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Stream Fauna of American Samoa

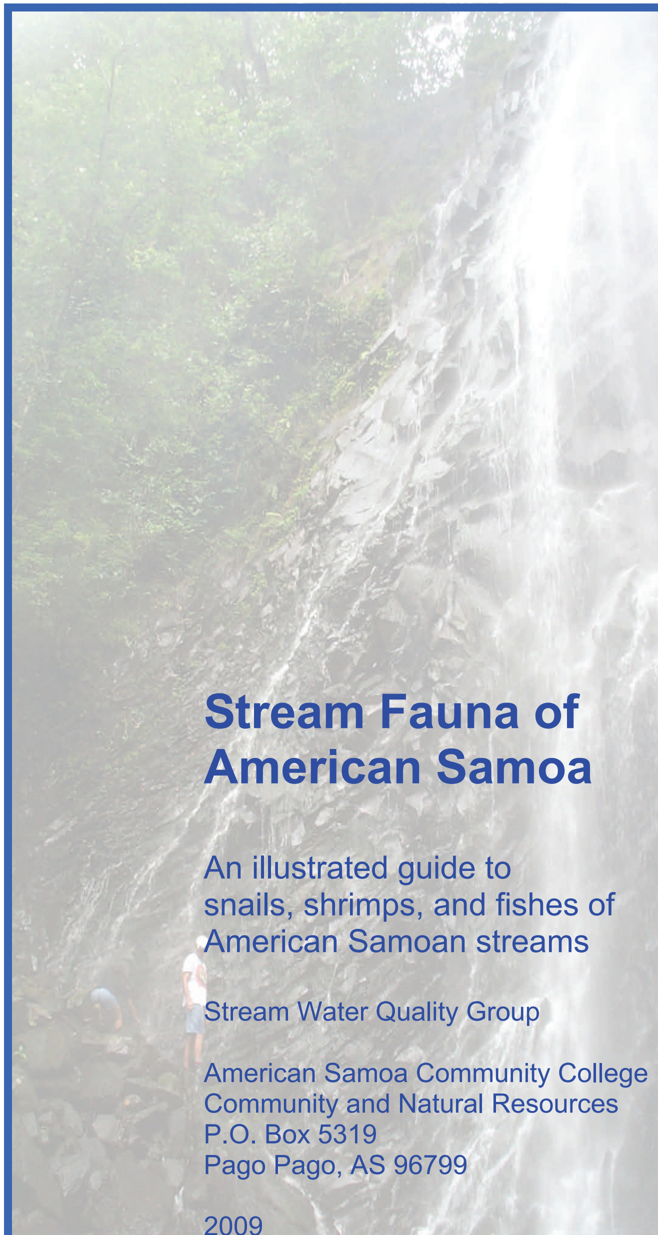
An illustrated guide to snails, shrimps, and fishes of American Samoan streams

Cover: Waterfall, Papa Stream, Nu’uuli.
Photo courtesy of K. van Houte-Howes.

Electrofishing. All of the shrimps and fishes in this guide were collected by stunning them with electric current, then quickly netting them before they had time to recover. This was done using a battery-powered backpack unit, shown above in green.

Electrofishing works by passing 350 V pulsed (30 Hz, 12% duty cycle) DC current from a cathode (a cable that trails the shocker) to an anode (an aluminum ring at the end of the yellow pole) that are immersed in the water. Current flows between cathode and anode because the water is slightly conductive. (For our streams, the conductivity is about 100 mS/cm.) Shrimp and fish bodies have a higher conductivity, that is, electric current flows easier in their bodies than in the stream water. So the electric current quickly enters their bodies, stunning them.

Caps with a brim and polarized sunglasses help the workers see despite glare off the water. Note that they are wearing fully-enclosing protective rubber coveralls and lineman's gloves resistant to 5,000 V. Their net poles are made of non-conductive fiberglass. These precautions are necessary because the electric current is capable of causing ventricular fibrillation, respiratory arrest, and asphyxia; all of which can cause death.



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Stream Water Quality Group

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Don Vargo, Principal Investigator

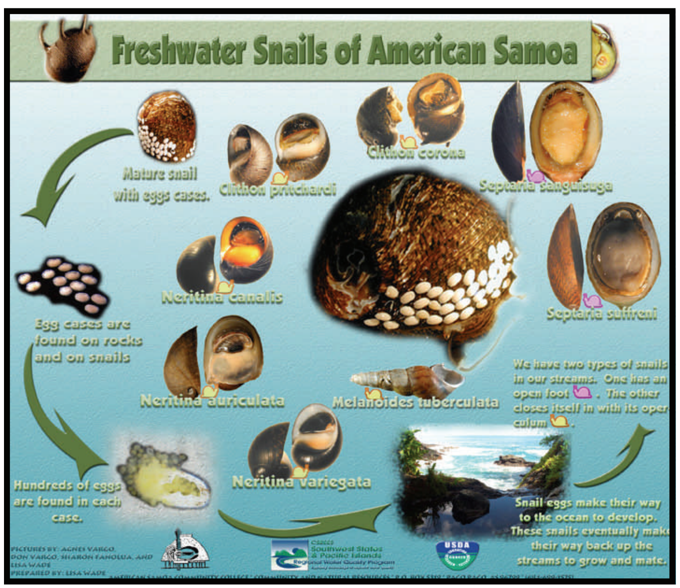
Posters

In addition to this field guild, we produced over a thousand posters of stream fauna and distributed multiple copies to all schools and several agencies in American Samoa. It was the popularity of these posters, produced by Lisa May Wade, that served as the impetus for this guide, prepared by Agnes M. Vargo. These posters, along with this guide, are freely available for download from…

http://www.ctahr.hawaii.edu/adap/ASCC_LandGrant/technical_papers.asp.

as…

Report No. 51 Freshwater Snails of American Samoa
Report No. 52 Freshwater Shrimps of American Samoa
Report No. 53 Freshwater Fishes of American Samoa
Report No. 54 Animals in American Samoa Streams
Report No. 55 Stream Fauna of American Samoa (Guide)



Foreword

Linnaeus classification, based on the hierarchical binomial system developed by the Swedish naturalist Carolus Linnaeus (1707-1778), is used to indicate an animal's place in the scheme of life. Each animal has a name with two parts. The first part of the name is for the genus (group). It is always capitalized. The second part is for the species (kind). It is not capitalized. Because both parts are from Latin or Latinized words, they appear in *italics*, indicating that they are non-English words.

Following the scientific name of the animal is the name of the person who first described it and the date. Parenthesis around the person's name and date indicate that the person placed the animal into a different genus than the one shown.

A word that appears as SMALL CAPITALS has its definition explained in the glossary. Samoan names for an animal are indicated with an <u>underline</u>.

Care should be taken whenever working in a stream. Owing to pigs, rodents, and dogs, streams of American Samoa are contaminated with bacteria of the genus *Leptospira.* These bacteria can cause a potentially deadly disease called leptospirosis. In 2005 leptospirosis was suspected as responsible for the death of a 38-year-old man. The following year the Centers for Disease Control, in cooperation with the AS Department of Health and AS Environmental Protection Agency, reported that 17% of the population had contracted a mild form of the disease, based upon finding antibodies to the bacteria in the blood of residents.

These same animals and humans may also contaminate streams with fecal coliform bacteria and viruses. While not considered deadly, they can cause severe diarrhea and a sore throat if ingested. Care should also be taken if you have any cuts or open wounds, since disease-causing microorganisms may enter through broken skin. By using sensible and basic precautions, you can safely enjoy working in our streams and reap the rewards they offer to the inquisitive mind.

D.V.

Contents

Lateral. At or along the side.

Merus. The fourth leg segment from the body of a crustacean. (See p 47).

Molt. To cast off an exoskeleton in order for the growing body to expand and build a new exoskeleton.

Operculum. A hard door of calcium carbonate used by a snail to close the opening of its shell. (See p 13).

Parthenogenisis. Reproduction where the female's eggs develop without fertilization by the male.

Pereopod. One of the ten legs of a shrimp. (See p 31).

Pleopod. One of the paired swimmerets on the underside of a shrimp. It is usually used for swimming, but also used by the female to carry her clutch of eggs and larvae. (See p 31).

Radula. A snail's ribbon of teeth.

Rostrum. The top-front projection of a shrimp's carapace between the eyes, usually armed with a teeth-like edge. (See p 31).

Shell lip. The margin of the shell at the shell opening. (See p 13).

Veliger. The larval stage of snails, characterized by tiny hairs, called cilia, used for swimming.

Ventral. Of, near, on, or toward the belly or lower surface.

Vertebrate. Animals with a backbone.

Glossary

Amphidromous. Any species that spawns in freshwater but whose larvae or young undergo a planktonic phase in the sea before returning to streams to grow and reproduce.

Androgynous. Having both male and female sexual characteristics in the same individual.

Apex. The uppermost tip of a snail's shell. (See p 13).

Anterior. At or toward the front.

Berried. Used to describe a female crustacean carrying eggs or developing larvae.

Carapace. The head shield of crustaceans, covering the head and thorax. (See p 31).

Carpus. The fifth leg segment from the body of a crustacean. (See p 47).

Caudal. At or pertaining to the tail.

Chela. (pl. chelae). A pincer or claw. (See p 47).

Dorsal. Of, on, or near the back.

Endemic. Native to a particular country or region.

Estuary. The lower part of a stream, where the salty tide meets the freshwater current.

Gonopodium. A male organ for reproduction.

Habitat. A place where a plant or animal naturally lives.

Invertebrate. An animal lacking a backbone.

Introduction

For the curious, no reason is needed for learning about American Samoa's stream animals other than it is fun. The soothing sound of clear, cool water as it rushes over algae-covered stones and the welcome shade of overhanging trees make a walk in or along a stream a stress-reducing experience. Being able to identify a fish, shrimp, or snail only adds to the enjoyment of this natural environment.

