

Samoan Snails and Slugs

A Field Identification Guide

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In preparation

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INTRODUCTION

The islands of the Samoan archipelago lie about 14 degrees south of the equator in the central Pacific Ocean (Fig. 1). Politically, they are divided into two groups: Samoa (formerly Western Samoa)¹, an independent state; and American Samoa, a territory of the USA (Fig. 2). The islands have been formed as a result of complex volcanic activity; they are geologically young. As for most islands of the Pacific, many of the plants and animals of the Samoan Islands are found nowhere else on earth.

This field guide is intended to permit identification of most of the snails and slugs found in terrestrial, freshwater and brackish-water habitats in the Samoan Islands. It is intended to be accessible to the amateur naturalist but also to provide the experienced scientist with a comprehensive yet compact resource of information. The guide covers both the native species and the non-native, introduced species, which are generally more frequently encountered, especially at low elevations and in habitats disturbed by human activities.

Much of our scientific knowledge of the native Samoan nonmarine snail fauna is founded on the work of nineteenth century European and American naturalists, who were the first Western scientists to describe, name and illustrate the many different species. Their work was published in the scattered technical literature of the time. Not only are these publications difficult to understand without intensive technical training and experience, but also they are only readily available in the libraries of major universities and natural history museums. The non-native snails and slugs come from all over the world; literature dealing with them is therefore also scattered and not easily accessible. Snails are an important part of the fauna of the Samoan Islands, and it therefore seemed valuable to produce this manual, with the aim of bringing this information together in a form accessible both to the interested but inexperienced amateur and to professional scientists, conservationists and land managers working in the Pacific.

The basic objective of the guide is to allow identification of all snails and slugs encountered in the Samoan Islands. A further objective is to stimulate interest and appreciation of these important animals, to enhance understanding of their biology and habitats, and to increase awareness of the importance of conservation.

WHAT IS A SNAIL?

Snails, and their shell-less or semi-shelled counterparts, slugs, belong to the second largest group of animals on earth, the mollusks. Only the arthropods (insects, crustaceans and their relatives) are more diverse. Snails and slugs (known scientifically as "gastropods") form the biggest subdivision of the mollusks.

Snail Biology

Snails live on land and in the water. The familiar sea-shells found on the beach are mostly the empty shells of snails that live in the ocean. But more than half the world's snails live on land or in freshwater (lakes, rivers, ponds, streams). Snails are found in almost every habitat, from the baking deserts of the Middle East to the steamy jungles of Southeast Asia, from the mountaintops of volcanic Pacific islands to the hedgerows and woodlands of Western Europe. Slugs are almost as widespread, but are not found in

¹ To avoid confusion, throughout this book the name "Western Samoa" is retained and "Samoa" is taken to mean the entire island group.

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such extreme hot and dry environments where their lack of a protective shell would make them vulnerable to desiccation.

Snails are an important part of many ecosystems, constituting a major portion of the total animal biomass. They are food for other animals; some snails are predators themselves; many consume dead and dying plant material and therefore are important in the cycling of nutrients through the ecosystem. A few species are important to humans. We eat escargot. We use shells as ornaments and jewelry. Other species of snails carry diseases, such as schistosomiasis, that infect humans, and some species have become crop pests when they have been introduced by people outside their natural range. There are many examples of the importance of snails and slugs to humans.

Most snails hatch from eggs laid by the parent, but some are born live. All have a shell, known as the protoconch, that is formed inside the egg or inside the parent. The protoconch becomes the apex of the shell, which then grows by successively adding new shell material at the shell opening, the aperture, thus forming an ever-increasing spiral. The shell is constructed from a number of layers, the outermost of which is called the periostracum. The periostracum is thin and often translucent; it may give the shell a shiny appearance. As snails get older, the periostracum often wears off; and in dead shells that have been lying around, exposed to rain and sunshine for a long time, it has usually disappeared altogether.

Shells and Identification Features

Most snails can be identified by looking at features of the shell: what shape it is; how big it is; what color it is; and so on. The main features of a snail shell are illustrated in Fig. 3. Technical terms used here and throughout this book are explained in the glossary that is provided towards the end of the book.

Shells coil to the right (dextral) or the left (sinistral). If you hold a shell with the apex upwards and the aperture facing you, the aperture of a dextral shell is on the right and that of a sinistral shell is on the left. Most species only coil in one direction. But in a few species, both sinistral and dextral individuals may be found.

As the shell grows, each successive coil is known as a whorl. The junction between successive whorls is known as the suture. As the whorls coil, they form a central column known as the columella. The columella may be solid or hollow. If hollow, the hollow center is generally open on the underside of the shell and forms a cavity known as the umbilicus. But in some cases it is almost or completely closed off.

Some species continue growth throughout life. Others, however, stop growing when they become adult. At this point the shell often forms a thickened lip around the aperture. There may also be structures, usually known as lamellae or teeth, within the shell aperture that restrict the opening.

The surface of the shell may be smooth or sculptured. The sculpture may take the form of ridges or grooves that run either along the whorls in the direction of growth, or across the whorls. As the shell grows, the laying down of successive shell material at the aperture may produce fine transverse growth lines. Sculpture of the protoconch may differ from that of the rest of the shell. Sculpture may be worn down in old individuals. Sculpture varies greatly among species. Some species have little or no sculpture but bear smooth, glossy shells.

Some species bear thick, heavy shells, while others bear thin almost translucent shells. Shell color is very variable among species and, because it may also vary considerably within species, it is not always a good identification feature. However, once the snails inside them have died and the shells have lain exposed to rain and sunlight for

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some time, almost all shells turn opaque white. Even shells that were very thin, translucent and glossy often turn opaque and white.

Slugs are species that have lost their shells through the course of evolution. Some slugs retain a small vestige of a shell, which might be visible externally, or in some cases is completely internal. Semi-slugs have a larger shell but are unable to retract the body fully inside it.

Snails' bodies vary little externally and features of the body are not as useful as those of the shells for field identification purposes. However, the internal anatomy of snails is important in their classification; some species can only be distinguished on the basis of differences in internal anatomy that can only be revealed by dissection. Most species in this field guide are distinguishable without dissection.

The main visible features of a snail's body (Fig. 4) are its head, with one or two pairs of tentacles, its foot and its tail. In general, those species with only one pair of tentacles the eyes are at the base of the tentacles; in those with two pairs, the eyes are at the tips of the upper, longer pair of tentacles. Some snails, known as operculates, carry a horny or calcareous structure, the operculum on their tails. When the snail withdraws into its shell, the operculum acts like a trap-door and seals the shell aperture. Snails' bodies may vary considerably in color. Color is not a good identification feature. Slugs may also be very variable in color.

Names of Snails

None of the native Samoan snails has a common English name. Only a few have Samoan names. This guide therefore uses the scientific names. Scientific names of animals are always in Latin and always formed from two words. The first is the generic name, which always begins with a capital letter and which places the species in a genus of closely related species. The second is the specific name, not capitalized, which defines the species within the genus. Both names are always italicized. Sometimes, names are given to subspecies, which are geographic subdivisions of a species, but these are ignored in this guide. When a species is mentioned for the first time in a book or article, the name of the person who first published its description and gave it its name, as well as the year in which the description was published, are often also given, following the species name. If someone at some time has decided that the original author placed the species in the wrong genus, the specific name is now associated with the new, correct genus, and the original author's name is placed in parentheses. Often, if it is clear which species is being discussed, the name is abbreviated to the first letter of the generic name, followed by the species name.

For example, the Samoan tree snail *Eua zebrina* (Gould, 1847) was described and named by the American naturalist Augustus Addison Gould in a work published in 1847. However, Gould named the species "*Partula zebrina*", placing it in the genus *Partula*. Subsequent workers decided that it should be placed in the genus *Eua*. Hence Gould's name and the date of the description are placed in parentheses. Often the name can be abbreviated simply to *E. zebrina*.

ORIGINS AND EVOLUTION

Most islands in the central Pacific have been formed as a result of isolated volcanic activity. They have never been connected to continental land masses. All the plants and animals that occur naturally on these islands arrived by chance dispersal or evolved on the islands from species that arrived by chance. Dispersal could have been by wind,

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perhaps blown high into the atmosphere during hurricanes and typhoons, and perhaps attached to leaves or other small bits of vegetation. Some organisms could have dispersed attached to floating logs and other debris. Yet others could have been carried accidentally by birds. Successful colonization of a new island would have been a rare event, but over the millions of years of geological time, would have been sufficiently frequent to allow many kinds of organisms to reach newly formed islands. Once there, many of these plants and animals evolved into diverse forms, taking advantage of the new ecological opportunities. Many of them, having evolved on a particular island, are unique to that island. Most original colonization of Pacific islands was in a west to east direction. Thus, many Pacific plants and animals are related to species in eastern Asia and Australasia. They have dispersed from these major continental sources of diversity, first to the closest islands of Melanesia and Micronesia. Then, with new species evolving as new islands were colonized, they have continued to disperse far out into Polynesia, reaching the most distant islands of Hawaii and the Marquesas. The chances of dispersing to these most distant islands are extremely low; some kinds of organisms have never reached them. However, those that did reach them frequently radiated into huge numbers of different but closely related species unique to particular islands. Less isolated islands tend to have fewer unique species.

Many of the islands of the Pacific have been formed as the Pacific tectonic plate moves northwestward over stationary "hot spots" in the earth's mantle. Every so often lava from the hot spot rises through the earth's crust, forming an island. As the plate moves, carrying these new islands with it, newer islands continue to be formed over the hot spot. Thus, a chain of islands is created. As the older islands in a chain are eroded away they eventually decline to become underwater seamounts. Newer islands may have been colonized not only by plants and animals dispersing directly from continental regions but also by colonizers from earlier islands that are now submerged. The Hawaiian Islands are a clear example. The Samoan Islands are more complex. They have also been formed largely through hot spot activity at the eastern end of the chain, but complicated by plate edge volcanism associated with the interaction of the Pacific plate and the Tonga trench to the south west.

Land snails on islands in the Pacific are classic examples of the kinds of patterns expected as organisms disperse to new islands and then radiate to produce many new species. The Hawaiian fauna comprises over 750 species, all but a handful of which are unique to the extremely isolated Hawaiian Islands. In the less isolated Samoan archipelago, there are only about 90 species, of which about a third are also found elsewhere, generally in the neighboring islands of Tonga and Fiji.

The native freshwater snails of Pacific islands contrast with the land snails. Many of them live in streams as adults, where they breed. But some of them release larvae that are washed out into the ocean before returning to the streams as they develop. This kind of life-cycle is known as diadromous. Thus there are far greater chances for wide dispersal between islands, so that relatively few of the native freshwater snails are unique to particular islands. The Samoan fresh- and brackish-water snails are not well known; their correct identification and taxonomy is unclear in many cases. However, Of the 40 or so Samoan species, possibly none is unique to the islands.

CONSERVATION

Declines

Like the native biotas of most tropical Pacific islands, the native plants and animals of Samoa are disappearing. The land snails have declined dramatically. Seven species are

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listed by the World Conservation Union in the 1996 IUCN Red List of Threatened Animals; one of them, *Diastole matafaoi*, is listed as extinct. In 1994, the United States Fish and Wildlife Service, with jurisdiction in American Samoa, listed eight species as "candidates" for endangered or threatened status, pending further information. Others should undoubtedly be listed, but have simply not yet been evaluated.

Most of the Samoan species were originally described for Western science by nineteenth century Europeans and Americans who did not visit Samoa. Their work was based on collections made by exploring expeditions and by a small number of amateur naturalists and collectors. The locations from which these specimens were collected are not well recorded; generally only the island where they were found is known. Major surveys were undertaken by Bishop Museum (Honolulu) in 1926 in American Samoa and 1967 in both American and Western Samoa. Surveys of Western Samoa in 1965 and Tutuila (American Samoa) in 1975 were undertaken under the auspices of the Field Museum (Chicago). In the 1990s survey work in both American and Western Samoa by Bishop Museum and other personnel has been carried out. All this twentieth century material has accurate and detailed locality information associated with it. It is thus possible to document the decline of the land snail fauna during the twentieth century and it is clear that while it is now often difficult to find native snails, they were once extremely abundant. It is also clear that the number and abundance of non-native species is increasing. Most of these introduced species are common species, widely distributed in the tropics. As they increase and the native species decrease, the faunas of tropical islands around the world are being homogenized.

The freshwater fauna is much less well documented historically. A notable major expedition was mounted by the University of Vienna (Austria) in 1985, and additional surveys were undertaken, also during the 1980s, by staff of the University of the South Pacific (Suva, Fiji). While a high diversity of species is recorded in Samoa, for many of these species it is not at all clear whether they are native or introduced, nor whether there has been a significant decline during historic times.

Threats

The decline in the native land snails has resulted from a number of causes, most of which remain significant threats.

Collection of shells for ornament, jewelry, and simply as a hobby may have had some impact. For instance, collection of the 10,000 or so shells of the endemic Tutuila tree snail *Eua zebra* that make up the chandeliers in the lobby of the Rainmaker Hotel in Pago Pago (Fig. 7) surely must have reduced at least some populations of that species. But most of the native snails are small and relatively inconspicuous, and of little interest for these purposes.

Habitat destruction and modification has probably had a much greater impact. Urban and suburban environments are unsuitable for most of these native snail species, which have evolved in the absence of humans and are closely adapted to the natural environment. Deforestation and clearing of land for agriculture have destroyed native forest that harbored native snails. Equally, the unintentional replacement of native vegetation with aggressively spreading non-native introduced species of plants, to which the snails are not adapted, has reduced available suitable habitat.

Predation by introduced predators has probably been a major cause of the decline of the native snails. The native snails evolved in the absence of many aggressive predators, such as rats. The slow reproductive rate of some of the species of snails (for instance the tree snails in the family Partulidae) meant that their populations were highly

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susceptible to sustained predation. Others (for instance the ground-dwelling Endodontidae) may have been especially susceptible to predation by introduced ants.

In general, with one notable exception, introduced snails and slugs (there are no native slugs in Samoa) have probably not had much impact on the native snail fauna, through competition or other interactions. The introduced species tend to be found in lowland, often disturbed habitats. Native species probably disappeared from these localities long before the arrival of most of the alien species. However, perhaps the single most significant factor in the recent drastic decline of native species has been the deliberate introduction of the predatory snail *Euglandina rosea* (Fig. 8) in ill-conceived attempts to control another non-native snail, the giant African snail, *Achatina fulica*. The predatory snail was introduced despite the lack of scientific evidence attesting to its ability to reduce populations of *Achatina fulica*, and in full knowledge of its likely impact on native snail populations, an impact that now seems to have been realized. Contrary to what some people think, *Euglandina rosea* will climb into trees in search of its prey. At the time of writing this field guide, this voracious predator is only thought to have been introduced to Tutuila and Ta'u. Recently however, the giant African snail has become a problem on 'Upolu. Authorities must not be tempted to introduce either *Euglandina rosea* or other predatory snails, nor to introduce other equally or even more voracious and indiscriminate predators such as the flatworm *Platydemus manokwari* (Fig. 9). Although a naturally terrestrial species, *Euglandina rosea* will also go underwater to search for its prey, so freshwater snails are not immune to attack either.

