

# DOCUMENTATION OF FIJI'S ENDEMIC AND INTRODUCED LAND SNAIL FAUNA



BIODIVERSITY  
CONSERVATION  
LESSONS LEARNED  
TECHNICAL SERIES

23

CONSERVATION  
INTERNATIONAL

Pacific Islands



# BIODIVERSITY CONSERVATION LESSONS LEARNED TECHNICAL SERIES

# 23

## Documentation of Fiji's Endemic and Introduced Land Snail Fauna

Biodiversity Conservation Lessons Learned Technical Series is published by:

Critical Ecosystem Partnership Fund (CEPF) and Conservation International Pacific Islands Program (CI-Pacific)

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*The Critical Ecosystem Partnership Fund is a joint initiative of l'Agence Française de Développement, Conservation International, the Global Environment Facility, the Government of Japan, the MacArthur Foundation and the World Bank. A fundamental goal is to ensure civil society is engaged in biodiversity conservation.*

Conservation International Pacific Islands Program. 2013. Biodiversity Conservation Lessons Learned Technical Series 23: Documentation of Fiji's Endemic and Introduced Land Snail Fauna.

Conservation International, Apia, Samoa

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Design/Production: Joanne Aitken, The Little Design Company, [www.thelittledesigncompany.com](http://www.thelittledesigncompany.com)

Cover images: *Top to bottom, left to right:* living *Partula* – Cicia Lau; living *Placostylus* – Nakorotubu Range; *Partula leefi* shell – Rotuma; living *Trochomorpha* – Nakorotubu; veronicellid slugs feeding on bele; *Bradybaena similaris* in BBQ salad; invasive slug *Parmarion martensi* in village garden; slug *Laevicaulis alte* – Nakorotubu. © Gilianne Brodie.

Series Editors: Leilani Duffy, Conservation International Pacific Islands and Oceans Program

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ISBN 978-982-9130-23-5

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This publication is available electronically from Conservation International's website:

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# ABOUT THE BIODIVERSITY CONSERVATION LESSONS LEARNED TECHNICAL SERIES

This document is part of a technical report series on conservation projects funded by the Critical Ecosystem Partnership Fund (CEPF) and the Conservation International Pacific Islands Program (CI-Pacific). The main purpose of this series is to disseminate project findings and successes to a broader audience of conservation professionals in the Pacific, along with interested members of the public and students. The reports are being prepared on an ad-hoc basis as projects are completed and written up.

In most cases the reports are composed of two parts, the first part is a detailed technical report on the project which gives details on the methodology used, the results and any recommendations. The second part is a brief project completion report written for the donor and focused on conservation impacts and lessons learned.

The CEPF fund in the Polynesia-Micronesia region was launched in September 2008 and will be active until 2013. It is being managed as a partnership between CI Pacific and CEPF. The purpose of the fund is to engage and build the capacity of non-governmental organizations to achieve terrestrial biodiversity conservation. The total grant envelope is approximately US\$6 million, and focuses on three main elements: the prevention, control and eradication of invasive species in key biodiversity areas (KBAs); strengthening the conservation status and management of a prioritized set of 60 KBAs and building the awareness and participation of local leaders and community members in the implementation of threatened species recovery plans.

Since the launch of the fund, a number of calls for proposals have been completed for 14 eligible Pacific Island Countries and Territories (Samoa, Tonga, Kiribati, Fiji, Niue, Cook Islands, Palau, FSM, Marshall Islands, Tokelau Islands, French Polynesia, Wallis and Futuna, Eastern Island, Pitcairn and Tokelau). By late 2012 more than 90 projects in 13 countries and territories were being funded.

The Polynesia-Micronesia Biodiversity Hotspot is one of the most threatened of Earth's 34 biodiversity hotspots, with only 21 percent of the region's original vegetation remaining in pristine condition. The Hotspot faces a large number of severe threats including invasive species, alteration or destruction of native habitat and over exploitation of natural resources. The limited land area exacerbates these threats and to date there have been more recorded bird extinctions in this Hotspot than any other. In the future climate change is likely to become a major threat especially for low lying islands and atolls which could disappear completely.

For more information on the funding criteria and how to apply for a CEPF grant please visit:

- [www.cepf.net/where\\_we\\_work/regions/asia\\_pacific/polynesia\\_micronesia/Pages/default.aspx](http://www.cepf.net/where_we_work/regions/asia_pacific/polynesia_micronesia/Pages/default.aspx)
- [www.cepf.net](http://www.cepf.net)

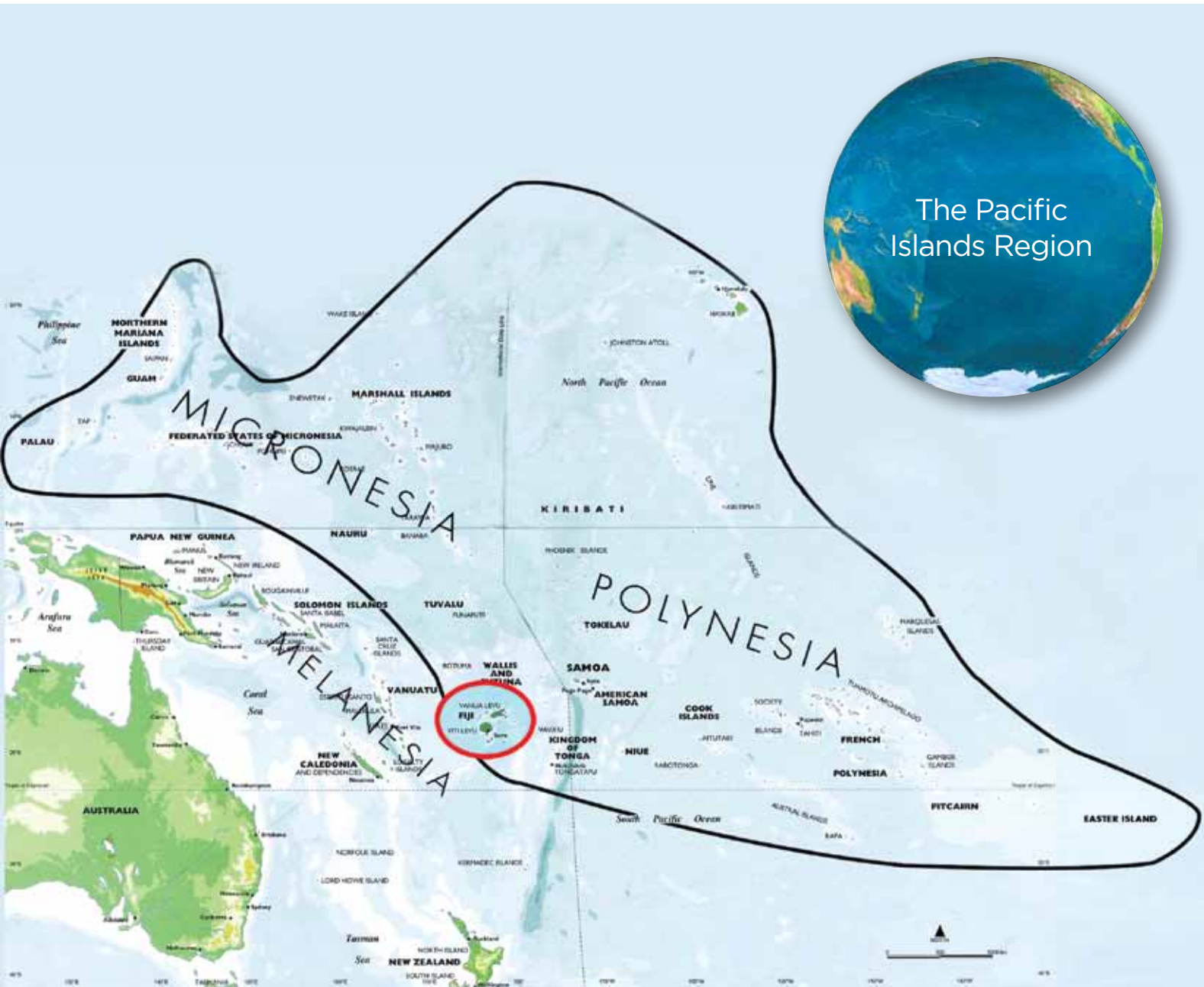
For more information on Conservation International's work in the Pacific please visit:

- [www.conservation.org/explore/asia-pacific/pacific\\_islands/pages/overview.aspx](http://www.conservation.org/explore/asia-pacific/pacific_islands/pages/overview.aspx)

or e-mail us at [cipacific@conservation.org](mailto:cipacific@conservation.org)



Location of the project in the Polynesia-Micronesia Biodiversity Hotspot







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Endemic *Trochomorpha*.



All photographs in this report were taken by Gilianne Brodie except for those in the factsheets as individually indicated.

# DOCUMENTATION OF FIJI'S ENDEMIC AND INTRODUCED LAND SNAIL FAUNA

## Lessons Learned

Involving local postgraduate students with family and cultural connections to your field trip location is appreciated by communities and improves informal communications, awareness raising and increases the chance of the program continuing.

Don't assume that any indigenous students in your project can speak their local language confidently in public.

Don't underestimate the time involved with factsheet production; collating existing data, assessing data quality, securing copyright and the checking of final outputs by many stakeholders is very time consuming and requires an experienced decision maker not a new graduate.

Translation to local languages requires considerable thought, particularly in respect to target audience as content for factsheets made for quarantine officers needs to be different to content made for relatively isolated village communities.

### Project Design Process

*Aspects of the project design that contributed to its success/shortcomings.*

One of the strengths of this project's design was its strong and continuous inclusion of local human resource capacity building and long term-training in both invasive species and threatened species conservation.

### Project Implementation

*Aspects of the project execution that contributed to its success/shortcomings.*

Involving multi-stakeholders is a strength however they also substantially increase the time involved with all aspects of the study particularly up to date reporting and communications.

### Other lessons learned

*relevant to the conservation community*

Working in remote small island communities is logistically very difficult and requires finding implementation partners with a high level of organization skill, community credibility and existing linkages into the individual communities involved – it also takes considerable time to build the respect and trust needed to implement projects successfully.





Figure 1. Photograph of the introduced invasive snail *Parmarion martensi* in a Fijian village garden.



Figure 2. Photograph of a living but 'stressed' *Bradybaena similaris* (Rang, 1831) in salad sold at a popular BBQ take-away stand in Suva City.



Figure 3. Photograph of an endemic member of the snail taxon *Placostylus*. Found in a forested area of Viti Levu.



Figure 4. Photograph of an endemic member of the snail taxon *Trochomorpha* found in Viti Levu forest.

# Land Snails of the Fiji Islands: A Summary of their Biodiversity, Quarantine and Agricultural Status and Human Health Relationships



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This summary report was written for the Fiji government departments of Environment, Agriculture and Forestry at the start of our project in July 2010 – only the reference details have been updated here.

## Abstract

The land snail fauna of Fiji is rich and diverse consisting of at least 245 species that cover 72 different genera and 28 families. There are undoubtedly new species to be discovered and described. Two hundred and sixteen of the known species are native (indigenous) of which 167 are endemic (known only from Fiji). The fauna is thus characterised by 77% endemism, confirming the importance of the unique Fijian land snail fauna at a national, regional and global level. The majority, but not all, of the endemic species are found in native forest.

In addition, there are 18 introduced species with variable risk levels to agricultural productivity, biodiversity loss or human and livestock health. Priorities for land snail species conservation assessment, quarantine, health and agricultural risk are provided. The consequences of not collating and utilising existing information includes risks to, unique biodiversity, human and livestock health, agricultural crop production and in turn will have potential economic implications for sustainable livelihoods and trade.

## Background

The Islands of Fiji form part of the Micronesia-Polynesia biodiversity hotspot, which is recognized by Conservation International as one of 25 key locations for conserving the world's biodiversity. A large proportion of the land-based fauna in this hotspot is endemic (a unique occurrence of species within a limited geographic area) but the distribution and status of much of this unique fauna is poorly documented, particularly for the enormously diverse invertebrate-animal groups. This lack of baseline information limits our ability to conserve it and from this perspective alone documenting Fiji's land invertebrate biodiversity resources are of global conservation importance.

Globally, land snails are in decline and the unique Pacific Island fauna is particularly threatened (Lydeard *et al.* 2004). Land snail research projects undertaken in Hawaii, Samoa, New Caledonia and French Polynesia have found very high levels of endemism but also alarmingly that many endemics are either extinct or under considerable threat from habitat destruction, human development and/or introduced species (Hadfield 1986, Cowie 2000, 2004, Bouchet & Abdou 2003, Brescia *et al.* 2008).

The diverse native land snail fauna of Fiji appears to be moving in a similar direction. Ecologically and historically the Fijian fauna is primarily connected to areas of native forest, a fact vital to understanding that this unique fauna cannot be conserved without protection of relatively large areas of native vegetation from land clearing and invasive species, such as ants and predatory snails. These latter species are often accidentally introduced by human-related activities such as logging, cattle farming, pig hunting and the movement of crop materials from one area to another.

Over the last 100 years the Fijian land snail fauna has been investigated by a large number of overseas visitors and a few Fijian residents (see review by Barker *et al.* 2005). As a result of this we now have a draft checklist of the land species present in Fiji and an associated distributional database. Leading from this an annotated and illustrated catalogue to the Fijian land snail fauna is currently in progress (Barker & Bouchet, in preparation). In addition to this, collation of basic identification and biological information about Fiji's introduced land snails is now underway at the University of the South Pacific (Biology Division). It is expected that this USP project will produce fact sheets, a field guide and a web-based key to aid quick identification of introduced species that may pose considerable threat to agricultural trade (crop pests) and human health (parasite vectors).

A Fijian land snail distributional database was developed by Landcare New Zealand and the Wildlife Conservation Society with the goal of using the spatial information species and communities to assist setting reservation priorities within the Fijian archipelago, and to determine the adequacy of environmental domain classifications as surrogates for biotic pattern (Barker 2003 & 2005). This work contributed to the 'Priority Forests for Conservation' network proposed by Olson *et al.* (2009). This ecological land snail work and the distributional database need to be merged and adapted more fully into the current Fijian government frameworks.

There is also a need for local up-skilling and more research in the areas of taxonomy, life history and conservation biology plus strengthened development of local access to information in usable formats.

## Terminology and Classification

According to Haynes (1998) land snails in Fiji are collectively referred to as 'sici vanua' or 'sirikoko'. Despite several common endemic and introduced species being relatively large (> 35 mm) there appears to be no specific Fijian names for different species. This does not result from a lack of historical presence in the environment but could be because snails are cryptic and predominantly nocturnal, not often being seen during daylight hours unless actively searched for in their daytime refuges.

Land snails belong to the invertebrate animals a vast group of organisms noticeably neglected in our estimates of biodiversity even at a global level. The term land 'snail' is used in this summary when referring to both 'snails' and 'slugs'. 'Snail' refers to a gastropod possessing a fully developed shell, capable of housing the retracted animal. 'Slug' refers to the gastropod body form where the shell is reduced to the extent that it is no longer capable of housing the animal. Slugs are simply snails with a reduced or absent shell.



# Snail Biodiversity

The land snail fauna of Fiji is rich and diverse consisting of at least 245 species that cover 72 different genera and 28 families (Table 1). Among these are 37 undescribed species (Barker *et al.* 2005; Barker & Bouchet, unpubl. data) but there are undoubtedly more species that await discovery. Additionally, Barker *et al.* 2005 also records an additional 11 described species that are of unconfirmed status as their taxonomy is unresolved.

Of the 245 species known for the Fiji Archipelago 216 are native (indigenous) of which 167 are endemic (known only from Fiji). The fauna is thus characterised by 77% endemism, confirming the importance of the unique Fijian fauna at a national, regional and global level. In addition, there are 18 introduced species, comprising a mixture of tropical tramp species and a few introductions from further afield.

How many of Fiji's native species are threatened is presently unknown however, what is certain is that without adequate information to enable species identification and limited knowledge on distributions and life history characteristics it is very hard to make informed decisions on conservation priorities. And without any conservation measures at all in place the words of the snail specialist Alan Solem in 1964 given below will undoubtedly soon be true.

'The famed endemic land snails of the Pacific islands are restricted to the rapidly shrinking patches of native forest. In all too short a time the land snail fauna of the Pacific islands will consist solely of a homogeneous blend of the introduced forms .... It is with a real sense of sadness that I have attempted to chronicle for the terrestrial malacologist of 2020 the places where the living land snails of Polynesia and Micronesia originated!' Solem (1964).

The majority of the Fiji Island native and endemic land snail fauna appears to be associated with native forest habitat (Table 2). However thirty-five members of three different families (Assimineidae, Ellobiidae and Truncatellidae) are associated with supralittoral or high intertidal habitats. According to Barker *et al.* 2005 thirty-one of these 35 'high intertidal' species are native and this includes six endemic species (Table 3). Four additional species of 'high intertidal' land snail are described but of unconfirmed taxonomic status.

Away from the ocean Fiji's land snail fauna also differs in its habitat location, for example, 30 species (17% of snail species for which data is available) are generally found to be arboreal (in vegetation above ground level) while 137 species are found at ground level (terrestrial) in leaf litter or under rotting wood. Only 5% of land snail species for which data is available commonly exhibit both arboreal and terrestrial activity (Table 4).