But a more compelling reason for studying these animals is that they are important. Snails keep algae growth under control. Shrimps filter organic debris from flowing water and hunt insect larvae hiding in sand and among small stones. They are also an important food source for fishes, birds, and—long ago—early settlers. Fishes, too, are an important food for large birds, and some people enjoy catching them for food and sport.

In addition, stream animals are important as indicators of water quality. Healthy streams have a balanced mix of native animals, while polluted streams are dominated by introduced species such as mosquito fish and tadpoles of the cane toad.

Lastly, American Samoa's freshwater animals are fascinating to study. A small aquarium is all that is needed to conveniently provide students an intricate look at how the animals eat and interact with one another and what they require to survive. This, in turn, can help students understand and appreciate how ecosystems function.

This field guide is intended to aid in the identifications of the small number of freshwater snails, shrimps, and fishes found in many of the 141 perennial streams on Tutuila Island and in Laufuti Stream, Taú Island. It uses distinguishable characteristics of living animals easily seen by the unaided eye. This makes it useful to anyone without a stereomicroscope or unfamiliar with taxonomic features used by specialists. The number of species is small primarily because of American Samoa's geographic isolation. As for terrestrial animals and plants found throughout the Pacific, the greatest number of species of freshwater animals is generally found near Southeast Asia with fewer and fewer of the same spe-

For Further Reading

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Dragonfly larvae are insects that belong to the suborder Anisoptera in the order Odonata. They are voracious predators both as aquatic larvae and as winged adults.

Tadpoles of the cane toad, *Bufo marinus*, are common in our streams. Several pairs of toads were introduced to Tutuila Island in 1953, ostensibly for mosquito control. (Note: although mosquito larvae are aquatic, they live in still water, such as ponds, tree holes, and containers. They are not found in flowing water, such as streams.) In an aquarium, none of our predatory fishes was ever observed to eat tadpoles. Anguillid eels, however, do eat adult toads.

cies found in streams of islands that are farther and farther east. For example, Fiji has 24 species of neritid snails, Samoa 16, and French Polynesia nine. Moreover, at the extremes of their range, some freshwater snails evolved into new species found only in a single island group. Fiji has three such ENDEMIC snail species, Samoa two, and French Polynesia two.

This raises the question, How did these freshwater animals get here? The answer is that freshwater animals are adapted to saltwater conditions during an early stage of their lives.

Hundreds of miles of Pacific Ocean separate islands from their nearest neighbors. Surely, snails did not crawl here. Nor did shrimps and fishes swim here. Freshwater fish differ physiologically from saltwater fish. Freshwater fish must constantly remove water absorbed through their gills and skin. If freshwater fish lose too many scales, a surplus of water diffuses in through the skin, causing the fish to die. Therefore, freshwater fish have larger kidneys than their saltwater cousins. Their gills are designed to keep salts inside their body, while the gills of saltwater fish are designed to keep excess salt out of the body.

All of the snails, shrimps, and fishes found in American Samoa's streams are believed to have evolved from saltwater ancestors. For this reason, though they spend their adult life stage in freshwater streams, they must spend a portion of their life in saltwater. Usually, this is during their larval or juvenile stage. When the young hatch, they are immediately swept out to sea by the stream current. They may drift in the open ocean for days, weeks, or months as plankton. Once they reach the right stage for returning to freshwater, and if they are extremely lucky to be near an island with a stream flowing into the ocean, they actively follow the freshwater trail. They enter the stream at its ESTUARY and migrate upstream until they find suitable HABITAT. There they live out the remainder of their lives and reproduce upon reaching maturity, thereby beginning the cycle once again.

Whatever your reason for using this book, we hope that it helps you to identify and understand the roles American Samoa's stream inhabitants play in maintaining a stable, balanced, and enjoyable island environment.

Snails

Snails, or sisi vai, are easily distinguished from other INVERTEBRATES in that they have a hard shell which encloses a soft body. The size, shape, texture, and color of the shell are important features to aid in identifying them to species.

Many snail species are ANDROGYNOUS, meaning that an individual is both male and female. Our stream snails, with one exception, have separate sexes. This is true of all of our snails that belong to the family Neritidae. The exception is the single species, *Melanoides tuberculata*, which belongs to the family Thiaridae. Here, all of the snails are female. They reproduce by PARTHENOGENISIS.

Neritids attach egg cases to submerged rocks or other hard surfaces in streams. Although only a millimeter or two in size, they are easily seen as clusters of white ovals against the dark basaltic rocks. In aquaria, where surfaces may be in short supply, they might attach egg cases to one another's shell. The egg cases are filled with hundreds of round yellow eggs. Only a few of these eggs may actually be fertile. When open, egg cases release VELIGER larvae which drift with the current to the sea.

Neritids and thiarids belong to the subclass Prosobranchia, meaning they have an OPERCULUM and breath by means of gills. Usually the OPERCULUM covers the aperture, or opening, of the shell. The snail pulls it shut when it hides inside. Our two *Septaria* species, though, have an OPERCULUM that is inside the snail's body. These snails are limpet-shaped with the entire base of their foot exposed. The internal OPERCULUM may help these snails use their large foot to stick strongly to rocks.

Our stream snails are grazers. They use a RADULA to scrape algal films and diatoms from stones, mud, and plants. As the snail grows, its shell must also grow. The shell is made of several layers of the mineral calcium carbonate. Snails get calcium from their food and from the stream water. A special organ called the mantle secretes the shell by combining calcium ions with carbon dioxide that is dissolved in the water. The mantle builds new shell by extending the

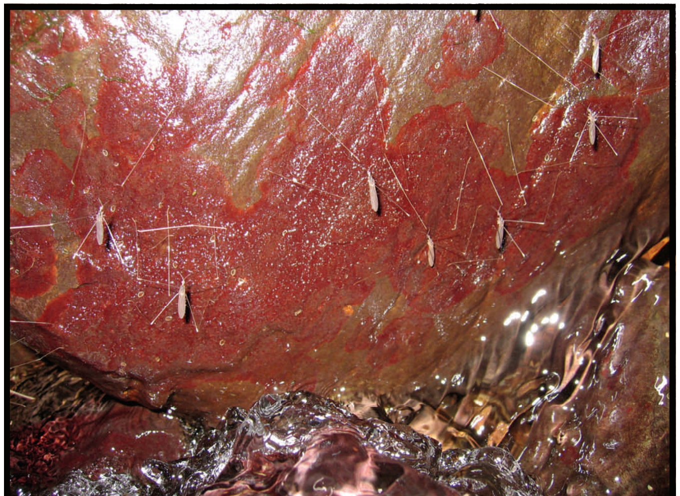
Water striders are insects that belong to the family Gerridae in the order Heteroptera. As their name implies, they stride across the water surface of quiet pools and puddles like ice skaters. Here is a mating pair of what may be *Limnogonus luctuosus*, one of four records for Samoa.

Midge larvae are abundant in our streams. They are insects belonging to the family Chironomidae in the order Diptera. They burrow into sediment and between stream pebbles. They are an important food source for most of the other animals. Many are red, accounting for their common name of "blood worm."

Other fauna

Although snails, shrimps, and fishes comprise the more obvious collection of our freshwater animals, they share streams with a number of other animals whose small size and cryptic habits make them less visible to the casual observer. But each of these other animals has an ecological niche that it fills in creating a balanced ecosystem.

We present here just a few of these animals that you may come across if you activity collect stream creatures. Some spend only a part of their life cycle in water. All of the insects are winged as adults, allowing them to easily move over long distances from one stream to the next and from one island to another. None of the three insect orders—Plecoptera, Ephemeroptera, and Trichoptera—commonly used elsewhere as bioindicators of water quality, are found in our streams.



Crane flies are insects that belong to the family Tipulidae in the order Diptera. They resemble large mosquitoes, but they do not bite. All of our stream crane flies seem to be of a single species, *Trentepohlia samoensis* Alexander, 1921. (Identification by Mark Schmaedick, ASCC entomologist.)

opening of the shell. This gives the shell its ever-widening helical shape.

Calcium carbonate is white. It, in turn, is covered by a brown complex protein material called conchiolin. It is the conchiolin that gives the characteristic features to the shell that help identify the snail to species.

The classification below uses the Linnaeus system to see how a given species fits into the overall scheme of life. Each of the snails, shrimps, fishes, and other animals discussed in this publication can be described using this system by making minor changes to the example given in the introduction section for each phylum.

Kingdom Animalia
  Phylum Mollusca
    Class Gastropoda
      Order Archaeogastropoda
        Family Neritidae
          Genus *Clithon*
            Species *corona*

Hand-collecting snails. Care should be taken to keep hands away from the face to avoid bacterial contamination.

Snail are grazers. They eat by scraping the algal film from rocks and other surfaces using a RADULA, or ribbon of teeth. Seen are the head with mouth and the single foot.

Damaged shell. About 5 to 10% of snails show this kind of damage to their shell, usually at the APEX. Inset: calcium carbonate shell underlying the conchiolin.

Fish (Cichidae)

Tilapia zilli (Gervais, 1848)?

Cichidae is a large family of fishes native to Africa, Central and South America. This diversity of locations has given rise to several genera that go by the common name "tilapia." Several species of tilapia have been introduced to American Samoa for fish farming. This has led to several instances of escape into our streams, where this predator competes with native fishes. We found one or two individuals in streams known to have tilapia fish farms along them. Escaped tilapia have not multiplied in our streams. Perhaps any eggs or fry are swept to sea, and unlike our native AMPHIROMOUS fishes, tilapia young do not return to streams.

Tilapia are difficult to identify, even for experts. To make matters worse, they may interbreed. This produces hybrids with characteristics of both parents.

We suspect the fish pictured below to be *T. zilli* based on photographs found on the World Wide Web. This species was also introduced in Hawaii, along with at least three other species. Our tilapia may, in turn, have come from fish farms there.

Tilapia can reach lengths up to 40 cm and weigh 300 g.

