

# WESTERN SAMOA (ILES SAMOA OCCIDENTALES)

by

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## I - GENERALITIES

The Samoan archipelago is located northeast of Tonga in the heart of Polynesia. It consists of 14 volcanic islands surrounded by corral reef barriers. Western Samoa, an independent country, 2 972 km<sup>2</sup>, consists of two large islands, Upolu and Savai'i, and 7 smaller islets. These islands, together with those of geologically related American Samoa, 179 km<sup>2</sup>, increase in age from west to east, Savai'i being the youngest. All the islands of the Samoan archipelago, except for 10 million year old Rose Island - a coral atoll at the eastern end of American Samoa, consist of volcanic rocks. The most recent series of eruptions on Savai'i took place at the beginning of this century (1905-1911).

**Upolu**, 70 by 24 km, is made up of a chain of now extinct shield volcanos with elevations to 1 100 m (Mt Fito). The main mass of Upolu consists of Pliocene basalts known as the "Fangalaoa Volcanics". Eruptions in the Pleistocene and Holocene from cones along the ancient central rift formed flows fanning out radially as they reached the coast.

**Savai'i**, 70 by 45 km, is a massive shield island consisting of broad coalescing volcanic domes topped by numerous cones reaching elevations to 1 858 m. It has a core of Fangalaoa Volcanics, mostly covered by flows of middle to late Pleistocene, Holocene and historic basalts. Three eruptions are recorded during the historic period: one around 1 760 from the volcano Mauga afi with a lava flow of "pahoe-hoe" type; another in 1902 of "aa" type from two craters located NE of volcano Mauga ali; the last in 1905-1911 produced lava tubes in a flow of "pahoe-hoe" type (THOMPSON, 1921).