Based on the unpublished report of Barker *et al.* 2005 several locations (e.g., isolated islands in the Lau Group; Rotuma) have assemblages of native species that should be conserved. The most obvious priority is the very isolated island of Rotuma which according to Barker *et al.* 2005 is known for 6 endemic species from 5 different families, including a member of the Pacific Island flagship partulid tree snails – a group designated as a high conservation priority for the Pacific Island region by the IUCN (Pippard, IUCN-Oceania, pers. comm.). The current status of the Rotuman land snail fauna is unknown as there have been no surveys since 1937. Land snail surveys of Rotuma are a high conservation priority not only because of the island's highly significant land snail records but because of the substantially increased extinction-risk levels that will result from the island's imminent conversion to a registered port of entry for the Fijian Islands. Potential new species introductions will without doubt be associated with the resulting trade developments.

Seven of the 28 land snail families found in Fiji consist solely of introduced fauna (*Valloniidae*, *Ariophantidae*, *Subulinidae*, *Streptaxidae*, *Bradybaenidae*, *Agriolimacidae*, *Zonitidae*). The family Pupillidae has two introduced species and one endemic member while the shell-less family Vaginulidae (= Veronicellidae), commonly known as 'leatherleaf' slugs, includes three introduced species.

Besides the taxonomic identification obstacles, which are currently being addressed, all of the eighteen known introduced species are considered to pose some level of potential 'risk' for either agricultural productivity, biodiversity loss or human and livestock health (Brodie & Barker, 2011). Some of these species have been present in Fiji for well over 30 years (Barker, 1979) and the soon to be published preliminary risk assessment is timely.

We need to know more about the biology and life history of existing introductions to enable more robust and specific risk assessment in the future and we also need to investigate lessons learnt elsewhere for preventing avenues (pathways) for further introductions (e.g. see Cowie 2008).



University of the South Pacific postgraduate students, Lia Bogitini, Ravikash Prasad and Froseann Stevens assist Koronivia agricultural research station staff member Anare Caucau to collect introduced land snail species for assistance to quarantine and biosecurity services.

# Priority Groups for Quarantine and Human Health

Fiji is very fortunate in having so far stopped populations of the world's two most high risk invasive land snails; namely the 'Rosy Wolf Snail' *Euglandina rosea* (Férussac 1821) and the 'Giant African Snail' *Lissachatina* [*Achatina*] *fulica* Bowdich, 1822 from becoming established. There is no doubt that the Fiji Government agricultural and quarantine services must be duly acknowledged for their hard work in achieving this, when so many of our Pacific Island trading partners have already suffered greatly from these two devastating invasive species.

The Fiji Islands however, does have at least 18 introduced species with variable risk levels to agricultural productivity, biodiversity loss or human and livestock health (Brodie & Barker, 2011). Based on a comparison of our current observations (Mila *et al.* 2010; Brodie & Copeland, 2010; Brodie 2009; Brodie, unpublished data) and past observations (Solem, 1978; Barker, 1979; Haynes 1998) some introduced species e.g. *Bradybaena similaris* (Rang, 1831) and *Quantula striata* (Gray 1834) have obviously increased in abundance, at least on the largest island of Viti Levu.

However, the most worrying 'new' snail introduction absent in the reports by Solem (1978) and Haynes (1998) is the presence and very obvious increase in abundance and distribution of the 'semi-slug' *Parmarion martensi* Simroth 1893 (Figure 1). First officially reported in Fiji by Barker *et al.* 2005, but known from southeast Viti Levu from as early as 1979 this species is now numerous and widespread in areas of human habitation, and alarmingly has also recently been found (Brodie 2009; Brodie & Copeland 2010; Brodie unpublished data) in three of Fiji's high priority forest areas highlighted by Olsen *et al.* (2009).

In addition to its newly reported highly invasive status in Fiji by Brodie & Barker (2011) *P. martensi* is also considered by these authors as a potential high-risk vector in Fiji for the rat lung worm *Angiostrongylus cantonensis* (Chen, 1935). This parasitic worm is associated with eosinophilic meningitis in humans. *Angiostrongylus cantonensis* and eosinophilic meningitis are already established in Fiji (Alicata 1962, Uchikawa *et al.* 1984, Sano *et al.* 1987, Paine *et al.* 1994) and is commonly reported as associated with less 'risky' invasive snail species such as the 'leatherleaf' slug *Laevicaulis alte* (Férussac, 1822).

However, recent discovery by the first author of a living *Bradybaena similaris* (Rang, 1831) in salad sold at a popular BBQ take-away stand in Suva City (Figure 2) highlights the reality of the potential for future health problems, particularly when many families, communities and tourism facilities are being actively encouraged to grow their own salad vegetables. As recently highlighted by senior Koronivia Research Station staff (pers. comm.), there is a strong need to investigate the life history characteristics and parasite infection levels of all introduced land snail species in Fiji.



# Priority Groups for Conservation and Biodiversity Assessment

Fiji's 167 endemic land snail species are very diverse, spanning 19 families (Table 1). Two groups in particular stand out as achievable species-level conservation priorities. These are: (a) Fiji's 12 endemic species of the taxon *Placostylus*, eight of which are found on only one island each in the Fiji group (see Figure 3 for an idea of what members of this genus look like); and (b) members of the taxon *Trochomorpha* which according to Barker *et al.* 2005 has at least 18 species endemic to Fiji (see Figure 4 for an example of this genus).

Besides the above groups, two additional groups are highlighted in the literature as extinction prone on islands because of their vulnerability to introduced predators – these are the microsnaills of the family Endodontidae and members of the family Rhytididae. The endemic members of the supralittoral snails (families Ellobiidae and Truncatellidae) should also be given some attention as they could well be directly impacted by the affects of climate change.

In addition the families Diplommatinidae and Assimineidae, with 15 and 12 as yet undescribed species respectively, should also be taxonomically revised for biodiversity assessment purposes.



Two species of partulid tree snails recently founded in Fiji, one is endemic to Rotuma and the other endemic to Lau. Both of these species need to be urgently assessed for their conservation status as many members of the genus are known for their highly threatened status in other parts of the world.

# Conclusion

Fiji has a large number of native (endemic and non-endemic) land snail species that require detailed conservation assessment.

Non-endemic natives are also important because Fiji could be significant for conservation if these species become threatened or locally extinct elsewhere in their range.

Introduced species are widening their distribution within Fiji and creating a homogenisation of the Fijian land snail fauna just like that already recorded across the Pacific Islands by Solem (1964) and Cowie (2001).

There is a need for, scientific human resource capacity building, specialised training about land snails and general awareness raising of the presence and significance of snails in the environment, at a local level. Support for at least one postgraduate student scholarship, funding for a two-day workshop on introduced snails every two years and an increase in media coverage would substantially address these capacity, training and awareness issues.

For introduced, native and endemic fauna there is an immediate need for collation of existing information into a form that can be made readily available for utilisation by resource managers and other community stakeholders. Funding is required for the preparation of photographic images in the Fiji land snail catalogue currently in progress and also for obtaining expert curation of material held in Fiji, as well as repatriation of at least some Fijian material held in overseas institutions.

The consequences of not collating and utilising existing information includes unrecognised risks to, unique biodiversity, human and livestock health, agricultural crop production and in turn will have potential economic implications for sustainable livelihoods and trade.



# Tables

Table 1. Summary of currently known species biodiversity of land snails of the Fiji Islands (including Rotuma). Data collated from Barker *et al.* 2005. \* Families containing species endemic to Fiji. # Families containing introduced species.

Super Order	Family	No. Species	No. Genera	No. known undescribed taxa
Neritopsina	Helicinidae*	13	2	3
	Hydrocenidae*	1	1	0
Architaenioglossa	Pupinidae*	2	1	0
	Diplommatinidae*	26	6	15
	Neocyclotidae*	5	2	0
Caenogastropoda	Assimineidae*	30	4	12
	Truncatellidae*	7	2	0
Heterobranchia	Vaginulidae#	3	3	0
	Ellobiidae*	32	9	0
	Succineidae*	1	1	0
	Partulidae*	4	2	0
	Achatinellidae	3	2	0
	Pupillidae#	3	2	0
	Valloniidae#	1	1	0
	Bulimulidae*	14	1	0
	Charopidae*	22	8	2
	Endodontidae*	6	3	0
	Euconulidae*	3	2	1
	Helicarionidae*	21	2	1
	Ariophantidae#	2	2	0
	Microcystidae*	12	3	1
	Trochomorphidae*	19	1	2
	Subulinidae#	6	4	0
Rhytididae*	4	3	0	
Streptaxidae#	2	2	0	
Bradybaenidae#	1	1	0	
Agriolimacidae#	1	1	0	
Zonitidae#	1	1	0	
<b>TOTALS</b>	<b>28</b>	<b>245</b>	<b>72</b>	<b>37</b>

Table 2. Numbers of 'Fijian' snails found in particular habitat locations. Data collated from Barker *et al.* 2005.

Habitat	No. Taxa	% of Total Known
Lowland forest	34	24.1%
Mid- altitude forest	47	33.3%
High land forest	40	28.4%
Supralittoral	20	14.2%
Other or Habitat unknown	75	

Table 3. Fijian endemic land snail species that can be associated with high intertidal or supralittoreal habitats. Source Barker *et al.* 2005.

Species	Family
<i>Truncatella avenacea</i> Garrett, 1872	Truncatellidae
<i>Truncatella granum</i> Garrett, 1872	Truncatellidae
<i>Melampus crebristriatus</i> Garrett, 1887	Ellobiidae
<i>Melampus incisus</i> Garrett, 1887	Ellobiidae
<i>Melampus rusticus</i> Garrett, 1887	Ellobiidae
<i>Pythia perovatus</i> Garrett, 1872	Ellobiidae

Table 4. Numbers of 'Fijian' snails recorded as found off the ground (arboreal) and at ground level (terrestrial). Data collated from Barker *et al.* 2005.

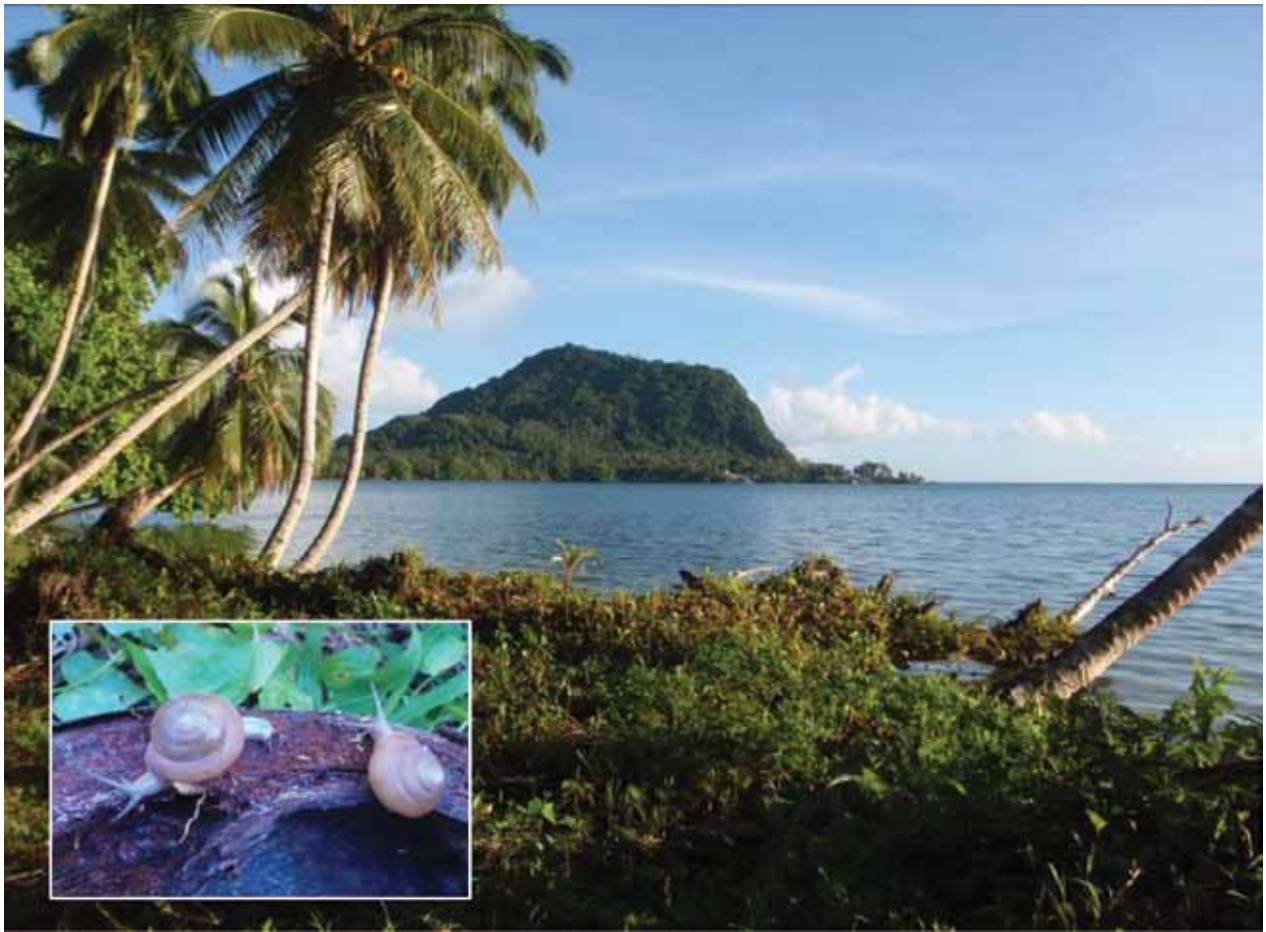
	Arboreal	Terrestrial	Arboreal and Terrestrial	Unknown
No. taxa	30	137	8	67
% of known	17%	78%	5%	Not applicable



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Mount Solrroa, in the district of Itu'muta, one of the higher elevated hills on the main island of Rotuma.  
Inset: two living specimens of the introduced land snail *Quantula striata* (Gray 1834).



# LAND SNAIL FAUNA OF ROTUMA

## A PRELIMINARY SURVEY

MAY 2012

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A hard copy of this report was distributed to the following stakeholders via the indicated leaders:

- Coordinator, LäjeRotuma Initiative
- Chairman, Rotuma Island Council
- Head, Prime Minister's Department (Rotuman Affairs)
- Director of Research, Koronivia Research Station
- Permanent Secretary, Department of Agriculture
- Director, Department of Environment
- Director, Biosecurity Authority of Fiji
- Chair, Fiji Invasive Species Taskforce
- Director, Fiji National Trust
- Trustees, NatureFiji-MareqetiViti
- Director, Land Resources Division, Secretariat of the Pacific Community
- Director, Biodiversity and Ecosystem Management, SPREP
- Director, International Union for the Conservation of Nature (IUCN-Oceania)
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## Abstract

In May 2012 a survey of the land snails of Rotuma was undertaken. The last previous survey that included land snails collections on Rotuma was conducted over seventy years ago but no dedicated report of that survey seems to exist. The current survey was carried out to; record the number and type of introduced 'snails' present and provide information on the potential risk to human, crop and livestock health of any introductions found, and investigate if any previously recorded native and endemic land snail fauna was still alive. Provision of land snail sampling and identification training to targeted community members was also undertaken. We found 70% of the living snail species identified during the survey were introduced and that 91 % of the native snail fauna found was recorded only as dead shells. Unexpectedly we also found the notorious land snail predator, *Platydemus manokwari*, a well-documented invasive flatworm native to Papua New Guinea. To our knowledge this introduced invasive species is not yet found in other parts of Fiji. These results mean that; an evaluation of existing quarantine measures is required to address the potential spread of the flatworm *Platydemus manokwari* to other parts of Fiji, that relatively simple education programs on non-cooked food preparation would be beneficial to the community in respect to the potential for introduced snails to act as disease vectors, and that sampling to further search for living endemic snail fauna, in less accessible areas, is urgently needed.

This report contributes to several different objectives of Fiji's National Biodiversity Strategy Action Plan (DoE 2007) particularly Objective 2.6 – the establishment of specific research programmes on Rotuma.

# Introduction

Eighteen introduced (alien) species of land snail were listed from the Fiji Islands by Brodie & Barker (2011). An additional species, *Semperula wallacei* (Issel 1874) has since been added to that list. Seven of these 19 species have known associated risks to human health, agricultural production and biodiversity loss (Brodie & Barker 2011). Fortuitously two of the world's worst invasive land snail species [*Achatina fulica* Bowdich 1822 and *Euglandina rosea* Férussac 1821]] are currently absent from Fiji and strict quarantine regulations are required to keep them out as their introduction would have major health, trade and other economic implications.

Until the current survey it was unknown how many introduced land snail species were currently found in Rotuma and a baseline survey was much needed to provide information to the Rotuman community and Fiji's biosecurity, agriculture and health management agencies.

Globally land snails have the highest number of documented extinctions of any major taxonomic group (Lydeard *et al.* 2004). Pacific Island land snails, and in particular the diverse and famous partulid tree snails have a history of extremely high levels of species extinction (Hadfield *et al.* 1993, Cowie 1992 & 2004).

Islands are of vital importance to the study of biodiversity loss, species extinction and evolution processes at a global and regional level. Small very isolated islands, such as Rotuma, are of particular importance because of the very fragile nature of their ecosystems and possession of very unique (endemic) fauna. This endemic fauna forms a valuable natural resource for the island communities that own them.

As acknowledged by the Fiji Government (DoE 2007) 'Rotuma's terrestrial biodiversity has elements which distinguish it from being merely a Fijian outlier as they are Central Pacific or Samoan in character'. Consequently, Rotuma requires special consideration in biodiversity conservation.

Rotuma is well known for several of its unique endemic species of birds (e.g. red and black Rotuman honeyeater) and other vertebrates (e.g. Rotuman gecko) that are not found anywhere else in the world. What is not well known is that Rotuma has at least four endemic land snail species (Table 1) including one member of the famous, critically-endangered, partulid tree snails.

