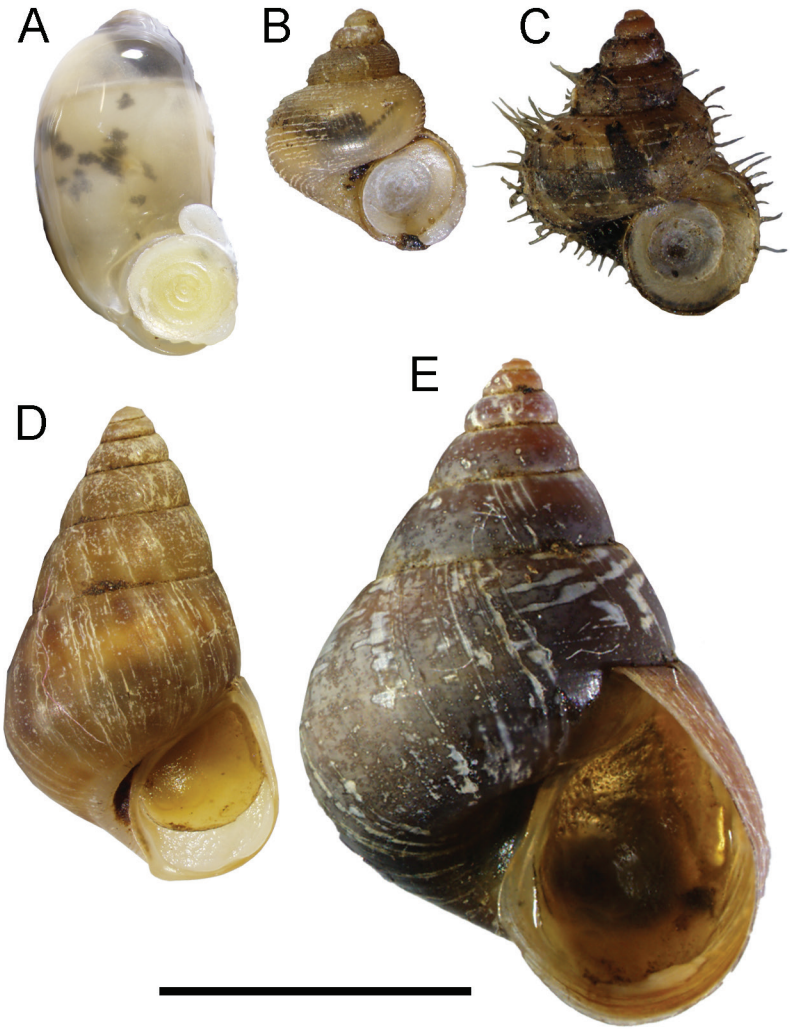

Figure 2. Representative specimens of Pupinidae and Assimineidae. A. *Pupina keraudrenii* AM C.557184. B. *Nesopoma eyerdami* AM C.557138. C. *Setaepoma hoodi* AM C.557139. D. *Omphalotropis nebulosa* AM C.557165. E. *Omphalotropis* sp. AM C.557137. Scale bar = 5 mm.