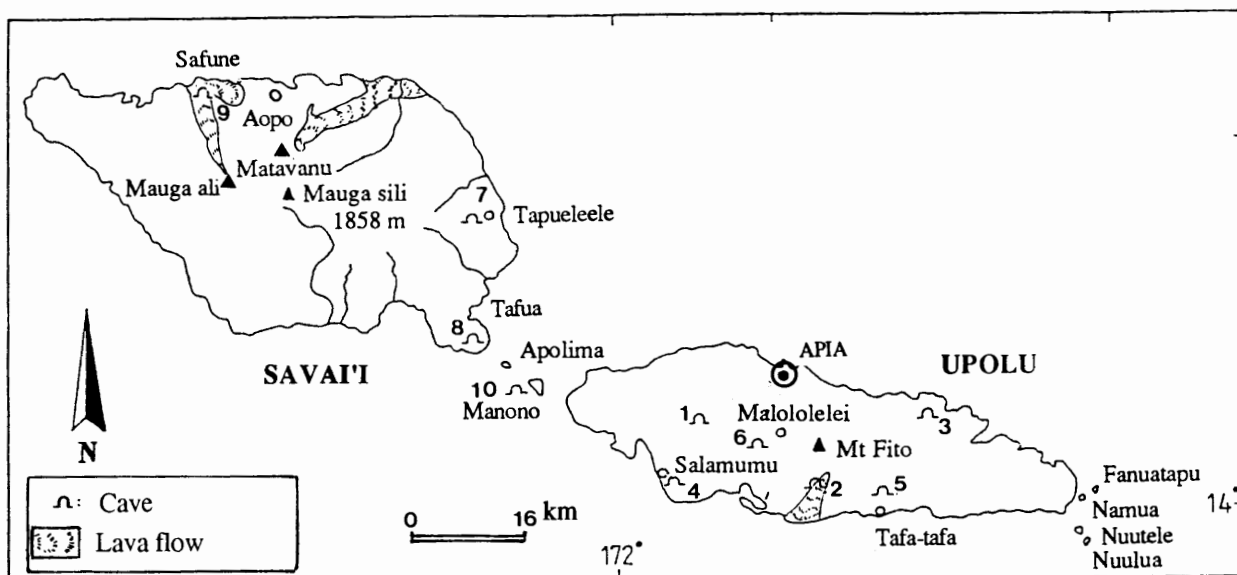


Fig. 1 - Western Samoa and location of several caves. A - Upolu Island. 1 = Falemaunga cave; 2 = Pe'ape'a cave d'O le Pupu (Ollier & Zarrielo); 3 = Piula Cave Pool; 4 = Ana Pe'ape'a, cave near Salamumu (Iliffe & Sarbu); 5 = Ana Pe'ape'a, cave near Tafa-tafa (Iliffe & Sarbu); 6 = Cave near Malololelei (Rechinger). B - Savai'i Island. 7 = O le ana o le nuu te tau (Ana Pe'ape'a at Tapueleele (Bulow)); 8 = Ana o le Malie; 9 = Ana Pe'ape'a at Safune; 10 = Lava tube on Manono island. (Ana = cave).

**Manono** is a small volcanic island between Savai'i and Upolu, 70 m elevation, with barrier coral reef.

**Apolima** is a very small island between Savai'i and Upolu; it is a crater, 6 to 14 m elevation.

**Nuulua, Nuutele, Namua, Fanuatapu** are small islands east of Upolu; one of them consists of stratified tuff that contains coral fragments.

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Due to the young age of these islands and the nature of the lava, numerous extensive lava tubes are present. Many of these lava caves have been known by the local Polynesians for thousands of years as indicated by archaeological investigations. Today, only a few of the more accessible caves are widely known and occasionally visited. Numerous spring caves located along the coast are used as sources of fresh water by the population of the nearby villages. With few exceptions, the coastal spring caves are small and became very low after only a few meters.

## II - HISTORY OF CAVE EXPLORATION

The first cave fauna exploration was by Dr RECHINGER, who collected a new species of Orthoptera described by HOLDAUS (1908) as *Rhaphidophora rechengeri* without precise locality; later BUXTON (1935) found again specimens of this species on guano in a lava tube near Malololelei on Upolu, and reports having collected pseudoscorpions. But the first documented exploration of a lava tube in Western Samoa was Falemaunga Cave, visited by H. SCHROEDER in 1914. This cave was later investigated by members of the New Zealand Expeditionary Force that occupied Samoa in August 1914. J. A. THOMPSON, director of the Dominion Museum in New Zealand, visited the cave in 1920 and J. D. FREEMAN, J. RADFORD and a pilot officer, J. D. COULTER, also visited this cave in 1941. A detailed description of the cave is given by L. STEWARD in 1974. STEWARD also visited the Piula Cave in April 1979. OLLIER & ZARRIELLO explored and described the Ana Pe'ape'a lava tube on Upolu. Aside from a few references to caves contained in archaeological reports, no other serious speleological studies have been conducted of the Samoan lava tubes. Two of the authors (ILIFFE & SARBUS) explored and investigated 17 caves and springs in Western Samoa in April 1988 as part of a year-long scientific expedition sponsored by the National Geographic Society. A total of 8 970 m of cave passage were surveyed during the expedition. Samples of aquatic and terrestrial cave fauna were collected from all the visited lava tubes.

## III - THE LAVA TUBES AND CAVE FAUNA

### III. 1 - The Island of Savai'i

The island of Savai'i has several well known caves with notable legends and taboos. Near Paia, a lava tube was used as a refuge by a non-fighting tribe who named the cave "o le ana o le nuu le tau". Numerous additional caves, hidden by thick jungle, may still lie unexplored.

Many of the Samoan caves are inhabited by large numbers of swifts - **Pe'ape'a** (*Collocalia spodiopygius*) - that gave their name to most caves. Swifts build 8-10 cm diameter nests constructed of moss on the cave walls. They are found throughout the caves, to the deepest sections. One or two eggs, incubation period 22-25 days and shared by both parents. They use echolocation for orientation, producing sounds that resemble those of Geiger counters.