Fish (Gobiidae)

Stiphodon elegans (Steindachner, 1879)

S. elegans may be found anywhere along the stream length, especially where water is fast flowing. They feed on the algal film covering stream rocks but may also take insects and insect larvae. They are poor swimmers, preferring to dwell along the bottom clinging to stones and pebbles.

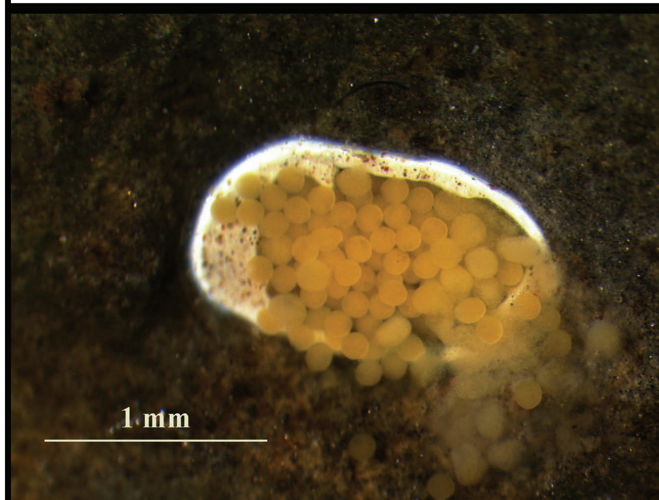
They make fine aquarium fish. Although they may burrow if they feel threatened, they spend much of their time sitting on stones and move about in quick darting bursts.

Watson reports another fish of this genus, *S. hydoreibatus* Watson, 1999, found only in Samoa. It is about half the length of *S. elegans* and may easily be mistaken for an immature *S. elegans*.

Top panel: *S. elegans* male. The neon green spots on this mature male are particularly striking. Maximum size 5 cm.

Bottom panel: *S. elegans* female. In contrast to the male, the female is golden brown with darker brown markings.

Snail egg cases attached to a stream rock. The egg cases are usually found in clusters, easily seen by the naked eye despite their small size.



Unhatched eggs. Egg cases generally remain intact until the eggs begin hatching. Each egg case may contain more than a hundred eggs.

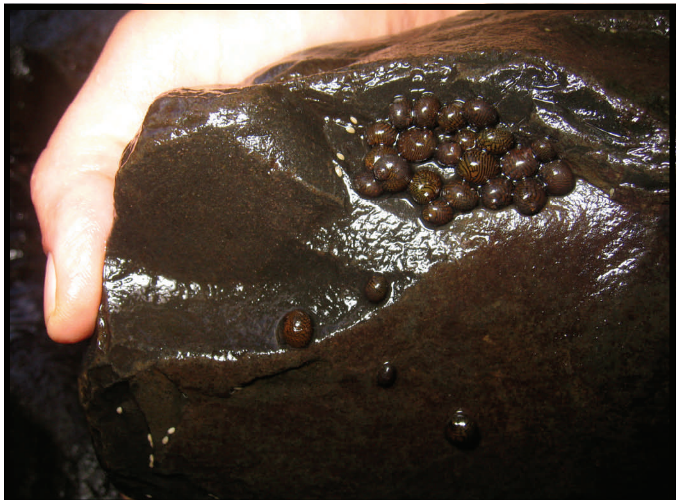
Snails (Neritidae)

Clithon corona (Linné, 1758)

Shell: Brown to dark brown and ridged. Smaller, younger specimens often have spines. These are usually broken or missing in older, larger specimens, as the one shown. The SHELL LIP and inner shell lining are white.

Operculum: Color similar to shell, with a narrow orange-brown horn border.

Habitat: On rocks in pools and in flowing water anywhere along the stream length. Common.



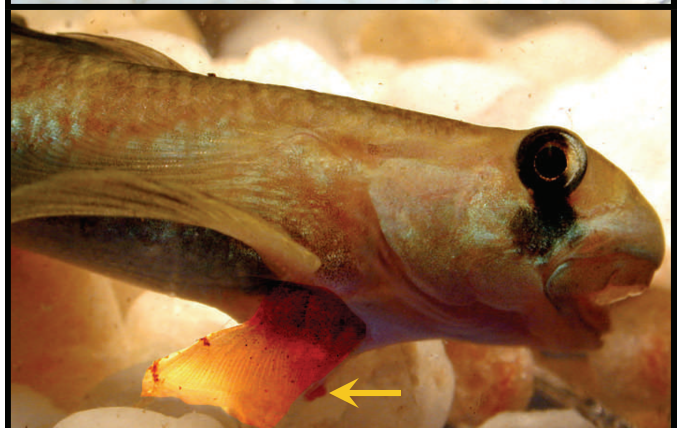
Migrating snails. Young snails are common near the mouth of streams, where they may be found migrating upstream following their developmental stage in the sea.

Fish (Gobiidae)

Sicyopterus caeruleus Lacépède, 1800

Watson previously identified this species as *S. lagocephalus*. *S. macrostetholepis* and *S. taeniurus* are junior synonyms commonly found in the literature.

The tail fin always has a horseshoe-shaped band, which may not be obvious. Large males have scales embedded in a spongy tissue just before the tail fin. This protects them from bites from rival males during competition for females. Maximum size of males is 6 to 7 cm.



Top panel: Note the horseshoe-shaped band in the tail fin.

Bottom panel: Gobies are characterized by a VENTRAL sucker disc (arrow, and highlighted here for emphasis) formed by the fusion of the pelvic fins. They use this sucker to great advantage in clinging to rocks in fast flowing streams and for climbing wet vertical surfaces of waterfalls.

Fish (Poeciliidae)

Poecilia gillii (Kner, 1863)

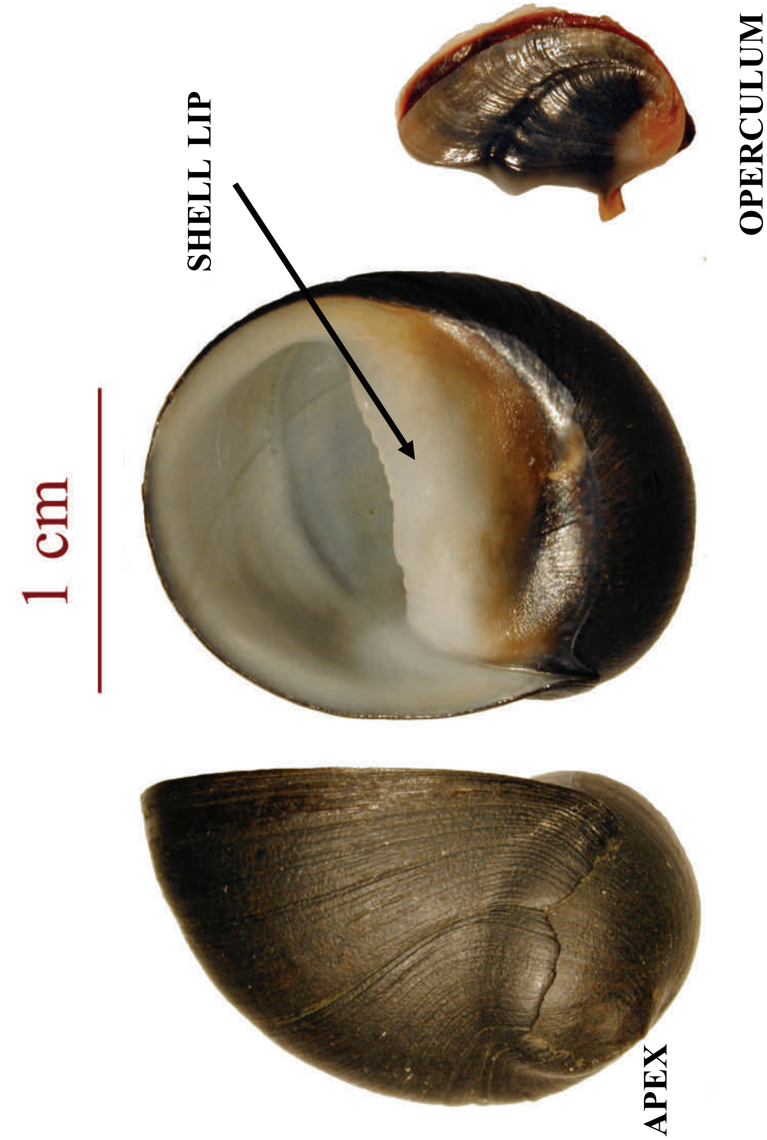
Poecilia spp. make up a hybrid complex known as the *P. salvatoris/mexicana* group. They are difficult to distinguish based on structural characters. Until notified by Brown in 2009, we referred to these introduced fish as *P. mexicana*. Brown had them identified as *P. gillii* by Wayne Starnes (North Carolina State Museum) and Fred Poeser.

Males can reach up to 6 cm and females nearly twice as large. They are quite hardy, living in polluted water, where native fishes are absent. They are popular aquarium fish for their hardiness and their gentle nature. They eat worms, crustaceans, insects, and plant matter.

Top panel: *P. gillii* male. Note the GONOPODIUM on the underside, developed from the modified anal fin.

Bottom panel: *P. gillii* female. Her descendent abdomen indicates that she is carrying eggs. These hatch inside, and the young emerge alive from her.

Clithon corona (Linné, 1758)



Snails (Neritidae)

Clithon pritchardi (Dohrn, 1861)

Shell: Brown, roughly wrinkled, with or without spines. The SHELL LIP is white to orange-yellow, and the inner shell lining is white.

Operculum: Color similar to shell, with a narrow orange-brown horn border.

Habitat: On rocks in pools and in flowing water anywhere along the stream length. Common.

Texture clue. *C. pritchardi* may be distinguished from *C. corona* by the rougher texture of the former's outer shell. Both species may or may not show spines.

Fish (Gobiidae)

Periophthalmus kalolo Lesson, 1831

P. kalolo, or mano'o, is one of three freshwater mudskippers recorded for Samoa. The others are *P. argentilineatus* and *P. koelreuteri*. It is an amphibious air-breather that spends most of its time out of the water. It is able to breathe as long as it stays wet. It typically rests on mud, rocks, or mangrove roots with its tail dipped in water. It feeds mainly on worms, small crustaceans, and insects. Its size is about 10 to 12 cm.