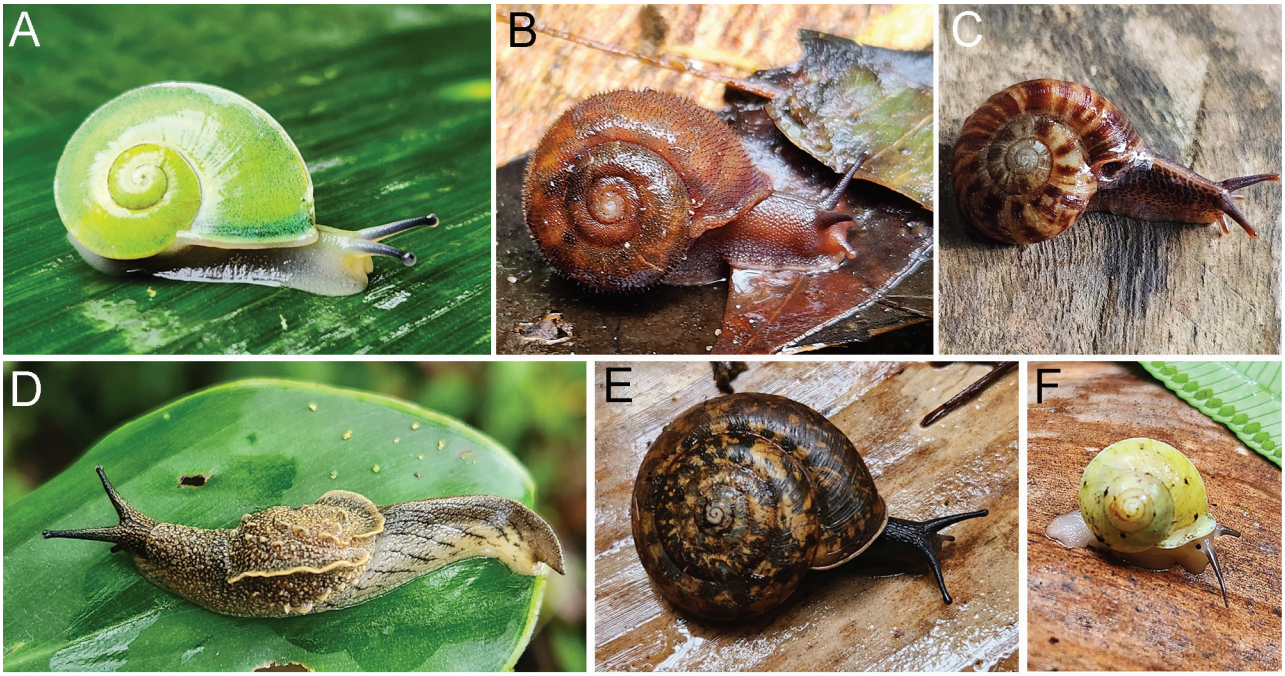

Figure 3. Larger living snails. A. *Crystallopsis balcombei* (Camaenidae). B. *Chloritis eustoma* (Camaenidae). C. *Ouagapia villandrei* (Rhytididae). D. *Sitalarion planospira* (Helicarionidae). E. *Trochomorpha mcleani* (Trochomorphidae). E. *Palaeohelicina* sp. (Helicinidae). Not to scale.

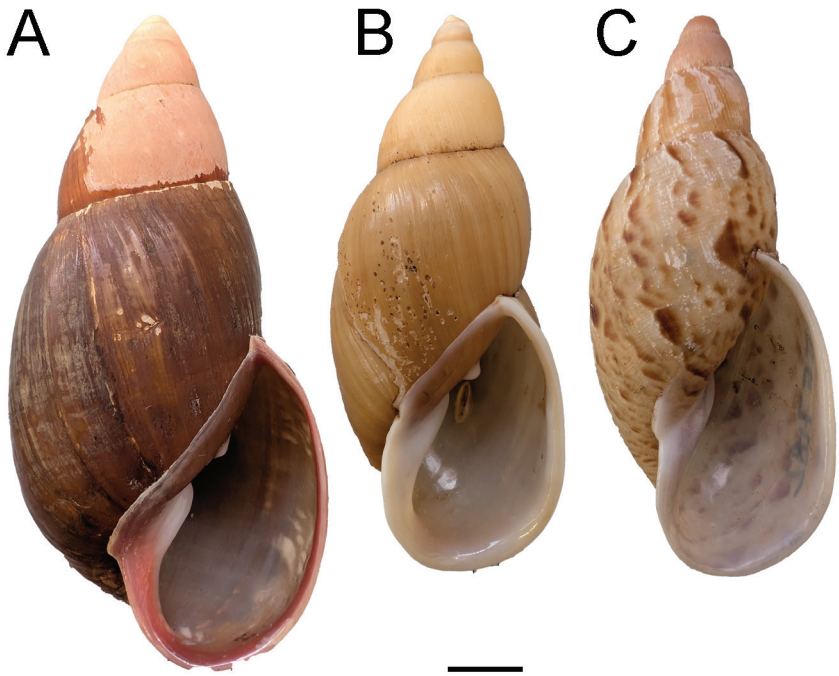

Figure 4. Representative specimens of Bothriembryontidae. A.*Eumecostylus macfarlandi* AM C.557190. B. *Eumecostylus ophir* AM C.557156. C. *Eumecostylus hargravesi* AM C.557182. Scale bar = 10 mm.