Bats, called **tagiti** by the locals, are also commonly found in the Samoan caves. Their heaps of guano are sometimes ecologically important.

**Ana Pe'ape'a at Tapuele'ele** (O le ana o le nuu te tau) is situated about 6 km inland (fig. 1, 7) and is one of the deepest caves on Savai'i. Its entrance is in a sinkhole 100 m in diameter and 25 m deep from which an imposing tube stretches into the darkness. At the lowest level, a lake, 30 m long and over 2 m deep, makes swimming necessary. On the far side of this lake, a steep breakdown slope ascends to the largest chamber of the cave. After a total of 370 m of passage with diameters of 10 to 15 m, the tube ends in a breakdown and guano choke. Total depth of the cave is 74 m. The cave is inhabited by a large population of swifts and bats that have produced thick layers of guano covering the floor in many sections.

**Ana o le Malie** is named after a rock near the entrance that supposedly resembles a shark. This cave, an example of stream capture by a lava tube, is situated about 5 km west of the Samaile on the eastern edge of Savai'i (Fig. 1, 8). The underground stream is especially large during rainy periods when it forms impressive waterfalls within the cave. After exploring 342 m of walking passage, further progress was halted by a deep lake and shear wall on the far side. According to local guides, the stream sink entrance to this cave is located about 1 km upstream. Fauna: copepods, ostracods. Another cave, **Ana o le Imoa** is located 2 km to the north.

**Ana Pe'ape'a at Safune** is located 300 m inland from the north coast (fig. 1, 9). It is the only known lava tube on Savai'i that continues underwater towards the sea. As no diving equipment was available on the island, the exploration was stopped at the downstream (in the direction of the lava flow) sump. Upstream, an easy walking passage abruptly ends in a pile of breakdown. The total explored length of the cave is 317 m. Fauna: ostracods, tanaidaceans, and a stygobitic amphipod, *Liagoceradocus lobiferus* Stock and Iliffe, 1991, were collected in the lake's brackish waters (salinity: 1-1,5 g/l).

**Saleolonga Burian Cave** is a short segment of a lava tube, partially filled with sediment. A narrow, 2 m deep, crack permits access to the 123 m long cave. The downstream section becomes very low, while the upstream passage ends in breakdown. Several human skeletons, bordered by stones, are laid out along the walls of the cave. Fauna: spiders.

**Lala Spring** is located 200 m inland from the south coast at Papa. This 10 m long, 5 m wide and 1 m deep pool is situated at the base of a 5 m high coastal cliff beside the main coastal road. A section of the pool extends back into darkness where the water flows out from a narrow hole. This water disappears again at the opposite edge of the pool. Fauna: *Macrobrachium* sp. shrimp and fish - neither stygobitic.

**Se'ese'e Spring** is a short spring-cave which becomes too low after 12 m. Several species of surface fresh-water fishes were observed in the stream. Fauna: *Macrobrachium* sp. shrimp and fish - neither stygobitic.

**Ana Va'atausili** is single, 2 m diameter chamber, occupied by a 2 m deep pool. The cave is taboo for the locals as it contains red water, which according to legend represents the blood of the warriors who died here in battle. The color of the water actually results from the presence of an extremely dense population of tiny crustaceans (Cladocera) living in the pool. Fauna: cladocerans, copepods, ostracods.

**Moa Cave** is located near Sataua, in a 100,000 year old lava flow (KEAR & WOOD, 1959). A troglitic meenoplid homopteran, *Suva oloimoa* Hoch and Asche 1988, with rudimentary eyes and unpigmented, living on roots of *Ficus benghalensis* was collected in the deep zone of the cave (see Hoch "Homoptera", Tome I).

### III. 2 - The Island of Upolu

On the island of Upolu, several caves situated close to the coast contain submerged passages.