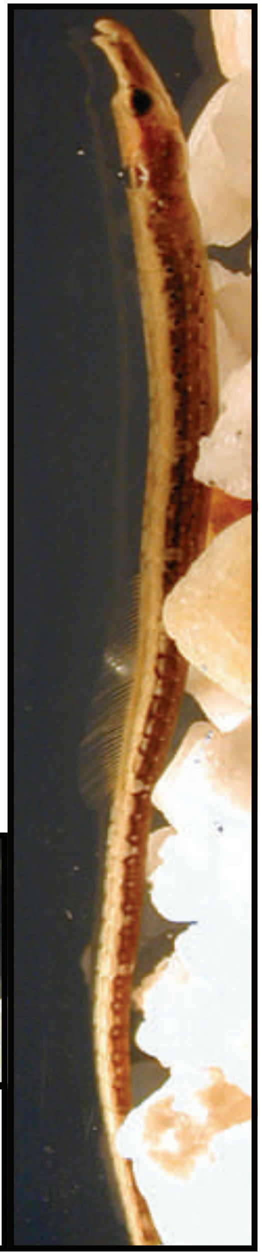
Fish (Syngnathidae)

Microphis argulus (Peters, 1855)

M. argulus is known as the flat-nosed pipefish. According to Brown, it is one of the easiest “brown” pipefish to identify due to its dual rows of spots. Brown also states that it is a new record for Samoa, joining two other of our freshwater pipefishes: *M. retzii* and *M. brachyurus brachyurus*.

An interesting feature of pipefishes and their relatives, the seahorses, is that the male carries the eggs in a brood pouch located on the abdomen. The female places the eggs in this pouch, where they hatch. The young pipefishes remain in the pouch until they can care for themselves and are able to leave.

Dual row of spots. The above image more clearly shows the double row of spots used to identify *M. argulus*. Maximum size: 14 cm.



Clithon pritchardi (Dohrn, 1861)

Snails (Thiaridae)

Melanoides tuberculata (Müller, 1774)

Shell: Yellow-brown, usually with red-brown lines or dots. Turreted with eight to nine whorls, the body whorl moderately large. The SHELL LIP ranges from white to brown.

Operculum: Black-brown.

Habitat: In still or flowing water. We never found it on rocks during hand-collecting, but it was abundant in green filamentous algae.

Preferred habitat. *M. tuberculata* can most easily be collected by collecting green filamentous alga that is common in streams.

Fish (Kuhliidae)

Kuhlia salelea Schultz, 1943

K. salelea, or sesele, was inaccurately named from the Samoan word for this genus. Unlike *K. rupestris*, *K. salelea* is currently known only from streams on Tutuila Island and Upolu Island, Samoa.

We found *K. salelea* to be more numerous than *K. rupestris*, but smaller. The average weight of 735 specimens of *K. salelea* was just 17.4 g, while the average weight of 179 specimens of *K. rupestris* was 50.8 g.

K. salelea may be identified by the continuous dark border running along the trailing edge of its tail fin (see figure below). For this reason, some authors mistakenly identified it as *K. marginata*, a species more common to the western Pacific.

The common name for this genus is "flagtail," owing to the distinctive markings on its tail.

Both kuhliids are easily collected by electrofishing. When stunned, they lie on their side, exposing their silvery surface as they drift in the current. This makes them very obvious for quick netting. They generally recover, unharmed, within a few seconds. They should be handled with care owing to their sharp DORSAL spine.

Kuhlia salelea showing the dark border along the CAUDAL fin.

Fish (Kuhliidae)

Kuhlia rupestris (Lacepède, 1802)

K. rupestris, or sesele, is widely distributed throughout the tropics as well as throughout our streams. It is one of the top predators, mainly feeding on crustaceans, insects, and insect larvae. It can get as large as 45 cm. It can most readily be distinguished from *K. salelea* by the markings on its tail. *K. rupestris* has two separate dark spots on the CAUDAL fin: one DORSAL and the other VENTRAL (see figure below).

Its Hawaiian relative, *K. sandvicensis*, is a desirable food fish. There, it is often found along the shoreline as well as in the lower reaches of streams.

We placed one mature specimen directly into a seawater tank. It survived with no sign of stress for five days, and it continued to survive when returned to a freshwater tank.

In American Samoa, this fish may be present far upstream as long as no barriers, such as a falls of about a meter or higher, intervene. It can swim without apparent difficulty up steep, fast-flowing cascades.

Given its ubiquitousness and ability to tolerate seawater for extended periods, it is surprising that Cook (see For Further Reading) did not report finding it in Laufuti Stream, Taú Island.

Kuhlia rupestris showing the two characteristic dark markings on its CAUDAL fin.

Melanoides tuberculata (Müller, 1774)

Snails (Neritidae)

Neritina auriculata Lamarck, 1816

Shell: Light brown, no pattern, often extended at the sides to form wings. SHELL LIP may be cream to gray.

Operculum: Cream to dark brown with gray radial lines and a red outer horn border.

Habitat: On rocks or sandy bottom close to the sea, often in brackish water.

N. auriculata restricts itself to ESTUARIES, where ocean tides and stream flow mix to form an environment of ever-changing salinity. Many snail species inhabit this zone, an area that we paid scant attention to during our studies.

Haynes found several snail species during visits to Tutuila Island that we either did not find or mistook for a species represented in this book. Her additional species are...

Clithon castanea
C. diadema
C. oualaniensis
Melanoides aspirans
M. lutosa
Neritilia rubida
Neritina macgillvrayi
N. turrita
Physastra nasuta
Septaria macrocephala

It should be noted that identification of some neritid snails is difficult even for experts. Both Haynes and Starmühlner mistook female *Septaria suffreni* or *S. bougainvillea* for *S. porcellana*. Therefore, a search of the literature will indicate that *S. porcellana* is found in Samoa and Fiji. But this species is in neither archepelago. (Note from Haynes, 01 Nov 2004)

Fish (Eleotridae)

Eleotris fusca (Forster, 1801)

E. fusca, or i'a moi, belongs to a family known as "sleepers." As its name implies, it spends much of its time resting quietly on the bottom. However, it is a formidable predator, able to capture fast moving fish and crustaceans.

Individuals may grow as large as 26 cm, but it is more common to find them at 10 to 15 cm.

Top: A nearly full grown *E. fusca*.

Bottom: A juvenile *E. fusca* swallowing a goby nearly half its size. The goby's tail protruded throughout the day but was no longer visible the following day.

Fish (Gobiidae)

Awaous ocellaris (Broussonet, 1782)

A. ocellaris is found near stream mouths, in an area known as the ESTUARY. It may grow to about 8 to 13 cm. It feeds on green filamentous algae, worms, small crabs and shrimps, and various insects and insect larvae. It is a shy fish, often burrowing into the sandy bottom with only its eyes showing.

Its Hawaiian relative, *A. guamensis*, deposits tens of thousands of 1 mm eggs just above the estuary. Newly hatched larvae have no eyes, no mouth, and no gills until about five days old. They feed solely on the yolk sac. They spend five to six months at sea before returning to a stream.

Adult *A. guamensis* are still considered a favorite food of native Hawaiians.

Top: *A. ocellaris* in a hand. Once netted, the fish is quite docile and easy to handle.

Bottom: *A. ocellaris* with its DORSAL and CAUDAL rays exposed.

Neritina auriculata Lamarck, 1816

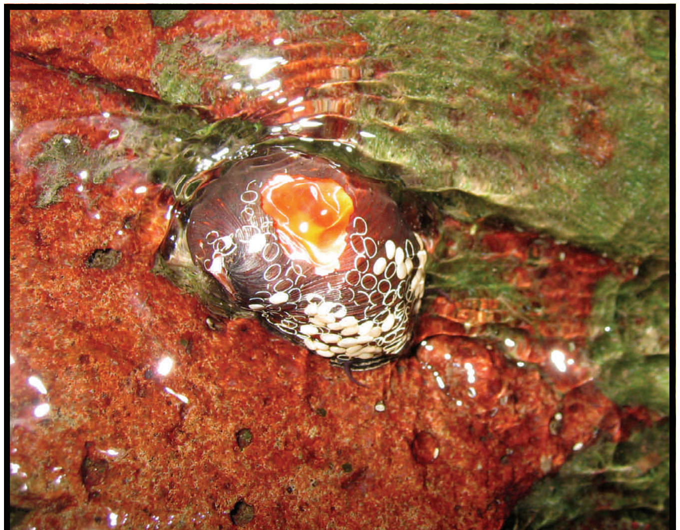
Snails (Neritidae)

Neritina canalis Sowerby, 1825

Shell: Brown to black. The SHELL LIP and inner shell lining are orange-yellow to red.

Operculum: Pale orange with black radial stripes and a narrow dark red horn border.

Habitat: On stones in flowing water. Uncommon.

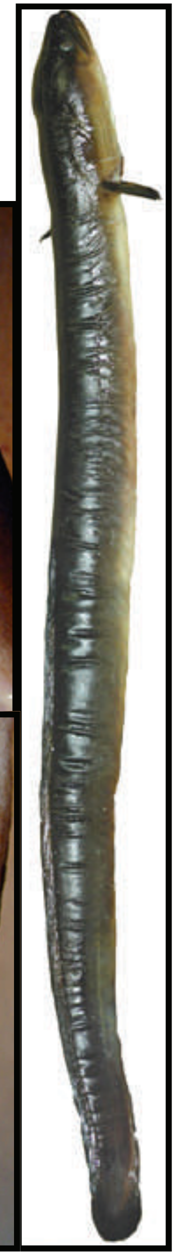


N canalis carrying intact and remnants of egg cases on its shell. Notice the damaged shell exposing the yellow-orange inner shell layer. About 5 to 10% of all snails show such damage. Some attribute it to birds, rats, or other predator. Others believe it to be caused by impacts with dislodged rocks during floods. Perhaps a parasite or a disease is responsible. We believe the cause remains an open question.