To the best of our knowledge none of these four endemic snail species have been sighted or studied since at least 1938 when scientists from the Bishop Museum (Hawaii) made a research visit to Rotuma (St John 1938, Barker & Bouchet 2010). In the case of the Rotuman endemic snail *Delos gardineri* the species has not been seen since its original collection by J. Stanley Gardiner, and subsequent description by Smith in 1897. A relatively brief land snail survey of the off-shore islet of Uea was undertaken during a marine resource survey for the Fiji government in mid-1986 but did not discover a single native land snail (Parkinson 1988).

Because of strong concerns for global and Pacific Island non-marine mollusc extinction rates (Lydeard *et al.* 2004) the majority of Fiji's native land snails (> 200 species) have recently been IUCN Red-List assessed for their conservation status. These assessments are not yet published (IUCN in press), however the expected outcomes for the four Rotuman endemics are; two critically endangered, one endangered and one data deficient (Table 1). A survey of the presence or absence of these unique snails in Rotuma was needed to determine if they have become extinct, or if they may be present in small numbers and in need of conservation assistance. Documentation of any other native land snails species present would also be beneficial to assist in Rotuma's terrestrial natural resource management (see DoE 2007).

The objectives of our field trip were therefore as follows:

- To undertake a survey of current introduced land snail species present on Rotuma.
- To identify any snail 'pest' species present and provide access to information on their crop production, quarantine and human health risks.
- To undertake a preliminary survey of native and endemic snail fauna including a search for known endemic and historic snail fauna considered unique to Rotuma.
- To provide recommendations for any future associated native snail conservation actions if deemed necessary.
- To conduct snail survey and identification training to local community members and government officials to enable continued monitoring of Rotuma's land snail fauna.

This survey also contributes to Objective 2.6 in Fiji's National Biodiversity Strategy Action Plan (DoE 2007) which states the need to establish specific research programs on Rotuma.



Members of the Rotuman community finding native land snails at Upu near Mount Kugai.

# Materials and Methods

The isolated archipelago of Rotuma (12° 50' ES, 177° 07' E) with a total land area of 43 km<sup>2</sup> lies 646 km north of Fiji's capital city Suva and approximately 550 km west of its closest neighbour Futuna Island in the French overseas collectivity of Wallis and Futuna.

The Rotuman archipelago consists of one large island (Rotuma) and eight rocky islets that lie offshore (Fatiaki *et al.* 1977). These islets include the highly distinctive Hafliua (Split Island) which is bisected by a massive fissure and the largest islet of Uea which is approximately one kilometre wide and rises steeply to over 200 metres in elevation. The land is covered with vegetation and surrounded by coral reefs. The large main island of Rotuma is elongate measuring approximately 15 kilometres in length and 4.5 kilometres in width at its widest point.

Geologically Rotuma is of volcanic origin, with a number of craters rising to heights of 200–260 meters above sea level. The resident population of a little over 2,100 people (2007 census) is spread along the coastline of the large island. Much of the main island is comprised of gardens and human-disturbed 'bushland', with coconut trees in abundance. Undisturbed indigenous forest is not considered to remain on Rotuma (Smith 1897) except as inaccessible remnants (Zimmerman 1943).

'Land snail' is used in this report when referring to both 'snails' and 'slugs'. The word 'snail' refers to a gastropod mollusc possessing a fully developed shell that is capable of housing the retracted animal. The word 'slug' refers to the gastropod body form where the shell is reduced to the extent that it is no longer capable of housing the animal. Slugs are simply snails with a reduced or absent shell (Brodie *et al.* 2010).

## Land Snail Surveys

Snail surveys were undertaken in nine locations (Table 2) within four of the seven districts of Rotuma (Figure 1). Surveys were conducted during daylight hours when the normally nocturnal snails were located in their day-time refuges.

Snail samples were obtained using the following collection methods; visual line transects, leaf litter samples, rock crevice soil samples plus directed visual sampling of vegetation, beneath large stones, logs and rotting organic debris.

The photographs used in this report were all taken by G. Brodie and show only species found on Rotuma during the survey period. All photographs of living animals were taken directly in Rotuma and no non-preserved material was returned to Suva.

All preserved material collected during this survey will be lodged in the reference collections of the University of the South Pacific; samples have also been given informal 'Brodie Lab' identification codes. All species identifications are considered tentative and molecular confirmation is required particularly for the family Subulinidae which are notoriously difficult to identify to species level morphologically even for specialists. Identification of the veronicellid slugs was based on information provided by S. Gomes which is comparatively summarized in Brodie & Barker (2012a and in progress).



Collection records from this survey will be added to the overall Fiji land snail database (maintained by Barker) which is regularly uploaded to the Fiji National Trust in Suva.

#### Snail Identification Capacity Building

Snail identification training occurred at two levels:

- a. at an informal non-scientific level with community members
- b. at a scientific level with formal training to targeted individuals

In addition to the above, general awareness raising, about local land snails, occurred within the community because of the survey visit in itself, particularly in Itu'muta where the reasons for the survey were presented directly to the community (in Rotuman) via our inclusion in an evening information session run by our partner organization LäjeRotuma<sup>1</sup>.

Therefore

- The involvement of local people in field sampling survey work, both children and adults, was encouraged at all locations. Local guides from the community accompanied researchers and volunteers on all surveys undertaken.
- The opportunity for scientific level identification training was extended to targeted individuals, both island residents and professional people operating within the community on a regular basis. The selection of individuals was made by our respective collaborative stakeholder organizations.
- Training involved field observation of associated collecting techniques, use of simple collecting equipment, provision of background context documents, formal identification materials prepared by USP, plus use of a dissecting microscope that was also supplied by USP.

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1 LäjeRotuma Initiative (LRI) is a community-based environmental education and awareness development programme for Rotuma. For more information see <http://www.rotuma.net/os/lajerotuma.htm>

# Results

## Land Snail Surveys

The total number of land snail species found in this survey was twenty-one (Table 3). Two additional species, found as dead shells on land are recorded here (Figure 2a and b) but removed from the land snail analyses because of their marine and freshwater locations when alive.

The twenty-one land snail species found cover eleven different gastropod families (Table 3). Of these twenty-one species, eight are introduced; *Parmarion martensi* Simroth, 1893, *Quantula striata* (Gray, 1834), *Bradybaena similaris* (Rang, 1831), *Allopeas gracile* (Hutton, 1834), *Paropeas achatinaceum* Pfeiffer, 1846, *Subulina octona* (Bruguière, 1789), *Sarasinula plebeia* (Fischer, 1868) and *Semperula wallacei* (Issel, 1874) (Figures 2c-f and 3a-d respectively) and thirteen are native *Elasmias apertum* (Pease, 1865), *Fijianella* sp., *Omphalotrophis zelirolata* Mousson, 1865, *Omphalotrophis* sp., *Melampus flava* (Gmelin, 1791), *Pythia scarabaeus* (Linnaeus, 1758), *Pleuropoma fulgora* (Gould, 1847), *Pleuropoma* sp., *Sturanga modesta* (Pfeiffer, 1854), *Partula leefi* Smith, 1897, *Delos gardineri* (Smith, 1897), *Truncatella granum* Garrett, 1872 and *Truncatella* sp. (Figures 3eandf, 4a-f and 5a-d respectively). No evidence of the Rotuman endemics *Succinea rotumana* or *Sinpolyea rotmana* was found.

Overall the majority of living snail species found (70%) were introduced and the majority of species represented only by dead shells were native (91%) (Table 4). *Partula leefi*, *Delos gardineri* and *Fijianella* sp., and possibly *Omphalotrophis* sp., and *Pleuropoma* sp. are endemic to Rotuma however no endemic or 'possibly' endemic snails were found alive during this survey (Table 4). Of the introduced snail species *Parmarion martensi* and *Subulina octona* were the most numerous and widespread. Only dead shells of the relatively hardy introduced snail species *Bradybaena similaris* were found.

## Additional Observations

The native land snail *Melampus flava* (Figure 4c) was found to be common along the high tide mark in two locations (Palag as ta, Noa'tau and Oinafa wharf area) during this study. This obviously abundant species was also observed to be used by humans for decorative purposes (Figure 5e). However, it is possible that these decorative items are not made directly on Rotuma but given as gifts from neighboring islands such as Tuvalu where the widespread species *M. flava* is also found.

In snail surveys of other islands the coastal snail *Melampus flava* is recorded as a marine species (e.g. Cernohorsky 1977) however this snail's ability to remain actively crawling during the day while exposed to the air (well out of the water) for relatively long periods marks it as behaviorally and anatomically different to most common marine shells.

During the course of snail sampling the well-known invasive flatworm *Platydemus manokwari* was found (Figure 5f). This worm was observed at two locations (6 and 7) within the districts of Itu'ti'u and Itu'muta on the far western end of the island. Thus *P. manokwari* was seen to be relatively abundant under lava stones in one village subsistence garden and also at higher elevation within well-shaded leaf litter directly beneath vegetation on which living populations of small native snails were located.

# Snail Identification Capacity Building

## INFORMAL

Community members with a particular interest and aptitude for snail survey and collection were identified.

## FORMAL

Rotuma-based training in sample acquisition and snail identification was provided for four individuals (three of which are Rotuman) from the following three organizations: University of the South Pacific (1), LājeRotuma (2) and Koronivia Research Station (1). An additional island-based individual from the Fiji Biosecurity Authority (BAF) was unable to attend because of other work commitments, so this person was provided with a set of the identification teaching materials, a poster about introduced land snail species (for education purposes) and two briefings, the first informally via Dr Brodie and the second via the staff member from Koronivia Research Station that attended the training session.



Snail identification training at the community hall in Savaea, Itu'muta.

# Discussion

The discovery of three species of living native land snails, one in coastal and two in 'forested' areas of Rotuma is encouraging. However, the unexpected discovery of the notorious snail predator *Platydemus manokwari* at both lowland and elevated sites means that the local populations of these snails, and other native species that may still persist on the island, should be considered highly threatened. It is well documented that small-island ecosystems (like Rotuma) are fragile making their ecosystems very vulnerable to the impacts of such introduced alien species (see Veitch *et al.* 2011).

Finding evidence (dead shells) of the endemic species *Partula leefi*, a member of the legendary Pacific Island tree snails, makes the results of this survey of international, as well as local interest. This finding will now allow an adequate assessment of the conservation status of *P. leefi* and substantially remove the potential for a 'data deficient' IUCN Red-list status. Based on specimens lodged in the Bishop Museum (Hawaii) it appears *Partula leefi* was alive and relatively common in 1938 when the Museum last undertook a survey of Rotuma. Many members of the diverse land-snail family *Partulidae*, which were used by Polynesians for ceremonial human decoration, are now extinct from all or part of their native range (Cowie 1992; Hopper & Smith 1992). Some remaining members from French Polynesia, critically endangered on the IUCN Red-List because of threats by alien predators and habitat loss, are currently being bred in captivity for conservation purposes.

Only dead shells of nine other native land snail species were found, including a single specimen tentatively identified as the Rotuman endemic species *Delos gardineri*. No evidence of the Rotuman endemics *Succinea rotumana* or *Sinpolyea rotumana* was found in this preliminary survey.

A more extensive survey of Rotuma and its less accessible separated islets is therefore urgently required to ascertain if any living individuals of the Rotuman endemic species *Partula leefi*, *Delos gardineri*, *Succinea rotumana* and *Sinpolyea rotumana* still exist.

Of the nineteen introduced land snail species recorded from other parts of Fiji, eight are found in Rotuma. Only two of these, *Parmarion martensi* (Figure 2c) and *Sarasinula plebeia* (Figure 3c) are considered to have medium to high risk 'pest' status resulting from their links to human, crop and livestock health (Brodie & Barker 2011). The highest risk species *Parmarion martensi* was found in Rotuma at all inland locations surveyed. This result answers the quarantine related questions highlighted by Brodie & Barker (2011: 33) and Brodie *et al.* (2010) about the presence or absence of this introduced species on Rotuma. There is therefore no need for specific quarantine restrictions to address the potential spread of this species, which is common in Viti Levu, to Rotuma because it is sadly already present. However, awareness raising activities are needed to inform community members, particularly women and children, of the human health risks associated with this invasive species and the need to thoroughly wash all non-cooked fruits and vegetables to be consumed by humans. This risk exists primarily because *P. martensi* is a known vector for the nematode parasite rat lung worm *Angiostrongylus cantonensis* which may lead to human illness (Brodie & Barker 2011).

The identification of the invasive flatworm *Platydemus manokwari* was unexpected as this serious pest species, to our knowledge, is not yet recorded from other parts of Fiji. As such we therefore consider it a significant quarantine related finding as *P. manokwari* is well documented as one of the world's top 100 invasive species (GISD 2010). The introduction of *P. manokwari* is a serious concern for the conservation of unique land snail fauna not just on Rotuma but on many tropical



islands (Sugiura *et al.* 2006). This flatworm is considered a cause of the extinction of native land snails on several Pacific and Pacific Rim islands (Sugiura & Yamaura 2009). Predation is a known important cause of the rapid decline or extinction of native arboreal snails on Pacific islands (Hadfield *et al.* 1993).

*P. manokwari* is an active and voracious predator of snails both native and introduced (Winsor *et al.* 2004) and is therefore not suitable for use as a biological control agent against introduced crop pests. The presence of *P. manokwari* on Rotuma is one likely reason that only dead shells of the introduced snail *Bradybaena similaris* were found as the flatworm is documented to feed readily on this species as well as on partulids (Winsor *et al.* 2004). The high proportion of native species recorded as dead-shells only (77%) may also result from either the influence of *P. manokwari* predation or other forms of native habitat degradation.

## Conclusions and Recommendations

As a result of human development the world's biodiversity is declining at an unprecedented rate (Singh 2002, Gaston 2005). This is affecting the functioning of our environment and is beginning to impact on human livelihoods in many parts of the world. Biodiversity loss and the impact of introduced species are known to be ecologically more significant on inherently fragile small-island ecosystems than they are on larger continental systems (Veitch *et al.* 2011).

The results of this survey will allow a formal IUCN Red List assessment of Rotuma's endemic partulid snail *Partula leefi* to be made. Based on similar assessments already in progress (IUCN in press) for other endemic Rotuman snails (e.g. *Succinea rotumana* Smith 1897), and the discovery of the introduced partulid eating snail-predator *P. manokwari*, it is highly likely that *P. leefi* will be classified as either Critically Endangered or Critically Endangered – possibly Extinct. The discovery of significant numbers of introduced snail species is likely to be representative of similar change in other terrestrial invertebrate groups.

The following recommendations are therefore made: organizations given in brackets indicate recommended lead agencies.

1. That appropriate education materials be designed, and awareness programs be undertaken in cooperation with community health officers and local schools to emphasize:
  - the potential risks to human and livestock health associated with several of the introduced snails currently found on Rotuma because they may carry parasites.
  - the strong need for adequate washing of non-cooked fruit and vegetables during their preparation for human consumption
  - the need for timely reporting by the community to island quarantine services any snails found that do not match those already documented in this current survey. (LäjeRotuma/ USP).
2. That the presence of the invasive predatory flatworm *Platydemus manokwari* on Rotuma be discussed (with the aim of determining the appropriate course of action needed) via Fiji's Invasive Species Taskforce (FIST) committee in the presence of representative(s) of LäjeRotuma and other Rotuman and/or government delegates as maybe determined appropriate by the Biosecurity Authority of Fiji (BAF) FIST Chair. (BAF/ LäjeRotuma)

3. That continued and strengthened support is provided by all report stakeholders to existing biosecurity measures on Rotuma and that government departments engage collaboratively with the local NGO LäjeRotuma to help address community education of the strong benefits of biosecurity measures to the health and economic well-being of the island communities (BAF/ Koronivia/LäjeRotuma/).
4. That funding is sought for postgraduate scholarships for Rotuman or Pacific Island research students to undertake molecular confirmation of (i) the species level taxonomy of introduced snails found and (ii) the presence of nematode parasites, with potential human and livestock health risks, within the individual species found on Rotuma (USP).
5. That appropriate information flyers be prepared for communities and a reward (to be determined by LäjeRotuma) be offered (upon confirmation of ID in the field; collection not recommended) for locating a living population of the Rotuman endemic tree snail *Partula leefei* (LäjeRotuma/USP).
6. That further collaboration with existing overseas specialist snail researchers (e.g. Landcare Research, Paris & Stuttgart Museums) occurs to assist with the confirmation of native snail species of uncertain identification (USP).
7. That funding be sought to undertake a 2nd land snail survey of Rotuma particularly to search the remaining hill areas of all districts and the vegetated islets for living native and endemic species (USP/ LäjeRotuma).

## Acknowledgements

We sincerely thank the following people and organizations for their support and encouragement to undertake this survey and its associated capacity building activities; the Rotuma Island Council, the Fiji Government (PM Dept. Rotuman Affairs), Monifa Fiu (LäjeRotuma); Critical Ecosystem Partnership Fund (CEPF), USP Faculty of Science, Technology and Environment. We thank Dr Leigh Winsor (James Cook University) for flatworm identification. Finally and most importantly we sincerely thank land owners for their permission to survey, and numerous individual community members in Rotuma for their very generous provision of transport, field logistics and collection assistance, in particular our host families for their generous hospitality, accommodation and subsistence.

## Tables

Table 1. The four endemic Rotuman land snails, with their proposed IUCN Red-List status (IUCN in press). Brackets in column three indicate change in genus-species combination since original publication of the species description.

