

White-rumped Swiftlet Breeding Colony Size and Colony Locations in Samoa

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Abstract

This paper describes the breeding and roosting caves used by the White-rumped Swiftlet (*Aerodramus spodiopygius*) on Upolu and Savai'i, Samoa. Because these sites tend to be permanent and often difficult to locate, their locations and other information to help find them are provided as a guide for future workers. This study lasted four years and followed close after two devastating cyclones (Val & Ofa) so the data can form the basis for further study once the populations have fully recovered and equilibria for the populations is reached.

Keywords: *Aerodramus spodiopygius*, Swiftlet colony, Lava caves, Samoa

Introduction

Swiftlets are smaller members of the Swift family [Apodidae] and like the larger members they fly all day without landing except to incubate eggs and feed young when breeding. Although they do not migrate like many of the swifts, swiftlets in the genus *Aerodramus* can echolocate accurately enough (albeit using audible frequencies) to build nests in totally dark portions of caves. The best-known swiftlets are probably the two species that produce edible nests in South-east Asia and are of great economic importance (Lim and Cranbrook, 2002). They both nest in large caves such as Niah Cave in Borneo: one (*A. fuciphagus*) producing a white nest from pure saliva and the other (*A. maxima*) adding breast feathers to the saliva to produce a "black" nest.).

The White-rumped Swiftlet (*Aerodramus spodiopygius*) is the most widespread swiftlet in the South Pacific, extending from Queensland, Manus and New Britain through New Ireland, Bougainville, Solomon Islands, Vanuatu, New Caledonia, Fiji, Niue, Tonga, and Samoa. The swiftlets on Atiu in the Cook Islands, Tahiti and the Marquesas are closely related though no one has made definitive comparisons with either morphological or DNA tools. Although the nominate subspecies was described from Samoa (Peale, 1848) it was not studied subsequently in that country prior to this (Tarburton, 2009). Peale, who was the first to describe the species, was taken to a single cave by the newly appointed and just arrived British Consul, where "he collected ... birds and reported on ... nests" and suggested that the clutch size was probably one (Peale, 1848).

Since then ornithologists have visited caves containing breeding colonies but have made very few useful observations mainly because almost all visits were one-off events made by persons unfamiliar with swiftlet behaviour and usually not well equipped to work in cave situations. An historic summary follows to help place the little published work in perspective.

- Whitmee (1875) visited a cave on 25 November 1874 where the "Cave Swallow" was plentiful and concluded from finding only young in the nests and none containing eggs, that the swiftlet "must breed very uniformly".
- Rollo H Beck observed swiftlets and 50 nests built of moss in a 300 foot-long lava cave near the Maloleilei Rest Home [7]¹ six miles inland from Apia (Beck, n.d). This was 23-29 April 1924 and "fresh eggs and young swifts of all sizes as well as fresh nests were seen". There is some confusion here, for Correia, who worked with Beck, states that "Mr Beck found young swifts at Savai[i] island in Samoa, but never any eggs" (Correia, n.d.).
- Armstrong (1932) did not agree with Whitmee's assertion that their breeding was very synchronised. He recorded that the breeding season seemed to be from November to June; and that by the end of June the birds "had practically forsaken the tunnels".
- Crossin (Univ. Kansas Museum Records per David Seibel) found new empty nests, nests with eggs, and nests with young at all stages on 6 November 1968 in Tafatafa Cave [2]. Some were 275 m from the cave entrance (Crossin & Seibel, 1986).
- Dhont (1976) reported visiting a cave that contained 50-100 nests and, looking into eight nests, repeated Peale's (1848) assertion that the normal clutch size appears to be one. He recorded moult in breeding birds and claimed that they possibly bred all year round. Dhont said that cave was near Aleisa. I could not find anybody in Aleisa who knew of a cave anywhere near there, so he may have been speaking of one of the Lower Falemauga caves [11,12]. In reference to possibly the same cave Cedric Schuster directed me to ask the people at the Sliding Rock to tell me how to find the cave he had visited near there; but they claimed ignorance of such a cave.

¹ Numbers in square brackets refer to the cave descriptions given in Tables 2 & 3.

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- David Blockstein while working on the Tooth-billed Pigeon in northern Savai'i, following information from R. Crossin and D. Seibel (1986), visited Ofisa Plantation and Aopo Caves [24] collecting swiftlets and recording measurements and moult data (Blockstein, 1987).

These constitute the best records made prior to this study. Lovegrove (*pers comm*) from the University of Auckland, New Zealand while helping with Samoa's Biodiversity study visited O le Pupu Pu'e cave [1] in the National Park of the same name on 29 June 1982. He estimated that there were hundreds of birds nesting on the cave walls but none on the overhanging ceilings.

Muse & Muse (1982) recorded that several large swiftlet colonies on Upolu contained thousands of birds and this was confirmed by the villagers who led me to caves, commonly making the comment that prior to the cyclones there had been "thousands" or "many birds" in the caves. The cyclones that severely reduced the swiftlet populations were cyclones Ofa (Feb 1-3, 1990) and Val (Dec 6-9, 1991). Ofa passed 80 km west of Savai'i and with its winds reaching over 200 km/hr "less than 1% of forest remained unscathed in the eastern third of Savai'i" according to a Spot Satellite image taken two weeks after the event (Elmqvist et al., 1994). From a study of the two Forest Preserves on Savai'i (Elmqvist et al., 1994) it was found that they suffered 28% tree mortality and another 33% after Val.