While the land snail fauna is severely threatened, it is difficult to assess the status of and threats to the freshwater fauna. Freshwater habitat degradation and modification can result from direct physical changes being made to stream channels, flow rate being manipulated to supply urban and agricultural needs, pollutants being discharged or dumped into the stream, and so on. Indirect effects of terrestrial habitat modification could include changes in turbidity and siltation due to erosional runoff, and chemical poisoning due to pesticide, herbicide and fertilizer runoff. There are many potential changes to freshwater habitats that could affect snail populations, but there is insufficient information to permit an assessment of the seriousness of these threats. But insufficient evidence does not mean there is no threat; there is no cause for complacency.

Action

The conservation of what is left of the unique Samoan snail fauna depends primarily on there being sufficient interest in conserving it. This depends on education. And it is part of the purpose of this book to educate people about the uniqueness and value of the Samoan snails.

In practical terms, conserving Samoan snails will involve establishing reserves, especially reserves that are free of rats and predatory snails. It will involve monitoring these and other areas in order to evaluate the continued well-being of the fauna. And it will involve preventing the introduction of the giant African snail to islands currently free of it, so that authorities will not be tempted to introduce predators such as *Euglandina rosea* or the flatworm *Platydemus manokwari* in attempts to control it.

You can help by valuing and taking pride in Samoa's native fauna and flora; by spreading the word about its special and unique nature; by becoming aware of projects that might impact natural areas, by speaking out against them, and by participating in community and governmental planning processes that shape them.

HOW TO USE THIS BOOK

If you are unfamiliar with snails and slugs and/or with Samoa, you are recommended to read the introductory material above. If you want to delve deeper, you will find many sources of additional information in the list of literature at the end of the book.

Most people will probably simply look at the pictures in the following species by species accounts and try to match the snails they find to them. This is quite appropriate. If some of the information given for the species you are looking at is clearly contradictory, this will give you a hint that perhaps your identification is incorrect. For instance if you found a snail on Ofu but it is only known to occur on Savai'i, it would be worth checking your identification—of course you could be correct and be the first person to have recorded that species on Ofu.

An alternative way to identify a specimen is to use the key provided at the end of the species by species accounts.....??????????????????

Many of the species are large enough to be identified with the naked eye. However, some species are very small, or have features that can only be seen clearly under magnification. A hand lens, magnifying glass, or if you have access to it, a binocular microscope, will be useful for identification of these smaller species.

Information Provided

Each species is illustrated, alongside a brief account that provides information about it under the following headings:

Distribution in Samoa. The islands from which the species has been recorded. If the records for a particular island are only tentative, a "?" precedes the island name. Apparent absence from a particular island may just reflect the fact that the species has not been recorded or collected from that island, and not necessarily its true non-occurrence there.

Natural range. This is the region in which the species occurs naturally. In some cases (for instance some of the freshwater species in the family Thiaridae), a species has been artificially distributed so widely and/or its true identity is so confused that it is impossible to know where it originally came from. In this case, its current *Known distribution* is listed.

Status in Samoa. Whether endemic (occurs naturally in the Samoan Islands and is only known from the Samoan Islands), indigenous (occurs naturally in the Samoan Islands but also elsewhere), or introduced (occurs in the Samoan islands only because of deliberate or inadvertent transport by humans). If endemic, the *Natural range* (above) is omitted.

Habitat. Some indication of the kinds of places the species is found in, as far as is known (e.g., forest, in leaf litter, around human habitation, etc.). This is only a rough guide, and the information provided in many cases is minimal. For many species, the range of habitats they live in is not well known.

Adult size. Shell height and shell width, as reported in other published work, with a range if this was given, or as determined by measurement of museum specimens. Height is measured perpendicular to the columellar axis; width at right angles to it (Fig. 3). For some species (e.g., Neritidae) in which height and width are not the most obvious indicators of size, simply the maximum dimension of the shell is given. Body length when extended and active is given for slugs. All measurements are given to the nearest millimeter if possible, but are only approximate as there can be much variation among individuals within a species.

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Identification hints. Any distinctive features to assist identification and to distinguish the species from other similar species.

Remarks. Other interesting or useful information about the species; for instance, is it endangered; is it a pest.

Limitations

The field guide should not be treated as a complete list of the nonmarine snails and slugs of the Samoan Islands, although most known species are dealt with. Much of the information given here has been obtained from the *Catalog of the nonmarine snails and slugs of the Samoan Islands* (Cowie 1998; listed in the bibliography towards the end of this manual), which should be consulted for more extensive and definitive treatment.

For this field guide, subspecies are ignored. Species that have been formally described but are of unknown taxonomic status are omitted. Species that have only been tentatively recorded from the Samoan Islands are also omitted, although future work may confirm their presence. Only the main archipelago is considered; Rose and Swains Island are omitted.

Only adult snails are illustrated, and only adult shell dimensions are given. Juveniles generally have similar characteristics to adults, just with fewer whorls. However, identification of juveniles is more difficult.

When dealing with invertebrates, such as snails, our knowledge of correct species identity, habitat, distribution, and so on is usually far less accurate and comprehensive than it is for vertebrates such as birds or mammals, or even for more popular invertebrates such as butterflies. Therefore, in contrast to field guides for such groups of animals, this field guide to the snails and slugs of Samoa contains much less complete and rigorous information. So, if you think you have found a particular species but outside its recorded distribution, or in a kind of habitat different from that stated in the guide, you may well have made a correct identification and have discovered a new distribution or habitat for the species.

Furthermore, there are undoubtedly species of snails in Samoa that have not yet been formally described in the scientific literature. Being unknown, they cannot be treated in a field guide such as this; but you may just find one.

Finally, nonindigenous species are increasingly being transported around the world, both accidentally and deliberately, through the activities of people. So if you find a species that does not appear in this guide, it could be a new introduction to Samoa.

Taxonomy

The sequential taxonomic arrangement of families and genera adopted in the field guide, follows that in the *Catalog of the nonmarine snails and slugs of the Samoan Islands* (Cowie 1998), except that land snails precede freshwater snails.

No taxonomic or nomenclatural changes are intended in this guide, which is an identification manual, not a work of taxonomy or nomenclature.

More Information

A bibliography of significant additional sources of information about Samoan snails is provided at the end of the main part of the field guide. This will allow the more interested reader to delve deeper into what is known about the Samoan nonmarine mollusk fauna.

TERRESTRIAL SPECIES

Family HELICINIDAE

The family Helicinidae is one of several groups of operculate land snails that have diversified on Pacific islands. The shells are generally fairly solid and the umbilical region is usually covered over with a distinct layer of shell known as a callus. Helicinids exhibit much variation and their identification can be confusing. It is possible that there are a number of undescribed species in the Samoan fauna. Details and illustrations are only provided for the better known species. Very little is known of their ecology or habits.

***Orobophana musiva* Gould, 1847.**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila, Ofu, Olosega, Ta'u.

Natural range. Samoa, Fiji, Tonga, Tuvalu.

Status in Samoa. Indigenous.

Habitat. Beneath decaying vegetation at low elevation, often near the coast.

Adult shell size. Height, 2 mm; width, 3 mm.

Identification hints. Very small. Periphery of shell not sharply keeled. Color various shades of yellow, orange and reddish-brown.

***Orobophana oberwimmeri* Wagner, 1910. Not figured.**

Distribution in Samoa. Unknown.

Status in Samoa. Endemic.

Habitat. Unknown.

Adult shell size. Height, 2-3 mm; width, 4 mm

Identification hints.

***Pleuropoma altivaga* Ancey, 1889. Not figured.**

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

Habitat. Upper elevations.

Adult shell size. Height, 5-6 mm; width, 9-10 mm.

Identification hints. Similar to *Pleuropoma fulgora*, but larger.

***Pleuropoma fulgora* Gould, 1847.**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila, Ofu, Olosega, Ta'u.

Natural range. Samoa, Fiji.

Status in Samoa. Indigenous.

Habitat. In forest litter.

Adult shell size. Height, 4 mm; width, 6 mm.

Identification hints. Shell strongly keeled. Shell color pale yellow to dull yellowish-brown, often but not always with reddish-brown zigzag transverse markings.

***Pleuropoma rogosiuscula* Wagner, 1909. Not figured.**

Distribution in Samoa. Unknown.

Status in Samoa. Endemic.

Habitat. Unknown.

Adult shell size. Height, 5 mm; width, 8 mm.

Identification hints. Yellow-white or reddish-white with a yellow apex. Strongly keeled.

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***Pleuropoma jetschini* Wagner, 1905.**

Distribution in Samoa. 'Upolu, Tutuila.

Natural range. Samoa, Fiji.

Status in Samoa. Indigenous.

Habitat. Unknown.

Adult shell size. Height, 4 mm; width, 6 mm.

Identification hints. Similar to *Pleuropoma plicatilis*, but smaller. Whorls slightly more rounded with a slightly deeper suture than in *P. plicatilis*. Shell white (particularly if the periostracum has worn off) or yellow, sometimes pink, lacking transverse zigzag markings, not keeled.

***Pleuropoma plicatilis* Mousson, 1865.**

Distribution in Samoa. Savai'i, 'Upolu.

Status in Samoa. Endemic.

Habitat. On trees.

Adult shell size. Height, 9 mm; width, 14 mm.

Identification hints. The largest Samoan helicimid. Similar to *Pleuropoma jetschini*, but larger. Shell white (particularly if the periostracum has worn off) or yellow, sometimes pink, lacking transverse zigzag markings, not keeled.

Family NEOCYCLOTIDAE

The Neocyclotidae (sometimes called Poteriidae) are terrestrial operculate snails in the superfamily Cyclophoroidea. Only one genus, *Ostodes*, occurs in Samoa, but it is endemic to the islands. All the species are ground dwellers in forest with heavy tree cover.

The 12 species are difficult to distinguish and the only certain way to identify some of them is to dissect the snails and look at differences in their internal anatomy. Such details are beyond the scope of this field guide, but for more information consult the paper by Girardi (1978) listed in the bibliography. Old and worn shells that have lost much of their sculpture may also be difficult to identify, as may juveniles.

***Ostodes adjunctus* Mousson, 1869. [Clench line drawing]**

Distribution in Samoa. Tutuila.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 4-7 mm; width, 6-9 mm.

Identification hints. Only two species of *Ostodes* are found on Tutuila: *Ostodes adjunctus* and *Ostodes strigatus*. Adult shells of *Ostodes adjunctus* are much smaller than those of *Ostodes strigatus*. Generally, only *O. adjunctus* occurs on the eastern part of the island, with *O. strigatus* on the western portion.

***Ostodes cookei* Clench, 1949. [Clench line drawing]**

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 6 mm; width, 8 mm.

Identification hints. The smooth shell of this species distinguishes it from the other small species of 'Upolu, *Ostodes upolensis*, which is strongly sculptured.

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Ostodes exasperatus Girardi, 1978. [Girardi line drawing - photograph holotype in Chicago]

Distribution in Samoa. Savai'i, 'Upolu.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 9-13 mm; width, 10-13 mm.

Identification hints. Distinguishable from most species of Savai'i and 'Upolu by its size, shape and sculpture, but very similar to *Ostodes savaii*. However, *O. savaii* has a more "stepped" appearance of the junction between the last whorl and the one immediately preceding it. The umbilicus of *O. exasperatus* is slightly larger in proportion to the width of the shell, and *O. exasperatus* is generally slightly shorter and wider. *Ostodes ilanero* is generally flatter.

Ostodes garretti Clench, 1949. [Clench line drawing]

Distribution in Samoa. Savai'i.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 11-15 mm; width, 13-19 mm.

Identification hints. Difficult to distinguish from *Ostodes tiara*, but is a little flatter with a slightly smaller aperture and an umbilicus a little wider in proportion to the width of the shell.

Ostodes gassiesi Souverbie, 1859. [Girardi line drawing]

Distribution in Samoa. Savai'i, 'Upolu.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 9-15 mm; width, 9-12 mm.

Identification hints. This species is generally higher in proportion to its width than *Ostodes savaii*, and is strongly radially sculptured. It is taller and narrower than *Ostodes reticulatus*, having a more acutely angled spire and a much narrower umbilicus. It is larger than *Ostodes cookei* and *Ostodes upolensis*, but smaller than *Ostodes garretti* and *Ostodes tiara*. It is difficult to distinguish from *Ostodes plicatus*. However, in *Ostodes plicatus*, the radial sculpture is stronger and the spiral sculpture is relatively unobtrusive and evenly distributed over the body whorl; in *Ostodes gassiesi*, the spiral sculpture is stronger, but concentrated on the lower part of the body whorl.

Ostodes ilanero Girardi, 1978. Not figured.

Distribution in Samoa. Savai'i.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 7 mm; width, 9-10 mm.

Identification hints. Very similar to *Ostodes exasperatus* but generally flatter than that species.

Remarks. Not a well known species. Only juveniles have been reported in the scientific literature.

Ostodes plicatus Gould, 1847. [Girardi line drawing]

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

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Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 9-12 mm; width, 9-11 mm.

Identification hints. Most similar to *Ostodes gassiesi*. However, the strong radial ridges of *O. gassiesi*, especially on the lower part of the whorls, serve to distinguish it. Also, *O. plicatus* is usually slightly taller than wide, whereas other species with which it might be confused tend to be wider than they are tall.

***Ostodes reticulatus* Girardi, 1978.** [Girardi line drawing - photograph holotype in Chicago].

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 8-11 mm; width, 9-11 mm.

Identification hints. The combined spiral and radial sculpture of this species, and the relatively wide umbilicus distinguish this species.

***Ostodes savaii* Clench, 1949.** [Clench line drawing]

Distribution in Samoa. Savai'i.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 8-14 mm; width, 8-13 mm.

Identification hints. Most similar to *O. exasperatus* but distinguished from it as explained under that species. The lack of radial sculpture in *O. savaii* distinguish it from *O. plicatus* and *O. gassiesi*, both of which tend to be slightly taller compared to their width.

***Ostodes strigatus* Gould, 1847.** [Clench line drawing]

Distribution in Samoa. Tutuila.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 7-11 mm; width, 9-12 mm.

Identification hints. Adult shells of *Ostodes strigatus* are much larger as well as taller in proportion to their width than those of *Ostodes adjunctus*, the only other species of *Ostodes* found on Tutuila.

