

The endangered partulid tree snail *Samoana thurstoni* (Cooke and Crampton, 1930) on Olosega and the land snail diversity of the Manu'a Islands, American Samoa*

Robert H. Cowie^{1#}, Rebecca J. Rundell², Falaniko Mika³, and Pasla Setu³

¹Bishop Museum, 1525 Bernice Street, Honolulu, Hawaii 96817, U. S. A.

²Department of Zoology, University of Hawaii, Honolulu, Hawaii 96822, U. S. A.

³American Samoa Community College, Land Grant Program, Pago Pago, American Samoa 96799, U. S. A.

Abstract: Survey work on the American Samoan island of Olosega, one of the three Manu'a Islands (Ta'u, Ofu, Olosega), increased the known land snail fauna of the island from 6 to 30 species. Of these species, 17 are native to the islands and 13 are introduced. Most notable was the discovery of *Samoana thurstoni* (Cooke and Crampton, 1930) (Partulidae), previously considered an Ofu endemic. The entire land snail fauna of Manu'a is composed of 45 species, with 40 on Ta'u, 32 on Ofu, and 30 on Olosega. The three islands have 23 species in common. Endemism is low. Each island appears to have a random subset of the total species, though this may partly reflect a need for further survey work as well as true randomness in the natural construction of the faunas. While some native species seem to be extinct, others are surviving. However, the faunas of all three islands, especially the ground-level faunas, are dominated by alien species, notably species of Subulinidae. That such a relatively accessible island as Olosega should yield so many new records suggests that additional survey work is necessary throughout much of the Pacific before we can have the baseline inventory of Pacific land snail biodiversity necessary for its conservation.

Key Words: biodiversity, conservation, land snail, Pacific, Partulidae, Samoa, *Samoana*

The Samoan archipelago lies in the south-central Pacific Ocean and is divided politically between Samoa (formerly Western Samoa) and American Samoa. The native land snail fauna of the islands includes numerous endemic species, but a number of widespread alien species are also present (Cowie, 1998, 2001a).

This paper focuses on the Manu'a group of American Samoa, with three main islands: Ofu, Olosega and Ta'u (Fig. 1). Until recently, the land snail faunas of these islands were poorly known. Although large collections, from Ta'u in particular, had been made in the early 20th century and are held in the Bishop Museum (Honolulu), little had been published on the faunas as a whole. Cowie (1998) listed all species reported from the Samoan archipelago in the literature up to 1997, giving island by island distributions as far as could be ascertained from that literature. Subsequent field work (Cowie and Cook, 1999, 2001; Cowie, 2001a) on Ofu and Ta'u, as well

as Tutuila (the main island of American Samoa) and the adjacent small island of Aunu'u (Cowie and Rundell, 2002), extended this knowledge of the faunas of these islands. This work demonstrated the precarious nature of some of the species, especially the four species of Partulidae, the decline of most native species, and the increase and continued introduction (Cowie, 2001a) of a relatively small number of widespread alien species.

None of this previously reported work has included more than scanty collecting on Olosega, the fauna of which thus remains almost unknown. Only six species have been recorded from Olosega in the literature (Cowie, 1998).

This paper reports on the land snail species collected during field work on Olosega in the early 2001, provides a faunal inventory for island based on these new collections and on earlier collecting, and compares the land snail fauna of Olosega with the faunas of the other Manu'a Islands.

METHODS

Field survey work was undertaken on Olosega in February and April 2001. Samples of snails were taken at

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#Current address: Center for Conservation Research and Training, University of Hawaii, 3050 Maile Way, Gilmore 408, Honolulu, Hawaii 96822, U. S. A.

