

**FINAL REPORT ON SURVEYS OF THE ARBOREAL AND
TERRESTRIAL SNAIL FAUNA OF AMERICAN SAMOA.**

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SUMMARY

The native land-snail fauna of Pacific islands is under assault by introduced predators. Some of these predators are intentional introductions aimed at controlling the agricultural pest *Achatina fulica*. Their ability to control this pest snail is questionable. However, these predators, and rats, are partly responsible for large decreases in the abundance and diversity of land snails throughout the Pacific basin. The surveys reported here evaluated the extent to which introduced snails have spread throughout the four main islands of American Samoa and qualitatively assessed the status of the four endemic partulid tree snail species and several other native and endemic snail species.

The giant African snail *Achatina fulica* was introduced into American Samoa prior to 1977, and populations rapidly increased. In an effort to eradicate the giant African snail, two carnivorous snails, *Gonaxis kibweziensis* and *Euglandina rosea*, were introduced in 1977 and 1980, respectively. Results of our surveys showed that *A. fulica* and *E. rosea* have spread throughout the main island of Tutuila. *Gonaxis kibweziensis* is present on Tutuila but seems to be in decline. *Achatina fulica* and *E. rosea* were also found on the northwest corner of Ta'u, but were absent from Ofu and Olosega.

Our surveys showed that several species of native or endemic snails are endangered. One endemic species of partulid tree snail is extinct, and the three remaining partulid species were seen in small numbers at only three of the 17 sites surveyed. Comparison to an earlier (1975) survey showed that other species of native arboreal and terrestrial snails have also greatly declined in abundance. Some native and endemic snails were not found during the 1992 surveys. Overall, the land-snail fauna is endangered with several species on the verge of extinction.

Immediate action is needed if the remaining snail fauna of American Samoa is to be saved. The declines and extinctions of native snails have resulted from loss of habitat to agriculture and hurricanes, and predation by introduced carnivorous snails and rats. Several recommendations are given to help mitigate the causes of the continuing decline in snail abundance and diversity. Most importantly, two refugia that are free of introduced snails have been identified in this report. Endangered populations of snails should be moved to these refugia and periodically monitored.

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1. INTRODUCTION.

The introduction of non-native land snails to Pacific islands has become a major cause of extinction among native molluscan fauna. The typical pattern of introductions begins with the arrival of the giant African snail, *Achatina fulica*. This large pulmonate is usually brought in, without governmental approval, as a food item or as an ornamental garden snail. Freed from normal controls, populations of this herbivore can rapidly increase (Mead, 1961) and become an agricultural pest. In response, island governments seek the advice of agricultural experts (usually from Guam or Hawaii) who recommend the importation of non-native predatory snails (*i.e.*, *Euglandina rosea*, native to the southeast United States, and *Gonaxis kibweziensis*, native to Africa) or flatworms (*e.g.*, *Platydemis manokwari*, native to Melasia). These carnivores feed on snails and slugs (Mead, 1961, 1979) and are supposed to reduce or eliminate populations of the giant African snail.

After an initial increase lasting up to several years, the populations of giant African snails decline (Mead, 1961). Available data does not definitively show that reductions in population size are due to predation by carnivorous snails (Mead, 1961; Hadfield and Kay, 1981; Christensen, 1984; Eldredge, 1988). In fact, *Euglandina rosea* is probably not of great importance as a predator of giant African snails (Mead, 1961), preferring instead to feed on small snails (Cook, 1989; Griffiths *et al.*, 1993), which include most of the native snails of Pacific islands. The lack of evidence for predatory control of the giant African snail has not stopped the intentional spread of snail predators like *E. rosea* into the Pacific basin. Other studies do show that *E. rosea* feeds on endemic island snails and is a major agent in their declines and extinctions (van der Schalie, 1969; Colman, 1977; Hart, 1978; Howarth, 1983, 1985; Clarke, *et al.*, 1984; Pointier and Blanc, 1984; Murray, *et al.*, 1988; Hadfield and Mountain, 1981; Hadfield, 1986; Hadfield, *et al.*, 1989, 1993; Kinzie, 1992).

The central Pacific islands of American Samoa (14°10'-14°22' S, 169°26'-170°50' W) present a classic example of the devastating effects that introduced snails have on native molluscan fauna. These high islands are part of a chain of islands that includes Western Samoa (Savai'i and 'Upolu). The islands were formed during the Pliocene Epoch about 2 million years ago (Stice and McCoy, 1968), thus the evolutionary history of the endemic terrestrial flora and fauna is relatively recent. The youngest island of the Samoan chain is Savai'i in Western Samoa and islands to the east-southeast are of increasing age. Thus the islands of American Samoa are the oldest and most heavily contoured in the chain. Tutuila is the largest of these islands. Ofu, Olosega and Ta'u, collectively called the Manu'a Islands, are 103 kilometers to the east-southeast. Several small offshore islands occur around these four main islands.

The surveys reported here were conducted to qualitatively assess the status of partulid tree snails and other snails of American Samoa, and to determine the extent to which the giant African snail and introduced carnivorous snails have spread throughout these islands. Seventeen sites were surveyed on the four main islands over a period of 18 days. This work was organized and lead by Dr. Stephen E. Miller of the University of Hawaii and included

Dr. Robert H. Cowie, malacologist for the B. P. Bishop Museum, Mr. Barry D. Smith, professor at the University of Guam, and Ms. Nora Rojek, graduate student at the University of Hawaii. Overall, the survey team represented expertise in the systematics, population biology and ecology of terrestrial snails.

The surveys showed that, in American Samoa, the partulid tree snails and other native arboreal and terrestrial snails are highly endangered. Current threats to the long-term survival of these snails include (1) loss of populations of native snails to predation by introduced snails and rats, (2) loss of habitat to forestry and agriculture, and (3) loss of forest structure to hurricanes. These threats may interact to greatly exacerbate the loss of populations and species. Each is discussed below along with recommendations for mitigating the continuing loss of species. If the endangered Samoan snails are to be saved from extinction these recommendations should be implemented as soon as possible.

2. BIOLOGICAL BACKGROUND.

2.1 Native snails of American Samoa.

The systematics of some groups of terrestrial Pacific island snails have been extensively studied. However, complete faunal lists for specific islands, including those of American Samoa, are often not available. Christensen (1980) compiled a minimum estimate of 33 species on the island of Tutuila, including six island-endemic species. Solem (1975) reported nine species endemic to Tutuila. Similar compilations for the Manu'a Islands are not available. However, Solem (1975) reported two endemic snails (one extinct) from Ofu and five endemic snails from Ta'u.