Remarks. Listed as a candidate for endangered/threatened status by the U.S. Fish and Wildlife Service in 1994.

***Ostodes tiara* Gould, 1847** [Clench line drawing]

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 13-16 mm; width, 16-23 mm.

Identification hints. Difficult to distinguish from *Ostodes garretti*, but is not quite as flat, has a slightly larger aperture and an umbilicus a little narrower in proportion to the width of the shell.

***Ostodes upolensis* Mousson, 1865** [Girardi line drawing]

Distribution in Samoa. Savai'i, 'Upolu.

Status in Samoa. Endemic.

Habitat. On the ground in forest areas with heavy tree cover.

Adult shell size. Height, 3-7 mm; width, 3-9 mm.

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Identification hints. Almost always higher than wide. The strongly sculptured shell of this species distinguishes it from the other small species of 'Upolu, *Ostodes cookei*, which is smooth.

Family DIPLOMMATINIDAE

The Diplommatinidae are operculate land snails in the superfamily Cyclophoroidea (with the Neocyclotidae—see above). They are especially diverse in Micronesia, but much less so in Polynesia, with only one very poorly known species in Samoa.

Diplommatina problematica Mousson, 1865. [one spm in BPBM general collections under Moussonia in Upolu]

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

Habitat. Unknown.

Adult shell size. Height, 1-2 mm; width, less than 1 mm.

Identification hints. Minute. Full-grown snails have about seven, well-rounded whorls. Aperture almost circular. Color brown. Details only visible under a microscope.

Family TRUNCATELLIDAE

The family name reflects the fact that in most species the apex and upper whorls of the shell are lost—the shell is truncated or decollate. The family is worldwide in distribution. Most species live close to the seashore, or near brackish water, and are therefore considered by some people as marine species or freshwater species.

Truncatella guerinii Villa & Villa, 1841.

Distribution in Samoa. Savai'i.

Natural range. Widespread in the Indo-Pacific.

Status in Samoa. Indigenous.

Habitat. Under leaf litter and other debris close to the seashore, usually in sheltered places just above the high water mark.

Adult shell size. Height, 6-10 mm; width, 2-4 mm.

Identification hints. Thin, cylindrical shell with marked transverse ridges and a somewhat flared aperture. The only species in the Samoan land snail fauna with a truncated shell.

Family ASSIMINEIDAE

The operculate family Assimineidae is world-wide in distribution. Many species are somewhat amphibious, living at the margins of streams and estuaries, often in areas with slightly brackish water. Species of *Assiminea* tend to be found in such habitats, but species of *Omphalotropis* are often found in entirely terrestrial, although damp, habitats.

The Samoan species of *Omphalotropis* have not been well studied. There may well be undescribed species. So identification is difficult and can often only be tentative. NEED TO CHECK TYPES

Assiminea parvula Mousson, 1865.

Distribution in Samoa. 'Upolu, Tutuila, Ofu, Ta'u.

Natural range. Widespread in the Pacific.

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Status in Samoa. Indigenous.

Habitat. Species of *Assiminea* are estuarine and amphibious; they require at least a small amount of salinity in the water; some live at the edge of almost strictly marine waters. This species usually found beneath decaying leaves, under stones and dead wood.

Adult shell size. Height, 3-4 mm; width, 2 mm.

Identification hints. Conical shell. Smaller than species of *Omphalotropis*.

Remarks. Identification of species of *Assiminea* using shells alone is almost impossible. Most of the species of *Assiminea* from Pacific islands belong to the "parvula-complex". Therefore this field guide only illustrates *Assiminea parvula* itself (sometimes it is called *Assiminea nitida*, but incorrectly), although two other species are reported from Samoa (below).

Assiminea crosseana Gassies, 1869. Not figured.

Remarks. See remarks under *Assiminea parvula*.

Assiminea similis Baird, 1873. Not figured.

Remarks. See remarks under *Assiminea parvula*.

Tutuilana striata Hubendick, 1952. Not figured.

Distribution in Samoa. Tutuila.

Status in Samoa. Endemic.

Habitat. Found on a dripping wet mossy cliff.

Adult shell size. Height, 3 mm; width, 2-3 mm.

Identification hints. Only two to three well-rounded whorls, separated by a deep suture

Remarks. Only recorded once (the original description of the species).

Omphalotropis bifilaris Mousson, 1865.

Distribution in Samoa. 'Upolu, Tutuila.

Natural range. Samoa, Tonga.

Status in Samoa. Indigenous.

Habitat.

Adult shell size. Height, 6-7 mm; width, 4 mm.

Identification hints.

Omphalotropis billratus Mousson, 1865.

Distribution in Samoa. Savai'i, 'Upolu, ?Tutuila.

Natural range. Samoa, Wallis Islands.

Status in Samoa. Indigenous.

Habitat.

Adult shell size. Height, 5-6 mm; width, 3-4 mm.

Identification hints.

Omphalotropis conoideus Mousson, 1865.

Distribution in Samoa. Savai'i, 'Upolu, Ta'u.

Natural range. Samoa, Wallis Islands.

Status in Samoa. Indigenous.

Habitat.

Adult shell size. Height, 7 mm; width, 5 mm.

Identification hints. The largest species of *Omphalotropis* in Samoa. Conical.

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Omphalotropis laevis Baird, 1873. Not figured.

Distribution in Samoa. Unknown.

Status in Samoa. Endemic.

Omphalotropis scitulus Gould, 1847. Not figured.

Distribution in Samoa. Manu'a Islands.

Natural range. Samoa, French Polynesia.

Status in Samoa. Indigenous.

Family VERONICELLIDAE

The Veronicellidae (sometimes called Vaginulidae) include a large number of species of terrestrial slugs distributed widely in the humid tropics and subtropics. The two species recorded from Samoa are widely distributed elsewhere, probably in large part due to human activities.

Laevicaulis alte Férussac, 1822. [Robinson photo]

Distribution in Samoa. 'Upolu.

Natural range. ?Africa.

Status in Samoa. Introduced.

Habitat. Usually in disturbed lowland areas.

Adult size. Length up to about 7-8 cm.

Identification hints. Generally black or dark gray, with paler, sometimes yellowish lines running the length of the dorsal surface.

Remarks. This species is widely distributed from East Africa, through southern Asia and the islands of the Indian Ocean, to Australia and the islands of the Pacific, probably largely through human activities.

Vaginulus plebeius Fischer, 1868. [Robinson photo]

Distribution in Samoa. 'Upolu, ?Savai'i.

Natural range. South America, Caribbean.

Status in Samoa. Introduced.

Habitat. Often found close to human habitation.

Adult size. Length up to about 7-8 cm.

Identification hints. Variable in color from deep chestnut brown to pale buff-brown, often with lines and mottling.

Remarks. Can be a pest in gardens and yards, feeding on vegetables and ornamental plants.

Family ELLOBIIDAE

The family Ellobiidae is found worldwide. Most species are found close to the seashore, either among rocks and debris just above the high water mark, in mangroves, or in forest immediately inland. A few species are found further inland.

The Pacific species are in need of detailed study by experts. It is therefore often difficult to be sure of identifications, as the characteristics defining the various species are not well understood.

Auriculastra subula Quoy & Gaimard, 1832.

Distribution in Samoa. 'Upolu.

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Natural range. Widespread in the Indo-Pacific.

Status in Samoa. Indigenous.

Habitat. Upper intertidal. Possibly along streams running into the ocean, immediately behind the mangrove zone.

Adult shell size. Height, 9-16 mm; width, about 5-6 mm.

Identification hints. Slender but rather variable shell shape. Height of aperture about half total shell height, or slightly more. Shiny surface, varying from pale olive-yellow to brown-black.

***Ellobium semisculptum* H. & A. Adams, 1854.**

Distribution in Samoa. 'Upolu.

Natural range. South Pacific, northern Australia.

Status in Samoa. Indigenous.

Habitat. Mangroves.

Adult shell size. Height, 19 mm; width, 9 mm; but variable and may reach 30 mm in height.

Identification hints. Shell elliptical in shape, yellowish and shiny.

***Melampus castaneus* Megerle von Mühlfeld, 1816.**

Distribution in Samoa. 'Upolu, ?Nu'utele, Nu'ulua.

Natural range. Tropical Pacific, northern Australia, Indonesia.

Status in Samoa. Indigenous.

Habitat. Above the spray zone under rocks and rubble.

Adult shell size. Height, 13 mm; width, 7 mm.

Identification hints. Shell light to dark brown. Larger than *Melampus parvulus*, which has a more pronounced pointed spire.

***Melampus fasciatus* Deshayes, 1830.**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila, Manu'a Islands.

Natural range. Widespread in the Indo-Pacific, from Africa and India, through Southeast Asia to Australia, New Guinea, the Philippines and islands of the Pacific.

Status in Samoa. Indigenous.

Habitat. Just above the high-water mark.

Adult shell size. Height, 15-18 mm; width, 7-12 mm.

Identification hints. Variable in color, from whitish or yellow to orange-brown, dark brown or black, often with brown spiral bands. Aperture height about three-quarters total shell height.

***Melampus luteus* Quoy & Gaimard, 1832.**

Distribution in Samoa. 'Upolu, Tutuila, Manu'a Islands.

Natural range. Widespread in the Pacific, north-eastern Australia.

Status in Samoa. Indigenous.

Habitat. Just above the high-water mark; often under leaves and seaweed washed ashore from the ocean.

Adult shell size. Height, 18 mm; width, 10 mm.

Identification hints. Large. Plain yellow or yellowish-white. Aperture height about two-thirds the total shell height.

***Melampus parvulus* Pfeiffer, 1856.**

Distribution in Samoa. Unknown.

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Natural range. Widespread in the Pacific, northeastern Australia.

Status in Samoa. Indigenous.

Habitat. Supralittoral, above the spray zone under rocks and rubble; on the margins of mangrove swamps.

Adult shell size. Height, 6-10 mm; width, 3-6 mm.

Identification hints. Smaller than *Melampus castaneus* and with a more pronounced pointed spire; more ovate in shape. Shell color dark-chestnut, olive-brown or fawn. Aperture height at least two-thirds the total shell height.

***Melampus philippii* Küster, 1845. Not figured.**

Distribution in Samoa. 'Upolu.

Natural range. Samoa, Tahiti.

Status in Samoa. Indigenous.

Remarks. Little is known about this species. It may be a synonym of one of the better known and more widespread species of *Melampus* illustrated in this guide.

***Melampus semisulcatus* Mousson, 1869.**

Distribution in Samoa. 'Upolu.

Natural range. Samoa, Tonga, Fiji.

Status in Samoa. Indigenous.

Habitat. The margins of mangrove swamps.

Adult shell size. Shell height, 11 mm; shell width, 6 mm.

Identification hints. Small. Uniform cinnamon color. Spire short, often eroded. Spiral grooves.

***Melampus striatus* Pease, 1861.**

Distribution in Samoa. 'Upolu.

Natural range. Samoa, Tahiti.

Status in Samoa. Indigenous.

Habitat. Margins of mangrove swamps.

Adult shell size. Height, 9-10 mm; width, XX mm.

Identification hints. Pale to dark brown, sometimes greenish-brown. Transverse sculpture, and on the upper part also longitudinal sculpture, giving a granulated appearance.

***Melampus tongaensis* Mousson, 1871. Not figured.**

Distribution in Samoa. Unknown.

Natural range. Samoa, Tonga.

Status in Samoa. Indigenous.

Habitat. Probably as for other species of *Melampus*.

Adult shell size. Height, 8-9 mm; width, 4-5 mm.

Identification hints. Small. Shell color uniform greenish black, paler along the suture and around the aperture.

Remarks. Little is known about this species. It may be a synonym of one of the better known and more widespread species of *Melampus* illustrated in this guide, perhaps *M. parvulus*.

***Allochroa layardi* H. & A. Adams, 1855.**

Distribution in Samoa. 'Upolu.

Natural range. Widespread in the Indo-Pacific.

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Status in Samoa. Indigenous.

Habitat. In crevices or under stones at about high tide level, sometimes above it, but usually seaward of the zone in which species of *Melampus* are found.

Adult shell size. Height, 4-8 mm; width, 2-4 mm.

Identification hints. Very variable in size, shape and sculpture. Usually markedly sculptured spirally, with transverse sculpture crossing the spiral sculpture to give a granulated appearance; but sometimes smooth. Color variable from chestnut-brown to pale yellow, but always with a more or less distinct pattern of color bands.

Remarks. Arguably, this species could be considered marine.

***Cassidula crassiuscula* Mousson, 1869.**

Distribution in Samoa. 'Upolu.

Natural range. Samoa, Tonga, Fiji and elsewhere in Melanesia.

Status in Samoa. Indigenous.

Habitat. On mud in mangrove swamps.

Adult shell size. Height, 10-16 mm; width, 7-11 mm.

Identification hints. Thick-shelled. Larger but with a less pronounced spire than *Cassidula paludosa*. Color varies from whitish or yellowish to various shades of brown, frequently with darker transverse bands; the apertural lip pale or whitish.

***Cassidula paludosa* Garrett, 1872.**

Distribution in Samoa. 'Upolu.

Natural range. Samoa, Wallis Islands, Fiji.

Status in Samoa. Indigenous.

Habitat. On mud surface in mangrove swamps; may be abundant.

Adult shell size. Height, 8-10 mm; width, 5-6 mm.

Identification hints. Smaller but with a more pronounced spire than *Cassidula crassiuscula*. Shell solid. Color variable from whitish through yellow-horn to dark brown.

***Pythia savaiensis* Mousson, 1869. Not figured.**

Distribution in Samoa. Savai'i, Manu'a Islands.

Natural range. Wallis, Fiji, Samoa.

Status in Samoa. Indigenous.

Habitat. As *Pythia scarabaeus*.

Adult shell size. Height, 30 mm; width, 17 mm.

Identification hints. Perhaps less flattened laterally and slightly more elongate than *P. scarabaeus*. Larger and more solid than *P. tortuosa*, with a more obviously open umbilicus.

Remarks. Little is known about this species. Both it and *P. tortuosa* may not be distinct from *P. scarabaeus*.

***Pythia scarabaeus* Linnaeus, 1758. [?Robinson photo]**

Distribution in Samoa. ?Savai'i, ?'Upolu, ?Nu'utele, ?Nu'ulua, Tutuila, Ofu, Ta'u. Probably on all islands??????check.

Natural range. Widespread in the Pacific, northern Australia, southern Asia.

Status in Samoa. Indigenous.

Habitat. In leaf litter on the forest floor, generally within a hundred meters or so of the intertidal.

Adult shell size. Height, up to 30 mm; width, up to 17 mm.