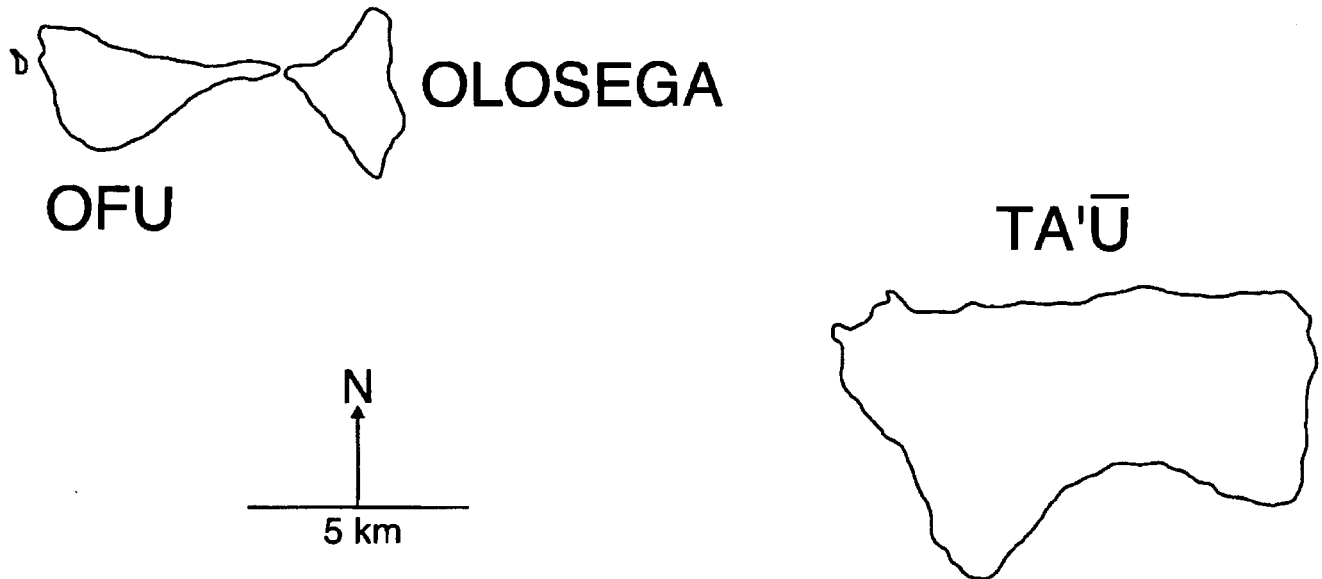


Fig. 1. The Manu'a Islands of American Samoa. The islands lie between 169° and 171° W and between 14° and 15° S. Tutuila, the main island of American Samoa lies approximately 100 km to the west of the Manu'a Islands.

14 locations on the island (Fig. 2). These locations ranged from lowland coastal habitats to the highest point on the island (elevation 634 m).

Collecting protocols followed Cowie and Cook (1999, 2001) and Cowie (2001a), essentially involving timed hand collecting from vegetation and from the ground-level litter and upper soil levels. This study, as those previous studies, was intended as a species inventory survey. Therefore, in the interests of maximizing number of species detected per unit effort, no litter/soil samples were taken for laboratory analysis (cf. Emberton *et al.*, 1996; Cowie, 2001a). At most sampling stations, the field team of 4 to 6 people searched the above-ground vegetation for 10 min and the ground-level litter/soil for an additional 10 min. Untimed samples were taken incidentally when interesting snails/slugs/shells were encountered (including one sample on Ofu). In addition, while moving through the forest, vegetation was continually scanned for tree snails, especially Partulidae.

The samples were returned to the laboratory for sorting and identification, with confirmation of identifications based on comparison with previously identified material (including type material) in the extensive Pacific island land snail collections of the Bishop Museum (Honolulu).

All samples have been deposited in the Bishop Museum mollusc collections (accession number 2001.067; catalog numbers BPBM 261780-261851). Representative specimens of most species were also deposited at the American Samoa Community College (Land Grant

Program) and at the National Park of American Samoa.

In addition, previous collections from the Manu'a Islands held at the Bishop Museum were reviewed and the database of the land snail collections of the Field Museum (Chicago), the only other major museum with large holdings of Samoan land snails, was scanned for records.