The Samoan tree snails are the best studies of the American Samoan snail fauna and were a major focus of our surveys. They are members of the family Partulidae, which is widely distributed throughout the high islands of Polynesia, Melanesia and Micronesia in the southern and southwestern Pacific basin (Cowie, 1992). Many of the 120 partulid species (Kondo, 1968) are restricted to single islands or isolated groups of islands. The Samoan tree snails are a good example of this endemism. The two large islands of Western Samoa (Savai'i and 'Upolu; not included in these surveys) are home to five partulid tree snails. Only one of these, *Samoana conica*, is found in American Samoa along with three additional species. Of the four partulid species of American Samoa, three are endemic to single islands; *Samoana abbreviata* and *Eua zebrina*, both on the island of Tutuila, and *S. thurstoni* on the island of Ofu. *Samoana conica*, is found on Tutuila and 'Upolu (Western Samoa).

2.2 Habits and habitat of Samoan partulid tree snails.

The biology of Samoan partulid tree snails has not been extensively studied. However there is considerable information (reviewed by Cowie, 1992) on the partulid tree snails of the Mariana Islands (Crampton, 1925a; Hopper and Smith, 1992) and the Society Islands

(Crampton, 1925b, 1932; Murray, *et al.*, 1982; Johnson, *et al.*, 1986a, b). The Partulidae is considered to be ovoviviparous, although viviparity may be a more accurate description, as considerable growth occurs *in utero*. Some species in the family are known to be self-fertile while other partulids, including *Samoana conica* of Tutuila, rely predominantly on outcrossing (Johnson, *et al.*, 1986a). In the genus *Partula*, shell length at birth is 3-3.5 mm and sexual maturity is attained in less than one year at a shell length of 11-30 mm, depending on the species. Adults live for about 5 years and give birth about every 20 days, producing about 18 offspring per year (Cowie, 1992). All members of the family are nocturnal, arboreal herbivores, feeding mainly on decaying plant material (Murray *et al.*, 1982). An exception to this general feeding preference was reported by Cooke (1928) for *Eua zebrina*. He reported that this species feeds on other non-partulid snails during periodic visits to the forest floor. Because of its unexpected nature, this observation needs to be confirmed. Cooke (1928) also suggested that habitat partitioning may occur among the three partulids of Tutuila. *Samoana conica* and *S. abbreviata* were commonly found on trunks and branches, and *Eua zebrina* was commonly found on leaves. A similar partitioning of habitat has been reported for the *Partula* of the Society Islands (Murray, *et al.*, 1982).

2.3 Introductions of non-native snails into American Samoa.

Achatina fulica was first seen near the fish canneries on Tutuila in March 1977 (Lai and Nakahara, 1980). Based on the size and numbers of snails found, it is thought that the initial introduction occurred 2 to 3 years earlier (Lai and Nakahara, 1980). Local government officials suggested that the snails may have been brought in by oriental commercial fisherman as food (Eldredge, 1988). Initial efforts to eradicate the giant African snail included applications of metaldehyde poison and hand collecting. In mid-1977 over 1 million snails were collected in a 2 month period. By 1978 the snails had spread over most of Tutuila, and between January and August 1980 more than 5 million snails were collected by 300 workers. In August 1977 *Achatina fulica* was reported to have spread to the Manu'a Islands, probably via a shipment of water pipes from Pago Pago (Lai and Nakahara, 1980). It is reported that the infestation was quickly eradicated (but see section 3.2).

Control of *Achatina fulica* was considered necessary because it is a known agricultural pest (Mead, 1961, 1979) and an intermediate host of the rat lung worm, *Angiostrongylus cantonensis*, which can cause human eosinophilic meningoencephalitis (Alicata, 1962; Mead, 1979). In American Samoa, the first case of this disease was reported in 1979 (Beck *et al.*, 1980; Whitten, 1981). The source population of the parasites was not found in rats but was found in giant African snails. The parasites are thought to have infected the Samoan patients through the consumption of raw or undercooked snails. The most commonly recommended biological control agent of the giant African snail is the predatory snail *Euglandina rosea*. Unfortunately, *E. rosea* is also a host to the rat lung worm (Wallace and Rosen, 1969). Since the habitat preference of this carnivore is wider than that of the giant African snail (van der Schalie, 1969; Mead, 1961), it may spread the rat lung worm through a wider range. It is not known if the parasite can be maintained in populations of native snails.

The introduction of predatory snails began in 1977. In June, 200 *Gonaxis kibweziensis* were released on Tutuila, followed by two additional shipments of this carnivorous snail in May 1979 and August 1980 (Lai and Nakahara, 1980). In August 1980, 240 *Euglandina rosea* were released on Tutuila (Lai and Nakahara, 1980). By 1984 this predatory snail was considered to be well established (Eldredge, 1988). There is no record of introductions of either *E. rosea* or *G. kibweziensis* to the Manu'a Islands (but see section 3.2).

Solem (1975) reported the occurrence of a previously unrecorded carnivorous snail, *Streptostele musaecola*, from West Africa. This snail was not seen in our surveys, but may have been partly responsible for the extinction of *Samoana abbreviata* (see section 4.2).

3. THE 1992 SURVEYS OF AMERICAN SAMOA.

3.1 Survey methods, mark-recapture and species identification.

The four main islands were surveyed between October 20 and November 6, 1992. Nine sites were surveyed on the main island of Tutuila, two sites on Ta'u, three sites on Ofu and three sites on Olosega. These sites were selected with the aid of local biologists from the Department of Marine and Wildlife Resources, American Samoa Government, and the United States National Park Service. Particular acknowledgement is given to Dr. Pepper Trail for his help in some of the surveys and his support throughout the study. The local terrain at each site often dictated the search strategy employed. The sites located on ridges were sampled periodically along a transect line. At several points along the transect the survey team would spread out and search for snails and shells. In more expansive areas, such as hillside slopes, the survey team would spread out and work upslope, across the face and back down. A similar search strategy was applied to flatter coastal areas. Specimens were collected and placed in vials labeled by location. Wherever possible, local biologists and residents were questioned about introduced and native snail populations. Appendix I gives detailed information for each survey site, including location and elevations surveyed, species seen, and a qualitative assessment of abundance. Field identifications were checked against the collections of the B.P. Bishop Museum, Honolulu, Hawaii. Taxonomic nomenclature followed Solem (1975), Christensen, 1 (1980), and Vaught (1989).