**Piula Cave**, the best known of these, is located 24 km east Apia (fig. 1, 3). The cave has two entrances, one of them being used as a swimming pool by the locals and by tourists. Through a short sump, one can reach a larger cave room occupied by a lake; this room is also accessible through the entrance. At the far end of the lake, the passage continues underwater at an average depth of 3 m. This gallery is very low and the bottom covered by thick silt. Underwater exploration was stopped after 65 m where the passage becomes too narrow. Fauna: collembola, *Macrobrachium* sp. shrimp and fish - none stygobitic.

**Vailoa Spring** is located 30 m inland from the east coast at the village of Vailoa. The spring consists of a 0.5 m deep pool extending back under an overhanging cliff. Fauna: *Macrobrachium* sp. shrimp, fish and amphipods - none stygobitic.

**Tosua-Tolesua** are two adjacent sinkholes which are actually windows in the ceiling of a large diameter lava tube. This is one of the most impressive caves of the island. The only non-vertical entrance to this lava tube is through an underwater passage opening onto coastal sea cliffs. By free diving a 7 m long and 2 m deep sump from the sea, one can reach a section of the tube occupied by a lake containing sea water. The cave continues inland to a second gaping window in the ceiling, the Tolesua sinkhole. A natural wall of breakdown beneath this window blocks access to any further upstream sections of the cave. Fauna: amphipods; a new alpheid shrimp: *Hamalpheus acanthops* (Fig. 2), described by BRUCE & ILIFFE (1991).

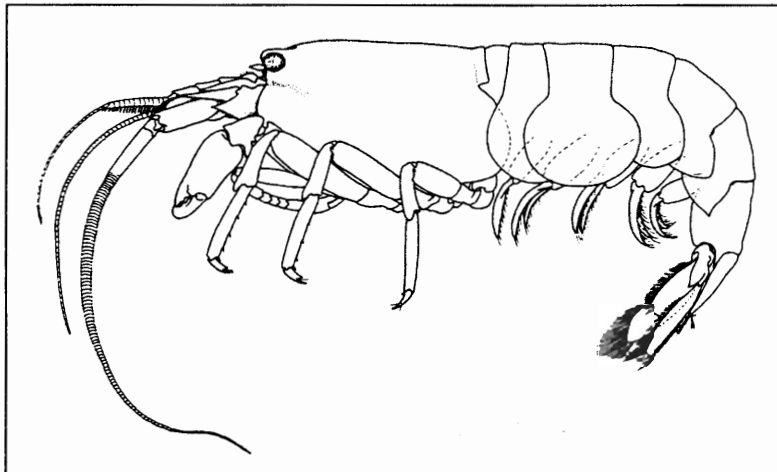


Fig. 2 - Decapoda Alpheidae. *Hamalpheus acanthops* Bruce & Iliffe, 1991 (After the authors).

**Ana Pe'ape'a at Tafa-tafa** is one of the longest caves in Western Samoa (fig. 1, 5). Its entrance in the Tafa-tafa village consists of a small collapse hole in the roof of the tube. Upstream (in the direction of the lava flow) from this entrance, the cave consists of broad passages inhabited by numerous swifts and bats. Towards its end, the tube becomes narrow. Lava stalactites are visible in some places. The section of the cave downstream from the entrance heads towards the sea. A lake with very clear water (23°C temperature) begins where tube reaches the water table with the tube sumping 40 m further. The underwater passage was explored by diving for 110 m but further progress was stopped by a huge lava boulder that blocks the whole tube except for a small window. By shining a light through the window, it could be seen that the cave continues. Fauna: terrestrial isopods and two species of shrimp, including *Macrobrachium microps* Holthuis (Fig. 3) (BRUCE &

ILIFFE, 1993), from bare rock bottom of an anchialine pool, temperature 23°C; species with reduced eyes and small well pigmented cornea, known from New Ireland (HOLTHUIS, 1978).

The other caves on Upolu island are located far from the seashore, while some are high in the mountains.