RESULTS

Species recorded on Olosega

Table 1 lists the species collected on Olosega during the 2001 survey, as well as those previously known from the island. It also indicates their biogeographic status: endemic (occurs naturally only in the Samoan archipelago), indigenous (occurs naturally in the Samoan archipelago but also elsewhere), alien (artificially introduced to the Samoan archipelago), cryptogenic (of unknown native or alien origin - Carlton, 1996).

Prior to this study, only six species of land snails had been reported in the literature from Olosega (Table 1). Of these, three were native, two were cryptogenic (probably introduced by early Polynesian colonizers though they may occur in the Samoan Islands naturally), and one was a more recent, probably late eighteenth or nineteenth century, introduction. Twelve additional unreported species are represented by previous collections in the Bishop Museum (Table 1); of these species seven are native, one is cryptogenic, and four are alien.

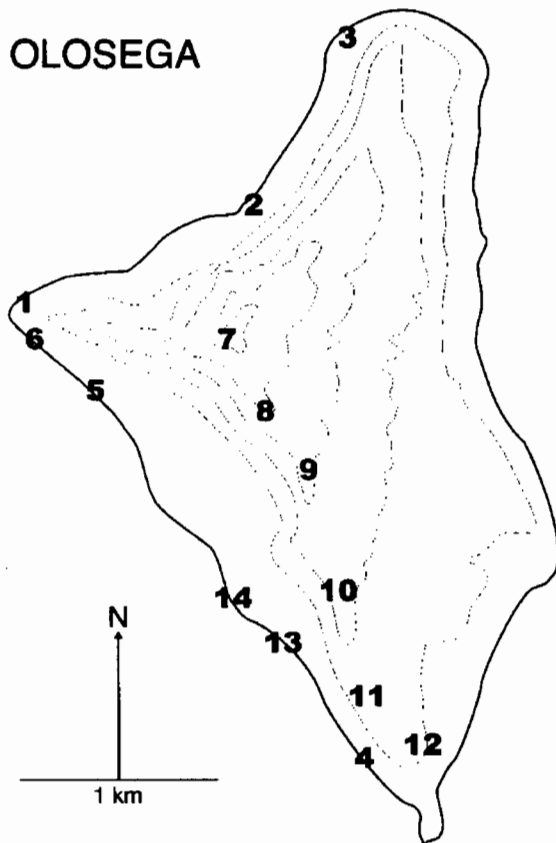


Fig. 2. Numbered sampling stations on Olosega. Contours at 122 m (400 ft) intervals.

The 2001 survey collected 22 species (Table 1), including 3 of the 6 previously recorded in the literature, 7 of the 12 previously collected but unreported, and 12 newly recorded species. Of these newly recorded species, seven are native and five are alien.

The most notable find was *Samoana thurstoni* (Partulidae), found at three mid- to high-elevation sampling stations (stations 8, 9, and 10; c. 300-500 m). At each of the two stations (9, 10) at which live individuals were found during the regular sampling, an additional 30 min of searching was undertaken by 5 members of the field team, but no additional *S. thurstoni* were found. A total of six live individuals was recorded, including three adults, two subadults, and one small juvenile. Four dead shells were also found at station 10 and a single dead shell was found at station 8. The habitat was mid-elevation forest (not cloud forest) with a relatively open understory and an incomplete canopy. Most *S. thurstoni* individuals were associated with the endemic Samoan tree *Syzygium samoense* (Burkhill) Whistler. No partulids were previously known from Olosega (Cowie, 1998), and *Samoana thurstoni* was previ-

ously known only from the summit of Ofu, where it is extremely rare and threatened (Cowie and Cook, 1999, 2001).

Notable absences in the 2001 survey were three of the six species previously reported: *Minidonta manuaensis* Solem, 1976 (Endodontidae), *Discocharopa aperta* (Möllendorff, 1888) (Charopidae), and *Lamellidea oblonga* (Pease, 1865) (Achatinellidae). Also, neither the giant African snail, *Achatina fulica* Bowdich, 1822, nor the alien predatory snail *Euglandina rosea* (Férussac, 1821) was recorded.

The study increased the reported land snail fauna of Olosega from 6 to 30 species.