At Tiatauala Ridge 8 *Eua zebrina* were tagged for later identification. The snail's shell was wiped clean with a damp cloth and then wiped dry. A small (3 mm diameter) "bee tag" was glued to the shell of each snail using a single drop of cyanoacrylate adhesive. The tags were red and numbered from 1 to 8. Length and width of each snail was recorded along with the presence (adult snail) or absence (juvenile snail) of an apertural lip.

3.2 Survey results for introduced snails.

The American Samoan Government no longer considers the giant African snail, *Achatina fulica*, to be problem on Tutuila. Live snails were not seen during our surveys of this island, although shells were seen at all but two of the surveyed sites (Table 1). On Ta'u, giant African snails were common in the northwest (Faleselau Ridge) near the harbor. From this we concluded that either the giant African snails introduced to Ta'u in 1977 (Lai and Nakahara, 1980) were not eradicated as reported or that a subsequent successful introduction occurred. In our survey along the east coast of Ta'u no giant African snails were seen. Residents of this area said the snails were only seen near the harbor. Most notably, we did not find the giant African snail or its shells on Ofu or Olosega, and local residents said that it has not been introduced to these islands.

Table 1. Records of introduced terrestrial snails seen in American Samoa during the 1992 surveys.

Species	Sites with live snails	Sites with shells only	Sites without snails or shells
Tutuila (9 sites surveyed)			
<i>Euglandina rosea</i>	3 ¹	4	2
<i>Gonaxis kibweziensis</i>	2 ²	---	7
<i>Achatina fulica</i>	---	7	2
<i>Subulina octona</i>	5	3	1
<i>Bradybaena similaris</i>	---	1	8
<i>Parmarion mortensi</i> ?	1	---	8
<i>Sireptostele muscecola</i> ³	---	---	---
Ofu and Olosega (6 sites surveyed) ⁴			
<i>Subulina octona</i>	5	---	1
<i>Bradybaena similaris</i>			
Ta'u (2 sites surveyed)			
<i>Euglandina rosea</i>	1 ⁵	---	1
<i>Achatina fulica</i>	1 ⁵	---	1
<i>Subulina octona</i>	2	---	---

1. Two seen alive at Tuasina Ridge in a bush 2-3 meters above the ground; 3 seen alive at Tiatauala Ridge, one within 2 meters of an adult *Eua zebrina*; several seen alive at Maloata Valley.

2. One seen alive at Fagasa Pass, eating a *Bradybaena similaris*; 6 seen alive on 'Alava Ridge.

3. This west African species was reported by Solem (1975) but was not seen in our 1992 surveys.

4. No *Euglandina*, *Gonaxis* or *Achatina* were seen on these islands.

5. One *Euglandina* and numerous *Achatina* were seen alive at Faleselau Ridge, northwest Ta'u. None of these species were seen in southeast Ta'u.

Euglandina rosea and *Gonaxis kibweziensis* were found alive at several sites on Tutuila (Table 1). *Gonaxis* was not common but *Euglandina* or its shells was found throughout the island. Two live *E. rosea* were seen crawling in bushes 2-3 m above the forest floor at Tuasina Ridge. Thus an arboreal habit does not serve to protect snails from this predator. In Hawai'i one of the survey team (SEM) has seen similar arboreal activity in which a *Euglandina* was eating an endemic *Achatinella mustelina* tree snail. *Euglandina rosea* was also seen alive at Tiatauala Ridge within 2 meters of live partulid tree snails. On Ta'u a single *E. rosea* was seen alive on Faleselau Ridge near the harbor. There is no information on the date of introduction of *Euglandina* to Ta'u, but it probably occurred shortly after the arrival of the giant African snail. *Euglandina* was not seen along the southeast coast of Ta'u, and *Gonaxis* was not seen at either survey site on Ta'u. Neither of these introduced predators were seen on Ofu or Olosega.

3.3 Survey results for native snails.

The surveys focused on the partulid tree snails of American Samoa, although observations on other arboreal, terrestrial and freshwater snails seen during the expedition are also reported here. Occurrences and qualitative assessments of abundance at each surveyed site are given in Appendix I and summarized in Tables 2 and 4. Taxonomy of the snails seen during the surveys is given in Appendix II.

Table 2. Records of native American Samoan snails seen during the 1992 surveys.

Species	Sites with live snails ¹	Sites with shells only	Sites without snails or shells
Tutuila (9 sites surveyed)			
<i>Pleuropoma musiva</i>	---	1	8
<i>Pleuropoma fulgora</i>	4	1	4
<i>Sturanyella beryllina</i>	7	1	1
<i>Neritina</i> sp. (freshwater)	1	---	8
<i>Septaria</i> sp. (freshwater)	1	---	8
<i>Omphalotropis</i> sp.	1	1	7
<i>Thiara</i> sp. (freshwater)	1	---	8
<i>Ostodes strigatus</i> (Tutuila endemic)	1	3	5
<i>Pythia scarabaeus</i>	1	---	8
<i>Melampus fasciatus</i>	1	---	8
<i>Melampus luteus</i>	1	---	8
<i>Elasmias</i> sp.	2	---	7
<i>Eua zebrina</i> (Tutuila endemic)	2 ²	4	3
<i>Samoana conica</i> (Samoa endemic)	1 ³	3	4
<i>Samoana abbreviata</i> (Tutuila endemic)	---	1	8
			continued

Table 2. (continued)

Species	Sites with live snails	Sites with shells only	Sites without snails or shells
Tutuila (continued)			
<i>Succinea</i> sp.	1	—	8
<i>Diastole schmeltziana</i> (Samoa endemic)	2	—	7
<i>Trochomorpha apia</i> (Samoa endemic)	—	2	7
<i>Trochonanina</i> sp.	1	1	7
unidentified assimineid sp.	1	1	7
unidentified subulinid sp.	4	1	4
unidentified endodontid sp.	—	1	8
Ofu (3 sites surveyed)			
<i>Pleuropoma musiva</i>	3	—	—
<i>Pleuropoma fulgora</i>	1	—	2
<i>Pythia scarabaeus</i>	1	—	2
<i>Melampus fasciatus</i>	1	—	2
<i>Samoaana thurstoni</i> (Ofu endemic)	1 ⁴	—	2
<i>Succinea</i> spp.	1	—	2
<i>Diastole schmeltziana</i> (Samoa endemic)	1	—	2
unidentified subulinid sp.	1	—	2
Olosega (3 sites surveyed)			
<i>Pleuropoma musiva</i>	3	—	—
<i>Pleuropoma fulgora</i>	1	—	2
unidentified assimineid sp.	3	—	—
unidentified subulinid sp.	1	—	2
Ta'u (2 sites surveyed)			
<i>Pleuropoma musiva</i>	2	—	—
<i>Pleuropoma fulgora</i>	1	—	1
<i>Pythia scarabaeus</i>	1	—	1
<i>Melampus fasciatus</i>	1	—	1
<i>Succinea</i> spp.	1	—	1
unidentified assimineid sp.	1	—	1

1. See Table 4 and Appendix II for qualitative assessments of abundance.
2. Eleven snails were seen at Tiatauala Ridge (165-175 m elevation); 23 snails were seen on the Nu'usetoga Island (55-70 m elevation) just offshore of Tutuila.
3. Four snails were seen at Tiatauala Ridge (165-175 m elevation).
4. One snail was seen at the summit of Tumu Mountain (494 m elevation).