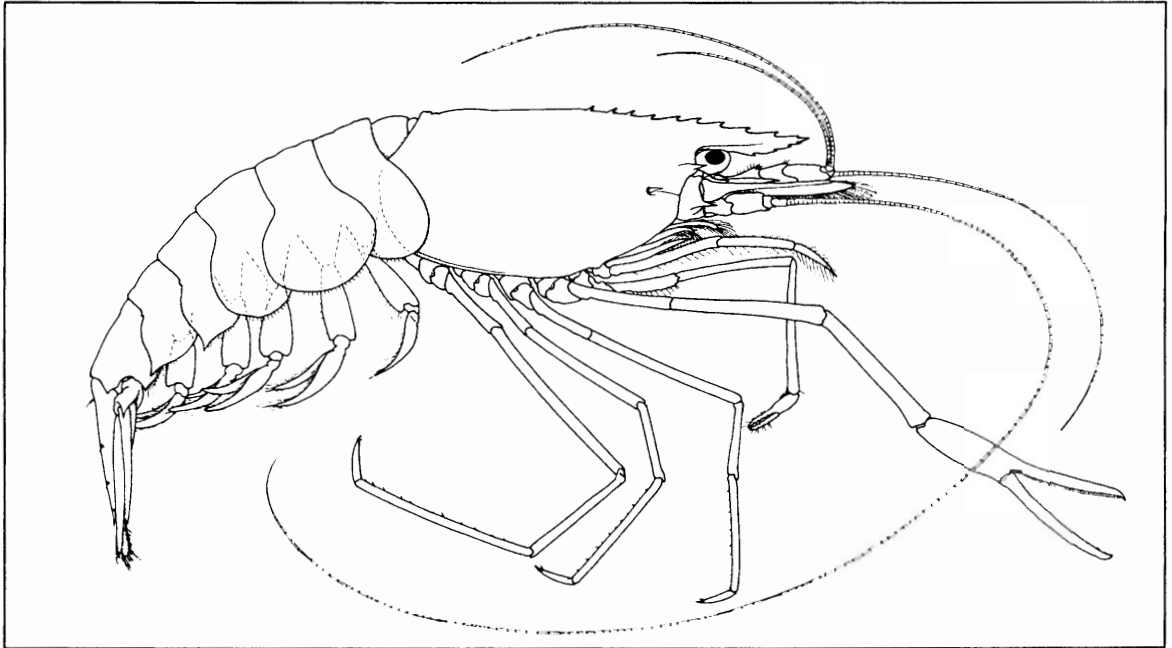


Fig. 3 - Decapoda Palaemonidae. *Macrobrachium microps* Holthuis (After Bruce & Iliffe, 1993).

**Falemaunga Cave** is located 10 km southwest of Apia (fig. 1, 1) and consists of two tunnels: a northern tunnel 429 m long dividing in two branches and a southern tunnel 350 m long. The cave also shows evidence of human occupation. Fauna: medium size bat colony; swifts.

**Malololelei Cave** (fig. 1, 6) is located near Malololelei at an altitude of 600 m and can be explored for about 200 m. A stream enters it and runs inside. The temperature is 22.5° C.

Bats and swifts form an important part of the fauna. Hundreds of bats, *Emballonura semicaudata*, an insectivorous species, live in the cave at all times of year. They were infested by a Diptera streblid, *Nycteribosca buxtoni* (Fig. 5). The swifts, *Collocalia spodiopygius*, construct minute nests of moss and liverwort on shelves upon the walls of the cave.

A pseudoscorpion, *Haplochernes buxtoni* (Kästner, 1927), described from this cave, was collected on sections of the floor above stream level.

On the heaps of bat dung, one finds the endemic Orthoptera, *Rhaphidophora rechengeri* (Fig. 4), described by HOLDHAUS (1908), red-described by CHOPARD (1929), with reduced eyes.

A spider Pholcidae, *Pholcus ancoralis* L. Koch, 1865, was collected in total darkness. A Decapoda Atyidae, *Caridina typus*, is common in the stream; stygophilic.