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Identification hints. Species of *Pythia* have curiously laterally flattened shells. Color varies greatly from pale buff to dark purplish, with or without dark blotches, flecks and other markings.

***Pythia tortuosa* Mousson, 1871. Not figured.**

Distribution in Samoa. 'Upolu.

Natural range. Samoa, Wallis and Futuna.

Status in Samoa. Indigenous.

Habitat. On the margins of mangrove swamps.

Adult shell size. Height, 18-25 mm, width, about 12 mm.

Identification hints. Described as smaller than *Pythia savaiensis*, otherwise very similar. The umbilicus perhaps more obviously open.

Remarks. Little is known about this species. Both it and *P. savaiensis* may not be distinct from *P. scarabæus*.

Family ACHATINELLIDAE

The Achatinellidae are widespread in the Pacific Basin. A number of species have also been recorded from Australia, Southeast Asia, and the islands of the Indian Ocean but these are probably introductions. The Achatinellidae are one of four land snail families endemic to the Pacific basin, the others being Partulidae, Endodontidae (both represented in the Samoan fauna; see below), and Amastridae (endemic to the Hawaiian Islands; not found in Samoa).

***Lamellidea oblonga* Pease, 1865 [Cooke & Kondo line drawing]**

Distribution in Samoa. Tutuila, Olosega, Ta'u.

Natural range. Eastern Polynesia.

Status in Samoa. Possibly introduced.

Habitat. Lowlands, often associated with human disturbance and in nonindigenous vegetation. Often on or under dead leaves and logs, and on stones.

Adult shell size. Height, 3-4 mm; width, 1-2 mm.

Identification hints. Small, uniformly brown shells. Generally taller in proportion to width than *Lamellidea pusilla*, and with slightly flatter whorls. But there is much variation within these two species, making their separation difficult. *Elasmias* sp. has fewer, more rapidly expanding whorls.

Remarks. Widespread in the Pacific, probably in large part due to human activities, including introduction by early Polynesian travelers. Further survey work may well find it on all of the main Samoan Islands. Often found together with *L. pusilla*. Often at high density.

***Lamellidea pusilla* Gould, 1847. [Cooke & Kondo line drawing]**

Distribution in Samoa. 'Upolu, Tutuila, Ofu, Olosega, Ta'u.

Natural range. Western Pacific.

Status in Samoa. Possibly introduced.

Habitat. Probably similar to *L. oblonga*: lowlands, disturbed areas, on fallen leaves and stones on the ground.

Adult shell size. Height, 3-4 mm; width, 1-2 mm.

Identification hints. Small, uniformly brown shells. Generally slightly more conical and wider in proportion to height than *Lamellidea oblonga*, and with slightly more rounded

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whorls. But there is much variation within these two species, making their separation difficult. *Elasmias* sp. has fewer, more rapidly expanding whorls.

Remarks. Widespread in the Pacific, probably in large part due to human activities, including introduction by early Polynesian travelers. Further survey work may well find it on all of the main Samoan Islands. Often found together with *L. oblonga*.

***Elasmias* sp.**

Distribution in Samoa. 'Upolu, Tutuila, Ta'u.

Natural range. Pacific islands.

Status in Samoa. Possibly introduced.

Habitat. Generally found on the leaves of trees and bushes.

Adult shell size. Height, 3-4 mm; width, 2-3 mm.

Identification hints. Conical shape. Whorls are fewer and expand much more rapidly than in species of *Lamellidea*.

Remarks. An unidentified species of *Elasmias*, but possibly *Elasmias aperta*, which has probably been transported widely by Polynesian voyagers.

Family PUPILLIDAE

The pupillids have a world-wide distribution and are one of the major groups of land snails in the Pacific, although Samoa does not exhibit great diversity. Both pupillids recorded from Samoa are tiny and possess distinct apertural barriers.

***Gastrocopta pediculus* Shuttleworth, 1852. (M of C vol 24, pl 25)**

Distribution in Samoa. 'Upolu, Tutuila.

Natural range. Pacific islands.

Status in Samoa. Possibly introduced.

Habitat. Generally at low elevations, in shaded places on stones, walls, under wood and leaves.

Adult shell size. Height, 2-3 mm; width, 1 mm.

Identification hints. The almost smooth shell and its greater height distinguish it from *Nesopupa godeffroyi*.

***Nesopupa godeffroyi* Boettger, 1881.**

Distribution in Samoa. ?Tutuila. (CHECK material)

Status in Samoa. Endemic.

Habitat. Under stones, rotten wood, leaf litter.

Adult shell size. Height, 2 mm; width, 1 mm.

Identification hints. More squat than *Gastrocopta pediculus* and with distinct transverse sculpture.

Remarks. Possibly a synonym of *Nesopupa tantilla* from Tahiti.

Family PARTULIDAE

With the exception of some doubtful records from New Guinea, the Partulidae are endemic to the islands of the Pacific. They are tree snails. Their distribution extends from Palau and the Marianas in the north west to the Marquesas, Austral, and Society Islands in the south east; they are absent from Hawaii.

Extensive work on the biology of partulids has been undertaken, in particular on the species of Moorea in the Society Islands. Tragically, these Moorean species are now

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extinct in the wild, largely as a result of predation by the introduced carnivorous snail *Euglandina rosea*. The partulids of Guam and the Marianas are succumbing to a similar fate.

The Samoan species are under severe threat of extinction from habitat loss and rat predation. Those of American Samoa are especially threatened because of predation by *Euglandina rosea*.

It is difficult to distinguish certain of the species; they may, in fact, not be distinct species in reality. Variation in shell color and in direction of coil may have little meaning in defining the species.

***Eua expansa* Pease, 1871. [Robinson photo]**

Distribution in Samoa. Savai'i, 'Upolu.

Status in Samoa. Endemic.

Habitat. Forest at low (formerly) and mid elevations.

Adult shell size. Height, 18-19 mm; width, 14-15 mm.

Identification hints. A grayish-white or sometimes pale tan colored shell, sometimes with faint darker spiral lines and flecks. The only species of *Eua* on Savai'i and distinguished on 'Upolu from *Eua montana* by its wider umbilicus, more squat shape, and by its more expanded aperture and body whorl.

***Eua montana* Cooke & Crampton, 1930.**

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

Habitat. High elevation forest.

Adult shell size. Height, 18 mm; width, 12 mm.

Identification hints. Dullish white in color. Narrower than *Eua expansa*, with a less flared aperture and a narrower umbilicus.

***Eua zebrina* Gould, 1847.**

Distribution in Samoa. Tutuila.

Status in Samoa. Endemic.

Habitat. Forest.

Adult shell size. Height, 18-21 mm; width, 11-13 mm.

Identification hints. Most shells have transverse patterning, but their color can vary from almost white, through pale brown, to dark brown and even purplish. Aperture more flared than in species of *Samoana*, which are unpatterned and generally uniform in color.

Remarks. Once abundant, as is illustrated by the enormous numbers of shells that make up the chandeliers in the Rainmaker Hotel in Pago Pago (Fig. 7). Now known only from very few localities. Listed as a candidate for endangered/threatened status by the U.S. Fish and Wildlife Service in 1994. Listed as threatened by IUCN in 1996.

***Samoana abbreviata* Mousson, 1869. Not figured.**

Distribution in Samoa. Tutuila.

Status in Samoa. Endemic.

Habitat. Forest.

Adult shell size. Height, 21 mm, width, 14 mm.

Identification hints. Dextral.

Remarks. May not be a valid species, just a smaller, more squat, dextral form of *Samoana conica*. Listed as a candidate for endangered/threatened status by the U.S.

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Fish and Wildlife Service in 1994. Listed as "data deficient" by IUCN in 1996, that is, probably threatened but IUCN has insufficient information to make that determination.

***Samoana canalis* Mousson, 1865.**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila.

Status in Samoa. Endemic.

Habitat. Forest.

Adult shell size. Height, 23-29 mm; width, 14-18 mm.

Identification hints. Sinistral (but see *Samoana abbreviata* and *Samoana stevensoniana*). Shell brown. Very similar to *Samoana conica* and may in fact be the same species. Distinguished by its darker color and by the lack of sculpture; *Samoana canalis* is pale-colored and has more obvious spiral sculpture.

***Samoana conica* Gould, 1847.**

Distribution in Samoa. 'Upolu, Tutuila.

Status in Samoa. Endemic.

Habitat. Forest.

Adult shell size. Height, 24-26 mm; width, 16-17 mm.

Identification hints. Sinistral (but see *Samoana abbreviata* and *Samoana stevensoniana*). Shell color pale. Very similar to *Samoana canalis* and may in fact be the same species. Distinguished by its pale color and by the very fine spiral sculpture, especially on the spire; *Samoana canalis* is brown and lacks the sculpture.

Remarks. Listed as a candidate for endangered/threatened status by the U.S. Fish and Wildlife Service in 1994. Listed as threatened by IUCN in 1996.

***Samoana stevensoniana* Pilsbry, 1909. [?Robinson photo]**

Distribution in Samoa. Savai'i, 'Upolu.

Status in Samoa. Endemic.

Habitat. Forest.

Adult shell size. Height, 22-25 mm; width, 13-14 mm.

Identification hints. Dextral.

Remarks. May not be a valid species, just a dextral form of *Samoana conica*.

***Samoana thurstoni* Cooke & Crampton, 1930.**

Distribution in Samoa. Ofu.

Status in Samoa. Endemic.

Habitat. Low forest near the summit of Ofu.

Adult shell size. Height, 19 mm; width, 12 mm.

Identification hints. The only partulid species on Ofu.

Remarks. Known from only one locality. Very few individuals have ever been seen. Undoubtedly severely threatened. Listed as a candidate for endangered/threatened status by the U.S. Fish and Wildlife Service in 1994. Listed as threatened by IUCN in 1996.

Family SUBULINIDAE

A number of subulinids are now widespread in the tropics and subtropics as a result of human activities. In the Pacific, one species at least (*Allopeas gracile*) appears to have been dispersed by Pacific islanders prior to European exploration, while others are more

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recent introductions. They are often extremely abundant, especially at low elevations and associated with habitats heavily disturbed by human activities.

Shell features of subulinids are very variable, making them very difficult to identify. Many of the reports in the scientific literature dealing with subulinids in Samoa have probably identified species incorrectly. Island distributions given below may well be inaccurate. CHECK with Fred Naggs.....

[Robinson photo of one species]

***Allopeas clavulinum* Potiez & Michaud, 1838.**

Distribution in Samoa. ?Tutuila.

Natural range. Probably tropical East Africa.

Status in Samoa. Introduced.

Habitat. Damp places, on the ground in leaf litter.

Adult shell size. Height, 7-9 mm; width, about 3 mm.

Identification hints. Shell shape very variable. Shell shiny. Often confused with *Paropeas achatinaceum*, but that species has a more globose apex and slightly flatter whorls, and is less glossy and transparent.

Remarks. Only tentatively recorded - needs confirmation based on BPBM material

***Allopeas gracile* Hutton, 1834.**

Distribution in Samoa. 'Upolu, Tutuila. Probably present on all main islands.

Natural range. Probably Neotropics.

Status in Samoa. Introduced.

Habitat. Damp places, on the ground in leaf litter.

Adult shell size. Height, 8-13 mm; width, 2-4 mm.

Identification hints. Shell very narrow in proportion to its width. Aperture long.

Remarks. One of the commonest and most widespread snails transported accidentally by humans through most of the humid tropics and subtropics.

***Opeas hannense* Rang, 1831.**

Distribution in Samoa. 'Upolu, ?Tutuila.

Natural range. Tropical Central America.

Status in Samoa. Introduced.

Habitat. Damp places, on the ground in leaf litter.

Adult shell size. Height, 5-7 mm; width, 2 mm.

Identification hints. Small. Fairly strongly striate. The edge of the aperture bending backwards along the suture.

Remarks. Often known as *Opeas pumilum* or *Opeas goodalii*.

***Paropeas achatinaceum* Pfeiffer, 1846.**

Distribution in Samoa. ?Savai'i, ?'Upolu, ?Tutuila.

Natural range. Unknown; now widespread in human disturbed areas around the Indo-Pacific.

Status in Samoa. Introduced.

Habitat. Damp places, on the ground in leaf litter.

Adult shell size. Height, 7-15 mm; width, 2-5 mm.

Identification hints. Shell shape very variable. Often confused with *Allopeas clavulinum*, but differs in possessing a more globose apex and slightly flatter whorls, and in being less glossy and transparent.

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Remarks. A widespread species, especially in the tropical Indo-Pacific, probably distributed in large part through human activities. Records from Samoa are tentative.....check BPBM

***Subulina octona* Bruguière, 1789.**

Distribution in Samoa. ?Upolu, Tutuila, Ofu, Olosega, Ta'u.

Natural range. Tropical New World.

Status in Samoa. Introduced.

Habitat. Damp places, on the ground in leaf litter.

Adult shell size. Height, up to 26 mm; width, up to 5 mm.

Identification hints. Generally larger than other subulinids, with a larger and more rounded protoconch (shell apex). Aperture more round than other subulinids and aperture height small in relation to overall shell height.

Remarks. Although identification of subulinids is extremely difficult, *Subulina octona* is perhaps the most clearly recognizable of the species in the Samoan Islands.

Family ACHATINIDAE

The Achatinidae are native to Africa and include some of the largest land snails known. A number of the larger species are eaten by people in some parts of the world, although they can carry parasites that cause serious illness and thorough cooking is essential. They are potentially dangerous pests and their further deliberate spread should be heavily restricted.

***Achatina fulica* Bowdich, 1822 [Burch/Cowie photo of shell]**

Distribution in Samoa. 'Upolu, Tutuila, Ta'u.

Natural range. East Africa.

Status in Samoa. Introduced.

Habitat. Widespread (especially on Tutuila) in disturbed areas at low and mid elevations, but also found in native forest.

Adult shell size. Height generally around 7-8 cm but can reach 20 cm or more.

Identification hints. Far larger than any other land snail in Samoa. Not as slender as *Euglandina rosea*, and generally browner and more mottled or streaked than *Euglandina rosea*, which has a more uniform pinkish shell.

Remarks. *Achatina fulica* was first reported in American Samoa in 1977, subsequently spreading rapidly throughout Tutuila. In 1992 it was also recorded on Ta'u, although not on Ofu or Olosega. It was first reported from 'Upolu in 1990 but seems not yet to have reached other islands of Western Samoa. *A. fulica* has been introduced widely in the humid tropics, frequently becoming an agricultural and garden pest. Its pest status has led to the introduction of predatory snails (see Spiraxidae, Streptaxidae) in attempts at biological control, with resultant serious impacts on native snail faunas (see Partulidae).

Family SPIRAXIDAE

Spiraxidae are carnivorous snails native to the southeastern United States through Central America and the Caribbean to Brazil and Peru.