In two weeks of intensive surveys, only 39 partulid tree snails, in three species, were seen alive. All but one of these snails were found in north-central Tutuila at two locations; Tiatauala Ridge and Nu'usetoga Island. At Tiatauala Ridge (122-168 m elevation) 11 *Eua zebrina* and four *Samoana conica* were seen alive. The snails were found scattered on understory vegetation in a forest with an intact canopy 10-20 m above the ground. *Euglandina rosea* was found alive within meters of some of these partulid snails. Shells of *S. conica* and *E. zebrina* were found on the ground at several of the locations surveyed on Tutuila (Table 2), often along with shells and live individuals of *E. rosea* (Table 1).

At one location on Tiatauala Ridge eight *Eua zebrina* were found about 3 m above the ground in a cluster of shrubs. These snails were measured and marked with bee tags for later identification (Table 3). Twelve days later we returned to this site and briefly searched for marked snails. Three marked snails and one new snail were seen and no marked or unmarked shells were found on the ground.

Table 3. Measurements of *Eua zebrina* tagged on Tiatauala Ridge, American Samoa, during the 1992 surveys.

Tag number	Maximum shell length	Maximum shell width	Apertural lip
Red 1	7.50	6.80	absent
Red 2	6.60	5.11	absent
Red 3	7.28	5.14	absent
Red 4	21.16	13.91	present
Red 5	19.11	12.82	present
Red 6	20.27	13.21	present
Red 7	20.21	13.80	present
Red 8	19.42	13.44	present

Twenty-three *Eua zebrina* were seen on Nu'usetoga Island (73 m elevation; about 100 meters offshore of Tutuila) cattered throughout the understory vegetation. This population was probably isolated from an ancestral parent population in prehistoric time. The upper two-thirds of Nu'usetoga Island is covered with an intact stand of native forest with a canopy about 10-20 m above the ground. A search of Nu'usetoga did not turn up any shells or live individuals of *Euglandina rosea*, *Gonaxis kibweziensis* or *Achatina fulica*. Thus, the *Eua zebrina* on this island are, for the moment, safe from predatory snails. However, predation by rats is a problem, as several rat-damaged shells were found on the island.

Samoana abbreviata, endemic to Tutuila, may be extinct. Live snails were not seen during our surveys, and Solem (1975) indicated that *S. abbreviata* had not been seen alive since 1940. In our surveys, shells of this species were found at one site (Fagatoga, 60-120 m elevation) where they were common. The shells of *Achatina fulica* and *Euglandina rosea* were also abundant at this location.

On the island of Ofu, only one live snail and one shell of *Samoana thurstoni* were seen in its historic habitat, the top of Tumu Mountain (494 m elevation). Hurricanes severely damaged this forest, and the living snail was on a bush that was once part of the forest understory. In this damaged habitat the snail was more directly exposed to sunlight and the ambient temperature was higher than would be found under a canopy forest.

Several other species of snails native to American Samoa were either not seen or were seen in low numbers. For instance, no live individuals of the large (20 mm shell diameter) terrestrial snail *Trochomorphia apia* were found during the surveys of Tutuila, although a single live individual was reported to us in February 1993 (P.W. Trail, pers. comm.). Other snails such as arboreal *Diastole schmeltziana*, and terrestrial *Pythia scarabaeus* and *Ostodes strigatus*, were also rare or absent in areas where introduced carnivorous snails were found. Several families (Tutuilanidae, Pupillidae, Streptaxidae, Rhytididae, and Charopidae) of snails recorded in American Samoa were not seen in 1992, although our surveys did not specifically focus on locating these taxa, which are often minute and live under rocks and litter.

During the surveys on Tutuila, one stream (north of Fagatoga at about 100 m elevation) was superficially sampled for freshwater snails. Several individuals of *Septaria* sp., *Neritina* sp., and *Thiara* sp. were identified. *Euglandina rosea* was abundant in this area and is a direct threat to these freshwater snails (see section 4.2).

4. STATUS OF THE NATIVE SNAIL FAUNA OF AMERICAN SAMOA.

4.1 Comparison of surveys done in 1975 and 1992.

There is very little data that can be used to assess long-term temporal changes in the snail fauna of American Samoa. However, qualitative comparisons can be made with the 1975 surveys conducted by Mr. L. Price and reported by Solem (1975). Of the 15 endemic species recorded in American Samoa (Solem, 1975; Christensen, 1980), we saw living individuals of five species and the shells of two additional species (one of which was later reported alive, see above). A comparative but qualitative assessment of abundance for some of the snails of American Samoa is given in Table 4. It is readily apparent that from 1975 to 1992 the native snail fauna has declined dramatically. The partulid tree snails and several other terrestrial and arboreal species are greatly endangered and on the verge of extinction.

Table 4. Qualitative changes in abundance of some native American Samoan snails between 1975 and 1992.

Species	Habitat	Qualitative Abundance ¹		
		1975 ²	1992 ³	
Tutuila				
<i>Ostodes strigatus</i>	ground	common	uncommon	
<i>Trochomorpha apia</i>	ground	common	not seen ⁴	
<i>Liardetia samoensis</i>	ground/shrubs	common	not seen	
<i>Lamprocystis upoluensis</i>	ground/shrubs	common	not seen	
<i>Diastole schmeltziana</i>	shrubs	common	rare	
<i>Eua zebrina</i>	shrubs/trees	common	rare	
<i>Samoana conica</i>	shrubs/trees	common	rare	
<i>Samoana abbreviata</i>	shrubs/trees	not seen	not seen	
Ofu				
<i>Samoana thurstoni</i>	shrubs/trees	common	rare	
Ta'u				
<i>succineids (Catinnella?)</i>	ground/shrubs	common	uncommon	

1. During our surveys, ellobiids and the minute heliciniids, assimineids and subulinids were common; Succineids, achatinellids and urocyclids were rarely seen; Tutuilanidae, Pupillidae, Stretaxidae, Rhytididae, and Charopidae are recorded from American Samoa (Christensen, 1980) but were not seen.
2. Information from Solem (1975).
3. Information from our 1992 surveys (see Appendix II).
4. Dr. P.W. Trail reported a single individual in February 1993.