Family	Species Name	Author of Species Name	Proposed IUCN Red-List Status	Date Last Seen
Rhytididae	<i>Delos gardineri</i>	(E.A. Smith, 1897)	Critically Endangered	< 1897
Succineidae	<i>Succinea rotumana</i>	E. A. Smith, 1897	Critically Endangered	1938
Partulidae	<i>Partula leefei</i>	E. A. Smith, 1897	Not assessed but Data Deficient	1938
Charopidae	<i>Sinployea rotumana</i>	(E.A. Smith, 1897)	Endangered	1938

Table 2. Details of snail sampling locations surveyed in Rotuma during May 2012.

Location No.	Location Name	District
1	Palag as ta (near Methodist Church)	Noa'tau
2	Palag as ta (sal uaf ta)	Noa'tau
3	Palag as ta (taro garden and surrounds)	Noa'tau
4	Oinafa Bay near wharf	Oinafa
5	Upu east side of Mount Kugai	Itu'ti'u
6	Savaea, O'oag ruru	Itu'muta
7	Mount Solroroa (Faniuva side)	Itu'muta
8	Faniuva near cemetery	Itu'muta
9	Maftoa near cemetery	Itu'muta

Table 3. Details of the snail species found on Rotuma during the May 2012 survey.

Family	Species	Habitat Found	Status for Rotuma	Locations Found
Achatinellidae	<i>Elasmias apertum</i> (Pease, 1865)	on vegetation	native	5
Ariophantidae	<i>Parmarion martensi</i> Simroth, 1893	leaf litter and on vegetation	introduced	2, 3, 5, 6 and 7
Ariophantidae	<i>Quantula striata</i> (Gray, 1834)	under rocks and logs in gardens	introduced	2, 3 and 6
Assimineidae	<i>Fijianella</i> sp. (dead shells only)	leaf litter, damp soil	endemic	7
Assimineidae	<i>Omphalotrophis zelirolata</i> Mousson, 1865 [= <i>Omphalotrophis rotumana</i> Smith, 1897] (dead shells only)	damp sand	native	8
Assimineidae	<i>Omphalotrophis</i> sp. (dead shells only)	soil	native/?endemic	3
Bradybaenidae	<i>Bradybaena similaris</i> (Rang, 1831) (dead shells only)	rock walls and village gardens	introduced	2, 6,7
Ellobiidae	<i>Melampus flava</i> (Gmelin, 1791) (3 colour forms)	coastal debris	native	1 and 4
Ellobiidae	<i>Pythia scarabaeus</i> (Linnaeus, 1758) (dead shells only)	coastal sands	native	
Helicinidae	<i>Pleuropoma fulgora</i> (Gould, 1847) (dead shells only)	soil	native	3, 7
Helicinidae	<i>Pleuropoma</i> sp.	on vegetation	native/?endemic	5
Helicinidae	? <i>Sturanga modesta</i> (Pfeiffer, 1854) (dead shells only)	soil and leaf litter	native	7

Family	Species	Habitat Found	Status for Rotuma	Locations Found
Naticidae	<i>Natica</i> sp. (dead shells only – marine sub-fossil)	lowland 'soil'	not applicable	5
Partulidae	<i>Partula leefei</i> Smith, 1897 (dead shells only)	rock crevices	endemic	7
Rhytididae	? <i>Delos gardineri</i> (Smith, 1897) (dead shells only)	soil	endemic	3
Subulinidae	<i>Allopeas gracile</i> (Hutton, 1834)	sand and soil	introduced	9
Subulinidae	<i>Paropeas achatinaceum</i> Pfeifer, 1846	soil, under rocks and logs	introduced	5
Subulinidae	<i>Subulina octona</i> (Bruguère, 1789)	soil and leaf litter	introduced	2, 5, 6, 7 and 9
Thiaridae	<i>Melanoides tuberculata</i> (Muller, 1774) [dead shells only, freshwater species]	lowland soil	not applicable	7
Truncatellidae	<i>Truncatella granum</i> Garrett, 1872 (dead shells only)	coastal sands	native	9
Truncatellidae	<i>Truncatella</i> sp. (dead shells only)	coastal sands	native	9
Veronicellidae	<i>Sarasinula plebeia</i> (Fischer, 1868)	under rocks and old coconut husks	introduced	2, 6
Veronicellidae	<i>Semperula wallacei</i> (Issel, 1874)	old coconuts husks	introduced	3, 5, 6, 7



Table 4. A comparison of the introduced, native and endemic land snail species proportions.

	Introduced	Native includes last two columns)	Total	Endemic to Rotuma	Possibly Endemic to Rotuma
Found Alive	7	3	10	0	0
Shell Only	1	10	11	2	4
Total	8	13	21	2	4

Figure 1. Map showing the seven districts of Rotuma and the nine locations sampled during this survey.

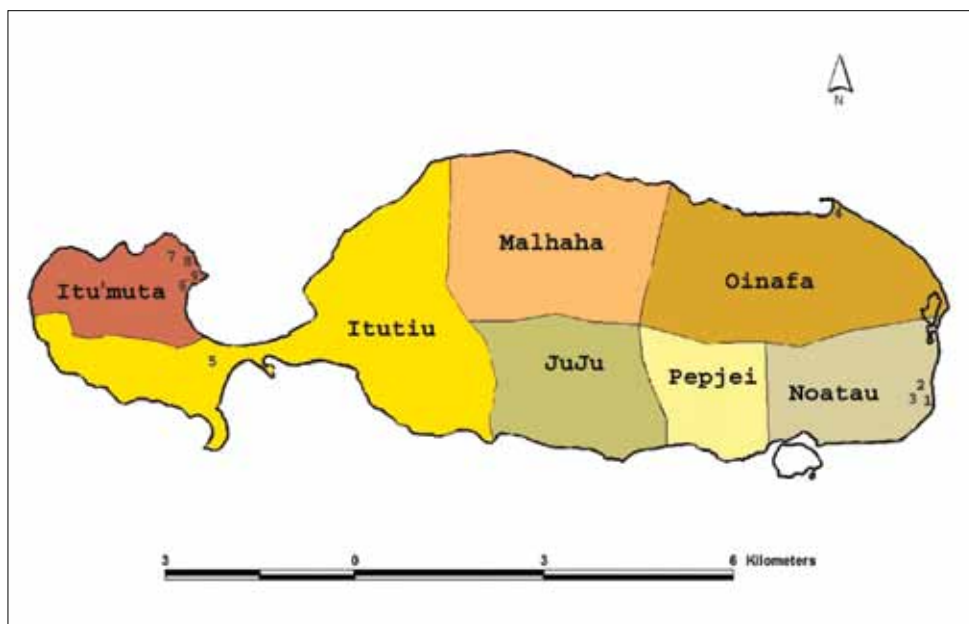


Figure 2 a – f. Photographs of (a) marine sub-fossil *Natica* sp. (b) dead freshwater shell of *Melanoides tuberculata* Muller, 1774. (c) the introduced semi-slug *Parmarion martensi* Simroth, 1893; note the reduced shell 'plate' partially hidden by the fleshy mantle. (d) a living specimen of the relatively large introduced snail *Quantula striata* (Gray, 1834). (e) a ventral view of the adult shell of the introduced snail *Bradybaena similaris* (Rang, 1831). (f) a shell of the introduced snail *Allopeas gracile* (Hutton, 1834).



A



B



C



D



E



F

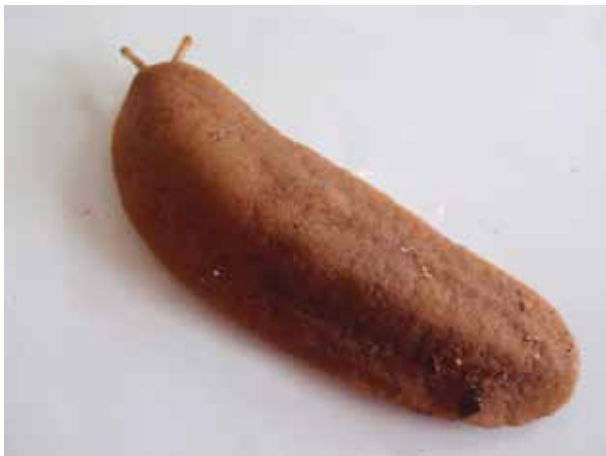
Figure 3 a – f. Photographs of (a) a living *Paropeas achatinaceum* Pfeiffer, 1846. (b) a dead shell of *Subulina octona* (Bruguière, 1789). (c) a living shell-less slug *Sarasinula plebeia* (Fischer, 1868). (d) a living shell-less slug *Semperula wallacei* (Issel, 1874). (e) a living native snail *Elasmias apertum* (Pease, 1865) on vegetation. (f) a dead shell of endemic *Fijianella* sp.



A



B



C



D



E

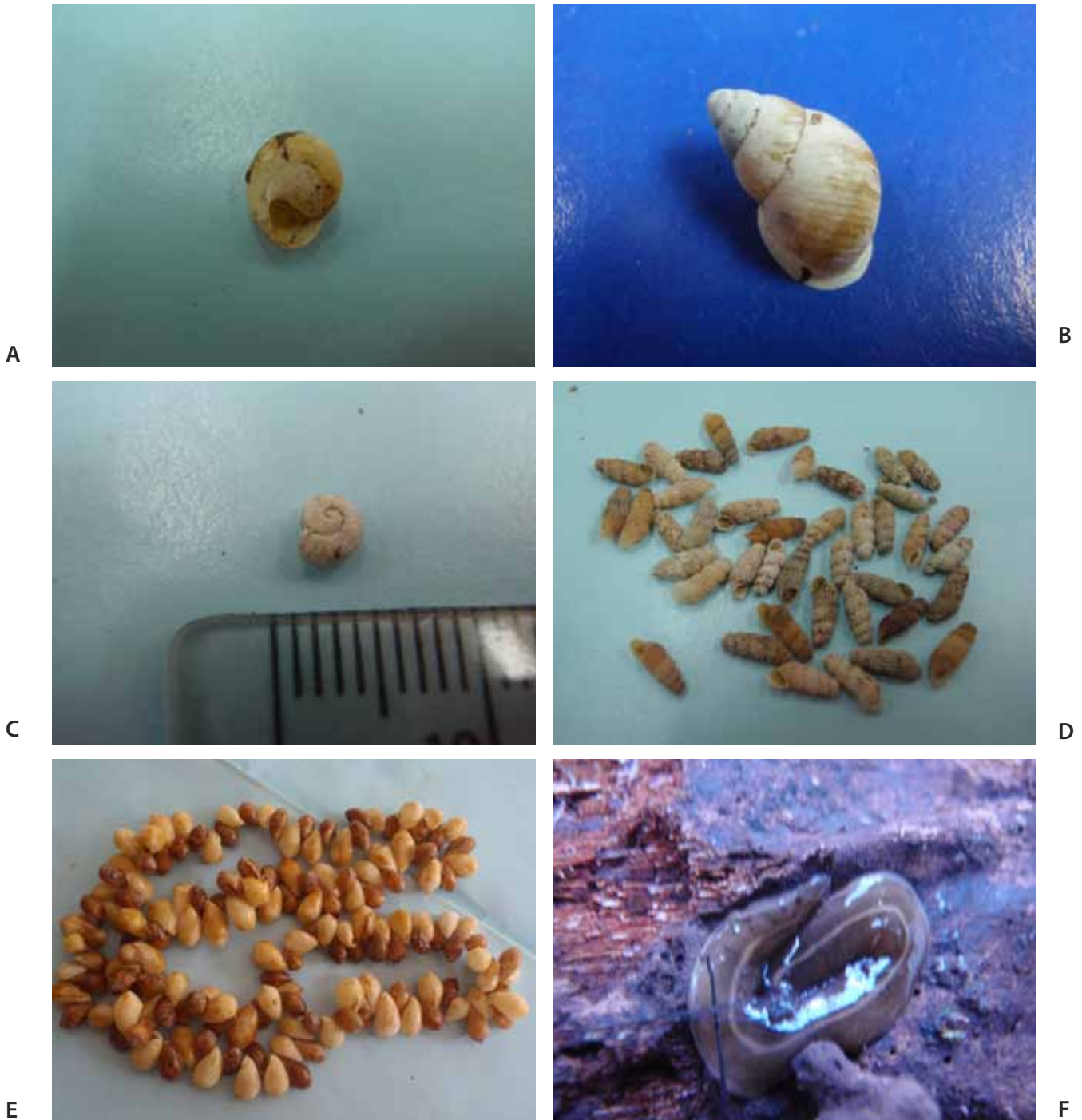


F

Figure 4 a – f. Photographs of (a) the shell of *Omphalotrophis zelirolata* Mousson, 1865. (b) two dead shells of *Omphalotrophis* sp. (c) living banded-colour form of the snail *Melampus flava* (Gmelin, 1791). (d) the shell of an adult *Pythia scarabaeus* (Linnaeus, 1758). (e) two adult shells of the native snail *Pleuropoma fulgora* (Gould, 1847). (f) a living native snail *Pleuropoma* sp. which may be endemic to Rotuma.



Figure 5 a – f. Photographs of (a) a snail shell likely to be *Sturanga modesta* (Pfeiffer, 1854). (b) the shell of an adult *Parula leefi* E.A. Smith, 1897. (c) the shell of a juvenile snail very likely to be *Delos gardineri* (Smith, 1897). (d) the shells of *Truncatella granum* Garrett, 1872 plus an other possible *Truncatella* sp. (e) Two colour forms of dead shells of the snail *Melampus flava* (Gmelin, 1791) as seen in a necklace. (f) the invasive flatworm and snail predator *Platydemus manokwari*.





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*Note: Further data analysis from this survey in comparison to past surveys has been submitted to the journal 'Pacific Conservation Biology' and we expect publication in 2013.*



Discussing *Placostylus* land snails with land owners.

# CONSERVATION, SYSTEMATICS AND CULTURAL CONNECTIONS OF FIJI'S *PLACOSTYLUS* LAND SNAILS

## RESEARCH IN PROGRESS

We gratefully acknowledge the continuous encouragement and support of Mr Dick Watling and staff members of NatureFiji/MareqetViti in this project particularly on Gau Island. Birdlife International supported field work in Kadavu and the South Pacific Regional Herbarium and Conservation International facilitated fieldwork in Nakauvadra and Nakorotubu Ranges. We also thank the National Trust of Fiji for permission to work in the Garrick Reserve.





*Placostylus guanensis* – endemic to Gau.



# CONSERVATION, SYSTEMATICS AND CULTURAL CONNECTIONS OF FIJI'S *PLACOSTYLUS* LAND SNAILS: RESEARCH IN PROGRESS

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University of the South Pacific (Biology) December 2012

## INTRODUCTION

*Placostylus* land snails are found only in the western Pacific. Their biogeography, relatively large size, vulnerability to extinction (e.g. poor dispersal ability) and their connection to declining forest areas has resulted in considerable attention from scientists focused on western Pacific areas outside of Fiji (e.g. Sherley 1996, Triggs & Sherley 2003, Ponder *et al.* 2003, Brescia *et al.* 2008, Neubert *et al.* 2009, Trewick *et al.* 2009, Buckley *et al.* 2011). Several members of the genus are considered threatened or already extinct in New Caledonia, Australia and New Zealand (see IUCN Red-list). As a result of escalating rates of land degradation (Lees & Siwatibau 2007) and continuing invasive species introductions (Cowie 2004; Brodie *et al.* 2012), *Placostylus* species known from small islands are of particular conservation concern. Fiji has 14 described endemic species of *Placostylus* (Barker *et al.* 2005), seven of which are recorded from a single small island. When this project started in 2009 these endemic species had been little studied beyond initial descriptions and some limited information of distributions and habitats. These species had not previously been formally assessed for their conservation status.

## PROJECT OBJECTIVES

1. Compare and review Fiji's recorded endemic *Placostylus* species.
2. Investigate the distribution, habitat and microhabitat preferences of selected members of Fiji's *Placostylus* species.
3. Investigate the life history characteristics of selected members of Fiji's *Placostylus* species.
4. Examine the genetic relationships among the known *Placostylus* species recorded from Fiji, including the populations of a single species found on more than one island within the archipelago.
5. Examine the genetic relationship between Fiji's *Placostylus* species and other Pacific Island members of the genus.
6. Search for any historical, traditional, cultural or ecological linkages between *Placostylus* land snails and human communities in Fiji.
7. Contribute information on endemic and endangered species to local education and scientific programs of NatureFiji-MareqetiViti and to the publication of an annotated catalogue to Fiji's native land snail fauna.

## RESULTS

### 1. Compare and review Fiji's recorded endemic *Placostylus* species

Numerous scientific names have been established in the literature for Fijian *Placostylus*. Currently, twelve species are recognized as valid, and a further two species of uncertain but possibly valid status (Barker *et al.* 2005). It is recognized, however, that the systematics of the Fijian species is in need of revision. In 2012, existing and newly collected data from the current project were used to formally assess the conservation status of the Fijian species for the 1st time via the IUCN Red List process. The results of those assessments are given in Table 1. Of the 14 assessments, two species were determined to be 'critically endangered', six species were determined to be 'endangered' and two species were designated as 'vulnerable'. This result means that Fiji now has 64% of the world's Red List assessed *Placostylus* species and 59% of the world's placostylid species that are formally considered as highly threatened (vulnerable or above). These figures relate strongly to effort and opportunity and should not be misinterpreted as placostylids in several other Pacific Island countries, such as the Solomon Islands and Vanuatu, have not yet been assessed. Three members of our research team (Brodie, Barker, Bogitini) were directly involved with the IUCN Red List training and assessment for regional land snails including GIS mapping. Brodie and Barker created the assessments for the Fiji *Placostylus* species and these were reviewed by members of the IUCN-Oceania assembled expert panel.