***Euglandina rosea* Férussac, 1821. [Burch/Cowie photo of shell]**

Distribution in Samoa. Tutuila, Ta'u.

Natural range. Southeastern USA.

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Status in Samoa. Introduced.

Habitat. Lives in damp places in both disturbed and undisturbed areas; generally on the ground but will climb trees; may still be expanding its distribution but probably able to survive at all elevations.

Adult shell size. Height up to about 6 cm; width, about 2 cm.

Identification hints. Readily distinguished by its large size—only *Achatina fulica* is larger—and its slender pinkish shell.

Remarks. This carnivorous snail has been widely introduced throughout the tropics and subtropics for control of the giant African snail, *Achatina fulica*. Although there is no good evidence that it has provided effective control of *A. fulica*, despite claims to the contrary, there is ample evidence of its devastating effects on native land snail faunas, especially in the Pacific. It will even go under water to attack freshwater snails. It was first introduced to Samoa in 1980. By 1992 it appeared only to have reached Tutuila and Ta'u, but it has been a major contributor to the decline of native snail populations on those islands.

Family STREPTAXIDAE

Streptaxids are carnivorous snails, distributed predominantly in South America, Southeast Asia, India and especially Africa. They are now widely distributed throughout the tropics and subtropics, in part due to human activities. Frequently, they have been introduced deliberately for use in attempts at biological control of the giant African snail (see family Achatinidae). Despite what some people believe, there is no satisfactory evidence that they have had a significant impact on populations of giant African snails. In general, streptaxids introduced for biological control have not become as abundant as *Euglandina rosea* (see family Spiraxidae), but they nevertheless may well have had a significant impact on native land snail faunas.

***Gulella bicolor* Hutton, 1834. [Naggs, 1989 photos]**

Distribution in Samoa. Tutuila. (tentative record - check material)

Natural range. Probably the Indian subcontinent.

Status in Samoa. Introduced.

Habitat. Generally at low elevation, associated with habitats disturbed by human activities.

Adult shell size. Height, 5-8 mm; width, 2 mm.

Identification hints. Small, narrow, cylindrical shell with prominent barriers in the aperture.

***Streptostele musaecola* Morelet, 1860. (fig in Pilsbry - Belgian Congo)**

Distribution in Samoa. Tutuila.

Natural range. West Africa (Guinea, Congo).

Status in Samoa. Introduced.

Habitat. Known from disturbed habitats and low elevation forest.

Adult shell size. Height, 5-7 mm; width, 2 mm.

Identification hints. Strongly ribbed sculpture.

Remarks. Introduced in the 1970s, but whether deliberately or accidentally is unknown. The impacts of this small carnivorous snail on other snail populations is also unknown.

***Gonaxis kibweziensis* Smith, 1894.**

Distribution in Samoa. Tutuila.

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Natural range. East Africa.

Status in Samoa. Introduced.

Habitat. Disturbed habitats at low elevations.

Adult shell size. Height, 18-20 mm; width, 14-16 mm.

Identification hints. Distinguished by its unusual shape, resulting from the slanted axis of coiling.

Remarks. One of the carnivorous species introduced (in 1977) in attempts to control the giant African snail, *Achatina fulica*. There is no good evidence that it has been successful in control, but it may have had an impact on native snail populations.

Family RHYTIDIDAE

Rhytididae (sometimes known as Paryphantidae) are carnivorous snails found in South Africa, the Seychelles, Indonesia, Melanesia, parts of Micronesia and Polynesia, New Zealand and Australia.

Ouagapia gradata Gould, 1846.

Distribution in Samoa. Savai'i, 'Upolu, Tutuila, Ofu, Ta'u.

Natural range. Samoa, Tonga.

Status in Samoa. Indigenous.

Habitat. Mid to high elevation forest, on the ground in damp places, in leaf litter.

Adult shell size. Height, 3 mm; width, 5-6 mm.

Identification hints. Shell thin and rather shiny with a very deep and wide umbilicus, distinct transverse growth lines and, especially on the lower parts of the whorls, spirally sculptured. Color orange-brown, sometimes with poorly defined darker transverse bands. No apertural teeth. Not strongly sculptured like *Sinployea complementaria* (see below—Charopidae).

Remarks. Was common.

Family ENDODONTIDAE

The family Endodontidae is endemic to the Pacific basin. It is the most diverse land snail family in the Pacific. Endodontidae have been severely affected by human activities and much of the once huge diversity has now disappeared. They are mostly ground-dwelling snails and many species have the curious habit of depositing their eggs in the shell umbilicus. Both these characteristics probably make them highly susceptible to habitat degradation and predation by introduced ants (on eggs and juveniles especially). Their relatively low diversity in Western Samoa may be related to the presence of endemic ants, which are not known from American Samoa.

Most endodontids (and charopids) possess flat, strongly ribbed shells, frequently with a number of apertural barriers. More information on endodontids throughout the Pacific can be found in volume 1 of *Endodontoid land snails from Pacific Islands* by Alan Solem (1976; listed in the bibliography towards the end of this manual).

Minidonta manuaensis Solem, 1976. [Solem line drawings]

Distribution in Samoa. Olosega, Ta'u.

Status in Samoa. Endemic.

Habitat. Recorded at low to mid elevations.

Adult shell size. Height, 1 mm; width, 2 mm.

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Identification hints. Minute size. Because of its size, the only species with which it could possibly be confused is *Discocharopa aperta* (see below, family Charopidae, for distinguishing features).

Remarks. Very few specimens have ever been found, none of them alive; but it may yet be living at higher elevations.

***Thaumatodon hystricelloides* Mousson, 1865. [Solem line drawings]**

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

Habitat. Formerly over much of 'Upolu, now restricted to high elevation forest areas.

Adult shell size. Height, 2-3 mm; width, 4 mm.

Identification hints. Readily distinguished by its relatively large size, coarse ribs and large number of prominent apertural barriers.

Remarks. Listed as threatened by IUCN in 1996.

Family CHAROPIDAE

The Charopidae are closely related to the Endodontidae but are not confined to Pacific islands as are the Endodontidae. Outside the Pacific they are found in New Zealand, Australia, South America, South Africa, and St. Helena. They exhibit particular diversity in New Zealand and Australia.

Charopids are to some extent arboreal, in contrast to the exclusively ground-dwelling endodontids, and they generally do not adopt the umbilical egg-laying habit of the endodontids. They may as a result be less susceptible to ground-level habitat degradation and ant predation than are the endodontids, and hence appear to have persisted in relatively fair diversity. Nevertheless, the island by island distributions given here may well be incomplete because there has been insufficient survey work.

The single species of *Discocharopa* is distinguished by its small size. Species of *Graeffedon* possess apertural barriers; those of *Sinployea* do not.

More information on charopids in the Pacific can be found in volume 2 of *Endodontoid land snails from Pacific Islands* by Alan Solem (1983; listed in the bibliography towards the end of this guide).

***Discocharopa aperta* Möllendorff, 1888. [Solem line drawings and SEMs]**

Distribution in Samoa. Aunu'u, Olosega, Ta'u.

Natural range. Southeast Asia, Australia, Philippines, Melanesia, Polynesia.

Status in Samoa. Indigenous.

Habitat. Under stones and leaf litter; recorded only from lower elevations, but may be more widespread.

Adult shell size. Height, less than 1 mm; width, 1-2 mm.

Identification hints. Minute size. Because of its size, the only species with which it could possibly be confused is *Minidonta manuaensis* (see above, family Endodontidae). However, *Minidonta manuaensis* has a much narrower umbilicus, is less flat, and possesses seven prominent apertural barriers, in contrast to the variable and sometimes absent single parietal barrier of *Discocharopa aperta*.

Remarks. The only species in the genus *Discocharopa*.

***Graeffedon graeffei* Mousson, 1869. [Solem line drawings]**

Distribution in Samoa. 'Upolu.

Status in Samoa. Endemic.

SAMOAN SNAILS AND SLUGS

Habitat. Under ground debris in heavy forest; upper elevations.

Adult shell size. Height, 2-3 mm; width, 5-6 mm.

Identification hints. The only species of *Graeffedon* recorded from 'Upolu. Seven apertural barriers; *Graeffedon savaiiensis* has nine. Larger than *Graeffedon savaiiensis*.

Remarks. Very rare.

***Graeffedon savaiiensis* Solem, 1983. [Solem line drawings]**

Distribution in Samoa. Savai'i.

Status in Samoa. Endemic.

Habitat. In leaf litter; the interior of Savai'i.

Adult shell size. Height, 2 mm; width, 3 mm.

Identification hints. The only species of *Graeffedon* recorded from Savai'i. Nine apertural barriers; *Graeffedon graeffei* has seven. Smaller than *Graeffedon graeffei*.

Remarks. Extremely rare; only a single specimen has ever been recorded.

***Sinployea allecta* Cox, 1870. [Solem line drawings]**

Distribution in Samoa. Savai'i, 'Upolu, Ta'u.

Status in Samoa. Endemic.

Habitat. Found in a range of habitats from heavy forest to more open vegetation, and from low to high elevations.

Adult shell size. Height, 2 mm; width, 3-4 mm.

Identification hints. Most similar to *Sinployea aunuuana*, but differs from that species by its much narrower umbilicus. Fine radial sculpture.

Remarks. Known from Ta'u as the subspecies *Sinployea allecta tauensis*.

***Sinployea aunuuana* Solem, 1983. [Solem line drawings]**

Distribution in Samoa. Aunu'u, possibly Ta'u.

Status in Samoa. Endemic.

Habitat. Low elevation.

Adult shell size. Height, 1-2 mm; width, 3 mm.

Identification hints. Very similar to *Sinployea allecta*, which differs, however, in its much narrower umbilicus. Fine radial sculpture.

***Sinployea clausa* Solem, 1983. [Solem line drawings]**

Distribution in Samoa. Ta'u.

Status in Samoa. Endemic.

Habitat. Low to mid elevations.

Adult shell size. Height, 1-2 mm; width, 2-3 mm.

Identification hints. Much narrower umbilicus than either *Sinployea allecta* or *S. aunuuana*. Fine radial sculpture.

Remarks. It has never been collected alive.

***Sinployea clista* Solem, 1983. [Solem line drawings]**

Distribution in Samoa. 'Upolu, Tutuila.

Status in Samoa. Endemic.

Habitat. Under stones and dead leaves at middle elevations.

Adult shell size. Height, 1-2 mm; width, 2-3 mm.

Identification hints. Very narrow or almost closed umbilicus. Coarser radial sculpture than *Sinployea allecta*, *S. aunuuana* or *S. clausa*.

Remarks. This species is only sparsely distributed, and very difficult to find.

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***Sinployea complementaria* Mousson, 1865 [Solem line drawings]**

Distribution in Samoa. 'Upolu

Status in Samoa. Endemic

Habitat. Usually in heavy forest, under dead leaves and rotting wood; occasionally on vegetation. In both disturbed and undisturbed areas at mid and upper elevations.

Adult shell size. Height, 2-4 mm; width, 4-6 mm.

Identification hints. Larger than other species of *Sinployea*. Fairly wide umbilicus. Coarse radial sculpture.

Family SUCCINEIDAE

Succineidae are found worldwide and constitute a major part of the land snail fauna of the Pacific. In many regions they are associated strongly with very wet places such as marshes and the edges of streams and ponds. On Pacific islands, however, some species have evolved to tolerate drier conditions. The Samoan species are generally arboreal in habit.

***Succinea crocata* Gould, 1846 [Robinson photo]**

Distribution in Samoa. 'Upolu, Tutuila, possibly Savai'i

Status in Samoa. Endemic

Habitat.

Adult shell size. Height, 16-19 mm; width, 13 mm.

Identification hints. Large; chestnut-brown to orangish-brown.

***Succinea manuana* Gould, 1846**

Distribution in Samoa. Ta'u

Status in Samoa. Endemic

Habitat. Forest, but also found in partially disturbed habitats.

Adult shell size. Height, 8-9 mm; width, 5-6 mm. Occasionally larger.

Identification hints. Small. Color greenish to pale, slightly greenish yellow.

Remarks. Still considered fairly common in 1975. May be a synonym of *Succinea modesta*.

***Succinea modesta* Gould, 1846. Not figured.**

Distribution in Samoa. 'Upolu, Tutuila

Natural range. Samoa, Tonga

Status in Samoa. Indigenous

Habitat. Tolerates moderate degrees of habitat disturbance, and may still be found on the edges of forest and plantations.

Adult shell size. Height, 8-9 mm; width 5-6 mm.

Identification hints. Very similar to *Succinea manuana*; similar size, shape and color.

Remarks. Still considered common in 1975. May be a synonym of *Succinea manuana*.

***Succinea putamen* Gould, 1846**

Distribution in Samoa. 'Upolu

Status in Samoa. Endemic

Habitat.

Adult shell size. Height, 11-12 mm; width, 9-10 mm; or perhaps larger.

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Identification hints. Distinguished by its tiny spire and very large, expanded, flat body whorl. Shell color generally pale yellowish.

Family HELICARIONIDAE

This large family constitutes one of the major elements of indigenous land snail diversity in the Pacific.

The monograph by H. Burrington Baker (1938; listed in the bibliography towards the end of this manual) should be consulted for more information on the Samoan species of Helicarionidae.

***Coneuplecta microconus* Mousson, 1865 (Baker line drawing)**

Distribution in Samoa. Tutuila

Natural range. Samoa, Fiji, Tonga, Futuna

Status in Samoa. Indigenous

Habitat. Usually under dead leaves and logs in forest.

Adult shell size. Height, 2 mm; width, 3 mm.

Identification hints. Very small, but distinctly conical in shape, with a strongly developed peripheral keel.

***Diastole matafaoi* Baker, 1938**

Distribution in Samoa. Tutuila

Status in Samoa. Endemic

Habitat. On leaves of pandanus and shrubs, at upper elevations.

Adult shell size. Height, 6 mm; width, 8 mm.

Identification hints. Adult whorls more rounded than in *Diastole schmeltziana* and *D. savaii*.

Remarks. Listed as a candidate for endangered/threatened status by the U.S. Fish and Wildlife Service in 1994. Considered extinct by IUCN in 1996.

***Diastole lamellaxis* Baker, 1938**

Distribution in Samoa. Savai'i

Status in Samoa. Endemic

Habitat. On ferns and shrubs at mid and upper elevations.

Adult shell size. Height, 8 mm; width 7 mm.

Identification hints. Shell higher than wide, in contrast to the other species of *Diastole*.

***Diastole savaii* Baker, 1938**

Distribution in Samoa. Savai'i

Status in Samoa. Endemic

Habitat. On ferns and shrubs and tree trunks at mid and upper elevations

Adult shell size. Height, 6 mm; width, 11 mm.