4.2 Current threats to the long-term survival of native snails.

Introduced predatory snails and rats.

At present, the major threat to long-term survival of the native snail fauna in American Samoa is predation by *Euglandina rosea*. This snail's dietary preference for small snails (Cook, 1989; Griffiths *et al.*, 1993) directly threatens native Samoan snails. Note that freshwater snails are not excluded from predation by *E. rosea*, which will stalk these snails underwater (Kinzie, 1992). Solem (1975) reported that the native representatives of the Charopidae could not be located in 1975. During our surveys, native members of the Tutuilanidae, Pupillidae, Stretaxidae, Rhytididae, and the Charopidae were not found. An absence of these previously recorded groups (Christensen, 1980) may be partly attributed to our focus on partulids, but also may indicate that declines in abundance of some or all of these groups is continuing. The introduction of *E. rosea* to Tutuila may account for the absence of *Streptostele musaecola* and for the currently low number of *Gonaxis kibweziensis*.

During our surveys we noted that some shells were damaged in a fashion that is typical of rat predation; the shell is missing a large piece of the body whorl or the apex. Old shells may be weathered in a similar fashion, except that the fracture lines are not sharp and angular. Signs of rat predation were seen at the sites with the largest remaining populations of partulid tree snails (Tiatauala Ridge and Nu'usetoga Island). Studies in Hawai'i (Hadfield *et al.*, 1993) have shown that both rats and *Euglandina rosea* can quickly devastate tree snail populations. Live trapping in Hawai'i implicated the Polynesian rat, *Rattus exulans*, although *R. rattus* and *R. norvegicus* may also be significant threats to native snail populations. All three species are introduced throughout the Pacific islands.

The date of introduction of the predatory snail *Streptostele musaecola* is not known, but the snail was reported in 1975 (Solem, 1975) but was not seen in 1992. This snail undoubtedly had a negative effect on native Samoan snails. However, the lack of historic data on abundance, along with the later introductions of *Euglandina rosea* and *Gonaxis kibweziensis* make it impossible to assess the effect of *S. musaecola* on the native snail fauna. *Samoana abbreviata* has not been seen alive since 1940 (Solem, 1975) and it is possible that *S. musaecola* may be partly responsible for its extinction. If so, it is unclear why the two other partulid snails on Tutuila have not suffered similar fates.

Habitat lost to agriculture and storms.

Loss of habitat to agriculture and to storms has greatly reduced the native habitat of Samoan snails. Except for a single individual *Samoana thurstoni* on Ofu, all the live partulid tree snails that we located were found on understory vegetation beneath remaining intact forest canopy. Three recent hurricanes (1987, 1990 and 1991) have greatly reduced this type of habitat on all the islands of American Samoa. The effects of a disrupted understory on Samoan tree snails may best be seen on the island of Ofu. At present, this island (along with Olosega) is free of *Euglandina rosea*, *Gonaxis kibweziensis* and *Achatina fulica*. Thus, the apparent low abundance *S. thurstoni* cannot be attributed to these exotic snails. However, hurricanes greatly damaged the upper elevation forests where our limited survey was set and where substantial populations of *S. thurstoni* were reported in 1975 (Solem, 1975).

Hurricane damage to the forest canopy combined with loss of forest habitat to agriculture may have had a strong negative effect on the stability of populations of *Samoana thurstoni*. Under natural conditions, loss of forest canopy to storms may not pose a great threat to the long term survival of these snails; enough intact forest with healthy populations of snails would support dispersal back into newly regrown canopy forest. However, agriculture has spread from low to middle elevations on all the islands, greatly reducing the forest area and thus reduced the potential resilience of the forest and its populations of snails. These reductions also increase the likelihood that future storms will lead to the extinction of populations or species that rely on the remaining canopy forest.

Introduced diseases in snails.

Disease may be a significant feature in the decline of native snail populations throughout the Pacific basin. No information is available on the transport and introduction of diseases specific to snails. In fact, identification and characterization of snail diseases is lacking. During our surveys, no obvious signs of disease were seen in any of the snails that we saw. However, we would have only seen those disease that affected the shells of the snails. One of the survey team (SEM) has noted "shell disease" in Hawai'ian achatinelline tree snails, often affecting up to a third of the adult snails seen. Typically, the apex of the shell is blackened or completely missing and the surface of the shell may be pitted. In the laboratory, similar effects can lead to thin, fragile shells and eventually to death.

5. RECOMMENDATIONS FOR THE CONSERVATION OF NATIVE SNAILS.

Despite the bleak conditions that prevail in American Samoa, especially Tutuila, the long-term survival of endangered arboreal and terrestrial snails can be significantly enhanced. Conservation efforts should include: (1) removal of threatened populations of partulid and other snails to protected headlands or offshore islands; (2) reestablishment of snail habitat lost to agriculture or storms; (3) protection of Ofu and Olosega from introductions of non-native snails; (4) monitoring the spread of *Acharina fulica* and *Euglandina rosea* on the island of Ta'u and removing endangered populations of native snails to refuges; and (5) captive propagation of snails from small, endangered field populations.

5.1 Surveys for threatened populations of Samoan snails.

Future surveys for partulid tree snails should focus on north-central Tutuila and the upper elevations of Ofu; locations where live Samoan tree snails were seen during our surveys. Other areas and other species, especially *Trochomorpha apia*, should also be included in surveys. The highest elevations of Olosega and Ta'u support the only cloud forests in American Samoa and may be the habitat of unique snail species. The recent historic connection between Ofu and Olosega suggests that populations of *Samoana thurstoni* may occur at high elevations on Olosega. No recent surveys have been done at these elevations on Ta'u or Olosega. Both of these islands need further surveys to assess the snail fauna.