The faunas of Ta'ū, Ofu, and Olosega

The entire fauna of Manu'a includes 45 land snail (and slug) species (Table 1). Ta'ū has 40 species, Ofu 32, and Olosega 30. Of these species, 23 are found on all 3 islands and 34 on at least 2 islands.

Endemism is low: only three species are endemic to Manu'a (*Samoana thurstoni*, *Minidonta manuaensis*, *Sinployea clausa* Solem, 1983), with two additional possible endemics (*Pleuropoma* n. sp., *Omphalotropis* sp.), and one subspecific endemic (*Sinployea allecta tauensis* Solem, 1983). Only *Sinployea clausa* is endemic to a single island, although *Pleuropoma* n. sp. may be, and *Sinployea allecta tauensis* is a single-island endemic at the subspecific level.

Of the seven species recorded from Ta'ū only, three are or may be endemic to the island (*Pleuropoma* n. sp., *Sinployea clausa*, *S. allecta tauensis*, see above). The other four are widespread species, either alien (*Achatina fulica*, *Euglandina rosea*) or native [*Allochroa layardi* Adams and Adams, 1855, *Coneuplecta microconus* [Mousson, 1865]]. Three species are recorded from Ofu only: *Tralia costata* (Quoy and Gaimard, 1832) is a naturally widespread Pacific species; *Eua zebrina* (Gould, 1847) is known also from Tutuila; and *Bradybaena similaris* (Rang, 1831) is a widespread alien in the Pacific. Only one species, *Ovachlamys fulgens* (Gude, 1900), is recorded from Olosega only; it is an increasingly widespread alien in the Pacific and elsewhere, including Tutuila.

A large proportion of the fauna is alien. Of the 45 species recorded from Manu'a, only 26 are native. The other 19 include 13 alien species and 6 cryptogenic species. Proportions of native to alien/cryptogenic species are not significantly different (log-likelihood G test) on the 3 islands: Ta'ū - 24:16, Ofu - 18:14, Olosega - 16:14.

DISCUSSION

This study of Olosega and the recent surveys of Ta'ū and Ofu (Cowie and Cook, 1999, 2001; Cowie, 2001a) constitute the most comprehensive land snail survey of

Table 1. Species of land snails from Ta'u, Ofu, and Olosega, with biogeographic status in the Samoan archipelago (see text for explanation of terms). Abbreviations: S, data from the 2001 survey; R, previous records in the literature (Cowie, 1998, 2001a); B, additional previously unpublished records from the malacological collections of Bishop Museum; F, unpublished information from the on-line database of the malacological collections of the Field Museum, Chicago.

