# An Investigation of the Land Snails and Slugs of Nakorotubu Range, Viti Levu, Fiji Islands.

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# Chapter 5

## An investigation of the land snails and slugs of Nakorotubu Range, Viti Levu, Fiji Islands.

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### SUMMARY

Twenty-two different species of terrestrial land snails and slugs were identified during the survey period. Eleven of these species are endemic to Fiji and another two species are either endemic or native. It is likely that at least some of the endemic species found during this survey are threatened and should be listed on the IUCN Red List as in need of some level of conservation action since closely related taxa from the same genera (e.g. *Placostylus*) in other Pacific Island areas are listed. Seven of the species found are introduced and two species are of unknown status. The introductions include *Parmarion martensi* Simroth 1893 which has well documented human health risks in overseas countries. Based on the total number of terrestrial gastropod species found in the Fiji archipelago a higher number of land snail species might be expected.

### INTRODUCTION

The diversity of Fiji's terrestrial, gastropod snails is known to be very high in respect to land area, with 160 endemic and 49 native species recorded (Barker 2005). Unfortunately this highly diverse and unique fauna is not well documented, particularly for identification purposes, which makes calculation of biodiversity loss estimates very difficult (Brodie 2009).

Despite being of global significance, terrestrial snails in most Pacific Islands countries like Fiji are known to be under serious threat (Lydeard et al. 2004; Cowie 2000) with native and endemic fauna affected by deteriorating habitat conditions and rising invasive species numbers (Cowie 2004).

Eighteen introduced terrestrial-gastropod species are recorded as present in Fiji (Brodie & Barker, in review) however to date these do not include two of the world's worst high-risk invasive land snails, the giant African snail *Lissachatina fulica* (Bowdich 1822) and the rosy wolf snail *Euglandia rosea* (Férussac, 1821). These two species are already a significant problem; for biodiversity loss, agricultural production and economic trade opportunities, in neighboring Pacific Island areas (Cowie 2001a, SPC/LRD pers. comm.) and it is a great credit to the Fiji government quarantine authorities that Fiji is so far free of these destructive high-risk alien snails.

It is vital to know what baseline biodiversity is present in our ecosystems in order to make informed decisions about future resource management. We also need to learn from what has occurred in other regional island areas (e.g. Samoa, New Caledonia, French Polynesia and Hawaii) as the risk of extinction of our unique Fijian endemic snail fauna, from habitat loss and invasive species, is extremely high.

Land snails and slugs are known collectively as "sici ni vanua" by Fijians. Surprisingly no

specific names appear to exist for even the most common species that have been in Fiji for many years.

## METHODS

Living snails, and dead snail shells, were collected by hand both opportunistically and by targeted searching throughout the survey period. Overnight pit-trapping was also undertaken. Snails were often found in leaf litter or under rotting wood or climbing on vegetation, such as leafy shrubs or the trunks of small trees. Some climbing (arboreal) snails were also found on human infrastructure such as tents. Almost all sampling was conducted on overcast and relatively wet days.

Specimens were photographed, measured and preserved for future identification in 80% alcohol. DNA samples (optimally small pieces of the tail) were also taken from 14 living species to facilitate future investigations of genetic relatedness to (i) populations in other parts of Fiji and (ii) similar snails being studied in other parts of the Pacific Island region.

Classifications given were determined using Barker (2005) in combination with Burch (1962), Smith & Stanisic (1998), Stanisic (2000) and Cowie (2001a). All specimens will be lodged with the South Pacific Regional Herbarium/ USP Marine Collections.