5.2 Removal of threatened snail populations to natural refugia.

At present, there is no known method of controlling or eradicating *Euglandina rosea*. Thus, arboreal and terrestrial snails living in areas known to be occupied by *E. rosea*, or other predators of snails, need to be moved to predator-free refuges. Two refuges have been identified on Tutuila: Nu'usetoga Island and Vainu'u Point. The physical setting of Nu'usetoga Island has been described previously. This small offshore island supports a population of *Eua zebrina* and should not be used for introductions unless it is absolutely necessary; the genetic constitution of the current population should be preserved.

The Vainu'u Point appears to be very similar to Nu'usetoga Island in its physical structure and forest cover. The major difference is that Vainu'u is connected to the main island of Tutuila by a forested isthmus roughly 200 m in width. To date, introduced predatory snails have not crossed this isthmus onto Vainu'u. The mainland side of the isthmus is fronted by a steep, 60 m high cliff. The exposed face of this cliff may partly protect the headland from invasion. These physical features make it a good, if not perfect, refuge for threatened populations of snails. Further protection from invasion could be rendered by excavating a narrow trench across the isthmus, providing a saltwater barrier to invasion.

Vainu'u Point does not support any known populations of partulid tree snails, but does have other native snails. Before partulid snails are moved to this location, consideration should be given to why *Eua zebrina* and *Samoana conica* are not present on Vainu'u. The unknown hazards of moving snails to Vainu'u must also be weighed against the certain extinction of snail populations on Tutuila if they are not removed to protected locations. Additional species that should be considered for removal to refugia are listed in Table 4.

During our surveys we found snail shells that were damaged in a fashion indicative of rat predation. Areas selected as refugia should be free of rats or should include a trapping program that will keep rat populations low.

5.3 Reestablishment of upper elevation forest habitats.

Populations of Samoan partulid tree snails are typically found on the understory vegetation of a canopy forest. The loss of forest to agriculture and storms has greatly reduced this habitat on all four of the main islands of American Samoa. To aid in the recovery of tree-snail populations, microhabitats should be reestablished in the areas previously or currently inhabited by partulid snails. Greenhouse shade cloth could be used to emulate subcanopy temperature, humidity and light levels. Snail populations and forest structure should be periodically monitored for changes in abundance and complexity. This effort would not only help conserve snails but would also provide useful information on forest recovery.

5.4 Protection of Ofu and Olosega from non-native snails.

At present, the islands of Ofu and Olosega do not have populations of *Achatina fulica*, *Euglandina rosea*, or *Gonaxis kibweziensis*. The government of American Samoa should be aided in efforts to keep these exotic snails from reaching these islands. Incentives for assisting the American Samoan Government include preventing agricultural losses and the spread of snail-transported human diseases as well as preservation of the native snail fauna.

5.5 Monitoring and protection of the native snails of Ta'u.

The island of Ta'u is under assault by *Achatina fulica* and *Euglandina rosea*. The spread of these introduced snails should be periodically monitored, and efforts should be made to locate populations of native snails that may become endangered. The extensive, high-

elevation terrain of Ta'u will require a considerable effort to survey; previously used paths into the forest have been overgrown with dense vegetation following the recent hurricanes. However, it may be possible to establish several contour transect lines through the forest that would give access to native snail populations and aid in monitoring the spread of the introduced snails.

5.6 Captive propagation of native Samoan snails.

When endangered snails cannot be moved to predator-free refugia, captive propagation should be considered. This means of conserving endangered species is labor-intensive and requires a long term commitment. Thus, its use should be applied to species with limited natural distributions, such as single- or multiple-island endemic species. The Samoan partulid tree snails and *Trochomorphia apia* are candidates for captive propagation. Partulid species from Morea and Tahiti have been in captive propagation for many years and could serve as a model system. Identification and treatment of snail diseases is in need of further research and may be critical for a successful captive propagation program.

6. CONCLUSIONS.

Extinctions of native terrestrial invertebrates due to introduced species and lost habitats is a theme that is being continuously repeated on Pacific Islands. This complex faunal assemblage is important in recycling forest nutrients and is a source of food for native vertebrate animals. The loss of invertebrate biodiversity is indicative of a decaying forest ecosystem. The declining native snail fauna of American Samoa is a classic example of this deterioration.

Conservation of Samoan snails and other land invertebrates requires immediate and direct intervention. The recommendations given in this report need to be implemented with the involvement of the American Samoan Government. Land needed for effective conservation is often under control of local villages, and the approval of the village leaders may be required if a recovery/conservation project is to be successful. It is important that the Department of Marine and Wildlife Resources of the Government of American Samoa approve and support any conservation activities that are undertaken. Biologists in the department are interested in conservation, and the auspices of the Department will greatly strengthen the local implementation of conservation programs.

The long term success of conservation in Pacific Islands will ultimately require the training of native residents as biologists that can oversee programs, identify new areas of concern, provide extended continuity to field studies and work effectively within local cultural traditions. It is important that interested people be identified and trained in conservation biology. Only by establishing a conservation ethic within the society can the preservation of habitats and species be successful.

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8. **APPENDIX I. Surveys of the four main islands of American Samoa during 1992.**
For each site, native species are listed first followed by introduced species.

21 October: Met with Department of Marine and Wildlife Resources, American Samoa Government and set up field schedule and local transportation.

22 October: Tuasina Ridge (137-229 m elevation); west Tutuila. Half-day survey. Dense ground cover and no forest canopy.

Pleuropoma fulgora - live snails common.
Sturanyella beryllina - live snails common.
Omphalotropis sp. - a few live snails.
subulinid sp. - live snails common.

Achatina fulica - several shells.
Euglandina rosea - 2 live snails 2-3 m up in the trees; shells common.
Subulina octona - live snails common.

Maloata Valley (37-122 m elevation); west Tutuila. Half-day survey. Lower valley in agriculture, upper valley has a canopy forest with a moderately open understory. Observations are from canopy forest.

Eua zebrina - no live snails; shells common.
Samoana conica - no live snails; shells common.
Pleuropoma fulgora - a few live snails.
Sturanyella beryllina - a few live snails.
Ostodes strigatus - several live snails; shells abundant.
subulinid sp. - a few live snails.

Achatina fulica - several shells.
Euglandina rosea - several live snails; shells common.
Subulina octona - a few live snails.

23 October: Tiatauala Ridge (122-168 m elevation); north-central Tutuila. Half-day survey. Agriculture near road quickly changes to canopy forest with a moderately open understory. Marked 8 *Eua zebrina* with red bee-tags.

Eua zebrina - live snails sparsely scattered; shells common.
Samoana conica - live snails rare, scattered; shells infrequent.
Pleuropoma fulgora - several live snails.
Sturanyella beryllina - several live snails.
Ostodes strigatus - numerous shells.
subulinid sp. - one shell.