we collected, we can clearly distinguish three species based on shell characters (Fig. 4). The classification of bothriembryontids in the Solomon Islands is messy as several nominal species were described with imprecise locality information. Because the variation of shell features can be substantial within species, some of these nominal species are probable synonyms of others. Here, we refer to the oldest available names introduced for taxa from Malaita or to taxon names previously reported from this island. These names are *Eumecostylus macfarlandi* (Brazier, 1876), *E. ophir* (Clench, 1941) and *E. hargravesi* (Cox, 1871). Another taxon represented among our samples is *E. malaitensis* (Clench, 1941), but whether this name should be treated as an accepted taxon or a synonym of *E. macfarlandi* is uncertain.

Family Camaenidae

Three camaenids have been found: *Chloritis eustoma* (Pfeiffer, 1857) lives in leaf litter while both *Crystallopsis balcombei* (Cox, 1873) and *Papuina motacilla* (Pfeiffer, 1855) are arboreal species (Fig. 3).

Family Rhytididae

One species of rhytidid has been found, which is identified herein as *Ouagapia villandrei* (Gassies, 1865) (Fig. 3). This species has also been recorded elsewhere in the Solomon Islands (Delsaerdt, 2016).

Family Helicarionidae

We recorded one species of helicarionid semislug, *Sitalarion planospira* (Pfeiffer, 1853) (Fig. 3). This species was represented by two different colour morphs. Some slugs were red, others gray. These different colour morphs may represent different developmental stages.

Family Trochomorphidae

Arguably, trochomorphids are the taxonomically most diverse family of land snail in the Solomon Islands. We recorded two genera on Malaita, Trochomorpha Albers, 1850 and Orpiella Gray, 1855. We found three species of the former genus: Trochomorpha mcleani Clench, 1958, T. henschei makaensis I. Rensch & B. Rensch, 1935 as well as one unidentified (potentially new) species (Fig. 3). In addition, we recognised five species of Orpiella that differ from each other in shell size and shape. Only two species have previously been recorded from Malaita, *O. malaitaensis* (Clapp, 1923) and *O. concave* (Clapp, 1923). These species may well be represented among our samples pending comparisons with the types. However, the other three species recorded here may be new to science.

Discussion

Diversity patterns in the three communal reserves

This is the first systematic study of the snail fauna of Malaita except for the works of Clench (1941, 1965), who examined museum samples from a selected few families collected by two historical expeditions on Malaita. Clench (1941) reported nine bothriembryontids, many more than we found (four). However, whether all these names should indeed be accepted remains a question to be answered in a detailed systematic review.

Our analyses showed that the three communal reserves within the Baru Conservation Alliance showed moderate similarity in species composition. The differences among sites revealed a signature of species turnover rather than nestedness as turnover accounted for more than 94% of total β-diversity in all pairwise comparisons (Table 2). This observation indicates that each site hosts a distinct faunal assemblage contributing to the overall species richness in the larger area. However, the predictive power of our surveys is limited as we cannot rule out the impact of sampling artefacts, which may result from the relatively casual collecting method, which likely introduces bias towards larger, visually more conspicuous specimens at the expense of minute and inconspicuous species. Because land snails

are generally cryptic, they can easily be overlooked in visual searches, especially when abundance is relatively low. As each site was surveyed only once or twice, it is likely that there is a high degree of false negative records because of these caveats. A more complete species inventory of each site (i.e., lower degree of false negative records) might lead to lowered dissimilarity between and increased nestedness among sites. Yet, based on the present, somewhat incomplete, knowledge, we conclude that all three reserves are important to preserve land snail species and that only all three sites combined are suitable to preserve a representative fraction of the overall land snail diversity in central Malaita. However, we also note that as these reserves are comparatively small, they can only contribute to conserving biodiversity as part of a larger network of comparatively undisturbed forest habitats. Large scale clearing in the vicinity of these reserves would probably negatively affect the quality of habitat within these reserves through edge effects rendering the reserves ineffective.

This conclusion is consistent with a prior study of the avifauna (Callaghan *et al*., 2019). This study reported that a substantial proportion of the avifauna known to Malaita was found in the conservation area surrounding Kwainaa'isi Cultural Centre in a short period suggesting that this reserve may be sufficiently protecting necessary habitat for the province's most important bird species.

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