## SITE DETAILS

Targeted snail collection occurred within a few kilometers of the following locations:

| | |
|---|---|
| Matuku Settlement: | S 17 °37'47.0", E 178°22'07.2" (altitude 59m) |
| Camp 1 | S 17.59; E 178.36 (altitude 162 m) |
| Camp 2 | S 17°35'53.4"; E 178°23'02.4"; (altitude 550m) |
| Nasau Village | S 17.73, E178.42 (altitude 35 m) |
| Camp 3 | S 17.72, E178.42 (altitude 50 m) |

## RESULTS

A total of 135 individual terrestrial snails were collected during the survey period. These spanned seven different families (Bulimulidae, Trochomorphidae, Helicarionidae, Helicinidae, Ariophantidae, Veronicellidae (=Vaginulidae), Subulinidae) and least twenty-two different species with an additional two species possible (Table 5.1). Eleven of the species found are endemic to Fiji and another two species are either native or endemic. Therefore 9% of the overall number of species found was native and 45% endemic. This is lower than expected.

Three different endemic species of the flax snail *Placostylus* were found, one of which could not be easily assigned to any of the four *Placostylus* species recorded from Viti Levu. Although 53 specimens of *Placostylus* (Family Bulimulidae) were collected (~ 40% of total number of snails collected) only 6 specimens in total were found alive. The presence of many dead shells of *Placostylus gracilis* (Brodrip 1840) [52 collected plus many more seen] suggests that this species has a very high mortality rate. Only one specimen of each of the other two *Placostylus* species, *Placostylus graeffei* Crosse 1875 and *Placostylus* sp. (Plate 12), were found. Two different endemic species of *Trochomorpha* (Family Trochomorphidae) were found (Figure 13a & 13b). One specimen of *Trochomorpha* sp.1 was found near each of the three camp locations surveyed while the second species was only found at one location.

Seven of the species found are introduced, 32 % of total number of species found. Five of these seven species are known "pests" and at least three have potential human health risks. One of the introduced species, *Parmarion martensi* Simroth 1893, was commonly found in all sheltered habitats searched, including higher altitude forest and is therefore considered very invasive. The species was observed to be extremely hardy and was found regularly both terrestrially and arboreally within forest habitats and on camping equipment such as tents.

## DISCUSSION AND CONSERVATION SIGNIFICANCE

Fiji's land snail fauna is known to be highly diverse and the 22 land snail species found during this survey is relatively low compared to the 230 species recorded as being found within the Fijian archipelago by Barker (2005). The proportion of native and endemic fauna recorded is also recorded as high, ~ 90% native and ~78% endemic to the archipelago. Thus the figures of 9% native and 45% endemic found during this study are lower than expected. However, calculation of the number of endemic and native snail fauna expected to be found in the forest habitats of Viti Levu is currently in progress (Brodie & Barker unpublished data) and it should be remembered that Barker's figures include non-forest habitats such as the coastal supra-littoral areas of all islands within the Fiji Group.

Considering the known decline in global land snail biodiversity, and the relevant importance of the Pacific Island endemic fauna to that biodiversity (Lydeard et al. 2004) the presence of living specimens of the families Bulimulidae, Trochomorphidae and Helicarionidae, for which all members recorded in Fiji are considered endemic (Baker 2005), during this survey is good news. This result makes the Nakorotubu and Wailotua forest areas significant in local, regional and global land snail biodiversity terms. The family Bulimulidae already has several endemic species from other Pacific Island regions listed as endangered on the IUCN Red List (Brescia et al. 2008) and it is well known that threatened species of Pacific Island mollusc fauna are currently missing from the IUCN data source.

The relatively high proportion of introduced species found during this study (32%) is worrying in light of the