(continued)

Appendix I. 23 October (continued):

Achatina fulica - several shells.
Euglandina rosea - several shells.
Subulina octona - several shells.

Nu'usetoga Island (10-73 m elevation); a small island 100 m offshore of north-central Tutuila. Half-day survey. Upper elevations in canopy forest with moderately open understory. Accessed by wading across Asaga Strait. No introduced snails seen on the islet. Possible refuge for threatened populations of *Samoana conica* or *Samoana abbreviata*.

Eua zebrina - scattered live snails; shells common.
Sturanyella beryllina - several live snails; some shells.

24 October: A'oloa-fuo-A'asu Trail (91-335 m elevation); northwest Tutuila. Three-quarter-day survey. Scattered agriculture and dense ground cover, no intact forest. Intensive agriculture above 365 m.

Achatina fulica - several shells.
Euglandina rosea - several shells.
Subulina octona - several live snails and shells.

Fagasa Pass (159-242 m elevation); north-central Tutuila. One-quarter-day survey. Canopy forest along Vaipito Stream up slope of the road.

Eua zebrina - one shell.
Samoana conica - numerous shells.
Pleuropoma musiva - one shell.
Pleuropoma fulgora - several shells.
Sturanyella beryllina - one shell.
Trochonanina sp. - one shell.
Ostodes strigatus - numerous shells.
Trochomorpha apia - several shells.
Omphalotropis sp. - numerous shells.
assimineid sp. - numerous shells.
endodontid sp. - one shell.

Achatina fulica - numerous shells.
Euglandina rosea - numerous shells.
Subulina octona - several shells.
Gonaxis kibweziensis - one live snail; abundant shells.
Bradybaena similaris - several shells.

(continued)

Appendix I. (continued)

25 October: 'Alava Ridge (244-491 m elevation); south-central Tutuila. One-day survey. Scattered patches of forest along the ridge looked suitable for tree snails.

Eua zebrina - several shells.
Samoaana conica - several shells.
Sturanyella beryllina - several live snails.
Trochonanina sp. - several live snails.
subulinid sp. - several live snails; several shells.

Achatina fulica - several shells.
Euglandina rosea - several shells.
Subulina octona - several live snails; several shells.
ariophantid sp. - one live snail (*Parmarion martensi*?).
Gonaxis kibweziensis - several live snails; several shells.

26 October: Faleselau Ridge (12-91 m elevation); northwest tip of Ta'u. Half-day travel to Ta'u and a half-day of surveying. Agricultural except at the highest elevation, which has a modest canopy of trees and a dense understory. The harbor for Ta'u is located at Falaesao, just below this ridge.

Pleuropoma fulgora - several live snails; several shells.
Pleuropoma musiva - several live snails; several shells.
Succinea sp. - several live snails; several shells.
assimineid sp. - several live snails; several shells.

Achatina fulica - numerous live snails; numerous shells.
Euglandina rosea - one live snail.
Subulina octona - several live snails; several shells.

27 October: Si'u Point to Saua (2-60 m elevation); southeast coast of Ta'u. Quarter-day travel and three-quarter-day survey. Agricultural except steepest slopes, which have a modest canopy and a dense understory. *Euglandina*, *Gonaxis* and *Achatina* were not seen in this area (see Faleselau Ridge survey, above).

Melampus fasciatus - numerous live snails.
Pythia scarabaeus - numerous live snails.
Pleuropoma musiva - numerous live snails.

Subulina octona - numerous live snails.

(continued)

Appendix I. (continued)

28 October: Sunu'itao Peak (2-107 m elevation); eastern tip of Ofu. Quarter-day travel and quarter-day survey. Coastal area in agriculture with a canopy forest and moderately open understory up slope. *Euglandina*, *Gonaxis* and *Achatina* were not seen in this area.

Melampus fasciatus - several live snails.

Pythia scarabaeus - abundant live snails.

Pleuropoma musiva - several live snails.

Subulina octona - numerous live snails.

Tamatupu Point (2-30 m elevation); western tip of Olosega briefly surveyed. *Euglandina*, *Gonaxis* and *Achatina* were not seen in this area.

Pleuropoma musiva - several live snails.

assimineid sp. - several live snails; several shells.

Subulina octona - several live snails.

North of Vaisa'ili Point (4-105 m elevation); southeast coast of Olosega. Quarter-day survey. Agriculture at base of cliff with a canopy forest and moderately open understory up slope. *Euglandina*, *Gonaxis* and *Achatina* were not seen in this area.

Pleuropoma musiva - several live snails; several shells.

assimineid sp. - several live snails; several shells.

subulinid sp. - several live snails; several shells.

Subulina octona - several live snails; several shells.

Mataala Ridge (120-212 m elevation); southeast end of Olosega. Eight-of-a-day survey. Agriculture and water reservoir in the area. No intact forest and dense brush. *Euglandina*, *Gonaxis* and *Achatina* were not seen in this area.

Pleuropoma musiva - several live snails; several shells.

Pleuropoma fulgora - several live snails; several shells.

assimineid sp. - several live snails; several shells.

subulinid sp. - several live snails; several shells.

Subulina octona - several live snails; several shells.

(continued)

Appendix I. (continued)

29 October: Tumu Mountain (400-494 m elevation); south-central Ofu. One-day survey. Native forest severely damaged by hurricanes; dense brush and vines but no canopy. *Euglandina*, *Gonaxis* and *Achatina* were not seen in this area.

Samoana thurstoni - one live snail; one shell.
Pleuropoma fulgora - several live snails; several shells.
Pleuropoma musiva - several live snails; several shells.
Diastole schmeltziana - several live snails; several shells.
Succinea sp. - several live snails; several shells.
subulinid sp. - several live snails; several shells.

Subulina octona - several live snails; several shells.
Bradybaena similaris - several life snails; several shells.

30 October: Tia Ridge (3-50 m elevation); northwest tip of Ofu. Half-day survey near the harbor. Traveled back to Tutuila. *Euglandina*, *Gonaxis* and *Achatina* were not seen in this area. Local farmers said the giant African snail is not on the island.

Pleuropoma musiva - several live snails; several shells.
Succinea sp. - several live snails; several shells.

31 October - 1 November: Late arrival in Tutuila; updated notes and collections and rested.

2 November: Fagatoga (60-120 m elevation); south-central Tutuila. Reviewed work with Department of Marine and Wildlife personnel. Half-day survey behind Fagatoga water-works upstream and along the hill sides. This small valley has a canopy forest and moderately dense understory.