Family/species	Ta'u	Ofu	Olosega	Status
HELICINIDAE				
<i>Orobophanu musiva</i> (Gould, 1847)	R	R	B, S	endemic
<i>Pleuropoma beryllina</i> (Gould, 1847)	R		S	indigenous
<i>Pleuropoma fulgora</i> (Gould, 1847)	R	R	R, S	indigenous
<i>Pleuropoma</i> n. sp.	R			endemic/indigenous
TRUNCATELLIDAE				
<i>Truncatella guerinii</i> Villa and Villa, 1841	R	R	S	indigenous
ASSIMINEIDAE				
<i>Assiminea parvula</i> (Mousson, 1865)	R	R	B	indigenous
<i>Omphalotropis</i> sp.	R	R	B	endemic/indigenous
VERONICELLIDAE				
<i>Vaginulus plebeius</i> Fischer, 1868 ^a	R	S	S	alien
ELLOBIIDAE				
<i>Allochroa layardi</i> Adams and Adams, 1855	B			indigenous
<i>Laemodonta monilifera</i> (Adams and Adams, 1854) ^b	B	B		indigenous
<i>Melampus castaneus</i> (Megerle, 1816)	R	R		indigenous
<i>Melampus fasciatus</i> (Deshayes, 1830)	R	R	S	indigenous
<i>Melampus luteus</i> (Quoy and Gaimard, 1832)	B	B	S	indigenous
<i>Pedipes sandwicensis</i> Pease, 1860	B	B		indigenous
<i>Pythia scarabaeus</i> (Linnaeus, 1758)	R	R	S	indigenous
<i>Tralia costata</i> (Quoy and Gaimard, 1832)		R		indigenous
ACHATINELLIDAE				
<i>Elasmias</i> sp.	R	R		cryptogenic
<i>Lamellidea oblonga</i> (Pease, 1865)	R		R	cryptogenic
<i>Lamellidea pusilla</i> (Gould, 1847)	R	R	R, S	cryptogenic
PUPILLIDAE				
<i>Gastrocopta pediculus</i> (Shuttleworth, 1852)	B	R	B	cryptogenic
<i>Nesopupa</i> sp.	B		B	endemic/indigenous
<i>Pupisoma orcula</i> (Benson, 1850)	B	R	B	cryptogenic
PARTULIDAE				
<i>Eua zebrina</i> (Gould, 1847)		R		endemic
<i>Samoana thurstoni</i> (Cooke and Crampton, 1930)		R	S	endemic
SUBULINIDAE				
<i>Allopeas clavulinum</i> (Potiez and Michaud, 1838)	R	R	B, S	alien
<i>Allopeas gracile</i> (Hutton, 1834)	B	R	S	alien
<i>Lamellaxis micra</i> (d'Orbigny, 1835)	F	R	S	alien
<i>Opeas hannense</i> (Rang, 1831)	B	R	B, S	alien
<i>Paropeas achatinaceum</i> (Pfeiffer, 1846)	R	R	B, S	alien
<i>Subulina octona</i> (Bruguière, 1789)	R	R	R, S	alien
ACHATINIDAE				
<i>Achatina fulica</i> Bowdich, 1822	R			alien
SPIRAXIDAE				
<i>Euglandina roseu</i> (Férussac, 1821)	R			alien
STREPTAXIDAE				
<i>Gulella bicolor</i> (Hutton, 1834)	B	R	B, S	alien
<i>Streptostele musaecola</i> (Morelet, 1860)	R	R	S	alien
RHYTHIDIDAE				
<i>Ouagapia gradata</i> (Gould, 1846)	R	R		indigenous
ENDODONTIDAE				
<i>Minidonta manuaensis</i> Solem, 1976	R		R	endemic
CHAROPIDAE				
<i>Discocharopa aperta</i> (Möllendorff, 1888)	R		R	indigenous
<i>Sinployea clausu</i> Solem, 1983	R			endemic
<i>Sinployea allecta tauensis</i> Solem, 1983	R			endemic

(continued)

Table 1. (continued)

Family/species	Ta'ū	Ofu	Olosega	Status
SUCCINEIDAE				
<i>Succinea manuana</i> Gould, 1846	R	R	B, S	endemic
HELICARIONIDAE				
<i>Coneuplecta microconus</i> (Mousson, 1865)	B			indigenous
<i>Diastole schmeltziana</i> (Mousson, 1865) ^c	R	R	S	probably endemic
<i>Liardetia samoensis</i> (Mousson, 1865)	R	R	B, S	indigenous
<i>Ovachlamys fulgens</i> (Gude, 1900)			S	alien
BRADYBAENIDAE				
<i>Bradybaena similaris</i> (Rang, 1831)		R		alien

^a The records from Ta'ū and Ofu are based on unidentified veronicellids that are here tentatively referred to *Vaginulus plebeius*.

^b New combination. Originally described in *Plectotrema* Adams and Adams, 1854 (see also Hubendick, 1956). *Plectotrema* now a synonym of *Laemodonta* Philippi, 1846 (see Cowie et al., 1995).

^c A possibly undescribed species of *Diastole* was found at high elevations on all islands (e.g., Cowie, 2001a). It may, however, be just a variant of *Diastole schmeltziana* and is not listed separately, pending further research.