**Ana Pe'ape'a in the Togitogiga Park** (fig. 1, 2) is one of the attractions of Western Samoa's first National Park, although a guide

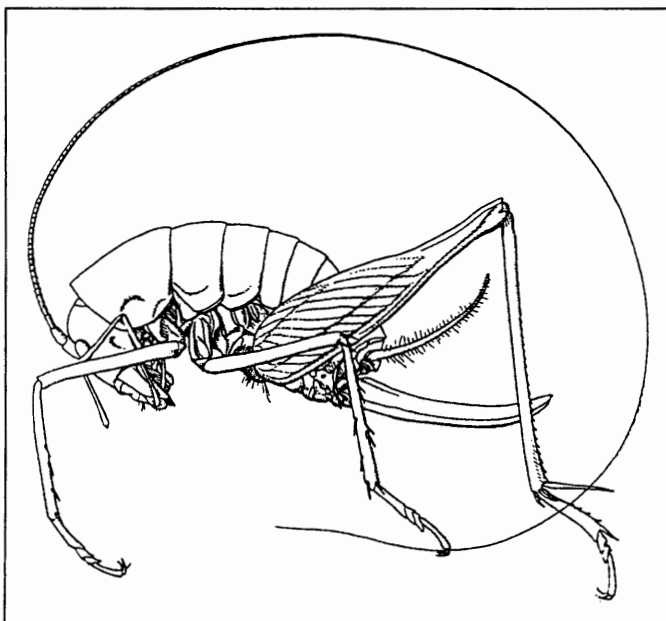


Fig. 4 - Orthoptera. *Rhaphidophora rechengeri* Holdhaus, 1908 (After Chopard, 1929).

is necessary to locate the cave. Approximately 3000 years ago, basaltic lava descended from Mt. Fito along a narrow valley and fanned out upon reaching the coastal plain. A 1.4 km long lava tube formed where the lava flow becomes larger. During the rainy season, the Pala river coming down from the mountainous central spine of the island is captured by this lava tube. The floor of the cave has been washed free of sediment and breakdown. Several collapse windows are present in the roof of the tube. The total explored length was 1 459 m, but down-

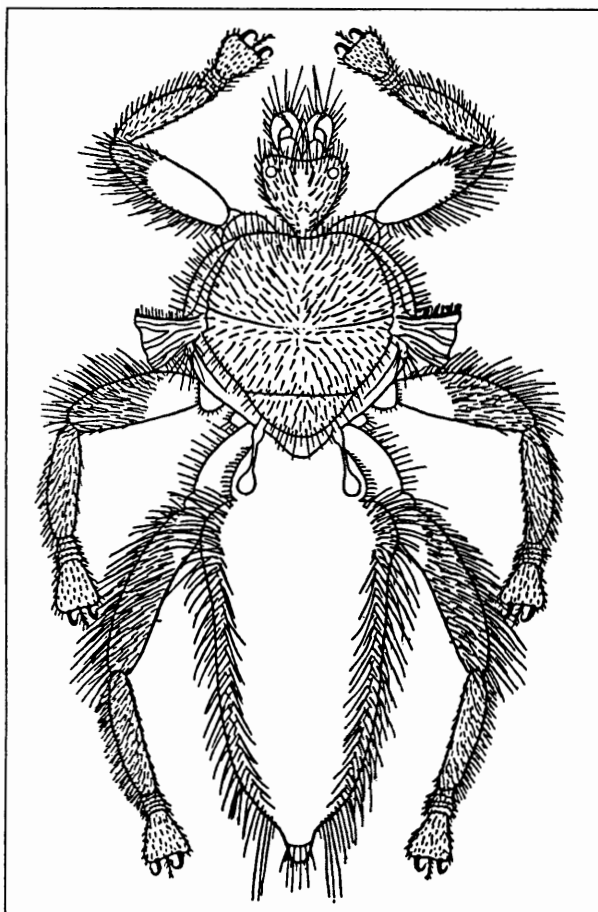


Fig. 5 - Diptera Streblidae. *Nycteribosca buxtoni* Falcoz, 1927 (After the author).

stream passages still continued. Fauna: at the time of our visit, numerous pools in the cave contained crayfish and some eels (*tuna*). Several thousands of bats (Sheath-tailed bat thousands of bats (Sheath-tailed bat = *tagiti*) and *Collocalia* (Swifts) are present.