Fish (Anguillidae)

Anguilla obscura Günther, 1871

DA:GD 0.42 ± 0.22



Fish (Anguillidae)

Anguilla marmorata Quoy & Gaimard, 1824

DA:GD 1.28 ± 0.31

Both *A. marmorata* and *A. obscura* are referred to as tuna. They may reach a length of 100 cm or more, though the largest we found among 84 captures were just over 80 cm. They may be distinguish from one another by their DA to GD ratio, that is, the distance from the beginning of the DORSAL fin to the anus (DA), and the distance from the gill opening to the beginning of the DORSAL fin (GD). In one 60-cm long specimen the DA:GD was 6.14.

A. marmorata always has the characteristic mottling seen at right, while *A. obscura* is always plain (opposite page, right).

A third anguillid reported for American Samoa is *A. megastoma* Kaup, 1856. It may be either mottled or plain. Taxonomists distinguish among them by counting the number of vertebrae: 100—110 for *A. marmorata*, 102—108 for *A. obscura*, and 110-114 for *A. megastoma*.

Another way of distinguishing them is by their teeth patterns (opposite page, top: upper jaw; bottom: lower jaw). As for the vertebrae counts, the differences in teeth patterns are subtle.

Besides these three anguillids, *A. australis australis* and *A. celebesensis* are also reported for American Samoa. But Smith regards these records as questionable.

Neritina canalis **Sowerby, 1825**

Snails (Neritidae)

Neritina variegata Lesson, 1831

Shell: Variable color ranging from olive to dark brown. The SHELL LIP and inner shell lining are white with a reddish splash on the SHELL LIP.

Operculum: White to black with no horn border.

Habitat: On stones in flowing water. We found it only in Faatafe Stream, Vatia, and on a mud flat in Alofau.

High density. *N. variegata* surrounding a coconut husk lying in organic-rich mud. This mud flat was part of a small mangrove stand that lay between the sea and a large piggery in Alofau. Runoff from the piggery flowed through the mud flat, supplying nutrients to support a large population of this single species of snail.

Some fishes are active during daylight hours, while others prefer the night. Day feeders generally depend upon sight for locating food. Night feeders, in contrast, usually have a keen sense of smell and taste by which they locate their food.

Fishes may be either solitary or social. The i'a moi, for example, spends most of its time alone on the bottom, quietly awaiting passing prey. Sesele, on the other hand, are generally seen actively hunting in small groups.

Most fishes lay eggs, but others, such as the poecillids, are live-bearers. Each species of fish has its own habits and characteristics, and these may change with age.

We report fish sizes as standard length, SL. This is the length from the tip of the snout up to—but not including—the tail fin. More precisely, it is the distance to the last vertebra. This can be determined as the crease formed by bending the tail fin.

Our freshwater fishes belong to several families. The anguillids are eels. They are long and slender, and the back (DORSAL) fin is continuous with the tail (CAUDAL) and bottom (anal) fins. Gobies are characterized by a VENTRAL sucker disc formed by the fusion of the pelvic fins. This allows them to stick to rocks in fast-flowing streams or to climb wet vertical walls. Eleotrids also have close-fitting pelvic fins, but they do not unite to form a sucking disc. Kuhliids have a sparkling bright silvery color. Poecilliids are small fish that were introduced to eat mosquito larvae. Another introduced fish is the tilapia, a cichlid. Syngnathids are pipefishes, relatives of the sea horse. Some of these fishes are found only near the mouth of streams, an area referred to as an ESTUARY. They are seldom, if ever, found far upstream of the mouth.

A typical classification scheme for fishes, then, is...

Kingdom Animalia
Phylum Chordata
Class Actinopterygii
Order Anguilliformes
Family Anguillidae
Genus *Anguilla*
Species *marmorata*

Fish*

Unlike snails and shrimps, fish are VERTEBRATES. But fish share two features with our snails and shrimps: they are cold-blooded, and they breath by means of gills.

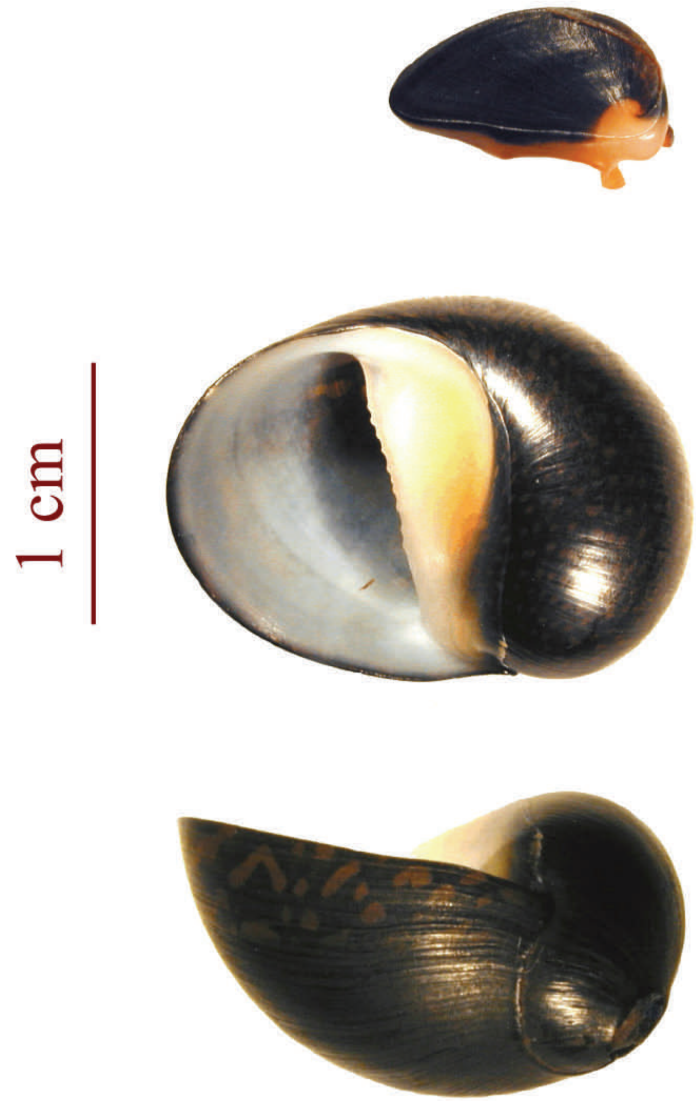
Being cold-blooded, fish cannot regulate their body temperature. Instead, their body temperature is the same temperature as the stream water. We took 1102 daytime temperature readings of 46 streams on Tutuila Island over a two-year period and found that 99% of the time the temperature was $26.4^{o} \pm 0.1^{o}$ C (about 79.5^{o}F).

Temperature has two effects on our stream animals. The higher the temperature, the higher an animal's metabolism. This means that an animal must eat more. Temperature also affects how much oxygen is dissolved in the water. Gills extract oxygen that is dissolved in water. Higher water temperature means less dissolved oxygen. So for stream animals living upstream of villages, where trees provide shade to keep the water temperature more-or-less constant, their metabolism and ability to extract oxygen is also constant. But in areas open to the noonday sun, the water temperature may rise. This, in turn, stresses an animal in two ways: it makes it hungrier and makes breathing more difficult. And any organic waste, such as sewage, further depletes water of oxygen as it decomposes. As explained in the Introduction, all of our stream animals spend the early part of their lives in the ocean before returning to a stream. Since most of our villages are located at the mouths of streams, the returning animals must pass through this section on their journey to upstream habitats. If the level of dissolved oxygen is low owing to no shade cover or to sewage, this may hinder an animal's return, especially for slow-moving animals such as snails.

Some of our fishes, such as gobies, are herbaceous, that is, they eat plants such as algae growing on stream rocks. Others, such as kuhlids, are predators. They feed on other fishes, shrimps, and small animals found in or along streams.

* **Fish** is both singular and plural. In referring to different species, **fishes** is used.

Neritina variegata **Lesson, 1831**



Snails (Neritidae)

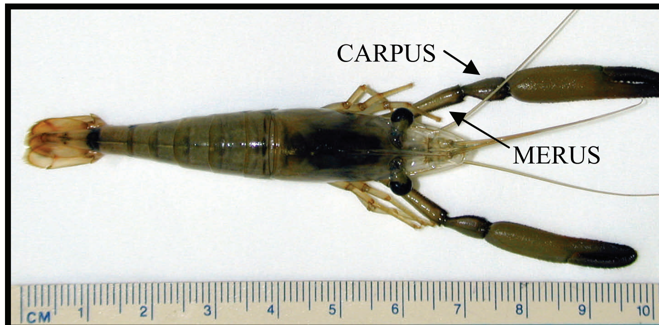
Septaria sanguisuga (Reeve, 1856)

Shell: Dark brown, oblong-ovate, sometimes with a fine network of black lines. The SHELL LIP is tinged orange, while the inner shell lining is white.

Operculum: Internal. Orange with two horns of nearly equal length.

Habitat: Infrequent on rocks in flowing water. Usually found on walls of waterfalls. Uncommon.

Internal operculum. *S. sanguasuga* sliced lengthwise to expose the inner operculum. The ANTERIOR, or front, of the snail lies to the right and the VENTRAL, or bottom, of the snail lies below.



Top: Top view of *M. latimanus* showing relative lengths of the CARPUS and MERUS of the second PEREOPOD.