Unknown juvenile *Placostylus* sp.

Table 1. Fourteen Fijian *Placostylus* species names and their recently released 2012 IUCN Red List status.

Species and Authority	2012 IUCN Red List Status (vers. 3.1)	Assessment Citation
<i>Placostylus elobatus</i> (Gould, 1846)	Vulnerable B1ab(iii)	Brodie, G. & Barker, G. 2012. <i>Placostylus elobatus</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a>
<i>Placostylus fulguratus</i> (Jay, 1842)	Least Concern	Brodie, G. 2012. <i>Placostylus fulguratus</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus garretti</i> Pilsbry, 1900	Data Deficient	Brodie, G. 2012. <i>Placostylus garretti</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus graeffei</i> (Crosse, 1875)	Endangered B1ab(iii)	Brodie, G. 2012. <i>Placostylus graeffei</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus guanensis</i> (Garrett, 1872)	Endangered B1ab(iii)+2ab(iii)	Brodie, G. 2012. <i>Placostylus guanensis</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus hoyti</i> (Garrett, 1872)	Endangered B1ab(iii)	Brodie, G. & Barker, G. 2012. <i>Placostylus hoyti</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus kantavuensis</i> (Crosse, 1870)	Endangered B1ab(iii)+2ab(iii)	Brodie, G. 2012. <i>Placostylus kantavuensis</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a>
<i>Placostylus koroensis</i> (Garrett, 1872)	Critically Endangered B1ab(ii,iii)	Brodie, G. & Barker, G. 2012. <i>Placostylus koroensis</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus malleatus</i> (Jay, 1842)	Vulnerable B1ab(ii,iii)	Brodie, G. 2012. <i>Placostylus malleatus</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus mbengensis</i> Cooke, 1942	Critically Endangered B1ab(iii)	Brodie, G. 2012. <i>Placostylus mbengensis</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus morosus</i> (Gould, 1846)	Least Concern	Brodie, G. 2012. <i>Placostylus morosus</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus ochrostoma</i> (Garrett, 1872)	Endangered B1ab(iii)	Brodie, G. 2012. <i>Placostylus ochrostoma</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus seemanni</i> (Dohrn, 1861)	Endangered B1ab(iii)+2ab(iii)	Barker, G. & Brodie, G. 2012. <i>Placostylus seemanni</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .
<i>Placostylus subroseus</i> Fulton, 1915	Data Deficient	Brodie, G. 2012. <i>Placostylus subroseus</i> . In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <a href="http://www.iucnredlist.org">www.iucnredlist.org</a> .

In the current study comparative measurements of shell morphology for each species observed was recorded and will be reported in the MSc thesis of Bogitini which is expected to be completed in 2013. Juveniles of an additional relatively large species of *Placostylus* (see below), which appears to have different shell features to other known members of the genus in Fiji was found in two widely separated areas of Viti Levu. Mature individuals are required before further conclusions can be drawn.

2. Investigate the distribution, habitat and microhabitat preferences of selected members of Fiji's *Placostylus* species.

*Placostylus* species have been recorded from eleven of the larger islands in the Fiji group and this historical record is reflected in the maps that accompany the Red List assessments. At least 6 species appear to be restricted to a single island, however some changes to the current understanding of species' distribution are expected once a taxonomic revision is completed using morphological and genetic data from the current study.

Observations of the current study, in addition to observations of previous workers has been combined to provide a summary of the lifestyles and habitats for each *Placostylus* species (Table 2). It is very clear that *Placostylus* species are strongly dependent on retention of non-degraded forest habitat. Retention of primary forest is particularly significant and urgent for the two species assessed in the Red List as 'Critically Endangered', *Placostylus mbengensis* and *Placostylus koroensis* endemic to the islands of Beqa and Koro, respectively.

**Table 2. Fijian *Placostylus* species with comparative details of their lifestyle and habitat. 'terrestrial' lifestyle = ground dwelling.**

Species and Authority	Lifestyle	Habitat
<i>Placostylus elobatus</i> (Gould, 1846)	terrestrial	Lowland and high elevation forest
<i>Placostylus fulgaratus</i> (Jay, 1842)	arboreal	Lowland to high elevation forest
<i>Placostylus graeffei</i> (Crosse, 1875)	terrestrial	Mid to high elevation forest
<i>Placostylus guanensis</i> (Garrett, 1872)	arboreal	Mid to high elevation forest
<i>Placostylus hoyti</i> (Garrett, 1872)	terrestrial	Unrecorded to date
<i>Placostylus kantavuensis</i> (Crosse, 1870)	terrestrial	Lowland to mid-elevation forests
<i>Placostylus koroensis</i> (Garrett, 1872)	terrestrial	Mid-elevation forest
<i>Placostylus malleatus</i> (Jay, 1842)	arboreal	Primarily mid-elevation forest
<i>Placostylus mbengensis</i> Cooke, 1942	arboreal	Lowland forest
<i>Placostylus morosus</i> (Gould, 1846)	arboreal	Primarily mid-elevation forest
<i>Placostylus ochrostoma</i> (Garrett, 1872)	arboreal	Lowland to mid-elevation forest
<i>Placostylus seemanni</i> (Dohrn, 1861)	terrestrial	Lowland to high elevation forest

As stated by Bogitini *et al.* (2011), even arboreal species need to descend to the ground to lay eggs and most likely require relatively deep leaf litter microhabitat similar to the strictly terrestrial species.

*Placostylus fulgaratus* and *Placostylus guanensis* were selected as foci for studies of habitat preferences and possible plant associations. These studies are being carried out on Viti Levu and Gau Islands, respectively. Preliminary observations suggest a linkage between *Placostylus* occurrence and particular plant species. Plant identifications are currently in progress via the South Pacific Regional Herbarium and details will be reported further in the MSc thesis of Bogitini.

3. Investigate the life history characteristics of selected members of Fiji's *Placostylus* species.

Data on the size and maturity of *Placostylus* individuals found in several locations on Viti Levu, Gau and Kadavu have been recorded but not yet analysed.

4. Examine the genetic relationships among the known *Placostylus* species recorded from Fiji, including the populations of a single species found on more than one island within the archipelago.

Seven different *Placostylus* species were considered to be seen at least once during the project to date; one species (*Placostylus fulgaratus*) is particularly common on Viti Levu while two other species (*P. graeffei* and *P. koroensis*) have only been seen as a single dead shell. Unlike *P. koroensis*, *P. graeffei* was searched for extensively and is therefore considered rare. Fresh tissue samples for the comparison of DNA have been obtained for four species to date. Efforts to obtain samples of the remaining species are in progress. Whatman FTA microcards (see Régnier *et al.* 2011) are being used to decrease the number of living animals needed for analysis, particularly for 'Critically Endangered' species. DNA samples are currently being analysed (MSc training for Bogitini) with direct assistance from research collaborator Buckley at Landcare Research, New Zealand.

5. Examine the genetic relationship between Fiji's *Placostylus* species and other Pacific Island members of the taxon.

DNA samples are currently being analysed (MSc training for Bogitini) with direct assistance from, and results shared with, two overseas research collaborators (Buckley, Trewick) who have already published on *Placostylus* in other regional Pacific Island countries. Tissue samples of *P. fulgaratus* will also contribute to a wider study of pulmonate gastropods being undertaken by a research group in Australia.

6. Search for any historical, traditional, cultural or ecological linkages between *Placostylus* land snails and human communities in Fiji.

A poster on the potential cultural aspects of *Placostylus* was presented at a regional conference on traditional knowledge held at the University of the South Pacific (Matewai & Brodie, 2011). However, information gathered to date suggests that Fijian communities have strong connections to freshwater and marine mollusc species, but no strong cultural link to land snails. Leads provided by several collaborators, including NatureFiji-MarequetiViti, turned out on investigation to be related to freshwater snails. A search for local names or totem use in select terrestrial locations is continuing.



7. Contribute information on endemic and endangered species to local education and scientific programs of NatureFiji-MareqetiViti and to the publication of an annotated catalogue to Fiji's native land snail fauna.

Educational materials on both native and introduced snails were provided to NatureFiji-MareqetiViti (NFMV) for use in their Garrick Reserve awareness programs. Material specifically on *Placostylus guanensis* from Gau island was provided for the NFMV website (threatened species of the month) and also provided to another USP community sustainable development program operating long-term on Gau Island.

A draft catalogue of the Fiji land snail catalogue by Barker (Landcare Research New Zealand) and Bouchet (Paris Museum), that includes Fiji's placostylid species, has been a pivotal resource in the project. USP provided letters of support, enabling funding to be secured for publication of the catalogue, illustrated and supplemented by a distributional database, due for completion in March 2013.

Additional factsheets, with photographs of living animals wherever possible, for each Fijian *Placostylus* species are now in draft form and will be collated into a guide e-book for publication via USP Press in 2013.

## CONCLUSIONS and FUTURE RECOMMENDATIONS

Considerably more research work on all aspects of Fiji's *Placostylus* land snails is needed. The current project, including the postgraduate student thesis expected in 2013, in tandem with the IUCN Red List training and assessments, has provided improved clarity of what species are of highest priority and what questions need to be the focus of ongoing research.



*Placostylus* shell from Kadavu.

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Cicia Island.

BRIEF REPORT ON A  
LAND SNAIL SURVEY  
OF CICIA ISLAND,  
LAU GROUP, FIJI ISLANDS

Dr Gilianne Brodie and Mr Jale Naivalurua

December 2012

## INTRODUCTION

The small island of Cicia, in Fiji's Lau island archipelago, has a land area of less than 35km<sup>2</sup>. The indigenous forest has undergone major deforestation and degradation and is now confined to small hard to assess coastal headlands, limestone ridges and ravines occupying less than 10% of the island (Barker 2012; pers. obs.).

In collaboration with a University of the South Pacific 'Climate change adaptation and food security project' led by Dr Jimaima Lako, the land snail fauna of the small island of Cicia in eastern Fiji was surveyed from the 5-10th of December 2012.

The land snail fauna of the Lau Group has been previously documented (e.g. Solem 1978; Cernohorsky 1978) however land snails on Cicia were not included in either of these two studies. The land snails of Cicia however, have been recorded at least once in the past (see Price 1971, Barker *et al.* 2005, Barker pers. comm.) and four (4) species are recorded (Table 1).

Table 1. Land snail species recorded from Cicia prior to the current 2012 survey.

Species and Authority	Reference	Status
<i>Thaumatodon spirrhymatum</i> Solem 1973	Price 1971, Barker <i>et al.</i> 2005, Barker 2012	Endemic to Cicia Island – Critically Endangered on IUCN Red-List
<i>Opeas</i> sp.	Barker pers. com.	Introduced, not identified to species level
<i>Orobophana</i> sp.	Price 1971; Barker <i>et al.</i> 2005	Native, possible endemic, not identified to species level
<i>Pleuropoma beryllina</i>	Barker, unpublished data	Native, also known from Samoa

The current survey carried out in early December 2012 is therefore the first survey of the land snail fauna of Cicia Island in over 40 years. The survey objectives can be divided into two parts (A and B) which generally link to surveys of different habitat types i.e., relatively human disturbed and less disturbed respectively: (A) targets introduced snail species and (B) targets native/endemic snail species.

## OBJECTIVES

### PART A

- (1) to identify any introduced land snail species that may be present on the island
- (2) to create awareness and report to the Cicia Island community an estimate of the potential risk (to human health and/or agricultural crop production) associated with any introduced land snail fauna found on the island
- (3) to establish if Cicia is free of the invasive land snail species *Parmarion martensi* and the invasive flatworm predator *Platydemus manokwari*, as already found and reported on the islands of Viti Levu and Rotuma respectively.



## PART B

- (4) To find out if any living member of the threatened Polynesian tree snails (partulids) exist on Cicia Island.
- (5) To attempt to find populations of the critically endangered snail *Thaumatodon spirrhydatum*, which is unique to Cicia and not found anywhere else in the world.

## METHODOLOGY

To address all five objectives land snails were surveyed at cooler times of the day in: relatively disturbed village community plantations and gardens and less disturbed vegetated headlands and limestone ridges; plus in ravine areas containing remnant patches of 'native' vegetation. All land snails specimens found both living and dead shells, were measured and photographed. A very limited number of specimens and dead shells were collected for reference lodgment in the USP References collections. DNA samples (snail slime) were also collected from these collected specimens before preservation to allow analysis of the genetic relationship between snail species on Cicia and very similar snails from other parts of Fiji and the region.

## RESULTS

Objective 1. To identify any introduced land snail species that may be present on the island.

At least four introduced land snail species were found (Table 2). Further microscopic analysis of smaller shell specimens may reveal additional species. In comparison to other parts of Fiji the absence of the Asian tramp snail *Brabybaena similis* Rang 1831 was unexpected and notable as this species is a known crop pest and is common on Viti Levu (Brodie & Barker 2012e).

Table 2. Four introduced species of land snail found on Cicia during the current survey In 2012 and their associated risks.

Introduced Species Found	Estimated Risk as per Brodie & Barker 2011	Primary Risk Factors as per Brodie & Barker (2011; 2012a-d)
<i>Parmarion martensi</i> Simroth, 1893	High (invasive)	Preference for non-cooked food crops such as papaya and lettuce. Known vector for rat lung worm parasite which may cause meningoencephalitis in humans. Potential trade barrier with Australia, New Zealand and mainland United States of America who do not have this species.
<i>Sarasinula plebeia</i> (Fischer, 1868)	Medium to High	Known agricultural pest on numerous crops, population numbers increase substantially in the wet season. Usually found association with cooked food such as bele, may function as a vector for serious parasites. Also recorded as a pest to nursery mahogany.
<i>Subulina octona</i> (Bruguère, 1789)	Low	Minor pest in gardens and nurseries – often found in large numbers
<i>Quantula striata</i> (Grey, 1834)	Low	No immediate crop threat but relatively large snail and may compete with native fauna.

Objective 2. To create awareness and report to the Cicia Island community an estimate of the potential risk (to human health and/or agricultural crop production) associated with any introduced land snail fauna found on the island.

As per Table 2, two of the above species have known associated medium to high risk (Brodie & Barker 2011; Brodie & Barker 2012a-d), these risks were discussed while on Cicia in community forums, in homes, with farmers, with local school teachers and the local agricultural officer. Associated factsheets for each of these species, and additional introduced species for which introduction may occur in the future, were provided to the following three Cicia residents Mata-ni-Tikina, Agricultural Officer, Secondary School Principal.

Objective 3. To establish if Cicia is free of the invasive land snail species *Paramarion martensi* and the invasive flatworm predator *Platydemus manokwari*, as already found and reported on the islands of Viti Levu and Rotuma respectively.

*Paramarion martensi* was found in variable abundance at several locations on the island. It was not found after extensive searching in some locations where the habitat was very suitable and it is therefore assumed that its introduction to the island is relevantly recent.

No specimens of the invasive flatworm *Platydemus manokwari* were found.

Objective 4. To find out if any living member of the threatened Polynesian tree snails still exist on Cicia Island as reported in 1970.

Living members of the Polynesian tree snail *Partula nr lanceolata* which is endemic to Fiji's Lau Islands was found in two separate locations. Additional dead shells found in an additional location suggest the presence in additional populations maybe possible.

Objective 5. To attempt to find populations of the critically endangered snail *T. spirrhydatum*, which is unique to Cicia and not found anywhere else in the world.

Microscopic analysis is required to determine if this species is present in any of the soil or detritus samples collected.

## LOCAL CAPACITY BUILDING AND TRAINING

The second author of this report (Jale Naivalurua) has very strong family and cultural linkages to Cicia Island. He had no prior exposure to any land snail training before this survey. However with guidance, he is now capable of leading and conducting future land snail surveys, both in Cicia and other parts of Fiji in a professional manner.

### Preliminary Conclusions and Recommendations

- Further community awareness for both introduced and native snail species is required, large posters in vernacular to each village and the 5 schools would probably be effective.
- Strict quarantine and biosecurity measures, particularly in respect to incoming planting materials or horticultural product are needed to reduce the risk of further introduced and invasive snail introductions, (e.g. Asian tramp snail *Bradybaena similaris*) and other related invasives, such as the predatory flatworm *Platydemus manokwari*, from other areas of Fiji.

- In light of community priorities and continuing deforestation a captive breeding program maybe necessary in the future to ensure the survival of the unique Lauan endemic species *Partula nr lanceolata*.
- An IUCN Red-list assessment needs to be completed for the Fiji endemic species *Partula nr lanceolata*.

A more detailed report to the Cicia community and associated stakeholders will be provided by the end of March 2013, this new document will include a more detailed set of recommendations.

## ACKNOWLEDGEMENTS

We sincerely thank all land owners for permission to conduct our surveys on their land and our host communities for their support and guidance. We particularly thank our donor Critical Ecosystem Partnership Fund (CEPF), Dr Jimaima Lako (USP Biology) and Mr Inoke Kama (Mata-ni-Tikana Cicia) and their respective family members without whom this survey would not have been completed.

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*University of the South Pacific postgraduate student Jale Naivalurua from Tarukua village observing living endemic snails on Cicia.*

# FACTSHEETS

## FIJI'S INTRODUCED LAND SNAIL FAUNA

These factsheets were prepared primarily to assist local quarantine and agricultural officers in Fiji. The risk assessment levels given are justified in the following publication:

Brodie, G. & Barker, G.M. (2011). *Introduced land snails and slugs in the Fiji Islands: are there risks involved?* Pages 32–36 In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds) 2011. *Island Invasives: Eradication and Management*. IUCN, (International Union for Conservation of Nature), Gland, Switzerland.