Eua zebrina - several shells.
Samoana abbreviata - abundant shells.
Trochomorpha apia - several shells.
Sturanyella beryllina - several live snails.
Ostodes strigatus - several shells.
Septaria sp. - several live snails (freshwater).
Neritina sp. - several live snails (freshwater).
Thiara sp. - several live snails (freshwater).

Achatina fulica - abundant shells, many fresh.
Euglandina rosea - abundant shells, many fresh.
Subulina octona - several shells.

(continued)

Appendix I. (continued)

3 November: Vainu'u Point (3-62 m elevation); north-central Tutuila. Briefly surveyed area near a cave at Anapeapea Cove; three-quarter-day survey on Vainu'u Point. The point is covered with a canopy forest with a moderately dense understory. The point is separated from the main island by a narrow but forested isthmus leading to a steep escarpment of partly exposed rock on the main island. No agriculture in the area, and *Euglandina*, *Gonaxis* and *Achatina* were not seen on the point. In addition, no partulids were seen on Vainuu Point. Recommended as a refuge for threatened snail populations.

Melampus fasciatus - several live snails at the cave.

Melampus luteus - several live snails at the cave and isthmus.

Pythia scarabaeus - several live snails and shells at the isthmus.

Pleuropoma fulgora - several live snails at the cave and on the point.

Sturanyella beryllina - several live snails on the point.

Diastole schmeltziana - several live snails on the point.

Elasmias sp. - numerous live snails on the point.

assimeid sp. - several live snails on the point.

subulinid sp. - several live snails on the isthmus and the point.

Subulina octona - several live snails on the isthmus and the point.

4 November: Tiatauala Ridge (152-305 m elevation); north-central Tutuila. One-day survey. Returned to this area to explore to end of the trail (about 275 m elevation) and to recapture previously marked *Eua zebrina*. Recaptured 3 marked snails plus one unmarked snail in 15 minutes of work. See October 23rd for information on the first visit.

Eua zebrina - live snails sparsely scattered; numerous shells.

Samoana conica - live snails rare, scattered; several shells.

Pleuropoma fulgora - several live snails.

Sturanyella beryllina - several live snails.

Diastole schmeltziana - several live snails.

Elasmias sp. - numerous live snails on the point.

Achatina fulica - numerous shells.

Euglandina rosea - several live snails; numerous shells.

5 November: Cleaned up and packed for return to Honolulu. Gave a talk at the Department of Marine and Wildlife Resources on our findings and recommendations.

9. APPENDIX II. Taxonomy of the snails seen in American Samoa during the 1992 surveys. Native (bold) and introduced taxa (underlined) were identified from collections at the B. P. Bishop Museum, Honolulu, Hawaii. Nomenclature follows Solem (1975) and Christensen (1980). Higher taxonomy follows Vaught (1989).

Phylum Mollusca	Subfamily Melampodinae
Class Gastropoda	<i>Melampus fasciatus</i> Deshayes, 1830
Subclass Prosobranchia	<i>Melampus luteus</i> Quay & Gaimard, 1832
Order Archaeogastropoda	
Superfamily Helicinoidea	Order Stylommatophora
Family Helicinidae	Suborder Orthurethra
Subfamily Helicininae	Superfamily Achatinelloidea
<i>Pleuropoma musiva</i> (Gould, 1847)	Family Achatinellidae
<i>Pleuropoma fulgora</i> (Gould, 1847)	Subfamily Lamellideinae
<i>Sturanyella beryllina</i> (Gould, 1847)	<i>Elasmias</i> sp.
Superfamily Neritoidea	Suborder Sigmurethra
Family Neritidae	Superfamily Partuloidea
Subfamily Neritinae	Family Partulidae
<i>Neritina</i> sp. (freshwater)	<i>Eua zebrina</i> (Gould, 1848)
Family Septariidae	(endemic to Tutuila)
<i>Septaria</i> sp. (freshwater)	<i>Samoaana conica</i> (Gould, 1848)
	(endemic to Samoa)
Order Mesogastropoda	<i>Samoaana abbreviata</i> (Mousson, 1869)
Superfamily Rissoidea	(endemic to Tutuila)
Family Assimineidae	<i>Samoaana thurstoni</i> (Cooke & Crampton, 1930)
Subfamily Assinimeinae	
unidentified sp. (<i>Assimineia nitida</i> ?)	Superfamily Achatinoidea
Subfamily Omphalotropidinae	Family Subulinidae
<i>Omphalotropis</i> sp.	Subfamily Subulininae
Superfamily Cerithioidea	<i>Subulina octona</i> (Bruguiere, 1792)
Family Thiaridae	unidentified sp. (<i>Opeas</i> ?)
Subfamily Thiarinae	Family Achatinidae
<i>Thiara</i> sp. (freshwater)	<i>Achatina fulica</i> (Bowdich, 1822)
Superfamily Cyclophoroidea	Superfamily Oleacinoidea
Family Poteriidae	Family Spiraxidae
<i>Ostodes strigatus</i> (Gould, 1848)	Subfamily Euglandininae
(endemic to Tutuila)	<i>Euglandina rosea</i> (Ferussac, 1821)
	Superfamily Streptaxoidea
Subclass Pulmonata	Family Streptaxidae
Order Archaeopulmonata	Subfamily Streptaxinae
Superfamily Ellobioidea	<i>Gonaxis kibweziensis</i> (E.A. Smith, 1894)
Family Ellobiidae	Superfamily Punctoidea
Subfamily Ellobiinae	Family Endodontidae
<i>Pythia scarabaeus</i> (L., 1758)	unidentified sp.

(continued)

Appendix II. (continued)

Suborder Elasmognatha
Superfamily Succineoidea
Family Succineidae
Subfamily Succineinae
Succinea sp.
Subfamily Catinellinae
Catinella manua?
Superfamily Helixarionoidea
Family Helixarionidae
Subfamily Microcystinae
Diastole schmeltziana (Mousson, 1865)
(endemic to Samoa)
Family Ariophantidae
Subfamily Parmarioninae
Parmarion martensi Simroth 1893
Family Trochomorphidae
Trochomorpha apia (Hombron & Jaquinot, 1852)
(endemic to Samoa)
Family Urocyclidae
Subfamily Trochozonitinae
Trochonanina sp.
Superfamily Helicoidea
Family Bradybaenidae
Subfamily Bradybaeninae
Bradybaena similis (Ferussac, 1821)