Identification hints. Very similar to *Diastole schmeltziana*, although full-grown shells are larger, more strongly keeled, and rather flatter than in that species.

Remarks. In fact may not be distinct from *D. schmeltziana*.

***Diastole schmeltziana* Mousson, 1865**

Distribution in Samoa. Recorded from Savai'i, 'Upolu, Tutuila, Ofu, Ta'u, but probably on all islands

Natural range. Samoa, possibly Futuna

SAMOAN SNAILS AND SLUGS

Status in Samoa. Probably endemic

Habitat. On ferns, shrubs and trees in forest at mid and upper elevations.

Adult shell size. Height, 4-6 mm; width, 7-9 mm.

Identification hints. Very variable, especially in the ratio of shell height to width. Generally smaller, less strongly keeled, and not as flat as *Diastole savaii*.

Remarks. Known from Savai'i and Ta'u only as the "variety" *usurpata*, which is taller, and which may or may not deserve separation as a distinct species. Listed as a candidate for endangered/threatened status by the U.S. Fish and Wildlife Service in 1994.

***Lamprocystis perpolita* Mousson, 1869**

Distribution in Samoa. Savai'i, 'Upolu

Status in Samoa. Endemic

Habitat. On ferns and shrubs at mid and upper elevations.

Adult shell size. Height, 4-5 mm; width, 7-8 mm.

Identification hints. Largest of the species of *Lamprocystis*, with rapidly expanding whorls.

***Lamprocystis ensifera* Mousson, 1869**

Distribution in Samoa. Unknown

Natural range. Samoa, Fiji, Tonga, Wallis and Futuna

Status in Samoa. Indigenous

Habitat. Under logs and on dead leaves, and on ferns and tree trunks, at low and mid elevations.

Adult shell size. Height, 2-3 mm; width, 3-4 mm.

Identification hints. Smallest of the species of *Lamprocystis*; spire more pronounced.

***Lamprocystis upolensis* Mousson, 1865**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. Samoa, Fiji

Status in Samoa. Indigenous

Habitat. Unknown

Adult shell size. Height, 3-5 mm; width, 5-7 mm.

Identification hints. Intermediate in size between *Lamprocystis perpolita* and *L. ensifera*.

***Liardetia samoensis* Mousson, 1865**

Distribution in Samoa. 'Upolu, Tutuila, Ofu

Natural range. Widespread in the Pacific

Status in Samoa. Indigenous

Habitat. Under logs, dead wood, and stones, from low to upper elevations.

Adult shell size. Height, 1-2 mm; width, 2-3 mm.

Identification hints. Very small. Shell almost as high as it is wide; variable.

Remarks. Also recorded outside the Pacific. Much of its current distribution probably the result of artificial introductions.

***Liardetia tutuillae* Cox, 1870. Not figured.**

Remarks. Probably a synonym of *Liardetia samoensis*.

Family ARIOPHANTIDAE

Ariophantidae are found naturally in southern Asia. Many species are semi-slugs.

***Parmarion martensi* Simroth, 1893 [Robinson photo]**

Distribution in Samoa. Tutuila

Natural range. Possibly Southeast Asia

Status in Samoa. Introduced

Habitat. Damp places at low elevations, but may be expanding its distribution.

Adult size. Length of extended body up to about 3 cm.

Identification hints. A semi-slug, that is, it possesses a shell that is clearly visible but largely covered by the soft body, and it cannot withdraw its body within the shell. The shell is much smaller than the body and simply sits atop the body. The only real semi-slug in Samoa. Some Samoan Succineidae cannot withdraw their body fully inside their shell, but the body does not cover the shell as in *Parmarion martensi*.

Remarks. The correct scientific name for this species is not certain. It seems to have been widely introduced in Southeast Asia and the Pacific, so its natural range is difficult to determine.

Family ZONITIDAE

The Zonitidae are one of the major groups of land snails on Pacific islands. The monograph of H. Burrington Baker (1941; listed in the bibliography towards the end of this guide) should be consulted for more information on the Samoan species, which are all in the genus *Trochomorpha*.

***Trochomorpha luteocornea* Reeve, 1854. Not figured.**

Remarks. Probably a synonym of *Trochomorpha troilus*.

***Trochomorpha samoa* Hombron & Jacquinot, 1841. Not figured.**

Distribution in Samoa. 'Upolu

Status in Samoa. Endemic

Habitat. Not known

Adult shell size. Height, 14-15 mm; width, 20 mm.

Identification hints. Shell higher relative to its width than all other Samoan species of *Trochomorpha* except *Trochomorpha tuber*, but *T. tuber* is smaller.

Remarks. Not known from recent collections. May not be a distinct species.

***Trochomorpha troilus* Gould, 1846**

Distribution in Samoa. 'Upolu

Status in Samoa. Endemic

Habitat. On ferns, shrubs and tree trunks in upper elevation rain forest.

Adult shell size. Height, 8-12 mm; width, 16-20 mm.

Identification hints. Much less strongly keeled and less conical than *Trochomorpha apia*.

***Trochomorpha tuber* Mousson, 1869. Not figured.**

Distribution in Samoa. 'Upolu

Status in Samoa. Endemic

Habitat. Not known

Adult shell size. Height, 9-10 mm; width, 12-13 mm.

Identification hints. Shell higher relative to its width than all other Samoan species of *Trochomorpha* except *Trochomorpha samoa*; but *T. samoa* is larger.

Remarks. Not known from recent collections. May not be a distinct species.

Trochomorpha apia Hombron & Jacquinot, 1853

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Status in Samoa. Endemic

Habitat. On ferns, shrubs and tree trunks at low and mid elevations.

Adult shell size. Height, 8-10 mm; width, 16-20 mm.

Identification hints. Much more sharply keeled and more conical than *Trochomorpha troilus*.

Remarks. Listed as a candidate for endangered/threatened status by the U.S. Fish and Wildlife Service in 1994. Listed as threatened by IUCN in 1996.

Family BRADYBAENIDAE

The Bradybaenidae are predominantly Asian, with their greatest diversity in eastern Asia. They are mainly found in tropical and warm temperate regions.

Bradybaena similaris Rang, 1831 [Robinson photo]

Distribution in Samoa. Recorded from 'Upolu, Tutuila, Ofu, ?'Aunu'u, ?Ta'u, but possibly on all main islands.

Natural range. Southern China, Southeast Asia, Indonesia.

Status in Samoa. Introduced.

Habitat. Often associated with human disturbance, although also found in undisturbed habitats.

Adult shell size. Height, 8-11 mm; width 11-15 mm.

Identification hints. A rather flat, rounded shell, generally pale brownish in color and often with a darker band around the periphery. Color varies from paler to darker yellowish-brown and the band may be absent.

Remarks. This species is now widespread in tropical and subtropical regions, including many Pacific islands, as a result of dispersal by humans.

FRESH- AND BRACKISH-WATER SPECIES

Family NERITIDAE

Neritidae are operculate snails found in marine, brackish, and freshwater habitats. Many of the species are widespread in the Pacific, no doubt in large part as a result of their diadromous life-cycle, which involves an oceanic larval stage. Entirely marine species are not included in this field guide, although drawing the line between marine and brackish-water or intertidal forms is somewhat arbitrary. With the Thiaridae (see below), the Neritidae make up the great majority of nonmarine aquatic snails in Samoa.

Neritilia rubida Pease, 1865

Distribution in Samoa. 'Upolu, Tutuila

Natural range. Widespread in the Indo-Pacific.

Status in Samoa. Indigenous

Habitat. Lower courses of streams in medium to strong currents; may also occur higher.

Adult shell size. Maximum shell dimension up to 6 mm.

Identification hints. Small. Yellow to brown but usually covered with a black encrustation. Columella gray-white and the edge straight, not corrugated.

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Clithon castanea Hombron & Jacquinot, 1853

Distribution in Samoa. 'Upolu, Tutuila

Natural range. Samoa, Caroline Islands (Micronesia)

Status in Samoa. Indigenous

Habitat. Upper and middle reaches of streams, in relatively fast-flowing water.

Adult shell size. Maximum dimension about 20 mm.

Identification hints. Shell with fine transverse sculpture; dark brown with fine black markings; spire usually eroded. Columella gray-white with some reddish-yellow; edge corrugated.

Clithon chlorostoma Broderip, 1833. Not figured

Distribution in Samoa. 'Upolu

Natural range. Widespread in the Pacific.

Status in Samoa. Indigenous

Habitat. Probably in the lower courses and brackish mouths of streams.

Adult shell size. Maximum dimension about 14 mm.

Remarks. Not well known in Samoa

Clithon corona Linnaeus, 1758

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. Widespread in the Indo-Pacific

Status in Samoa. Indigenous

Habitat. Lower courses and brackish mouths of streams; possibly also higher.

Adult shell size. Maximum dimension up to about 26 mm.

Identification hints. Very variable. Spines short (broken or eroded) or absent. Shell dark yellow, greenish, violet, or cream-fawn, with a pattern of pointed flecks. Inside aperture orange. Columella orange or yellow, to bluish-white at the bottom edge; corrugated.

Clithon diadema Récluz, 1841

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. Widespread in the Pacific and eastern Indian Oceans.

Status in Samoa. Indigenous

Habitat. On and around stones near mouths of streams.

Adult shell size. Maximum dimension up to 20 mm (excluding spines) but generally smaller.

Identification hints. Shell with spines, although the spines may mostly be broken in older specimens. Shell smooth, often with colored flecks and lines. Columella and aperture white-gray, sometimes with hints of yellow.

Clithon olivaceus Récluz, 1843

Distribution in Samoa. Tutuila

Natural range. Samoa, Fiji, Melanesia, Southeast Asia

Status in Samoa. Indigenous

Habitat. On stones in relatively fast-flowing parts of the lower reaches of streams.

Adult shell size. Maximum dimension up to about 27 mm.

Identification hints. Lacks spines. Shell smooth with only very fine transverse sculpture (growth lines); color greenish to olive-brown, with black transverse lines. Apex often eroded. Aperture green-yellow; columellar area cream to yellow with some red-brown; columella edge slightly corrugated.

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***Clithon oualaniensis* Lesson, 1831**

Distribution in Samoa. Tutuila

Natural range. Asia, Pacific islands

Status in Samoa. Indigenous

Habitat. Brackish water at stream mouths.

Adult shell size. Maximum dimension less than 10 mm.

Identification hints. Small. Lacks spines. Shell shiny with highly variable patterns on a yellowish background. Mouth white. Columella area white; yellow-orange on the upper edge. Shell round and bead-like.

***Neritina auriculata* Lamarck, 1816**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. Widespread in the Indo-Pacific

Status in Samoa. Indigenous

Habitat. Lower courses of streams close to the brackish zone, on and under stones in parts with moderate current. May occur sporadically at higher elevations.

Adult shell size. Maximum dimension up to about 25 mm.

Identification hints. Almost limpet-like in form, often with projecting "wings", but rather variable in shape. Shell color olive-green to dark brown. The expansive columellar area whitish-gray, yellowish or yellowish-brown.

***Neritina canalis* Sowerby, 1825**

Distribution in Samoa. 'Upolu

Natural range. Widespread in the South Pacific, from Tahiti to New Guinea and the Bismarck Islands

Status in Samoa. Indigenous

Habitat. On stones in the lower reaches of fast-flowing streams.

Adult shell size. Maximum dimension up to 20 mm.

Identification hints. Body whorl virtually completely covers over the shell spire. Often eroded. Aperture whitish with some orange-yellow. Columellar area yellowish-white, becoming yellow to pale orange at the upper edge, where there is a distinct channel. Inner edge of columella very finely corrugated.

***Neritina petitii* Récluz, 1841**

Distribution in Samoa. 'Upolu, Tutuila

Natural range. Widely distributed in Southeast Asia, Melanesia, Fiji, Samoa, and the Caroline Islands (Micronesia).

Status in Samoa. Indigenous

Habitat. On stones in fast-flowing water in the lower courses of streams.

Adult shell size. Maximum dimension up to 45 mm.

Identification hints. Large. Body whorl virtually encloses spire. Shell black-brown with clear growth lines. Mouth red. Columellar area pale to bright red or purple. Inner edge of columella finely corrugated.

***Neritina porcata* Gould, 1847**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. South-west Pacific (Admiralty Islands, Solomon Islands, Vanuatu, Fiji, Samoa)

Status in Samoa. Indigenous

Habitat. On rocks in the middle and upper reaches of fast-flowing streams.

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Adult shell size. Maximum dimension up to 23 mm.

Identification hints. Body whorl virtually encloses spire. Shell olive-brown with dark network pattern. Inside of mouth pale bluish with some orange. Columellar area yellow-orange to reddish at its upper end. Columellar with 12-16 fine corrugations.

***Neritina pulligera* Linnaeus, 1767**

Distribution in Samoa. Tutuila

Natural range. Widely distributed throughout the Indo-Pacific

Status in Samoa. Indigenous

Habitat. Generally in faster flowing parts of streams at low and middle elevations.

Adult shell size. Maximum dimension up to 45 mm.

Identification hints. Large. Body whorl virtually encloses spire. Shell very variable, dark greenish-brown, with a network of darker patterning (at least on young individuals). Mouth edge yellow to orange but may also be dark bluish-black. Columellar area blue-black, perhaps with some orange; columella with 17-20 fine corrugations.

***Neritina squamaepicta* Récluz, 1843. Not figured.**

Distribution in Samoa. Unknown

Natural range. South-east Asia, Pacific islands.

Remarks. Only recorded from Samoa as the "variety" *iris* Mousson, 1849, which may be a synonym of *Neritina pulligera*.

***Neritina macgillivrayi* Reeve, 1855**

Distribution in Samoa. 'Upolu, Tutuila

Natural range. Widespread in the south-west Pacific from the Bismarck Archipelago to Fiji and Samoa.

Status in Samoa. Indigenous

Habitat. In fast-flowing streams at elevations up to 800 m.

Adult shell size. Maximum dimension up to 20 mm.

Identification hints. Shell brown-black with clear growth lines. Inside of aperture yellow. Columellar area large and whitish to orange-yellow, without corrugations.

***Neritina turrita* Gmelin, 1791**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. Widespread in the Indo-Pacific

Status in Samoa. Indigenous

Habitat. On stones or mud in brackish water, usually in mangroves.

Adult shell size. Height, 16-21 mm; width, 12-19 mm.

Identification hints. Shell variable but thick and distinctly high-spined; the spire usually somewhat eroded. Color dark with olive or yellowish often zig-zag lines, which may be broad or narrow. Inside mouth bluish-white or yellowish. Columellar area whitish-gray, yellow at the edge, with 5-7 strong corrugations (teeth).