We gratefully acknowledge the kind assistance of Mr Rob McGill, staff at Koronivia Research Station and the Fiji Biosecurity Authority for their proof reading of these factsheets.





## *Parmarion martensi*

Simroth, 1893

FAMILY ARIOPHANTIDAE

**Current Risk Status in Fiji:**  
High (invasive)

**Body Type:**  
Semi-slug: small plate-like shell carried on mid-posterior dorsum

**Size:**  
Live body length to 45 mm, shell ~ 8 mm length and 5 mm width



USP Introduced Land Snails of the Fiji Islands Fact Sheet Series, No. 1



Manaaki Whenua Landcare Research

CRITICAL ECOSYSTEM PARTNERSHIP FUND



Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

### Special Points of Interest:

- *Parmarion martensi* is well established in several areas of Fiji and is currently considered to be Fiji's highest risk introduced land snail species.
- *Parmarion martensi* is considered invasive in Fiji because it is common in relatively undisturbed native forest and is very likely to out compete native fauna.
- Introduced land snails in Fiji are known vectors for the rat lung worm parasite which may cause illness in humans.

## Description & Distribution

### Description

*Parmarion martensi* Simroth 1893 is a long elongate semi-slug, with a visceral hump whose mantle flaps mostly conceal a small oval plate-like shell. The tail has a distinct pale cream line (keel) ending over a short caudal horn at body posterior. The shell is often covered by the mantle tissue and therefore is not always directly visible. The species is variable in body colour ranging from pale grey to very dark brown occasionally with an orange tinge. It is possible these different colour morphs may be a different species of the same genus.

### Distribution

*Parmarion martensi* is indigenous to south-east Asia but now distributed in the Pacific territories of Fiji, Samoa, and Hawaii. Not yet recorded as established in Australia, New Zealand or mainland USA. Re-



Source and location of photographs:  
M. Matewai & G. Brodie (Viti Levu)

corded from Fiji's three largest islands, Viti Levu, Vanua Levu and Taveuni. Occurrence on more isolated islands e.g. Rotuma is currently unknown. Dispersal has been facilitated by humans (Barker *et al.* 2005) and this species is likely to be transported within the Fijian islands with harvested crops, horticultural produce and camping equipment.

## Habitat

*Parmarion martensi* is found both on the ground (terrestrial) and in trees (arboreal). In Fiji, *P. martensi* is often found directly on crops or in moist leaf litter or within loose upper soil layers. It is obviously adaptable and can be found in all sheltered microhabitats, both in disturbed areas (including human

infrastructure) and relatively "undisturbed" high priority forest areas e.g. Taveuni Forest Reserve. Found at low, mid and high (>800m) altitudes. The shells of dead animals are often found in soil used for agricultural purposes particularly after land clearing burns.

## FIJI LAND SNAILS



## Biology & Behaviour

### Biology

Herbivore and detritivore. Recorded to prefer a diet of soft plant material particularly fresh lettuce, papaya, hibiscus flowers and decaying vegetables. *Parmarion martensi* is hermaphroditic meaning it can function as both a male and a female. Extremely hardy, readily aestivates

(shuts down) and can withstand being sealed in a small closed container for several weeks.

### Behaviour

Excellent climber, very active, defecates readily when handled. Found singularly or in groups. Particularly active nocturnally, but has no obvious aversion to light or humans.

## Threats & Similar Species

### Threats

*Parmarion martensi* has a high livestock and human health risk; it is a known vector for the nematode parasite rat lung worm *Angiostrongylus cantonensis* which may lead to human eosinophilic meningoencephalitis. Risk is also heightened by the ready connection of the species to human food that is not normally cooked e.g. lettuce and papaya. Smaller specimens are likely to have a higher parasite load (Hollingsworth *et al.* 2007). Thorough washing of fruit and vegetable produce before consumption is required to avoid related parasite ingestion in humans. This species is a potential quar-

antine risk to non-infected trading partners and is also likely to reduce crop yields. The relative importance of *P. martensi* as a health risk, crop pest, or as a potential competitor to native land snails in Fiji, has yet to be fully documented.

### Similar Species

The introduced slug *Deroceras laeve* (Müller, 1774) is less common in Fiji but similar in size and colour to *Parmarion martensi*. However, *D. laeve* has a very much reduced visceral hump, with the shell entirely internal, prefers only areas with cool temperatures, and does not generally display such a distinctly vigorous, active climbing habit.

## Further Reading

- Barker, G.M., Price, R. & Briggs, C. (2005). Priorities for additions to the Fijian protected natural areas network: an assessment based on complementarity in land snail assemblages. New Zealand Landcare Research contract report prepared for Wildlife Conservation Society, Suva. 162 pp.
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### How to Cite:

Brodie, G. & Barker, G.M. 2012. *Parmarion martensi* Simroth, 1893. Family Ariophantidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 1.

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## *Bradybaena similaris*

Rang, 1831

FAMILY BRADYBAENIDAE

**Current Risk Status in Fiji:**  
Medium - High

**Body Type:**  
Snail with fully developed rounded shell

**Size:**  
Adult shell diameter ~14 mm, shell height ~ 11 mm



USP Introduced Land Snails of the Fiji Islands Fact Sheet Series, No. 2



Manaaki Whenua Landcare Research



Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

### Special points of interest:

- *Bradybaena similaris* is common in suburban gardens. It can be found in large numbers particularly during extended periods of cool, rainy weather.
- *B. similaris* is a well documented agricultural pest and considered to be particularly problematic in cucurbit (= melons and gourds such as cucumber and pumpkin) crops.
- *Bradybaena similaris* is not considered invasive in Fiji because it is normally only found in disturbed areas.

## Description & Distribution

### Description

The head of the living *Bradybaena similaris* (Rang, 1831) is round with two long, dark tentacles, each with a simple eye at the tip. A shorter set of tentacles lie closer to the mouth. The adult shell is round and coiled, consisting of five whorls. The shell apex is broadly rounded (helicoid) and ventrally a distinct umbilicus is visible. The shell aperture lip is slightly flared. This species is polymorphic as banded and non-banded, yellow and brown morphs have been documented (Stanisic 1998). Once the animals die the shell leaches of colour and becomes white or dirty translucent pale cream.

### Distribution

*Bradybaena similaris* is native to Asia and considered to be widely distributed by human commerce



Source and location of photographs:  
G. Brodie (Suva, Viti Levu)

(Barker *et al.* 2005). In Fiji this species is very common in Suva and known from many other areas of Viti Levu. Also reported on the islands of Mana, Ovalau, Matuku and Lakeba (Barker *et al.* 2005). It is found in several other Pacific island areas including the Cook Islands (McCormack 2007), New Caledonia, Vanuatu, Guam and Samoa (Cowie 2001).

## Habitat & Behaviour

### Habitat

In Fiji, *Bradybaena similaris* is most reported from disturbed lowland to highland areas (Barker *et al.* 2005). The species is also common in well-shaded areas of suburban gardens, including the gardens of USP's Laucala campus.

### Behaviour

*Bradybaena similaris* is often found

on the ground (terrestrial) but can also climb onto vegetation (arboreal). Like most land snails *B. similaris* is nocturnally active and can be found "resting" in groups during the day (gregarious). Because of its high dispersal ability, *B. similaris* is often referred to as the Asian tramp snail.



## FIJI LAND SNAILS



## Biology

The life history of *Bradybaena similaris* is characterized by a combination of short lifespan, early sexual maturity, and few reproductive events, with a huge reproductive effort in each event and high mortality in the first reproduction (Carvalho *et al.* 2008). This species is an “r-strategist” meaning that they mature and reproduce quickly with little to no parental care.

Leahy (1984) reported that breeding and nest building in Brazil occurs in the wet season (October to January). Nests are excavated just under the surface in moist soil. Less than 20 eggs are laid per nest and eggs hatch in ~15 days. Eggs are considered relatively resistant to desiccation. *B. similaris* can function as both a male and female i.e. it is a hermaphrodite (Leahy 1984).

## Threats & Similar Species

### Threats

*Bradybaena similaris* is a cosmopolitan pest feeding on ornamental plants in many subtropical and tropical areas (Leahy 1984). Lee (1973) reported this species as a serious agricultural pest in Hong Kong, feeding mainly on Chinese white cabbage, flowering cabbage, watercress and beans. Documented in Australia as an agricultural pest (Stanisic 1998) and considered to be particularly problematic in cucurbit (= melons and gourds such as cucumber and pumpkin) crops. May occur in large numbers so that animals and their faecal matter hinder clean harvesting of produce. *B. similaris* can also serve as

an intermediate host for several serious parasites including the infamous rat lung worm that can be harmful to humans, the trematode *Postharmostomum gallinum* which infects domestic chickens (Amato & Bezerra 1992), and *Eurytrema coelomaticum* a fluke of ruminants such as cattle. The latter parasite can cause losses in milk and meat production (Lapage 1958).

### Similar Species

Very similar in shell shape to *Quantula striata*, which is much larger (adult shell diameter ~ 25 mm, shell height ~ 16 mm). The shell of adult *Q. striata* is also a much deeper reddish brown on the upper surface and has six shell whorls, while *Bradybaena similaris* has five. The umbilicus of *B. similaris* is also more distinctly rounded.

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### How to Cite:

Brodie, G. & Barker, G.M. 2012. *Bradybaena similaris* (Rang, 1831). Family Bradybaenidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 2.

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## *Laevicaulis alte* (Férussac, 1822)

FAMILY VERONICELLIDAE (=VAGINULIDAE)

**Current Risk Status in Fiji:**  
Medium - High

**Body Type:**  
Slug, no shell

**Size:**  
Adults up to 4 cm in length



**USP Introduced Land  
Snails of the Fiji  
Islands Fact Sheet  
Series, No. 3**



**Manaaki Whenua  
Landcare Research**



Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

## Description & Distribution

### Description

No shell is present. Mantle covering entire dorsum and overlapping the head; a pair of eye-bearing tentacles protrude anteriorly from under the mantle when the animal is active. The mantle is leathery and its surface has a slightly granulated appearance. The mantle is dark brown to blackish, with a pale line running more-or-less the entire length of the dorsum. *Laevicaulis alte* is well camouflaged and it is commonly referred to as the "Tropical Leatherleaf". An inferior pair of tentacles on the head are bilobed and inconspicuous. The ventral side is broad, with a broad hyponotum on either side of a narrow (~ 5 mm wide) foot. The respiratory orifice and anus are ventral, at the body posterior.

### Distribution

An African origin is likely. Wide-



Source and location of photographs:  
G. Brodie (Viti Levu)

spread in northern Australia (Stanisic 1998) and also reported from Hawaii, New Caledonia, Vanuatu and possibly Samoa and American Samoa by Cowie (2000). Widely distributed in the Fiji Islands (Barker *et al.* 2005).

## Habitat & Biology

### Habitat

Terrestrial, found in leaf litter and under rotting wood. Lowland to high elevation forests, plantations and moist tall grasslands (Barker *et al.* 2005).

### Biology

Individuals of *Laevicaulis alte* are protandric hermaphrodites, that is they change sex from male to female during their lifetime. Detailed anatomical investigations have been made by Bishop (1977) & Thomé (1989). This slug hatches

from eggs and can reportedly grow from 0.5 cm to ~ 4 cm in length in 7 months. The species has several adaptations for living in dry conditions, for example a leathery dorsum (surface) and a narrow foot to reduce evaporation. Populations of the slug have been documented to reach maximum density during rainy seasons reaching up to 20 slugs/m<sup>2</sup>. It appears that good summer rainfall and increased relative humidity provide a favourable environment for growth and abundance of the pest.

### Special points of interest:

- *Laevicaulis alte* is considered a medium to high risk introduced land snail species in Fiji because it is a documented crop pest and a known vector for human parasites.
- *Laevicaulis alte* is not considered an invasive species in Fiji as it is generally found only in disturbed areas.
- *Laevicaulis alte* changes sex from male to female during its life cycle.



## FIJI LAND SNAILS



## Behaviour

Juvenile specimens usually search for food at night, and stay buried in the soil during the day time. Larger specimens can be active during

cooler times of the day but prefer night time activity. This is why the species is sometimes referred to as a “night crawler”.

## Threats &amp; Similar Species

## Threats

*Laevicaulis alte* is a recorded agricultural pest in Australia and is also medically significant as a vector for vertebrate nematode worm infections (Stanisic 1998). Like most veronicellids it is also considered to have likely environmental impacts (Cowie 2000). It will eat tomatoes, spinach and cucumbers and has been reported by African farmers to be harmful to chickens if ingested. This slug is a known intermediate host for the rat lungworm, which has caused death in dogs and humans.

## Similar Species

The paler *Sarsinula plebeia* (Caribbean Leather-leaf) is very similar but has a narrower body shape. The taxonomy of the veronicellid slugs is notoriously difficult (Cowie 2000) and confirmation of species often requires confirmation by molecular methods. Another similar species the semi-slug *Parmarion martensi* often has a similar thin pale stripe to the mid-posterior of the mantle, but its body is not broad and *P. martensi* also has an obvious visceral hump and a small plate-like shell on its back.

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## How to Cite:

Brodie, G. & Barker, G.M. 2012. *Laevicaulis alte* (Férussac, 1822). Family Veronicellidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 3.

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## *Sarasinula plebeia* (Fischer, 1868)

FAMILY VERONICELLIDAE (=VAGINULIDAE)

**Current Risk Status in Fiji:**  
Medium to High

**Body Type:**  
Slug, no shell

**Size:**  
Adults up to 5 cm in length



**USP Introduced Land  
Snails of the Fiji  
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## Description & Distribution

### Description

*Sarasinula plebeia* (Fischer, 1868) is a relatively large shell-less slug. The upper surface (notum) is leathery and can sometimes appear pitted. The body form is flattened and becomes more elongate when the animal is alive and crawling. The notum colour is generally light to dark mottled brown with no pale stripe. Like all members of its family a mantle cavity is absent. The pneumostome (breathing pore) is very small (Shea 2006) and located at the posterior, under the notum. The head has two pairs of tentacles; the upper pair have terminal eyes. The tentacles are hidden under the notum when the slug is inactive. Because of its surface texture, mottled brown colour and elongated oval shape, *S. plebeia* is sometimes referred to by the common name "Caribbean Leatherleaf".



Source and location of photographs:  
G. Brodie (Viti Levu) & P. Ryan

### Distribution

*Sarasinula plebeia* is native to Central America however it is now widely distributed throughout the Americas and the Pacific. According to Barker *et al.* (2005) this species is widely distributed across the Fiji Islands.

## Habitat & Behaviour

### Habitat

*Sarasinula plebeia* is generally found in moist leaf litter or organic material on the ground, or under stones or rotting logs in areas relatively close to human habitation. It is also found to be arboreal on low vegetation. In Fiji, *S. plebeia* is found in low to midland disturbed forests, plantations, grass lands and gardens (Barker *et al.* 2005).

### Behaviour

*Sarasinula plebeia* is nocturnal, hiding during the day. According to Rueda *et al.* (2002) the species is most active between 2 to 4 am and individuals can travel up to eleven metres in a single night. It has also been recorded that these slugs can bury themselves to depths of 25cm to 1 metre during the dry season (Garcia *et al.* 2007).



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Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

### Special points of interest:

- Veronicellid slugs are notoriously hard to identify. Fiji's *S. plebeia* is most readily confused with *Semperula wal-lacei*.
- With breeding in the wet season *S. plebeia* can reach high population densities in disturbed habitats.
- *S. plebeia* is an important agricultural pest. It is ranked in the top 10 mollusc species with potential to have major pest significance for the United States.

## FIJI LAND SNAILS



## Biology

*Sarasinula plebeia* is an hermaphrodite i.e. individuals are able to function as both male and female during their lifetime. If kept in isolation, self-fertilization may occur (Rueda *et al* 2002). The species lays eggs (oviparous) and produces 1 - 4 clutches per year that average ~ 30 eggs. The species regulates its food intake in response

to water and diet quality. Reproduction is generally high during the rainy season with maturity reached at ~ 2.5 months (Garcia *et al.* 2007). Populations in Mexico are known to increase substantially during heavy continuous rain and this phenomenon has also been observed in Fiji.

## Threats & Similar Species

### Threats

*Sarasinula plebeia* is an agricultural pest on numerous crops and can be extremely abundant (Cowie *et al.* 2009). The species is a polyphagous herbivore (feeds on a variety of plants) but prefers young leaf tissues and soft stems. *S. plebeia* is the most important pest of bean crops in Central America. It is also a known pest in several overseas countries for sweet potatoes, cucurbits and nursery mahogany (Rueda *et al.* 2002, Garcia *et al.* 2007, USDA 2010).

*S. plebeia* is a possible vector in Fiji for parasites like the rat lung worm *Angiostrongylus cantonensis*, which can cause meningoencephalitis in humans. The species is also known as an interme-

diate host for the related nematode, *A. costaricensis*, which causes an inflammatory disease of the intestine in humans (Rueda *et al.* 2002).

### Similar Species

Two other introduced veronicellid slugs occur in Fiji. *S. plebeia* is most similar to *Semperula wallacei*, but the latter is smaller, generally paler brown and with an indistinct pale stripe running longitudinally over the mantle (*S. Gomez pers. comm.*). *Laevicaulis alte* is larger and darker, with a pale stripe running longitudinally over the mantle. These slugs are very variable in body colouration however they are readily distinguished by their internal anatomy, especially that of the reproductive system (Gomes & Thomé 2001).

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Brodie, G. & Barker, G.M. 2012. *Sarasinula plebeia* (Fischer, 1868). Family Veronicellidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 4.