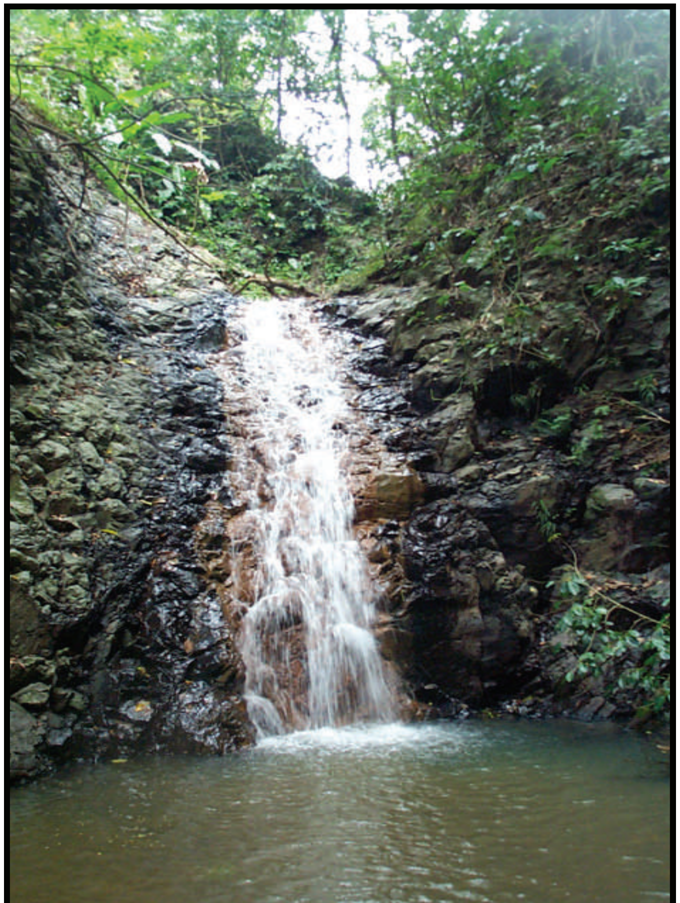
Bottom: Another top view of *M. latimanus* showing dominant CHELATE on opposite arm to the specimen above.

Possible unidentified species. The shrimp, above, shares the robust PROPODUS typical of *M. latimanus*. However, the CARPUS and MERUS are of similar length, and the eyes are positioned closer together. We collected only a single specimen of this shrimp and sent it to the Netherlands for identification. Unfortunately, it was lost in the mail before arriving at its destination.

Shrimps (Palaemonidae)

Macrobrachium latimanus (von Martens, 1868)

CARPUS of second PEREOPOD: Length shorter than MERUS.



Falls are vertical drops of water flowing over erosion-resistant rock. They are common near the headwaters of canyons. They form a plunge pool at their base.

Septaria sanguisuga **(Reeve, 1856)**

Snails (Neritidae)

Septaria suffreni (Récluz, 1841)

Shell: Yellow-brown, oblong-ovate, with variable markings ranging from transverse wavy lines, triangles, or zig zags. The SHELL LIP may be tinged yellow to orange.

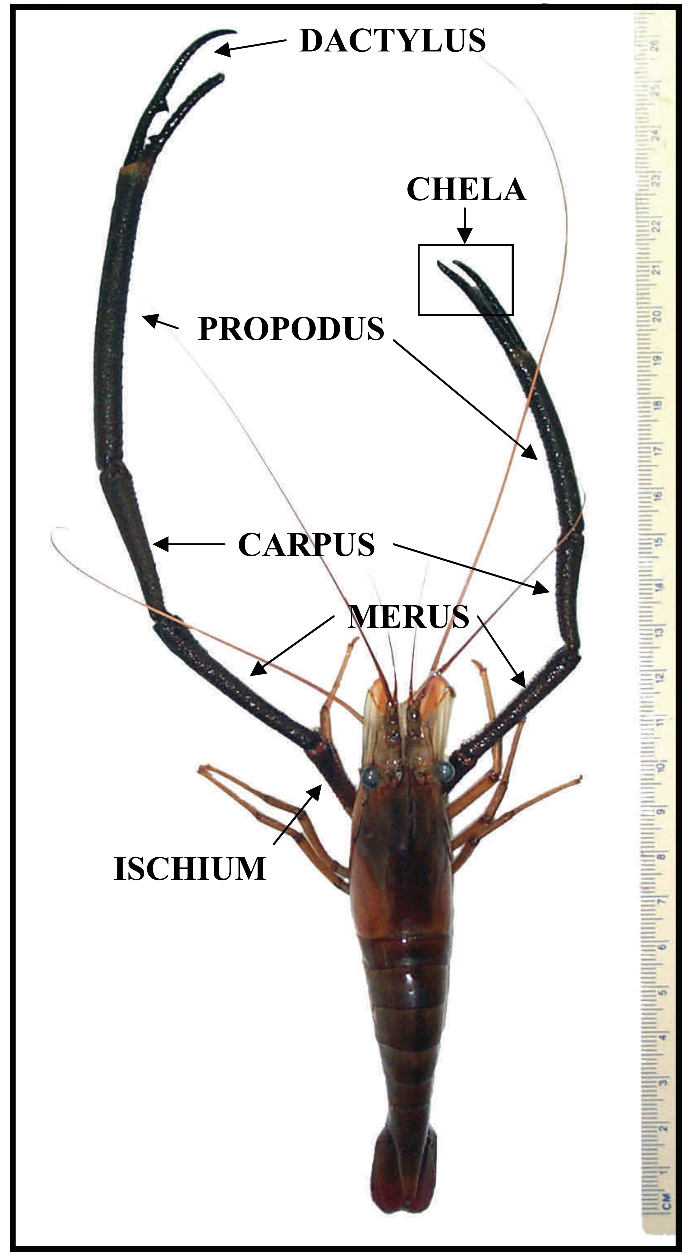
Operculum: Internal. Orange with one horn.

Habitat: On rocks in pools and flowing water. Common.

Identification: The two species of *Septaria* that are found in our streams—*S. sanguasuga* and *S. suffreni*—are most easily distinguished by the color of their fleshy foot. That of *S. sanguasuga* is pale yellow (previous page) while the foot of *S. suffreni* (opposite page) is gray. This is helpful when the shell, which is distinctly different for both species and the better way of differentiating them, is covered by a thick algal film.

An interesting feature about *S. suffreni* is that the edge of the SHELL LIP of the male snail has a tongue-like projection (shown on the opposite page). The edge of the female snail is straight, similar to that of *S. sanguasuga* (previous page). The sexes also differ in that the OPERCULUM of the male is narrower than that of the female (shown on the opposite page).

S. suffreni is more common than *S. sanguasuga* on stream rocks, while *S. sanguasuga* is the more common species on waterfall walls.



Shrimps (Palaemonidae)

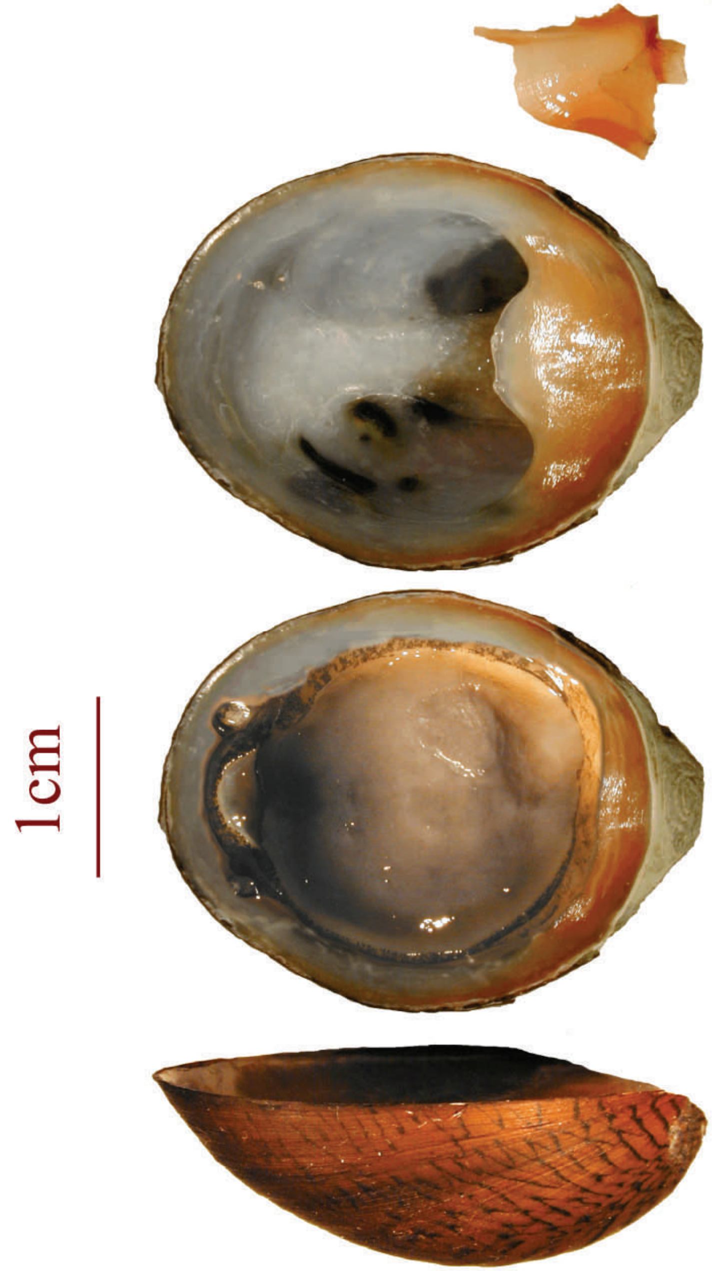
Macrobrachium lar (Fabricius, 1798)

CARPUS of second PEREOPOD: Length equal to MERUS.

Top: A *M. lar* BERRIED female carrying developing larvae. Inset: Another female carrying bright orange-red eggs.

Right: A mature *M. lar* male with formidable CHELA. *M. lar* is the second most common palaemonid shrimp found in our streams. Large males, such as that at right, are much less common, though, than females and immature males.

Septaria suffreni (Récluz, 1841)



Shrimps

Shrimps, or ula vai, are the most abundant large animals in our streams. Most are smaller than a few centimeters and are well camouflaged, making them difficult to see. Others, belonging to the genus *Macrobrachium* (“large arm”), are easy to see because of their larger size and bold behavior.