***Neritina turtoni* Récluz, 1843**

Distribution in Samoa. 'Upolu, Tutuila

Natural range. Recorded from the Bismarck Archipelago, Solomon Islands, and Fiji, as well as Samoa

Status in Samoa. Indigenous

Habitat. Brackish to fresh water near the mouths of slow-flowing streams.

Adult shell size. Height, 16-27 mm; width, 13-23 mm.

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Identification hints. Shell thinner and more shiny than *Neritina turrata*. Shell color variable; dark brown to black, often with yellow or red zig-zag transverse bands. Aperture bluish inside; columellar region orange to red, with numerous teeth or corrugations.

***Neritina variegata* Lesson, 1831**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. Widespread in the Indo-Pacific from the Andaman Islands to Tahiti

Status in Samoa. Indigenous

Habitat. On stones in the lower reaches of fast-flowing streams.

Adult shell size. Maximum dimension up to 28 mm.

Identification hints. Shell very variable; pale to dark brown with black, mostly broad zig-zag or net-like patterning. Apex often eroded. Shell quite smooth with fine growth lines. Inside of aperture white; columellar area white with a small red, orange or brown region at its upper end. Columella edge with 6-10 teeth or corrugations.

***Puperita amoena* Gould, 1847**

Distribution in Samoa. 'Upolu, Tutuila

Natural range. Samoa, Fiji, and perhaps more widely

Status in Samoa. Indigenous

Habitat. In fast-flowing water in the brackish zone near stream mouths.

Adult shell size. Maximum dimension up to 10 mm.

Identification hints. Small. Color gray to grayish-violet, with rows of black and white flecks. Inside aperture bluish to yellowish at the edge. Columellar area grayish and finely granulate, the edge with 7-10 corrugations.

***Septaria freycineti* Récluz, 1842**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. Western Pacific and eastern Asia, specifically recorded from Sulawesi, Vanuatu, and Fiji, as well as Samoa

Status in Samoa. Indigenous

Habitat. Fast-flowing streams.

Adult shell size. Maximum dimension up to about 30 mm (males and females similar).

Identification hints. Species of *Septaria* are extremely difficult to distinguish. Shell yellow-brown with a bold pattern of lines, triangles or network. Apex relatively pointed. Septum orange, and in males with a characteristic convex expansion.

Remarks. Senior synonym of the more frequently used name *Septaria suffreni*.

***Septaria laperousi* Récluz, 1842. Not figured.**

Distribution in Samoa. 'Upolu

Natural range. Western Pacific, specifically recorded from Guam and Fiji, as well as Samoa.

Remarks. Probably a synonym of either *S. macrocephala* or *S. freycineti*.

***Septaria macrocephala* Récluz, 1842**

Distribution in Samoa. ?'Upolu, Tutuila

Natural range. South Pacific, specifically recorded from Fiji, Vanuatu, and Tahiti, as well as Samoa.

Status in Samoa. Indigenous

Habitat. On rocks in fast-flowing streams, often in direct sunlight.

Adult shell size. Maximum dimension up to about 15 mm (males) or 26 mm (females).

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Identification hints. Species of *Septaria* are extremely difficult to distinguish. Often confused with *Septaria sanguisuga*. Shallow convex shell, yellow-brown with wavy black lines. Apex usually eroded away. Septum tinged gold-brown, often with black at the corners. Septum the widest part of the shell.

Remarks. Apparently males change to females when they reach about 12-15 mm.

***Septaria porcellana* Linnaeus, 1758**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila

Natural range. Eastern Indian Ocean (Sri Lanka, Andaman Islands, etc.), through Malaysia and Indonesia to Melanesia, Micronesia, and western and southern Polynesia (specifically recorded from Samoa and Tahiti).

Status in Samoa. Indigenous

Habitat. Lower and middle courses of streams in medium and strong currents.

Adult shell size. Maximum dimension up to about 18 mm (males), 30 mm (females).

Identification hints. Species of *Septaria* are extremely difficult to distinguish. *S. porcellana* is especially variable in shell shape and color, usually yellow-brown or yellow-green with or without a variable network of dark lines or flecks. Apex not as protruding as *S. macrocephala* or *S. sanguisuga*.

Remarks. Males only reach about 18 mm in size. It is not known whether they only grow to this size or whether they continue to grow but change into females.

***Septaria sanguisuga* Reeve, 1856**

Distribution in Samoa. Savai'i, 'Upolu, ?Tutuila

Natural range. West Pacific, specifically recorded from Fiji, Solomon Islands, Pohnpei, and New Caledonia, as well as Samoa.

Status in Samoa. Indigenous

Habitat. On rocks in fast-flowing streams, usually in shade.

Adult shell size. Maximum dimension up to about 31 mm (males and females similar).

Identification hints. Species of *Septaria* are extremely difficult to distinguish. Often confused with *Septaria macrocephala*. Deeply convex shell, brown, sometimes with wavy black lines that follow the prominent growth ridges. Apex usually eroded to produce a flat end. Septum orange. Shell widens below the septum.

Family THIARIDAE

Thiaridae (sometimes called Melaniidae) are operculate snails, worldwide in distribution, but with greatest diversity in the tropics. They are predominantly found in fresh waters of streams, rivers, ponds, lakes, and irrigation systems, but some species can inhabit brackish water. With the Neritidae (see above), the Thiaridae make up the great majority of nonmarine aquatic snails in Samoa.

A number of thiarids have been introduced widely through human activities. For instance, *Melanoides tuberculata*, considered Asian in origin by some authors but of Middle Eastern and East African origin by others, is now so widespread that its origins may well never be truly understood.

Thiarid taxonomy is confused and, perhaps because of their predominantly clonal mode of reproduction that can lead to much variation in shell shape and sculpture among populations, many local species, subspecies and forms of rather doubtful validity have been described. The endemic, native, or introduced status of most of the species in Samoa is not clear. However, whether native or artificially introduced, most, if not all, of

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the Samoan thiarids probably belong to a small number of morphologically variable and widely occurring species.

The entry for "*Status in Samoa*" has therefore been omitted, and the entry for "*Natural range*" replaced by "*Known distribution*". Details and illustrations are given only for the well recognized species. Other species recorded from Samoa are simply listed.

In many thiarids the upper whorls of the shell are lost as the animal grows, a process known as decollation. Thus, shell height is extremely variable, depending on how much of the upper part of the shell has been lost. Figures given here for shell size are only rough guides.

***Melanoides laxa* Mousson, 1869**

Distribution in Samoa. 'Upolu

Known distribution. Samoa, Niue

Habitat. Mountain springs in forest around 200-300 m above sea level. Found in the sandy and muddy stream edges among plant debris.

Adult shell size. Height variable, depending on decollation of the apex, up to 16 mm; width, 6 mm.

Identification hints. Small. Apex almost always strongly decollate. Whorls more rounded than in other thiarids, except *Melanoides peregrina*. Less squat than *M. peregrina*, usually with more whorls. Shell smooth, olive-colored, often with transverse reddish lines.

***Melanoides peregrina* Mousson, 1869**

Distribution in Samoa. 'Upolu

Known distribution. Samoa

Habitat. Springs and upper reaches of mountain streams, in forest, up to over 300 m elevation. Found at the stream edges, often in pools between waterfalls, on muddy sandy bottoms with plant debris and overhanging vegetation.

Adult shell size. Height variable, depending on decollation of the apex, up to 16 mm; width, up to 9 mm.

Identification hints. Small. Apex almost always strongly decollate. Whorls more rounded than in other thiarids, except *Melanoides laxa*. Squatter than *M. laxa*, and usually with fewer whorls. Shell smooth, brownish-olive.

***Melanoides tuberculata* Müller, 1774**

Distribution in Samoa. Savai'i, 'Upolu, Tutuila, ?'Aunu'u, ?Ta'u

Known distribution. Widespread in many parts of the world

Habitat. Found from mountain springs at 300-500 m elevation to the lower brackish stream mouths, on sandy and muddy bottoms with rich plant debris at the edges of the streams or in pools between waterfalls.

Adult shell size. Height variable, depending on decollation of the apex, up to 30 mm (or perhaps larger); width, up to 11 mm.

Identification hints. Shell relatively thick with the surface often strongly sculptured with spiral grooves and transverse ridges, although in some populations the shells may be almost smooth. More conical than *Melanoides aspirans* or *M. lutosa*. Aperture not as elongate as in the other large species of *Melanoides*.

Remarks. The commonest and most widespread thiarid in Samoa.

***Melanoides aspirans* Hinds, 1844**

Distribution in Samoa. Savai'i, 'Upolu

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Known distribution. Widespread in the southwest Pacific

Habitat. Not well documented in Samoa. Known from streams in muddy sand and on rocks in pools. May occur from the upper limits of the brackish zone to about 100 m elevation.

Adult shell size. Height variable, depending on decollation of the apex, up to 55 mm (or perhaps as tall as 74 mm); width, up to 16 mm.

Identification hints. Large. Almost always decollate, leaving only 3-5 whorls and a somewhat columnar appearance. Shell olive-brown, smooth and unpatterned, but almost always covered with a thin black encrustation. Difficult to distinguish from *Melanoides lutosa*, but that species is smaller, rather more conical and somewhat sculptured.

Remarks. Probably not common.

***Melanoides brenchleyi* Baird, 1873. Not figured**

Distribution in Samoa. 'Upolu, Tutuila

Known distribution. Samoa, Tonga

***Melanoides funiculus* Quoy & Gaimard, 1834. Not figured**

Distribution in Samoa. 'Upolu

Known distribution. Samoa, Moluccas

***Melanoides luctuosa* Hinds, 1844. Not figured**

Distribution in Samoa. 'Upolu

Known distribution. Samoa, Fiji

***Melanoides lutosa* Gould, 1847**

Distribution in Samoa. 'Upolu, Tutuila, Ofu

Known distribution. Samoa, Fiji

Habitat. Known from the sandy, muddy edges of the lower reaches of streams, perhaps tolerant of strong currents.

Adult shell size. Height variable, depending on decollation of the apex, up to at least 35 mm; width, up to at least 12 mm.

Identification hints. Shell brown, but often with black encrustation. Difficult to distinguish from *Melanoides aspirans*, but smaller and somewhat more conical and sculptured. Shell less strongly sculptured than *Melanoides tuberculata*, and the aperture, which is white inside, is more elongate than in *M. tuberculata*.

***Melanoides persulcata* Mousson, 1869. Not figured**

Distribution in Samoa. 'Upolu

Known distribution. Samoa, Fiji

***Melanoides plicaria* Born, 1780**

Distribution in Samoa. 'Upolu

Known distribution. Widespread in the Indo-Pacific

Habitat. Muddy or sandy inlets along the banks of the lower reaches of streams, sometimes possibly in brackish water. Mostly found on detritus-rich smooth bottoms.

Adult shell size. Height variable, depending on decollation of the apex, up to at least 47 mm (maybe as large as 90 mm); width, up to at least 12 mm.

Identification hints. Very tall and thin, with many, straight-sided whorls. Usually olive-brown with many red-brown transverse markings. Usually does not lose as many apical whorls as *Melanoides aspirans* and *M. lutosa*. Much narrower than *M. tuberculata*.

***Thiara amarula* Linnaeus, 1758**

Distribution in Samoa. Unknown

Known distribution. Throughout coastal regions of the Indo-Pacific, from south-east Africa, Madagascar and southern India, through Indonesia and Malaysia, to New Guinea, Australia, Melanesia, Fiji and Samoa.

Habitat. The lower parts of streams, on or between stones, and in sand or gravel.

Adult shell size. Height variable, depending on decollation of the apex, up to at least 45 mm; width, up to at least 25 mm.

Identification hints. A large black species with distinct spines around the periphery of the shell. Often decollate to such an extent that as few as only two whorls remain.

***Thiara macrospira* Morelet, 1857. Not figured**

Distribution in Samoa. Unknown

Known distribution. Samoa, New Caledonia

***Thiara scitula* Gould, 1847. Not figured**

Distribution in Samoa. 'Upolu

Known distribution. Samoa, Fiji

***Thiara terpsichore* Gould, 1847.**

Distribution in Samoa. Unknown

Known distribution. Samoa, Fiji

Habitat. Poorly known in Samoa. Recorded among stones along the edges of the middle reaches of streams.

Adult shell size. Height variable, depending on decollation of the apex, up to at least 28 mm; width, up to at least 12 mm.

Identification hints. Smaller than *Thiara amarula*, and with much less pronounced spines. Usually with more whorls remaining after decollation. Transverse ridges and variable red-brown transverse stripes.

Family PHYSIDAE

Physidae in the Pacific are poorly known. There may be more than one species, probably all introduced. They are common domestic aquarium snails. They are pulmonates.

***Physa* sp.**

Distribution in Samoa. Tutuila

Natural range. Unknown

Status in Samoa. Introduced

Habitat. Generally found in still waters, especially taro patches.

Adult shell size. Variable. Height 6-8 mm; width, 3-4 mm.

Identification hints. The shell is sinistral (coils to the left).

Remarks. A single species of *Physa* has been recorded from Samoa but has not been identified to species.

Family PLANORBIDAE

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Planorbidae in the Pacific are poorly known. Only a single species is listed here. It has a tall, pointed shell. However, new survey work may well find other species of planorbids. They are popular aquarium snails and have been widely distributed for this purpose. Many of them have flat coiled "ramshorn" shells. They are pulmonates.

***Physastra nasuta* Morelet, 1857**

Distribution in Samoa. Tutuila

Natural range. Southwest Pacific (New Caledonia, Vanuatu, Tonga, Fiji, Cook Islands).

Status in Samoa. Unknown: native or possibly introduced

Habitat. Near banks and in pools in streams, ponds, ditches.

Adult shell size. Height, up to 20 mm; width, up to 10 mm; but very variable in size and shape.

Identification hints. Sinistral. Apex of older specimens sometimes eroded.

Remarks. The genus *Physastra* is found in Australasia, eastern Asia, and the southwest Pacific, but these snails have not been well-studied and species identities are uncertain.

***Planorbis* sp. Not figured.**

Distribution in Samoa. 'Upolu

Natural range. Unknown

Status in Samoa. Introduced

Habitat. Generally found in relatively still waters, ponds, taro patches.

Adult shell size. Width may be up to about 30 mm.

Identification hints. The shell is a flat coil of the "ramshorn" type.

Remarks. A single record in the literature reports unidentified species of "*Planorbis*", although this genus name may be incorrect.

Family ANCYLIDAE

Pacific Ancyliidae (freshwater pulmonate limpets) are poorly known. There are very few species and they are very small and difficult to distinguish. Only one is recorded from Samoa and its correct identification is unsure.

***Ferrissia noumeensis* Crosse, 1871 [Hubendick line drawing]**

Distribution in Samoa. Tutuila

Natural range. Unknown, possibly Melanesia

Status in Samoa. Possibly introduced

Habitat. The middle and lower reaches of mountain streams, in slower-moving water along the banks, attached to submerged plants and stones.