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## *Gulella bicolor* (Hutton, 1834)

FAMILY STREPTAXIDAE

**Current Risk Status in Fiji:**  
Medium - High

**Body Type:**  
Snail with elongate pupiform shell

**Size:**  
Shell < 8 mm high and 2 mm wide



**USP Introduced Land  
Snails of the Fiji  
Islands Fact Sheet  
Series, No. 5**



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**CRITICAL ECOSYSTEM  
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Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

### Special points of interest:

- Despite its small size *Gulella bicolor* is a carnivorous predator capable of threatening populations of small native snails and other invertebrates.
- *Gulella bicolor* feeds in a similar way to the famous high risk carnivorous snail *Euglandina rosea*.
- *G. bicolor* are gregarious (social) and can be found in colonies

## Description & Distribution

### Description

A living *Gulella bicolor* has two pairs of tentacles on the head. The upper pair of tentacles, and a line leading from it along the back, are vermilion (red) in colour giving the front of the animal a very distinctive Y-shaped pattern. The lower tentacles are minute and hard to see. The shell is cylindrical with seven or eight whorls and a blunt apex. The shell is thin and takes on the body's vermilion colour. When empty the shell is transparent and colourless (Hutton 1834). Four prominent teeth, just inside the shell aperture, are easy to see in empty shells (Auffenberg & Stange 1986). The anterior and posterior portions of the body are orange-red and yellow respectively, hence the common name "two-toned" and the specific name "bicolor".

### Distribution

A circum-tropical species, native to India and south-east Asia (Neck 1976). Reported to be widely distributed in the Fiji archipelago in lowland forests and modified ar-



Source & location of all photographs:  
Bill Frank (Florida, USA)

reas but most prevalent in Viti Levu, Ovalau and Vanua Balavu (Barker *et al.* 2005). Reported also as introduced to American Samoa, the Federated States of Micronesia, Guam and the Northern Mariana Islands (Cowie 2001).

## Habitat & Behaviour

### Habitat

*Gulella bicolor* is found in leaf litter and soil and is associated with decaying wood, limestone rocks, caves, stone walls, gravestones, river edges and wharves (Dundee & Baerwald 1984). It is generally found in disturbed areas.

### Behaviour

*Gulella bicolor* is a carnivorous predatory snail that feeds on other snails (e.g. subulinids & pupillids) as well as on earthworms. Commonly found in shaded areas, they are active only when the humidity is high (Dundee & Baerwald 1984).

## FIJI LAND SNAILS



## Biology

*Gulella bicolor* is hermaphroditic (functions as both a male and female) and lays eggs that are comparatively large and few in number. The eggs are capable of with-standing desiccation

for periods of up to nine months. Reproduction is frequent (every other month in warm weather) and they are known to form colonies (Dundee & Baerwald 1984).

## Threats & Similar Species

### Threats

Being carnivorous and with a high reproduction rate, *Gulella bicolor* poses a potential threat to native Fijian species. Impact may be considerable if invasion into native forest occurs.

### Similar Species

The shell of *Gulella bicolor* is similar to other

small elongate snails such as the pupillids (Family Pupillidae) which include the introduced *Gastrocopta* snails and endemic members of the *Nesopupa*. They are also similar to subulinid snails and other members of the Family Streptaxidae. *G. bicolor* is often assigned to the genus *Huttonella*.

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### How to Cite:

Brodie, G. & Barker, G.M. 2012. *Gulella bicolor* (Hutton, 1834). Family Streptaxidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 5.

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## *Streptostele musaecola* (Morelet, 1860)

FAMILY STREPTAXIDAE

**Current Risk Status in Fiji:**  
Medium - High

**Body Type:**  
Snail with well developed elongate shell

**Size:**  
< 9 mm in shell height



**Source of photograph:**  
Robinson *et al.* 2009 via

[http://en.wikipedia.org/wiki/Streptostele\\_musaecola](http://en.wikipedia.org/wiki/Streptostele_musaecola)

Also reported to have been introduced to Australia (Robinson *et al.* 2009), American Samoa (Cowie 2001a & b), Vanuatu and French Polynesia (Solem 1988).

### Description & Distribution

#### Description

The body of a living *Streptostele musaecola* is red (Stanisic 1998). The shell is small (generally 4-7 mm in height) and elongate with strong radial ribs which are prominent on the seven whorls (Solem 1988). The shell aperture has quite a distinct curvature to the upper section of the expanded and thickened outer lip. There are no aperture "teeth" or barriers present. The shell when unoccupied or freshly empty is colourless but it may become "chalky white" with age once empty.

#### Distribution

Members of this family are common in Africa, South America and mainland Asia (Stanisic 1998). Over ninety genera and six hundred species are known and many are recorded as threatened on the IUCN Red List. *Streptostele musaecola* is native to western Africa but has been widely dispersed through human activity (Barker *et al.* 2005). The species is introduced to Fiji but to date known only from Viti Levu.

### Habitat & Threats

#### Habitat

In Fiji, *S. musaecola* is found in lowland disturbed forest (Barker *et al.* 2005). The species is generally found in litter and under stones and logs. In Malaysia members of this family are almost exclusively associated with limestone hills (Bentham Jutting 1954) but this is not the case

elsewhere. In Tahiti recorded in gardens and secondary-growth scrub (Solem 1988).

#### Threats

*S. musaecola* has the capacity to feed voraciously on small or young native snails. However, its impact on the native snail fauna of Fiji is to date undocumented.



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Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

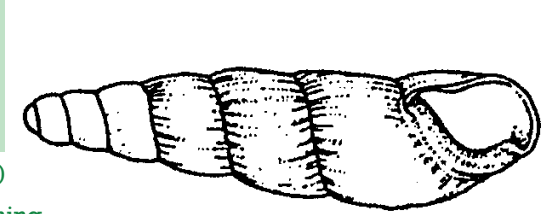
#### Special points of interest:

- Despite its small size *Streptostele musaecola* is a carnivorous predator capable of impacting on populations of small native snails.
- *S. musaecola* has the same feeding method as the famous high risk carnivorous snail *Euglandina rosea*.
- The impact of *S. musaecola* on native fauna of the Fiji Islands is to date undocumented.

## FIJI LAND SNAILS

Drawing adapted from Solem (1988)  
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<http://www.publish.csiro.au/nid/120/paper/IT9880455.htm>



## Behaviour & Biology

Almost all members of the family Streptaxidae are carnivores that can feed on a variety of invertebrates including other snails (Stanisic 1998). *Streptostele musaecola* however is considered to be a molluscivorous species. That is, it is known to primarily feed on other molluscs (see Robinson *et al.* 2009). Although it is primar-

ily a carnivorous predator, *S. musaecola* may also consume fungi and vegetable matter. The species is hermaphroditic (an individual may function as both male and female over their life time). According to Stanisic (1998) the eggs of members of the family Streptaxidae are comparatively large and few in number.

## Similar Species

In shell shape and body colour *Streptostele musaecola* is most often mistaken for *Gulella bicolor* (Hutton). This latter species is less elongate than *S. musaecola* and has obvious “teeth” clearly visible in the shell aperture. The shell of *S. musaecola* is also similar in appearance to members of the family Subulinidae, some of which are also introduced to Fiji. All subulinids

currently found in Fiji have small, elongate, pale shells that have no armature in the shell aperture. However, subulinids do not have a thickened aperture lip, as do *S. musaecola* and *G. bicolor*. *S. musaecola* is widely reported under the name *Luntia insignis* (E.A. Smith, 1898) (see Hausdorf *et al.* 2003) and also under the genus *Tomostele* (Solem 1988).

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### How to Cite:

Brodie, G. & Barker, G.M. 2012. *Streptostele musaecola* (Morelet, 1860). Family Streptaxidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 6.

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***Quantula striata***  
(Grey, 1834)

FAMILY ARIOPHANTIDAE

**Current Risk Status in Fiji:**  
**Low**

**Body Type:**  
**Snail with well developed shell**

**Size:**  
**Shell height ~ 15-20 mm,**  
**shell diameter ~ 26 mm**



**USP Introduced Land Snails of the Fiji Islands Fact Sheet Series, No. 7**



**Manaaki Whenua Landcare Research**



Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

**Description & Distribution**

**Description**

Living *Quantula striata* (Gray, 1834) are variable in body colour but generally reddish brown, pale grey or cream. The relatively thick, well-developed shell reportedly grows to 50 mm in diameter in some countries but this has not been observed in Fiji. The shell is dextral (right handed coiling) with a broadly rounded apex (= helicoid). The shell is relatively large, round and wide with six whorls. In colour the shell is generally deep reddish brown with a creamy white underside. A clear but narrow umbilicus (central opening) can be seen on the ventral surface. Dead shells are usually bleached to pale brown or a dirty white.

**Distribution**

Native to the southern Malay Peninsula. Established in Fiji prior to



P. Ryan

Source and location of photographs:  
P. Ryan, V. Chandra & G. Brodie (Fiji)

1913 (Barker *et al.* 2005) and now widely distributed in Fiji. Found in lowland to mid-elevation forests and gardens. Also introduced in Singapore, Malaysia, Cambodia, the Philippines and some islands in the Rhio Archipelago. *Quantula striata* is sometimes given the common name "Bioluminescent Snail".

**Habitat & Behaviour**

**Special points of interest:**

- *Quantula striata* is reportedly the only land snail in the world capable of true bioluminescence.
- *Quantula striata* is considered a comparatively low risk introduced land snail species in Fiji because it has not been observed as a crop pest or a disease vector and is generally found only in disturbed areas.
- *Quantula striata* is common on USP's Laucala campus and in the Sigatoka Sand Dunes Park. It is generally only active at night or during cool wet weather.

**Habitat**

*Quantula striata* is generally found on the ground but can also climb on low vegetation. Found predominantly in human-disturbed areas such as disturbed forests, gardens, waste ground, lawns, rubbish dumps, under concrete and in open shrubland. It is generally found all year around, but is especially abundant during the wet seasons (Isobe *et al.* 1991).

**Behaviour**

*Quantula striata* prefers cool damp areas with shady vegetation. It is gregarious in nature and can therefore often be found together with other individuals, particularly when inactive during the hotter and drier times of the day. *Quantula striata* is an omnivore (feeds on both plants and animals) however it appears to prefer decaying flesh. More research is needed to confirm this.

## FIJI LAND SNAILS



## Biology

*Quantula striata* is regarded as the only land gastropod in the world capable of true bioluminescence (Councilman & Ong 1988). There is a special organ inside the head which creates flashes of yellow-green light (Copeland *et al.* 1987) although the bioluminescence is reportedly found only in eggs and juveniles

(Isobe *et al.* 1991). The biological function of the bioluminescence in *Q. striata* has not been well established. To the best of our knowledge this phenomena has not been recorded in Fiji. *Quantula striata* reportedly reaches reproductive maturity at about 16mm in shell diameter (Councilman *et al.* 1988).

## Threats & Similar Species

### Threats

*Quantula striata* evidently poses no immediate threat but it is a relatively large snail that can occur in high numbers, so it is likely to compete with native species at the very least. More research is needed.

### Similar Species

*Bradybaena similaris* (Rang, 1831) has a very

similar shell shape but is smaller and generally paler in shell colour when the animal is alive. The comparative adult shell size of *B. similaris* is shell diameter ~14mm, shell height ~11mm. The umbilicus of *Q. striata* (seen as a small hole centrally in the shell's ventral surface) is also narrower than in *B. similaris*. *Q. striata* is often assigned to the genus *Dyakia*.

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### For Further Information Contact:

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***Subulina octona***  
**(Bruguère, 1789)**

FAMILY SUBULINIDAE

**Current Risk Status in Fiji:**  
**Low**

**Body Type:**  
**Snail with elongate shell**

**Size:**  
**Shell up to 17 mm in height**



**USP Introduced Land  
Snails of the Fiji  
Islands Fact Sheet**  
Series, No. 8



**Manaaki Whenua  
Landcare Research**



Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

**Special points of interest:**

- *Subulina octona* is capable of self-fertilization so theoretically only one individual is necessary to create a new population.
- *S. octona* and its eggs are easily transported in soil or via ornamental or crop planting materials.
- Although relatively common *S. octona* is considered a low risk species in the Fiji Islands.

**Description & Distribution**

**Description**

Living individuals of *Subulina octona* (Bruguère, 1789) are uniformly cream to pale yellow in colour. The shell is thin, elongate and translucent. Up to eleven convex whorls are parted by deep sutures. The first two and a half to three whorls are regularly crenulated (notched). The aperture is small and ovate, the outer lip thin (Pilsbry 1946). No aperture teeth or barriers are present. The mature adults often have several relatively large white eggs in the uterus that are visible through the last whorl of the shell (Stanisic 1998).

**Distribution**

*Subulina octona* is indigenous to the tropical Americas including the Caribbean (Pilsbry 1946, Deisler & Abbott 1984). Introduced to many areas including Hawaii, Cook Islands, Samoa, American



Source and location of photographs:  
G. Brodie (Viti Levu) &  
L. Jurickova (Czech Rep.)

Samoa, Tonga, New Caledonia, Vanuatu, Solomon Islands, Marshall Islands, FSM, Palau and Guam (Cowie 2001). It is widely distributed in Fiji particularly in lowland to mid-elevation forests (Barker *et al.* 2005).

**Habitat & Behaviour**

**Habitat**

*Subulina octona* is a terrestrial species that can be found in leaf litter, loose soil and in disturbed habitats (Barker *et al.* 2005). The species is restricted to wetter areas and often found in village crop plantations such as banana.

**Behaviour**

Individual *S. octona* are very

rarely found alone and are most commonly found in small groups (=gregarious). Although some members of the family can aestivate (shut down) during dry months *S. octona* is not known to do this. However, it secretes a mucous membrane over the shell aperture to retard water loss (Stanisic 1998).



## FIJI LAND SNAILS



## Biology

*Subulina octona* feeds mostly on plant materials and debris. It's radula (feeding tongue) is not specialised. It is documented to be a prey item for the introduced predatory snail *Gulella bicolor* (Solem 1988) but the latter should not be used as a biological control agent (Stanisic 1998) because it also consumes native species.

*Subulina octona* is an hermaphrodite i.e. possesses both male and female reproductive organs, and is documented as being capable of self-fertilization under laboratory conditions (Bessa & Araujo 1996). Egg-capsules are hard-shelled and white, measuring 1.8 by 1.5 mm (Pilsbry 1946).

## Threats & Similar Species

### Threats

*Subulina octona* may sometimes become a minor pest in gardens or nurseries by making holes in cultivated plant leaves (Stanisic 1998). However, they are not documented as major pests in other countries. *Subulina octona* is also reported as a second intermediate host for the trematode *Postharmostomum gallinum*, a worm which infects domestic chickens (Juričková 2006).

### Similar Species

The taxonomy of subulinids is notoriously difficult and identification often requires confirmation by specialists. *Subulina octona* is very similar to other members of family Subulinidae such as *Paropeas achatinaceum* or *Allopeas clavulinum*. These latter species have a similar shell morphology except that the whorls have a less rounded periphery (outline). Further the living animal is often more strongly pigmented.

## Further Reading

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Brodie, G. & Barker, G.M. 2012. *Subulina octona* (Bruguière, 1789). Family Subulinidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 8.

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## *Achatina (Lissachatina) fulica* Bowdich, 1822

FAMILY ACHATINIDAE

**Current Risk Status for Fiji:**  
**Very High**

**Body Type:**  
**Snail with well developed shell**

**Size:**  
**Adult shells can reach 20cm in height**



**USP Introduced Land  
Snails of the Fiji  
Islands Fact Sheet  
Series, No. 9**



**Manaaki Whenua  
Landcare Research**



Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

### Special points of interest:

- *Achatina fulica* is considered one of the world's worst invasive pests because of its ability to create high economic loss.
- *A. fulica* has NOT yet become established in Fiji although it is sometimes intercepted by quarantine services on incoming cargo vessels.
- *A. fulica* is a voracious herbivore (plant eater) that is highly active at night.

## Description & Distribution

### Description

*Achatina fulica* Bowdich, 1822 has a narrow, conical shell, which is twice as long as it is wide and comprises 7 to 9 whorls when fully grown (GISD 2010). The shell is generally reddish-brown in colour with weak yellowish vertical markings but coloration varies with environmental conditions and diet. A light coffee colour is common. Adults of the species may exceed 20cm in shell length but generally average about 5 to 10cm. Because of its large size and country of origin *A. fulica* is often referred to as the Giant African Snail or GAS for short.

### Distribution

*Achatina fulica* is native to East Africa. It has been introduced, sometimes intentionally, to many parts of the world including American Samoa, Samoa, Solomon Islands, Vanuatu, New Caledonia, Kiribati, Tuvalu, Cook Islands, French Polynesia, Marshall Islands, Federated



Source and location of photographs: P. Skelton (Samoa) & A. Derksen (Florida)

States of Micronesia, Palau, Wallis & Futuna and PNG (GISD 2010). Some reports need reconfirmation as introductions have in some cases been brought under control and the species has not become established. Despite some reports to the contrary *A. fulica* **is not currently established in Fiji**, although it is sometimes intercepted by quarantine control on cargo vessels arriving from overseas.

## Habitat & Behaviour

### Habitat

*Achatina fulica* is usually found in agricultural areas, coastal areas, natural and planted forests, scrubland, urban areas, riparian zones and wetlands. It is commonly transported locally via plant mate-

rials and equipment (GISD 2010).

### Behaviour

*Achatina fulica* is highly active at night. A voracious herbivore it eats >500 varieties of plants. Also documented to prey on veronicellid slugs (Meyer *et al.* 2008).