Manu'a so far undertaken. Nevertheless, the absence of certain species, especially more generally widespread species, from one or more of the islands may well reflect a need for additional work rather than real absence. The neighboring islands of Ofu and Olosega have 24 species in common, yet these islands both share 28 species with more distant Ta'ū. Ta'ū, the largest and highest (but youngest—Keating, 1992) island, has 40 species; Ofu, slightly larger in area than Olosega, but also slightly lower, has 32; and Olosega, smallest in area but intermediate in elevation, has 30. Ta'ū has the greatest number of native species (24); Ofu has 18; Olosega has 16. Although these numbers appear to reflect a clear species-area relationship, the determinants of species richness on islands are complex (Cowie, 1996a) and certainly three islands, even with complete data, are insufficient to detect large-scale trends or to confirm theoretical predictions (Cowie, 1996b). Patterns of distributions among the Manu'a Islands may reflect a combination of incomplete sampling of the islands' faunas, randomness in the natural construction of those faunas, and the influence of other factors such as elevation and habitat diversity, all superimposed on an underlying species-area relationship.

The low level of endemism probably reflects the short distances between the three Manu'a Islands as well as the relatively short distance from the larger islands of the Samoan archipelago. In addition, endemism among native Samoan land snail species as a whole is relatively low (63%; Cowie, 1998), compared for instance to the level in the Hawaiian fauna (over 99%; Cowie, 1996a). Less than one fourth of the species of Tutuila, the probable source of most of the Manu'a species, are endemic to Tutuila (Cowie, 1998; Cowie and Cook, 2001). Most of the non-endemic native Samoan species are also found in Fiji, Tonga, and neighboring areas, and indeed most of the native (but not endemic) species of Manu'a are distributed through the

Samoan archipelago and westwards; some are more widespread Pacific species.

Many of the previously reported native species of the Manu'a Islands (Cowie, 1998) were detected during the present survey of Olosega and recent surveys of Ta'ū and Ofu (Cowie and Cook, 1999, 2001; Cowie, 2001a). However, among the species of Ta'ū and Ofu, native species are declining while alien species are increasing in distribution and abundance (Cowie, 2001a). Because so few of the species recorded from Olosega had been reported prior to the present study, it is not possible to say for most of them whether they are declining or increasing. Nevertheless, the two endodontoids (*Minidonta manuaensis*, *Discocharopa aperta*) probably declined long ago because when they were first reported from Olosega, as dead shells (Solem, 1976, 1983), they were already considered extinct (see Cowie, 2001a). Perhaps they were never particularly abundant or widely distributed. Similarly, the partulid tree snail *Samoana thurstoni*, never previously reported from Olosega and the only partulid known from the island, is extremely rare on the island, although apparently distributed over a fairly wide elevational range from at least 300 m to 500 m. Its absence from previous records of land snails on Olosega may be because no one had searched for snails at these elevations on the island. It is similarly rare on Ofu, but known from a similar elevational range of 322 m to 491 m (the summit) (Cowie and Cook, 1999, 2001). Most partulids are single island endemics, but Olosega and Ofu are very close to each other, lie within the same reef on a single platform, and are the remnants of a single volcano (Wingert, 1981; Keating, 1992). It is thus not surprising to find the same partulid species on both islands. Similarly, another Samoan partulid, *Eua zebrina*, was recently discovered on Ofu (Cowie and Cook, 1999, 2001) although it was previously considered a Tutuila

endemic. The tree snails of the family Partulidae, to which *S. thurstoni* and *E. zebrina* belong, are considered the "flagships" of invertebrate conservation in the Pacific (Cowie and Cook, 2001). Partulids are especially vulnerable to the suite of threats faced by native snails on Pacific islands, perhaps because of their long life-cycle and slow reproductive rate (Cowie, 1992). Despite the fact that *S. thurstoni* is now known from two islands it remains under serious threat. Because the population on Olosega is much less accessible than that on Ofu, the Olosega population is of especial significance for the conservation of this rare species. No partulids have been recorded on Ta'ū despite intensive survey work extending to the summit of the island (Cowie and Cook, 1999, 2001). They may indeed be absent from that island, the youngest of the main Samoan islands (Keating, 1992), perhaps simply because they have not yet chanced to reach it.