Adult shell size. Length, 2-5 mm; width, 1-3 mm; height, 1 mm

Identification hints. A tiny freshwater limpet, with a thin, pale yellowish or brownish shell.

Remarks. Only tentatively identified as *Ferrissia noumeensis*. May occur in large numbers: 100-200 per square meter.

LITERATURE

A comprehensive bibliography is available in the *Catalog of the nonmarine snails and slugs of the Samoan Islands* (Cowie, 1998; listed below). It is impossible to cite here all the works from which information for this field guide has been obtained; the following list provides some of the more important ones. Some of them are books, obtainable in libraries, bookshops or direct from the publisher (the publisher and city of publication are given). Others are journal articles in the technical scientific literature, which can generally be found in the libraries of most major universities and natural history museums. Almost nothing has been published previously on the snails of Samoa in the popular or semi-popular literature. Some more general texts on both snails and Samoa are also listed.

Abbott, R.T. 1989. *Compendium of Landshells. A Color Guide to more than 2,000 of the World's Terrestrial Shells*. American Malacologists, Inc., Melbourne, Florida.

Amerson, A.B., Jr., W.A. Whistler & T.D. Schwaner. 1982. *Wildlife and Wildlife Habitat of American Samoa*. 2 vols. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Baker, H.B. 1938. Zonitid snails from Pacific islands—part 1. 1. Southern genera of Microcystinae. Bernice P. Bishop Museum Bulletin 158: 1–102, pls. 1–20.

Baker, H.B. 1940. Zonitid snails from Pacific islands—part 2. 2. Hawaiian genera of Microcystinae. Bernice P. Bishop Museum Bulletin 165: 105–201, pls. 21–42.

Baker, H.B. 1941. Zonitid snails from Pacific islands—parts 3 and 4. 3. Genera other than Microcystinae. 4. Distribution and indexes. Bernice P. Bishop Museum Bulletin 166: 205–370, pls. 43–65.

Civeyrel, L. & D. Simberloff. 1996. A tale of two snails: is the cure worse than the disease? *Biodiversity and Conservation* 5: 1231–1252.

Cooke, C.M., Jr. & H.E. Crampton. 1930. New species of *Partula*. Bernice P. Bishop Museum Occasional Papers 9(11): 1–9.

Cooke, C.M., Jr. & Y. Kondo. 1960. Revision of Tornatellinidae and Achatinellidae (Gastropoda, Pulmonata). Bernice P. Bishop Museum Bulletin 221: 1–303.

Cowie, R.H. 1992. Evolution and extinction of Partulidae, endemic Pacific island land snails. *Philosophical Transactions of the Royal Society of London (B)* 335: 167–91.

Cowie, R.H. 1993. Why tree snails are becoming scarce in Samoa. *Hawaiian Shell News* 41(3): 1, 9.

Cowie, R.H. 1996. Pacific island land snails: relationships, origins and determinants of diversity, p. 347–372. In: A. Keast & Scott E. Miller (editors), *The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes*. SPB Academic Publishing, Amsterdam, The Netherlands.

SAMOAN SNAILS AND SLUGS

- Cowie, R.H. 1997. Catalog and bibliography of the nonindigenous nonmarine snails and slugs of the Hawaiian Islands. Bishop Museum Occasional Papers 50, 66 p.
- Cowie, R.H. 1998. Catalog of the nonmarine snails and slugs of the Samoan Islands. Bishop Museum Bulletin in Zoology 3, viii + 122 p.
- Cowie, R.H., N.L. Evenhuis and C.C. Christensen. 1995. *Catalog of the Native Land and Freshwater Molluscs of the Hawaiian Islands*. Backhuys Publishers, Leiden, The Netherlands.
- Eldredge, L.G. 1988. Case studies of the impacts of introduced animal species on renewable resources in the U.S.-affiliated Pacific islands. In: B.D. Smith (editor), *Topic reviews in insular resource development and management in the Pacific U.S.-affiliated islands*. University of Guam Marine Laboratory Technical Report 88: 118-146.
- Garrett, A. 1887. The terrestrial Mollusca inhabiting the Samoa or Navigator Islands. Proceedings of the Academy of Natural Sciences of Philadelphia 1887: 124-53.
- Girardi, E.-L. 1978. The Samoan land snail genus *Ostodes* (Mollusca: Prosobranchia: Poteriidae). The Veliger 20: 191-250, 1 pl.
- Griffiths, O., A. Cook & S.M. Wells. 1993. The diet of the introduced carnivorous snail *Euglandina rosea* in Mauritius and its implications for threatened island gastropod faunas. Journal of Zoology 229: 79-89.
- Hadfield, M.G. 1986. Extinction in Hawaiian achatinelline snails. Malacologia 27: 67-81.
- Haynes, A. 1984. *Guide to the Brackish and Fresh Water Gastropods of Fiji*. Institute of Natural Resources, University of the South Pacific, Suva, Fiji.
- Haynes, A. 1990. The numbers of freshwater gastropods on Pacific islands and the theory of island biogeography. Malacologia 31: 237-48.
- International Union for the Conservation of Nature and Natural Resources (IUCN). 1996. *1996 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland.
- Johnson, M.S., J. Murray & B. Clarke. 1993. The ecological genetics and adaptive radiation of *Partula* on Moorea. Oxford Surveys in Evolutionary Biology 9: 167-238.
- Kami, K.S. & Miller, Scott E. Samoan insects and related arthropods: checklist and bibliography. Bishop Museum Technical Report 13, v + 121 p.
- Kay, E.A. 1995. *The Conservation Biology of Molluscs*. IUCN, Gland, Switzerland.
- Kinzie, R.A., III. 1992. Predation by the introduced carnivorous snail *Euglandina rosea* (Ferussac) on endemic aquatic lymnaeid snails in Hawaii. Biological Conservation 60: 149-55.
- Mead, A.R. 1979. *Pulmonates, Volume 2B. Economic Malacology with particular reference to Achatina fulica*. Academic Press, London, New York, San Francisco.

SAMOAN SNAILS AND SLUGS

- Miller, Stephen E., R.H. Cowie, B.D. Smith & N. Rojek.** 1993. The decline of partulid snail populations in American Samoa. *Tentacle, The Newsletter of the IUCN/SSC Mollusc Specialist Group* 3: 28–29.
- Murray, J., E. Murray, M.S. Johnson & B. Clarke.** 1988. The extinction of *Partula* on Moorea. *Pacific Science* 42: 150–53.
- NEMS Task Team.** 1993. *Western Samoa: National Environment and Development Management Strategies*. South Pacific Regional Environment Programme, Apia, Samoa.
- Pace, G.L.** 1973. The freshwater snails of Taiwan (Formosa). *Malacological Review, Supplement 1*, 118 p.
- Parkinson, B., J. Hemmen & K. Groh.** 1987. *Tropical Landshells of the World*. Verlag Christa Hemmen, Wiesbaden, Germany.
- Pearsall, S.H. & W.A. Whistler.** 1991. *Terrestrial Ecosystem Mapping for Western Samoa: Summary, Project Report, and Proposed National Parks and Reserves Plan*. South Pacific Regional Environment Program, Nouméa; East-West Center, Honolulu.
- Robinson, A.C.** 1994. *The Ecology of Samoa: an Annotated Bibliography*. South Pacific Regional Environment Programme, Apia, Samoa.
- Solem, A.** 1976. *Endodontoid land snails from Pacific islands (Mollusca: Pulmonata: Sigmurethra). Part I. Family Endodontidae*. Field Museum of Natural History, Chicago, USA.
- Solem, A.** 1983. *Endodontoid land snails from Pacific islands (Mollusca: Pulmonata: Sigmurethra). Part II. Families Punctidae and Charopidae. Zoogeography*. Field Museum of Natural History, Chicago, USA.
- Starmühlner, F.** 1976. Beiträge zur Kenntnis der Süßwasser-Gastropoden pazifischer Inseln. Ergebnisse der Österreichischen Indopazifik-Expedition des 1. Zoologischen Institut der Universität Wien. *Annalen des Naturhistorischen Museums in Wien* 80: 473–656, pls. 1–21.
- Starmühlner, F.** 1992. The fresh- and brackish-water gastropods of the Tongan and Samoan Islands, p. 375–386. In: E. Gittenberger & J. Goud (editors), *Proceedings of the Ninth International Malacological Congress, Edinburgh, 31 August–6 September 1986*. Unitas Malacologica, Leiden, The Netherlands.
- Starmühlner, F.** 1992. Die Gastropoden der berg-fließgewässer isolierter kontinentaler und ozeanischer Inseln des Indopazifik und der Karibik, p. 403–416. In: C. Meier-Brook (editor), *Proceedings of the Tenth International Malacological Congress, Tübingen, 27 August–2 September 1989. Volume 2*. Unitas Malacologica, Tübingen, Germany.
- Starmühlner, F.** 1993. Ergebnisse der österreichischen Tonga-Samoa Expedition 1985 des Instituts für Zoologie der Universität Wien: Beiträge zur Kenntnis der Süß- und

SAMOAN SNAILS AND SLUGS

Brackwasser-Gastropoden der Tonga- und Samoa-Inseln (SW-Pazifik). *Annalen des Naturhistorischen Museums in Wien* Series B 94/95: 217–306, pls. 1–11.

Taule'alo, T. I. 1993. *Western Samoa: State of the Environment Report*. South Pacific Regional Environment Programme, Apia, Samoa.

Trail, P.W. 1993. *Invaders are here*. American Samoa Department of Marine and Wildlife Resources Report 42: 48–50.

Van Bruggen, A.C., S.M. Wells & T.C.M. Kemperman. 1995. *Biodiversity and Conservation of the Mollusca*. Backhuys Publishers, Oegstgeest-Leiden, The Netherlands.

GLOSSARY

- amphibious**—capable of living both in and out of water; in some cases, may not survive if forced to live either entirely in or entirely out of water.
- apertural barriers**—the “teeth” and lamellae seen inside the opening of the shell.
- apex**—the uppermost point of a snail’s shell.
- arboreal**—living in trees.
- biological control**—control of pest organisms using other organisms (usually introduced) as predators, parasites, or pathogens of the pest.
- biomass**—the total amount of biological material in an area or ecosystem.
- brackish**—intermediate salinity, neither fully fresh nor as salty as seawater; usually at the mouths of streams and rivers.
- clonal**—reproduction without sexual fertilization; offspring are genetically identical to their parent.
- columella**—the central column of a snail’s shell, formed as successive whorls coil around a central axis.
- decollation**—loss of the upper whorls of the shell.
- diadromous**—life-cycles in which adults inhabit freshwater rivers and streams, releasing larvae which develop in the ocean and then migrate back into freshwater.
- dorsal**—upper.
- endemic**—indigenous organisms occurring only in one restricted geographical area, such as an island or country; in the context of this book, occurring only in the Samoan Islands.
- estuarine**—habitat lying at the interface between freshwater and marine environments; usually the mouths of streams and rivers.
- fauna**—the full complement of animals living in an area.
- genus**—the scientific term for a group of closely related species.
- genera**—plural of genus.
- growth lines**—fine transverse ridges (see sculpture) formed by the incremental addition of shell material at the growing edge of the shell.
- indigenous**—organisms occurring naturally in a particular area; in the context of this book, occurring naturally in the Samoan Islands, but also elsewhere.
- Indo-Pacific**—the geographic area encompassing the Indian and Pacific Oceans, the islands within them, and the surrounding continental edges.
- intertidal**—the strip of land lying between the high and low tide marks.
- IUCN**—the International Union for the Conservation of Nature and Natural Resources, known also as the World Conservation Union.
- keeled**—shell with a sharply angled periphery.
- lamella**—plural “lamellae”; flanges or teeth forming barriers inside the aperture of a snail’s shell.
- Melanesia**—one of the three major subdivisions of the islands of the Pacific, roughly comprised of the islands of the southwestern Pacific, south of the equator, from New Guinea to Fiji, and including the Solomon Islands, Vanuatu and New Caledonia.
- Micronesia**—one of the three major subdivisions of the islands of the Pacific, roughly comprised of the islands of the western Pacific, north of the equator, from Palau in the west and the Mariana Islands in the north, to the Gilbert Islands (part of Kiribati) in the east, and including the Federated States of Micronesia and the Marshall Islands.
- morphological**—relating to the physical form of an organism.
- native**—organisms occurring naturally in a particular area; also termed indigenous.

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non-indigenous—organisms not occurring naturally in a particular area; also termed introduced, alien, exotic, adventive; in the context of this book, not occurring naturally in the Samoan Islands.

operculate—possession of an operculum; a snail that possesses an operculum.

operculum—the trap-door like structure, attached to the body of the snail, that seals the shell opening (aperture) when the snail withdraws into its shell.

periostracum—the thin outer protein layer of a snail's shell.

periphery—the outermost pedge of the shell whorl; the midline of the whorl.

Polynesia—one of the three major subdivisions of the islands of the Pacific, a roughly triangular region stretching from New Zealand in the south, to Hawaii in the north and the Juan Fernandez Islands in the east.

predation—the act of one organism (the predator) eating another (the prey).

protoconch—the shell formed within the egg; becomes the apex of the growing shell.

pulmonate—snail that breathes with a lung; lacks an operculum.

salinity—the amount of salt in the water.

sculpture—patterns of ridges and grooves running spirally or transversely along or across the shell.

septum—the transverse ledge on the underside of the shells of species in the genus *Septaria*; equivalent to the columella of other snails.

species—the scientific term for an individual kind of organism, often defined as those individuals among which successful breeding can take place.

suture—the junction between successive whorls of a snail's shell.

synonym—in the context of this book, two or more scientific names of an organism are synonyms if they refer to the same real species; the name published first is the senior synonym; later names are junior synonyms.

taxonomy—the scientific description, naming, and classification of organisms.

umbilicus—the cavity that opens at the base of a snail's shell; may vary considerably in size, and may be absent in some species.

whorl—each successive coil of a snail's shell.

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Dr. Robert H. Cowie earned his Bachelor's degree in Natural Sciences from the University of Cambridge, England. He subsequently went on to obtain a Ph.D. at the University of Liverpool, England, under the tutelage of Prof. Arthur J. Cain, a world-renowned evolutionary biologist and snail specialist. After obtaining his Ph.D. working on the ecology of a European land snail that has become a serious pest in other parts of the world (California, Australia), he moved to the University of London where he continued research on the ecology and evolution of European land snails. He then moved to become head of the termite ecology and control section of what was then known as the Tropical Development Research Institute (a British Government organization), traveling to many parts of Africa and Asia and undertaking research on termites, the agricultural problems caused by them, and means of controlling them.

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