Whether small or large, all are decapods, that is, they have five pairs of legs. The first two pairs of legs, or PEREOPODS, subdivide our shrimps into two families: atyids and palaemonids. For atyids, the tips of these legs resemble artist paint brushes. For palaemonids, the tips are pincers. Brushes and pincers determine how and what shrimps catch as food.

Atyids catch food in two ways: in quiet pools or slow-flowing water, they pick up organic debris from the bottom much as you pick up objects from the ground while keeping your fingers stiff. More often, though, they aim their brushes into the current and open them much like an inverted umbrella. They then catch fine particles trapped on the hairs of their brushes. Most of their food, therefore, is plankton and tiny particles filtered from the current.

Palaemonids, too, often pick up debris from the bottom. They can also shred large pieces of plant material that is inaccessible to atyids. More importantly, they can capture and shred smaller animals, such as atyids. As hunters with well developed pincers for digging, predation, and defense, palaemonids are aggressive. Atyids, on the other hand, are shy and elusive.

All of our shrimps have a CARAPACE topped with a ROSTRUM, which aids in their identification. Also of importance in identification is the anatomy of the second pair of PEREOPODS. For the atyids, a 10x magnifier may be needed to examine the ROSTRUM and PEREOPODS. Because this booklet is intended for identifying living or freshly killed specimens, it ignores many identifying features used by taxonomists. The professionals must often rely on long-dead specimens preserved in alcohol or formalin. These specimens lack colored features used here. So professional taxonomist must use their detailed knowledge of crustacean anatomy to view features that may require a stereomicroscope to see.

Shrimps (Palaemonidae)

Macrobrachium gracilirostre (Miers, 1875)

CARPUS of second PEREOPOD: Length equal to MERUS.

M. gracilirostre is easily recognized by its conspicuous brown and blue stripes. When viewed from above while in the stream, however, the tan "saddle" behind the CARAPACE is the more obvious marking.

We found *M. gracilirostre* only in Vaialae Stream, Utumea, and in Vaisa Stream, Aloautuai.

Cook (see For Further Reading) reported finding *M. hirtimanus* in Laufuti Stream on Taú Island of the Manua Island Group. Fransen states: "It is very unlikely that *M. hirtimanus* (Olivier) has been recorded from Samoa. The species type-locality is in the Indian Ocean and the species seems restricted to Mauritius and Reunion. *M. hirtimanus* very much resembles *M. lepidactyloides* and *M. gracilirostre*." Neither *M. gracilirostre* nor *M. hirtimanus* was reported by Devaney (see For Further Reading).

Pools form by the scouring action of water upstream of blockages, such as this man-made reservoir.

Living specimens have dark markings that are lost shortly after death. If preserved in alcohol, the shrimp first turns yellow-orange. This color is due to astaxanthin, a vitamin source that the shrimp acquires from eating plants. Once the astaxanthin dissolves in the alcohol, the shrimp is pale white.

Males are generally larger than females. The five pairs of legs, or PEREOPODS, of males are set close together where they join the body in nearly parallel lines. In females, a wide gap separates the last pair of legs.

Shrimps have a hard exoskeleton made of protein and chitin, a polysaccharide that is analogous to cellulose. The exoskeleton must be discarded in order for the shrimp to grow. This process, called MOLTING, happens several times throughout the life of a shrimp. During and shortly after each molt, the shrimp is especially vulnerable to predators. Lost body parts may be incrementally regenerated with each successive molt.

A female attaches her fertilized eggs to the underside of her tail. Such an egg-bearing female is called BERRIED. She protects and cares for her many eggs until they hatch. The larvae are then released to drift to the ocean. They cannot survive in fresh water beyond a few days.

Shrimps generally move forward by walking. They can move very quickly backward, though, if threatened. They do this by flipping their fan-shaped tail.

They have well developed compound eyes. They also have two pairs of feelers, which taste the water to locate food.

Both atyids and palaemonids are edible. Much of the information about palaemonid biology in this booklet, when unavailable for the species under discussion, comes from the commercial production of the Malaysian Prawn, *Macrobrachium rosenbergii*.

Kingdom Animalia
Phylum Arthropoda
Class Malacostraca
Order Decapoda
Family Palaemonidae
Genus *Macrobrachium*
Species *lar*

Newly hatched shrimp larvae. Larvae are easily collected with a plankton net as stream drift (below). Their eyes are proportionally much larger than those of adults. Larvae swim tail-first and upside down. They are attracted to light; a behavior known as "phototaxis."

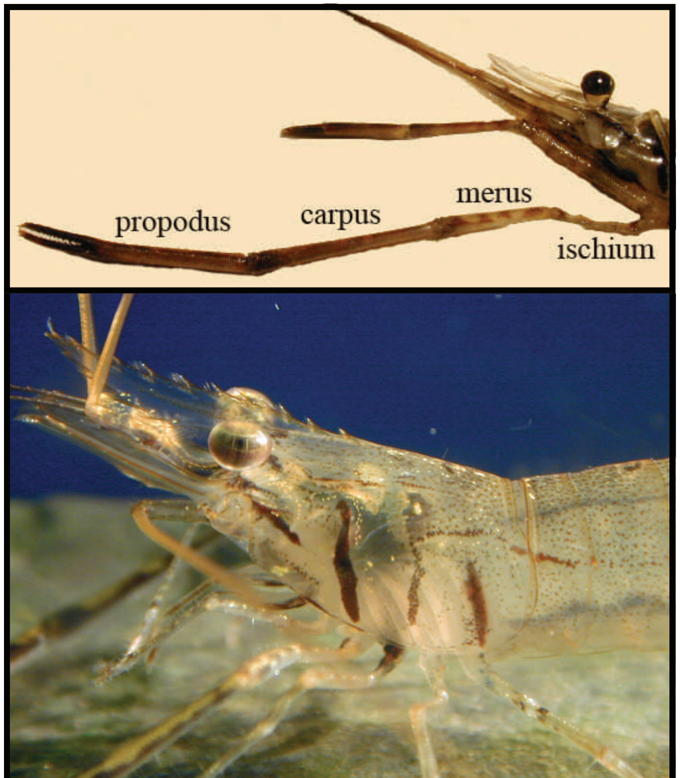
Top: *M. australe*, BERRIED female. Specimens invariably have a hyaline appearance, often with distinctive brown markings.

Bottom: Devaney (see For Further Reading) identified this shrimp as *Macrobrachium* sp. aff. *australe*, that is, it has an affinity to this species. His caution may have been due to specimens of juveniles now referred to as the 'lepidus' stage of *M. australe*.

Shrimps (Palaemonidae)

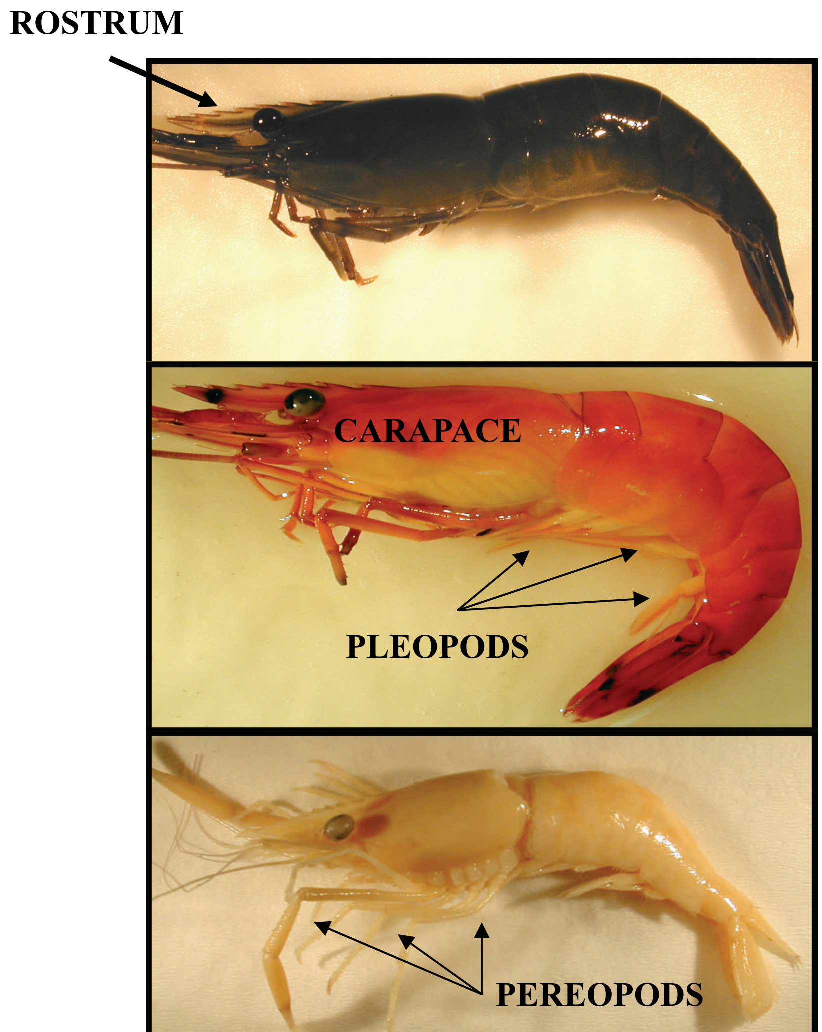
Macrobrachium australe (Guérin-Méneville, 1838)

CARPUS of second PEREOPOD: Longer than MERUS.



Top: Relative lengths of CARPUS and MERUS.

Bottom: Although a glassy body is the immediate characteristic for identifying *M. australe*, most larger specimens show three brown vertical stripes on each side of the CARAPACE and one stripe forward of these three, but at an angle.