While many of the native species may be declining, alien species, especially subulinids, are probably increasing on Olosega, as on the other Manu'a Islands (Cowie, 2001a). Ten alien species were recorded on Olosega during the 2001 survey (Table 1) and six of these were subulinids. Of these six subulinids, four had been previously collected on the island [*Allopeas clavulinum* (Potiez and Michaud, 1838), *Opeas hannense* (Rang, 1831), *Paropeas achatinaceum* (Pfeiffer, 1846), *Subulina octona* (Bruguière, 1789)]. *Allopeas clavulinum* and *O. hannense* have never been especially common (evidenced by the extent of collections in the Bishop Museum) and very few individuals were found. However, the other two species are the most widespread and abundant alien snails on Pacific islands (Cowie, 2000, 2001a, 2002). The fifth subulinid, *Allopeas gracile* (Hutton, 1834), has been considered the most widespread land snail species in the world (Pilsbry, 1906-1907; Deisler and Abbott, 1984). It was once relatively common on Ofu (Kirch, 1993) and appears to have been introduced widely in the Pacific prior to western exploration (Christensen and Kirch, 1981, 1986), unlike the other subulinids, which are more recent introductions. However, *A. gracile* is now rarely encountered except as a fossil/subfossil and only a single shell was found during the Olosega survey. The sixth subulinid, *Lamellaxis micra* (d'Orbigny, 1835), has never been common and has only been recorded from scattered locations in the Pacific (Cowie, 2000, 2002); only a single shell was found.

The absence of *Achatina fulica* and *Euglandina rosea* from Olosega and Ofu (Cowie and Cook, 2001) is encouraging. *Euglandina rosea* has been widely introduced as a putative biological control agent of *A. fulica* (Griffiths *et al.*, 1993; Civeyrel and Simberloff, 1996; Cowie, 2001b) but nowhere has successful control been demonstrated, and *E. rosea* has been heavily implicated in the decline and extinction of native land snail species in the Pacific,

notably Partulidae (Murray *et al.*, 1989; Cowie, 1992) and Achatinellinae (Hadfield, 1986; Hadfield *et al.*, 1993). *Achatina fulica* and *Euglandina rosea* are both present on Ta'ū (Cowie, 1998) but we hope they can continue to be kept out of Ofu and Olosega.

The absence of *Lamellidea oblonga* from the survey collections may reflect difficulty in distinguishing it from *Lamellidea pusilla* (Gould, 1847); however, all the material collected in 2001 was referred to *L. pusilla* relatively confidently.

There remain a number of taxonomic difficulties that render some of the present identifications somewhat tentative. Cowie and Cook (1999) and Cowie (2001a) may have been incorrect in not listing *Melampus luteus* but listing *M. castaneus* from Ta'ū and Ofu (and Tutuila). Unidentified ellobiids are present in the Bishop Museum collections and may represent additional species. Identification of veronicellid slugs also remains difficult but is important because of their increasing abundance and spread throughout much of the Pacific, and their possible ecological impacts. Additional taxonomic work on other groups unstudied in the Pacific since the early twentieth century or before is necessary if identification of some of these difficult-to-identify species is to be made more rigorous.

The native land snail fauna of the islands of the Pacific (excluding New Guinea) probably numbers around 4,000 species and exhibits high levels of single island or single archipelago endemism (Cowie, 1996b, 2000). However, this number is only an educated guess, as many islands remain poorly known. The alien land snail fauna contains far fewer species, probably between 100 and 200, with many of these widely distributed (Cowie, 2000, 2002). The island by island distributions of many of these aliens have not been well documented. The present survey of the relatively accessible Samoan island of Olosega underlines the need for much more detailed survey work and suggests that the land snail faunas of other more isolated and less studied islands or island groups in the Pacific are probably extremely poorly known. Many of the native species are declining and being replaced by widespread aliens, but the extent to which this is happening remains unknown on most islands. As a fundamental step in the conservation of these native Pacific island species, much more survey work, especially on the more remote and under-studied islands, is essential to provide the necessary baseline biodiversity information.

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