work of Cowie (2001b) and Cowie & Robinson (2003) that our regionally unique fauna is in decline and introductions are producing increasingly homogenized Pacific faunas. The presence of the introduced invasive species *Parmarion martensi* in the more isolated areas of the forest range is of considerable concern as such a common, hardy alien species is capable of contributing significantly to native species extinction via competition alone. In addition, *Parmarion martensi* is a potential vector for parasitic helminths such as the rat lung worm *Angiostrongylus cantonensis* (Chen, 1935) which is associated with eosinophilic meningitis in humans (Boray 1998). *Angiostrongylus cantonensis* and *Eosinophilic meningitis* are already established in Fiji (Alicata 1962, Uchikawa et al. 1984, Paine et al. 1994). However a recent study of *Parmarion cf. martensi* in Hawaii (Hollingsworth et al. 2007) highlights that this species is of particular concern in respect to spreading *A. cantonensis* because it is often associated with poorly washed home-grown crops such as lettuce and has a high infection rate by the parasite. Its vigorous climbing behavior on human infrastructure as see during this current survey makes it much more likely to come into contact with humans (and their food or water sources) than any of the other known snail vectors currently found in Fiji (Brodie & Barker, in review). However, the presence of *A. cantonensis* in Fijian *P. martensi* has not yet been confirmed.

In a report to the South Pacific Commission and the Fiji Government Parkinson (1982) listed seven relatively large species of *Placostylus* land snails as having potential value as specimen shells in the commercial shell trade industry (selling overseas). However, considerable habitat loss in the last 28 years and a strengthened understanding of the extinction risk to our unique molluscan species places a much more cautious view as to a need for their conservation today. The limitation is that it is very difficult to establish or develop conservation plans when we have so little data about species distribution and life history characteristics.

Many terrestrial snails are nocturnally active because of their need for cool, damp conditions. Targeted sampling at night or during wet season conditions may produce additional species in the surveyed area. Many species are arboreal (found in trees) and therefore spot-lighting in trees at night may be effective as would an increased focus on limestone dominated areas because of the calcium required by snails for shell development.

## CONCLUSIONS

### Conservation and future research recommendations

Land snails are excellent sentinel taxa for ecosystem change. Identification of taxa to genus or species level for native or endemic fauna is currently hindered by a lack of readily accessible taxonomic identification information. There is a need for more baseline surveys like this one in the priority forest areas highlighted by Olson et al. 2009 as the unique nature of Fiji's land snail fauna, and the high potential for its irretrievable loss by high risk invasive species, makes strategic planning for their long-term conservation vital. Relatively large scale habitat conservation in areas such as native forest, small islands and areas with significant deposits of limestone (needed by many terrestrial gastropod species for shell development) is required.

Two obvious follow-up studies are needed.

1. A review of the Fijian *Placostylus* species and an investigation of the cause of the observed high mortality in *Placostylus gracilis*.
2. Further investigations into the human health risks and feeding habits of *Parmarion martensi* to fully assess its potential to impact on humans and native fauna in Fiji.

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**Table 5.1:** Details of specimens found in during survey. * Indicates separate DNA sample taken.