**Ana Pe'ape'a at Salamumu** (fig. 1, 4) starts under the main road along the southern coast of the island near Salamumu village. The entrance is partially blocked by an old man-made stone wall. The average diameter of the tube is 8 to 10 m. Over the first 800 m of the tube, level, artificially constructed "sleeping platforms" are present along the walls. According to the estimates, the cave could have served as a refuge for hundreds or even thousands of people during times of war. In many places, lava stalactites hang from the ceiling. Swifts (*Collocalia*) and bats are present in much of the cave and in some places, the floor is covered by thick layers of guano. After the first 1.5 km of passage, the cave begins to branch and becomes a labyrinth of passages which eventually end. This section of the cave might have been near the edge of the flow and causing the lava to branch out in the form of a delta. Particularly unusual was the observation in sections of the tube situated far from the entrance of lava boulders with the consistency of soft cheese. Boulders the size of a table were unable to support the weight of a person such that you would sink to your knees with every step. This might be the result of some chemical or microbial alteration of the lava under the influence of water infiltrating into the tube from the surface. Total explored length: 3 487 m - the longest cave in Western Samoa.

**Ana Pe'ape'a at Fale'ase'ela** is located about 3 km inland from the south coast at an altitude of approximately 200 m. A collapse window bisects the cave into two parts. The upstream section is short and ends in a pile of breakdown. Downstream, the cave is more complex with parallel interconnected passages and lava flow visible on the floor. Several sleeping platforms are located near the downstream entrance. The ceiling lowers and lava completely fills the passage at the downstream end. The total explored length of the tube is 812 m. Fauna: a few bats and swifts.

**Ana Tausangi** at Mulifauna is situated in a large coconut plantation. This cave is entered through a small hole at the bottom of a sinkhole near the upstream, breakdown-blocked terminus. Downstream, the cave ends after 121 m in sediment fill. As the tube lies very close to the surface of the ground, numerous tree roots penetrate into the tube and hang down from the ceiling. Several apparently ancient sleeping platforms and a small well are present in this cave. Fauna: spiders.

### III. 3 - The island of Manono

A lava tube, at sea level, is located on the western coast (Fig. 1, 10) (FRIEDLANDER, 1910).

Tabl. 1 - Cave species of Western Samoa.

<b>Amphipoda</b> Hadziidae <i>Liagoceradocus lobiferus</i>	<i>Pholcus ancoralis</i>
<b>Decapoda</b>	<b>Orthoptera</b> Rhaphidophoridae <i>Rhaphidophora rechingeri</i>
Alpheidae <i>Hamalpheus acanthops</i>	<b>Homoptera</b> Meenoplidae <i>Suva oloimoa</i>
Atyidae <i>Caridina typus</i>	<b>Diptera</b> Streblidae <i>Nycteribosca buxtoni</i>
Palaemonidae <i>Macrobrachium microps</i>	<b>Aves</b> Apodidae <i>Collocalia spodiopygius</i>
<b>Pseudoscorpiones</b> Chernetidae <i>Haplochernes buxtoni</i>	<b>Chiroptera</b> Emballonuridae <i>Emballonura semicaudata</i>
<b>Araneae</b> Pholcidae	

## IV - LIMESTONE AREAS

Savai'i and Upolu have several small coral sand plains, with unexplored ground water.

## V - CONCLUSION

It can be concluded that the biological investigation of the Samoan caves is still in a preliminary phase. So far, studies show that both the terrestrial and aquatic (freshwater and anchialine) fauna appears to be rich and consisting of local and regional endemics.

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