**If you find this snail in Fiji please report it urgently to the Biosecurity Authority of Fiji: Phone Suva 3312512.**

## FIJI LAND SNAILS

### Biology

Maturity is reached in approximately 6 months depending on temperature, and life expectancy is between 5 and 10 years (GISD 2010). *Achatina fulica* has the ability to aestivate (shut down) for up to three years in times of extreme drought. Individuals are hermaphrodites (possess organs of both sexes) but instances of self-fertilization



A. Derksen

are rare. The sperm transferred from one individual to another can be stored for up to two years. The snail may lay about 200 eggs per clutch and it may produce about five to six clutches per year. Unlike many native Pacific island land snails, *A. fulica* has a relatively high natural dispersal rate.

### Threats & Similar Species

#### Threats

*Achatina fulica* is considered one of the worst snail pests of tropical and subtropical regions (Raut & Barker 2002). The aggregated nature of infestations can lead to severe damage in crops and high economic losses both in yield and control measures. *A. fulica* may also spread disease through transmission of plant pathogens (such as fungi) and by acting as a vector for parasites with serious human health implications (Wallace & Rosen 1969). Because of their density and relatively large size *A. fulica* can also change the nutrient-cycling dynamics of their ecosystem. They are a nuisance when found near hu-

mans and can be hazardous to drivers on roads. Their decaying bodies release a bad odour and the calcium carbonate in their shells alters soil properties and in turn the types of plants that can grow (Mead 1961).

#### Similar Species

*Achatina fulica* is superficially similar in shape and overall colour to some of the endemic *Placostylus* species found in Fiji. However *A. fulica* grows much larger, the shell has a more rounded, less elongate body whorl, and *A. fulica* does not have an expanded aperture lip.

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Brodie, G. & Barker, G.M. 2012. *Achatina (Lissachatina) fulica* (Bowdich, 1822). Family Achatinidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 9.

#### For Further Information Contact:

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## *Euglandina rosea* (Férussac, 1821)

FAMILY SPIRAXIDAE

**Current Risk Status for Fiji:**  
**Very High**

**Body Type:**  
**Snail with fully developed shell**

**Size:**  
**The adult shell is usually 5 – 8 cm in height and ~ 2 cm in diameter**



**USP Introduced Land  
Snails of the Fiji  
Islands Fact Sheet  
Series, No. 10**



**Manaaki Whenua  
Landcare Research**

**CRITICAL ECOSYSTEM  
PARTNERSHIP FUND**



Direct funding from the Critical Ecosystem Partnership Fund (CEPF) and a USP FSTE Grant is gratefully acknowledged.

### Special points of interest:

- *Euglandina rosea* is a voracious predator that has decimated native snail populations in many Pacific islands.
- To date *Euglandina rosea* has NOT become established in Fiji. It would be an environmental disaster if *Euglandina rosea* was introduced to Fiji either intentionally or accidentally.
- Following strict quarantine regulations is vitally important to keep this species out of Fiji.

## Description & Distribution

### Description

The rosy wolf snail *Euglandina rosea* (Férussac, 1821) is a relatively large terrestrial snail with a long and slender body-shape. The well developed shell is pinkish brown and almost translucent. The shell has four whorls and numerous distinct vertical ridges that can be seen with the naked eye. The body of the living animal is uniformly ginger-brown and the “neck” region is noticeably elongated. A distinct groove runs along the upper mid-line of the “neck” region. In comparison to other species the front anterior edges of the foot (labial palps) are very large and protrude distinctly on either side of the head. Two sets of tentacles are present, with the eyes located on the first and longest pair.

### Distribution

*Euglandina rosea* is native to the south-eastern United States and has been introduced to many areas including Kiribati, French



Source and location of photographs:  
B.Frank (Florida, USA) & T. Ross

Polynesia, American Samoa, New Caledonia, Vanuatu, Solomon Islands, Palau, Guam, Northern Mariana Islands, Papua New Guinea, Japan, Hong Kong, Taiwan, North Borneo, Madagascar, Seychelles, Mauritius, Reunion Islands, India, Andaman Islands, Sri Lanka, the Bahamas and Bermuda (GISD 2011). *E. rosea* is **not currently established in Fiji**, New Zealand or Australia.

## Habitat

*Euglandina rosea* is normally found singularly in a wide variety of habitats including natural forest, planted forest, rural disturbed areas, shrub lands and urban areas (GISD 2011). In the past the

species has been deliberately introduced by humans as a biological control agent for the major agricultural pest *Achatina fulica* but this practice has now been formally condemned by the IUCN.

**If you find this snail in Fiji please report it urgently to the Biosecurity Authority of Fiji: Phone Suva 3312512.**

## FIJI LAND SNAILS



T. Ross

## Biology & Behaviour

### Biology

*Euglandina rosea* is a carnivorous species and a voracious predator, hunting and eating other snails and slugs. It possesses chemical receptors that are used to track snail prey by following their mucus trails. The species is commonly referred to as the “Rosy Wolf Snail” or “Cannibal Snail”.

### Behaviour

In comparison to other snails *E. rosea* moves relatively fast. It is an active predator, hunting and ingesting small invertebrates including smaller snails. *E. rosea* can consume small snail species whole, while larger specimens are maneuvered in such a way that their soft parts are exposed for easier extraction.

## Threats & Similar Species

### Threats

*Euglandina rosea* is listed as one of the world's top 100 invasive species (GISD 2011). It is a very high quarantine risk for Fiji because its large size and carnivorous feeding behaviour makes it an extremely high risk to native fauna (as a predator). *E. rosea* was deliberately introduced to several oceanic islands to control (in theory) the Giant African Snail [*Achatina fulica*] and other snail pest species. Since its introduction to these islands, *E. rosea* has been linked to extinctions and declines of native snail species in every area where it has been introduced

(Kinzie 1992, Cowie 1998, Loope 2002).

### Similar Species

*Euglandina rosea* is similar in size and shape to several of Fiji's endemic *Placostylus* snail species. However, in living animals, *E. rosea* has a very distinct elongate neck in comparison to *Placostylus*. *E. rosea* also has very obvious, extremely large elongated labial palps either side of the mouth, and the shell has distinct vertical ridges that can be seen with the naked eye. *Placostylus* also differs in that it has a distinct lip to the shell aperture in adults that *E. rosea* does not possess.

## Further Reading

- Barker, G.M. & Efford, M. (2004). Predatory gastropods as natural enemies of terrestrial gastropods and other invertebrates. Pp. 279-403 In: Barker, G.M. (ed.), *Natural Enemies of Terrestrial Molluscs*. CABI Publishing, Wallingford.
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Brodie, G. & Barker, G.M. 2012. *Euglandina rosea* (Férussac, 1821). Family Spiraxidae. 'USP Introduced Land Snails of the Fiji Islands Fact Sheet Series', No. 10.

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# BIODIVERSITY CONSERVATION LESSONS LEARNED TECHNICAL SERIES

## CEPF Small Grant Final Project Completion Report

Conservation, systematic and cultural connections of Fiji's endemic *Placostylus* land snails

### *Organization Legal Name*

University of the South Pacific

### *Project Title*

Documentation of Fiji's Endemic and Introduced Land Snail Fauna

### *Date of Report*

December 2012

### *Report Author and Contact Information*

Dr Gilianne Brodie

Phone: 679 3232876

Email: [brodie\\_g@usp.ac.fj](mailto:brodie_g@usp.ac.fj)

### *CEPF Region*

Polynesia-Micronesia Hotspot

### *Strategic Directions*

Strategic Direction 1: Prevent, control, and eradicate invasive species in key biodiversity areas

Strategic Direction 2: Strengthen the conservation status and management of key biodiversity areas

### *Grant Amount*

\$19,327

### *Project Dates*

December 2009 – December 2012

## Implementation Partners for this Project

*Please explain the level of involvement for each partner*

Landcare Research New Zealand – involvement in almost all aspects of study except direct field work

South Pacific Regional Herbarium – facilitation of field survey work in Viti Levu highlands

NatureFiji/MareqetiViti– direct support for field work and community liaison on Gau Island

LäjeRotuma Initiative – logistical assistance with field work and community liaison in Rotuma

Koronivia Research Station – advice and feedback on introduced species fact sheet content and layout

Biosecurity Authority Fiji – feedback on introduced species factsheets

IUCN-Oceania – collaboration and knowledge exchange via IUCN Red listing training and assessments

National Trust of Fiji – assistance with backup storage of Fiji land snail distribution database

## Conservation Impacts

*Please explain/describe how your project has contributed to the implementation of the CEPF ecosystem profile*

This project collated basic information to assist with the identification of introduced, invasive and endemic species in key biodiversity areas. It also helped to identify which areas had critically endangered species and also which areas did not have invasive or introduced species and therefore where strengthened biosecurity measures are required. This information was fed back to land owning communities as well as the national Fiji Invasives Species Taskforce (FIST) committee and provided to the Department of Environment for inclusion in their National Biodiversity Strategy Action Plans.

The project fieldwork was undertaken in several of Fiji's key biodiversity areas including less disturbed 'forested' areas of Gau, Rotuma, Viti Levu and Kadavu, plus the limestone ridges of Cicia Island in the Lau archipelago.

The project increased awareness of endemic and introduced fauna and encouraged strong inclusion of local leaders, plus hands on participation and training of community members, in what we see as the initial stages of the possible implementation of threatened species conservation. Recommendations were provided to stakeholders which will hopefully lead to the development of collaborative recovery plans in the future.

Many aspects of the project have also been directly integrated into the undergraduate and postgraduate teaching programs of the University of the South Pacific.

*Please summarize the overall results/impact of your project against the expected results detailed in the approved proposal*

A summary report of the status of Fiji's lands snail provided to the Fiji government departments of Environment, Agriculture and Forestry.



A checklist of Fiji's introduced land snails produced and published.

Lucid Key Development software obtained and established.

The estimated risk of each of the introduced species; to biodiversity loss, human health and agricultural production has been assessed and results published.

Posters and awareness materials designed and provided to numerous stakeholders.

Factsheets, targeted at quarantine and agricultural officers, to allow rapid identification, have been produced and made publically available. Two additional factsheets on potentially serious land snail invasive species not yet in Fiji also included.

Conversion of factsheets into field guide book via USP Press in progress, completion expected in 2013.

#### EXPECTED RESULTS AS PER ORIGINAL LOI – ENDEMIC SPECIES

Land Snail surveys undertaken in numerous locations but most significant are:

Rotuma Island – detailed report produced (dead shells of *Partula leefi* only found, no *Succinea rotumana* located may be extinct) and scientific paper in revision to journal *Pacific Conservation Biology*.

Cicia Island – brief report produced (more detailed in progress to be completed by early 2013) – two populations of living Fiji endemic partulid *Partula nr lanceolata* found. DNA samples will be sent to partulid specialist in USA for regional comparative analysis.

Checklist of Fiji's endemic *Placostylus* species established after field trips to Navakavadra Range, Nakorotubu and material provided by NFMV from Gau. Fourteen species possible therefore separate *Placostylus* project established as a Master's student project with a molecular component. Scholarship was obtained – thesis completion expected in mid 2013.

No *Fijipoma liberate* found to date.

*Please provide the following information where relevant*

- *Hectares Protected:* N/A
- *Species Conserved:* Assessments for two high priority Fijian endemic partulid snails, *P. leefi* (endemic to Rotuma) and *P. nr lanceolata* (endemic to Lau), that were not included in recent 2012 IUCN land snail assessments because of a lack of data, can now be undertaken as a result of this project.  
IUCN red-listing assessments were undertaken for 14 species of placostylids for the first time – 2 determined as critically endangered, 6 endangered and 2 assessed as vulnerable.  
Project has created a strong foundation for future conservation of numerous other Fiji endemic species e.g. *Trochomorpha* – 17 endemic species now Red-List assessed.  
Globally significant land snail reference collections now established locally in Fiji at the University of the South Pacific.
- *Corridors Created:* N/A

*Describe the success or challenges of the project toward achieving its short-term and long-term impact objectives*

Assessments for two high priority Fijian endemic partulid snails, *P. leefi* (endemic to Rotuma) and *P. nr lanceolata* (endemic to Lau), that were not included in recent 2012 IUCN land snail assessments because of a lack of data, can now be undertaken as a result of this project.

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Project has created a strong foundation for future conservation of numerous other Fiji endemic species e.g. *Trochomorpha* – 17 endemic species now Red-List assessed.

Globally significant land snail reference collections now established locally in Fiji at the University of the South Pacific.

This project has been very success and the outcomes and outputs have created a strengthened local foundation that was previously lacking for land snail conservation and research in Fiji. There is still much work to do collating widely scattered information and identifying gaps, but we have now set clear priorities for where introduced and invasive species management is required and also priorities for future threatened species conservation work on Fiji's endemic land snail fauna. Importantly, in close collaboration with our local and overseas counterparts the project has also began to build local human resource capacity and create the public and community awareness necessary to have conservation work continue in the longer term.

*Were there any unexpected impacts (positive or negative)?*

Positive – Unexpected linkages to IUCN-Oceania Red-list project and opportunities to encourage completion of Fiji Land snail catalogue of Barker & Bouchet.

Negative – Finding the invasive flatworm *Platydemus manokwari* (voracious snail predator) on the only island in the world (Rotuma) reported to have the unique Polynesian tree snail *Partula leefi*.

## Lessons Learned

*Describe any lessons learned during the design and implementation of the project, as well as any related to organizational development and capacity building. Consider lessons that would inform projects designed or implemented by your organization or others, as well as lessons that might be considered by the global conservation community.*

Don't underestimate the time involved with factsheet production; collating existing data, assessing data quality, securing copyright and the checking of final outputs by many stakeholders is very time consuming and requires an experienced decision maker not a new graduate.

Involving local postgraduate students with family and cultural connections to your field trip location is appreciated by communities and improves informal communications, awareness raising and increases the chance of the program continuing.

Don't assume that any indigenous students in your project can speak their local language confidently in public.



Translation to local languages requires considerable thought, particularly in respect to target audience as content for factsheets made for quarantine officers needs to be different to content made for relatively isolated village communities.

*Project Design Process: (aspects of the project design that contributed to its success/ shortcomings)*

One of the strengths of this project’s design was its strong and continuous inclusion of local human resource capacity building and long term-training in both invasive species and threatened species conservation.

*Project Implementation: (aspects of the project execution that contributed to its success/ shortcomings)*

Involving multi-stakeholders is a strength however they also substantially increase the time involved with all aspects of the study particularly up to date reporting and communications.

*Other lessons learned relevant to conservation community:*

Working in remote small island communities is logistically very difficult and requires finding implementation partners with a high level of organization skill, community credibility and existing linkages into the individual communities involved – it also takes considerable time to build the respect and trust needed to implement projects successfully.

## Additional Funding

*Provide details of any additional donors who supported this project and any funding secured for the project as a result of the CEPF grant or success of the project.*

Donor	Type of funding*	Amount	Notes
USP	A	\$21,683 FJD	
CEPF	B	\$17,754 USD	Specific focus on endemic genus established as a high priority in the current project

\*Additional funding should be reported using the following categories:

- A Project co-financing (Other donors contribute to the direct costs of this CEPF project)
- B Grantee and Partner leveraging (Other donors contribute to your organization or a partner organization as a direct result of successes with this CEPF project.)
- C Regional/Portfolio leveraging (Other donors make large investments in a region because of CEPF investment or successes related to this project.)

## Sustainability/Replicability

*Summarize the success or challenge in achieving planned sustainability or replicability of project components or results.*

Local training and capacity building considerably improved the chances of continued work and replication of successes in other locations.

*Summarize any unplanned sustainability or replicability achieved.*

IUCN Red-listing assessment and training.

## Safeguard Policy Assessment

*Provide a summary of the implementation of any required action toward the environmental and social safeguard policies within the project.*

Quarantine related recommendations now included in the Fiji's National Invasive Species Taskforce committee work plan for 2013.

Selected land snails species, now added to Fiji's protected species decree and associated policies via direct Department of Environment.

Project results will be reflected in future National Biodiversity Strategy Action plans for Fiji Islands

## Additional Comments/Recommendations

We have only just scratched the surface there is lots more to be done ...

## Information Sharing and CEPF Policy

*CEPF is committed to transparent operations and to helping civil society groups share experiences, lessons learned, and results. Final project completion reports are made available on our website, [www.cepf.net](http://www.cepf.net), and publicized in our newsletter and other communications.*

*Full contact details:*

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## Performance Tracking Report Addendum

### CEPF GLOBAL TARGETS

*Provide a numerical amount and brief description of the results achieved by your grant. Please respond to only those questions that are relevant to your project.*

PROJECT RESULTS	If relevant, provide your numerical response for results achieved during the annual period.	Provide your numerical response for project from inception of CEPF support to date.	Describe the principal results achieved from 1 February 2009–31 January 2010. (Attach annexes if necessary)
1. Did your project strengthen management of a protected area guided by a sustainable management plan? Please indicate number of hectares improved.	N/A		
2. How many hectares of new and/or expanded protected areas did your project help establish through a legal declaration or community agreement?	N/A		
3. Did your project strengthen biodiversity conservation and/or natural resources management inside a key biodiversity area identified in the CEPF ecosystem profile? If so, please indicate how many hectares.			Gau Island
4. Did your project effectively introduce or strengthen biodiversity conservation in management practices outside protected areas? If so, please indicate how many hectares.			Rotuma Island, Cicia Island (Lau Group), Nakauvadra range, Nakorotubu
5. If your project promotes the sustainable use of natural resources, how many local communities accrued tangible socioeconomic benefits?	N/A		

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