| Taxon No. | Brodie Code | Species | Common name | Location plus no. found & collected | Body form | Size | Status |
|---|---|---|---|---|---|---|---|
| 1 | A26, A30, A31, A37, A41, A43, A52*, A53, A58, A64, A72, A59*, A62* | Family Bulimulidae *Placostylus cf gracilis (Broderip 1840)* | Flax shell | 53 in total only 5 alive Camp 2 [A43 (adult), A52 (juv)]; near Nausau village [A58 (juv) A59 (adult)]; and on trip to Camp 3 [A62 (juv)]. Aboreal. | Many weathered shells (white or bleached) collected on ground and one already dead. Fresh and two living shells, mottled brown with pink apex. Thickened aperture in adults, many juvenile shells found dead. | Average size shell height 45 mm, width 25 mm | Endemic |
| 2 | A61 | Family Bulimulidae *Placostylus cf. graeffei* Crosse 1875 | Flax shell | 1 x near Nasau village | Dead shell only, not overly weathered, larger and more elongate shape than P. gracilus. | 64 mm shell height, shell width 29 mm | Endemic |
| 3 | A36* | Family Bulimulidae *Placostylus* sp. (shell appears juvenile) | Flax shell | 1 x Camp 1 S 17.35; E 178.21. arboreal | Board foot, tentacles very long and black. Tail much paler almost yellow. Dark strip down each side of neck. Foot uniform pale creamy yellow. Shell irregularly mottled ginger brown and cream. | Shell height 22 mm | Endemic |
| 4 | A28, A55 | Family Trochomorphidae *Trochomorpha* sp. 1 | | 4 collected in total (1 living each at Camp 1 2 plus two dead shells near Nasau village), arboreal found on tree trunks | Angular pyramid shaped shell with sharp apex, aperture set off to right side, wide umbilicus, distinct pale keel obvious from ventral, aperture oval with pointed sides, aperture edge smooth. Not particularly active when alive. | 13 mm shell diameter, 8 mm in shell height | Endemic |
| 5 | A65* | Family Trochomorphidae *Trochomorpha* sp. 2 | | Camp 3 x 2 (one dead, one alive found separately), arboreal found on tree leaf | Flattened shell, no barriers to aperture, distinct keel to outer whorl, large, wide umbilicus, body pale grey but anterior head and tentacles black, living specimen relatively active | 14 mm shell diameter, 7 mm shell height, 6 mm aperture width (larger specimen) | Endemic |
| 6 | A24*, A27*, A38, A39, A56, A69 | Family Helicarionidae Unknown sp 1 | | 11 in total collected, A24 - Camp 1 x 2; A27 x 1 (juv); arboreal | Mottled look probably caused by semi-transparent shell. No keel present. Pale body but with dark stripes to tentacles. Tentacles and tail/foot relatively long. Very active. | A24 - Living crawling length 19 mm, diameter of shell 11 mm; A27 (juvenile) - 7 mm shell diameter, 11 mm length, 3 mm shell height; A38 Shell diameter 9.5 mm, shell height 7 mm. A56 smaller | Endemic |

*(Table 5.1 Contn'd)*

| Taxon No. | Brodie Code | Species | Common name | Location plus no. found & collected | Body form | Size | Status |
|---|---|---|---|---|---|---|---|
| 7 | A29* | Family Helicarionidae Unknown sp. 2 | | Forest near Camp 1 arboreal | Rounded shell transparent ginger brown. Similar in shape to A71. | 3 mm shell diameter, 8 mm active crawling length, shell height 2 mm | Endemic |
| 8 | A42 | Family Helicarionidae Unknown sp.3 | | 2 x Camp 1, arboreal on shrubs | dull brown shell not transparent, body brown with black tentacles | 15 mm shell diameter, shell height 11 mm; 13 mm shell diameter, shell height 11 mm | Endemic |
| 9 | A46 | Family Helicarionidae Unknown sp. 4 | | 2 x stuck on limestone on way to Camp 2, terrestrial | Light brown transparent shell, fairly transparent long tentacles | 30 mm crawling length, 10 mm width | Endemic |
| 10 | A71* | Family Helicarionidae | | 2 x stuck on limestone on way to Camp 2, terrestrial | Have very uniformly dark iridescent blue body in sunlight. Fast moving, can hang on tight. Shell relatively fragile, similar in shell shape to A29. | 30 mm crawling length, 10 mm width | Endemic |
| 11 | A44 | Family Helicinidae | | 1 on way to Camp 2, found on ground, fallen? | No photograph of living specimen | 12 mm live length, 5mm wide | Native or Endemic |
| 12 | A45, | Family Helicinidae | | 4 x Camp 2 | Shell with sharply pointed apex, aperture with a smooth edge, parietal callus present | Shell diameter 5 mm, height, shell height 4 mm | Endemic |
| 13 | A66* | Family Helicinidae | | 1 x Camp 3, arboreal | Globular brown shell, active. Distinctly textured shell, with raised ridges. | Live crawling length 10 mm, shell diameter 5 mm | Native or Endemic |
| 14 | A21*, A47, A49, A50, A51, A54* | Family Ariophantidae | | All locations, 18 collected , many others seen | Semi-slug, dark colored, semi-slug, relatively narrow, smooth body with small oval shell into which the snail cannot retract | ~ 35 mm, live crawling length, 7 mm width | Introduced, (highly invasive, associated health risk). |
| 15 | A21 | Family Arophantidae *Parmarion aff. martensi* Simroth, 1893 | | 1 x Camp 1 | As above but wider rough textured body and distinctly ginger in colour | Not recorded | Introduced, (health risk likely) |