Loss of markings. When preserved in alcohol, shrimp lose the markings that are useful for the identification of fresh specimens. The top panel shows a newly killed *M. lar*. The middle panel photo was taken after 24 hours in 70% ethanol. The orange astaxanthin is clearly visible. The bottom panel is of a different shrimp preserved for over a year. All trace of astaxanthin is gone along with any markings .

Shrimps (Atyidae)

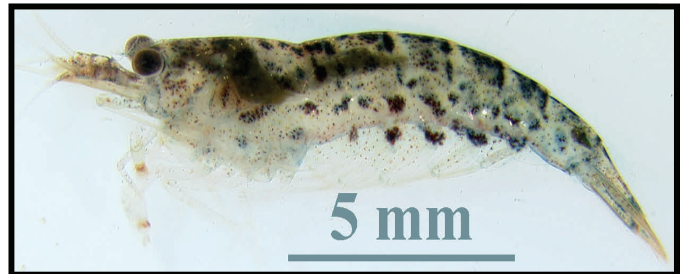
Atyoida pilipes (Newport, 1847)

Fingers of CHELAE:	Brushes.
Size:	4 to 5 cm.
LATERAL markings:	No striking pattern.
CARPUS of second PEREOPOD:	Width greater than length.
CARAPACE spine:	Absent.
Identification:	The easiest way to identify *A. pilipes* is to ensure that it is not *Atyopsis spinipes*, that is, it does not have a pattern of horizontal lines along its sides. These two species are our only large atyids.

Taxonomic note:

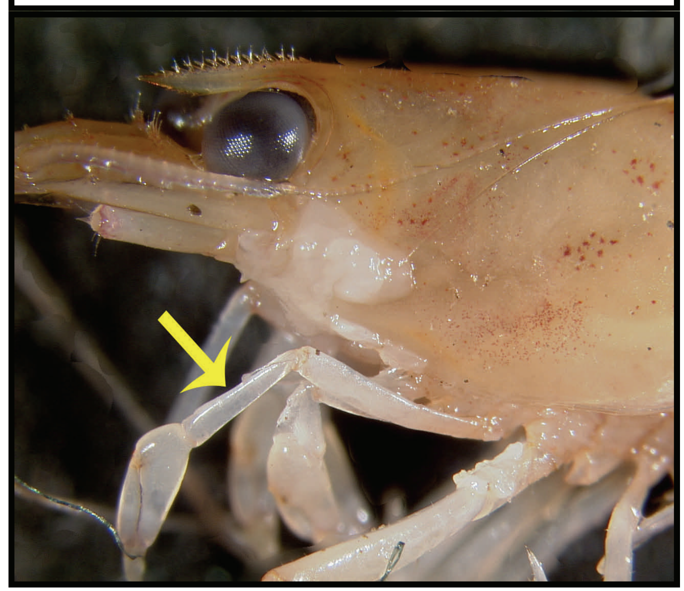
A 1980 key to freshwater crustaceans of American Samoa by Devaney (see For Further Reading) listed *Atyoida pilipes* as *Atya serrata,* and it listed *Atyopsis spinipes* as *Atya spinipes*. Fransen responded (Note from Fransen, 14 Sep 2004):

"In *Atyoida*, the third maxilliped has a terminal spine which is absent in *Atyopsis*. In *Atyoida pilipes* the rostrum is bent somewhat ventral and the pterygostomian margin bluntly acute. In *Atyoida serrata* the rostrum is nearly horizontal and the pterygostomian margin sharply acute, spinous."



Top: *C. weberi* is the most common *Caridina* spp. found in our streams. It can easily be collected using a kick net, indicating that it prefers to hide among small stones and cobbles. This behavior is also seen in aquaria provided with such a substrate.

Bottom: The shorter ROSTRUM, compared with that of *C. serratirostris*, easily distinguishes these two species. Likewise, the presence of "teeth" on the upper edge of the ROSTRUM of *C. weberi* distinguishes it from the "untooth" *C. typus*. This photo also clearly shows the long CARPUS (yellow arrow) of the second PEREOPOD.



Shrimps (Atyidae)

Caridina weberi De Man, 1892

Fingers of CHELAE:	Brushes.
Size:	10 to 15 mm.
ROSTRUM:	Upper edge has teeth that extend backwards no further than the eye.
CARPUS of second PEREOPOD:	Length greater than width.

Run is a section of the stream where the water flows without turbulence. The gradient is similar to that of a riffle, but the water is deeper. Consequently, the underlying cobbles do not disturb the water surface.

TOP: In the field, *Atyoida pilipes* can readily be distinguished from *Atyopsis spinipes* by the absence of a striking pattern of horizontal lines along its side. These two species are the only atyids in our streams that are 4 cm long or longer. They may be found in clusters of several dozen climbing up cascades or up waterfalls. They are a favorite prey of predatory fishes.

Bottom: The two pair of feelers extending forward from the head are used to sense the presence of odors in the water. The brushes on the first two PEREOPODS are slightly open.

Shrimps (Atyidae)

Atyopsis spinipes (Newport, 1847)

Fingers of CHELAE:	Brushes.
Size:	4 to 5 cm.
LATERAL markings:	Strong stripe pattern.
CARPUS of second PEREOPOD:	Width greater than length.
CARAPACE spine:	Present on the ANTERIOR of the CARAPACE. (See white circle in bottom panel of the opposite page.)

Filtering drift. *A. spinipes* exhibiting typical feeding behavior in fast flowing current. The brushes on its first two pair of PEREOPODS are open to catch fine organic particles. It quickly swipes a brush against its mouth and immediately returns it open to the current.

Top: *C. typus* is the least common *Caridina* spp. found in our streams. In fact, we found *C. typus* in two streams only: Fuafua Stream, Malaeloa, and Taumata Stream, Malaeimi Valley. Interestingly, these two streams do not have an uninterrupted connection to the sea. Although they are permanent streams, with running water year-round, their channels are empty for a considerable distance at some point between their headwaters and their mouths. The channels fill only during periods of heavy rainfall.

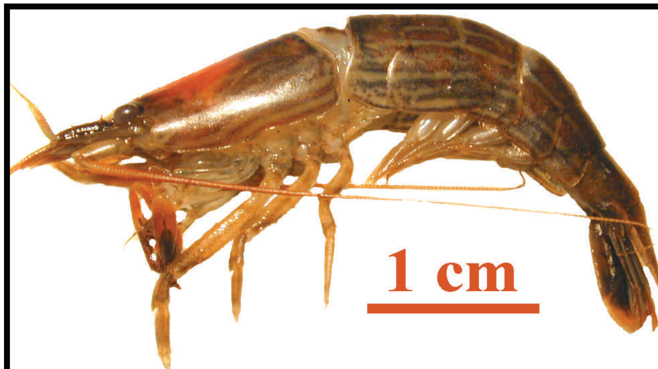
Bottom: The short, smooth upper ROSTRUM edge can be seen between the eyes, and the long CARPUS (yellow arrow) of the second PEREOPOD.

Shrimps (Atyidae)

Caridina typus H. Milne Edwards, 1837

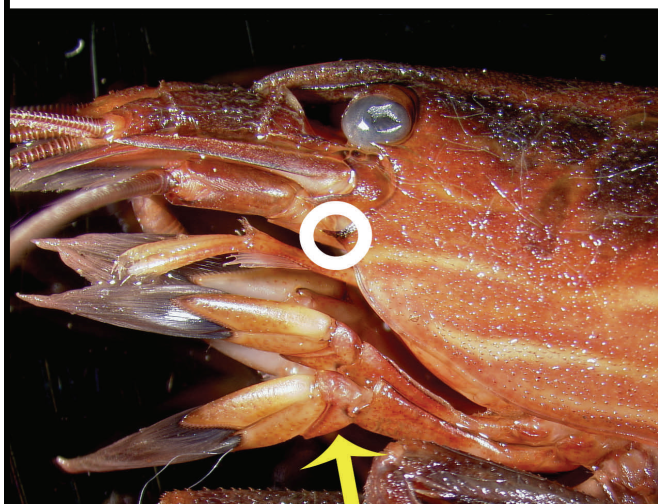
Fingers of CHELAE:	Brushes.
Size:	10 to 15 mm.
ROSTRUM:	Upper edge has no teeth.
CARPUS of second PEREOPOD:	Length greater than width.

Riffle is a stretch of choppy water caused by cobble-sized rocks just beneath the water surface. This is a favorite spot for many of our stream animals.



Top: LATERAL view of *A. spinipes* showing the striping pattern along the CARAPACE and the abdominal segments.

Bottom: Close-up of head and first two PEREOPODS. Note the small spine (white circle, and darkened for emphasis) along the pterygostomian region of the CARAPACE. This spine is absent in *Atyoida pilipes*. Also note the brush-like fingers of the CHELAE. Immediately behind the CHELA is the deeply excavated CARPUS (yellow arrow), which is quite short. Compare the CARPUS of *A. spinipes* and *Atyoida pilipes* with that of *Caridina* spp. on the following pages.



Shrimps (Atyidae)

Caridina serratirostris De Man, 1892

Fingers of CHELAE:	Brushes.
Size:	10 to 15 mm.
ROSTRUM:	Upper edge has teeth and extends backward for at least half the CARAPACE length, well behind the eyes.
CARPUS of second PEREOPOD:	Length greater than width.

C. serratirostris is called the "ninja shrimp" because of its ability to quickly change colors and disappear into its surroundings, like a ninja. Chromatophores, or color markings in its skin, expand or contract to accomplish this feat.

Cascades are areas of fast-flowing, turbulent water that tumbles over and around large rocks on a steep gradient. Atyids and gobies prefer this HABITAT.

Top: *C. serratirostris*, BERRIED female. Note the bright orange cluster of eggs clutched within the PLEOPODS, or swimmerets, on the underside of the abdomen. Once the eggs develop into larvae, they are released by the female to drift to the sea, where the larvae undergo metamorphosis through several MOLTS.

Bottom: Note the row of small "teeth" along the top edge of the ROSTRUM, the extent of the ROSTRUM behind the eye, and the length of the CARPUS (yellow arrow).