*(Table 5.1 Contn'd)*

| Taxon No. | Brodie Code | Species | Common name | Location plus no. found & collected | Body form | Size | Status |
|---|---|---|---|---|---|---|---|
| 21 | A25, A60 | Family: Ariophantidae *Quantula striata* (Gray, 1834) | luminescent snail | 8 in total collected only one alive, 2 worn shells on way to Camp 1, Camp 3 and near Matuku settlement | Relatively large shell, white when worn, dark rosey brown when alive, ventral paler | Shell diameter ~ 28 mm, shell eight approximately 18 mm | Introduced, (little known risk, however clear evidence of flatworm association seen in one specimen [A60] |
| 16 | A22, A34, A57 | Family Veronicellidae (= Vaginulidae) Laevicaulis alte (Férussac, 1822) | Tropical Leatherleaf | 2 on way to Camp1, 2 x Camp 1, 1 x Nasau village | Shell-less slug, relatively large board, uniform dark brown with distinct pale line down central dorsum | ~ 50 mm long, 20 mm wide, foot width 6 mm | Introduced, (agricultural pest and documented human health risk) |
| 17 | A35 | Family Veronicellidae (= Vaginulidae) *Sarasinula plebeia* (Fischer, 1868) | Caribbean Leatherleaf or bean slug | 1 on way to Camp 1 | Shell-less slug, very active. Paler than A34, faint pale line centrally, mottled network of dots and lines. | Live crawling length 39 mm, width 13 mm, foot with 4 mm. | Introduced, (agricultural pest) |
| 18 | A70 | Family Veronicellidae (= Vaginulidae) Unknown sp. 1 Likely to be same as A35 & A48. | | 1 x Camp 3 | Shell-less slug, no photograph taken. | Preserved length 31 mm | Introduced |
| 19 | A23, A67 | Family Veronicellidae (= Vaginulidae) Unknown sp. 2. Could be *Semperula wallacei* (Issel 1874) | | 2 collected, 1 on way to Camp 1, other near Camp 3 | Shell-less slug, relatively dull uniform brown, with pitted appearance to mantle. | A23 = 42 mm length, 24 mm wide; A67 = 49 mm live crawling length, 19 mm wide, 5 mm foot width. | Unknown could be native |
| 20 | A48 | Family Veronicellidae (= Vaginulidae) Unknown sp. 3. Same as A35 & A70 likely. | | 2, in leaf litter near Camp 2 | Shell-less slugs, no photograph taken | 30 mm length, 10 mm width | Introduced |

*(Table 5.1 Contn'd)*

| Taxon No. | Brodie Code | Species | Common name | Location plus no. found & collected | Body form | Size | Status |
|---|---|---|---|---|---|---|---|
| 22 | A63 * | Family Subulinidae *Subulina* cf. *octona* (Bruguière, 1792) | subulinid | 8 collected, 4 dead shells, 4 alive, others seen all Camp 3. | Uniform pale yellow elongate shell, lowest shell whorl with white gonad/egg in living specimens. Terrestrial. | Shell height ~13 mm, width ~ 3 mm, aperture width ~ 2 mm | Introduced, agricultural pest |
| 23 | A40 | Family Subulinidae Unknown sp. 1 (juveniles) | subulinid | 4 x Camp 1 in rotting log | Pale yellow shell and bodies, smooth aperture with no barriers | 3-4 mm live crawling length | Introduced, pest species |
| 24 | A68* | Unknown | | 1 x Camp 3 | Shell apex sharp, body pale yellow damaged, preserved shell transparent | ~ 3 mm | Unknown |