Val passed over the Islands of Samoa, performing a loop as it did so, and with winds up to 240 km/hr completely defoliated the trees making up the canopy and sub canopy, as well as de-blossoming them and snapping off many twigs and branches (Epila-Otara, 1996). What this did to swiftlet numbers can be estimated by comparing a pre-cyclone and post cyclone census of two caves in American Samoa. The pre-cyclone census (Enbring & Ramsey, 1989) estimated 11,000 White-rumped Swiftlets and 10,000 Polynesian Sheath-tailed Bats (*Emballonura semicaudata*) occupied two caves in Anape'ape'a Cove on Tutuila. The post-cyclone census of the same two caves found only 20-30 swiftlets and one bat (Grant, 1993).

I began my surveys in 1994, three years after the cyclones, at which time the effects were still obvious by the large numbers of dead and damaged trees, the small size of the swiftlet colonies and the disappearance of most of the colonies of the Polynesian Sheath-tailed Bat. This bat is known as *Tagiti* by older Samoans and often confused with the swiftlet and called *Pea'pea'* or *Pea'pea'vai* by most Samoans.

Swiftlets occupy their natal cave site for roosting during the whole year and although this makes it easier to study some aspects of their behaviour it makes them vulnerable to human interference and sometimes vulnerable to specific predators. Their big brothers the swifts cannot echolocate, but as most swifts migrate, the

reliability that predators might enjoy in finding them at one site throughout the year is reduced. Swiftlets do not have the protection that migration provides, but most echolocate and they nest up to one kilometre from the light of a cave entrance, thus increasing their chance of survival. All swiftlets use saliva to construct their nests, with most species building much vegetable matter into the structure. The White-rumped Swiftlet lives in compact colonies in Australia, Tonga and Fiji but in dispersed colonies in the Cook Islands. In Samoa at the moment it practices both strategies.

Methods

Contrary to what some Samoans told me, as some believe that lava is only found on Savai'i and not on Upolu, all major breeding sites of the White-rumped Swiftlet located in Samoa were in lava-tube caves or collapses and erosional fissures associated with them. Some caves are short and low while others are more than a kilometre long and may contain chambers estimated to be 45-50 m in height.

All these caves were mapped to ASF grades between 22 and 33 (ASF, 1999). The large caves of Salamumu #1 [9] & Aopo Cave [24] were mapped at ASF grade 33 with the main passage measured by cord and marker stations. All caves less than 100m were mapped at ASF grade 22, while intermediate-length caves were mapped at ASF grade 32.

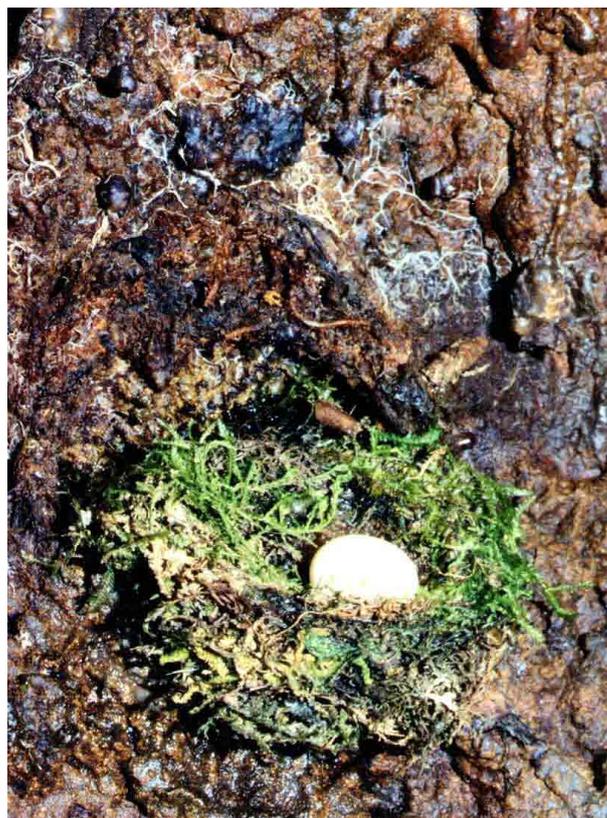
The approach was to ask colleagues, acquaintances and village people about the location of caves near particular villages. This was a slow process and it took time to locate caves containing White-rumped Swiftlets. It helped to use the Samoan name for the birds – *Pe'a pe'a*. However, it proved useful to ask for the insectivorous Polynesian Sheath-tailed Bat (*Emballonura semicaudata*), *Tagiti*, as it was sometimes known and not always differentiated from the bird. It was also useful to ask for any caves, as it appears that the swiftlets previously used all caves and even rock overhangs and even now most caves contain a remnant of a swiftlet colony.

Most caves in which White-rumped Swiftlets nest are known as *Pe'a pe'a* caves or *Ana Pe'ape'a*, and therefore, although a useful name to know when seeking local help in locating caves, is not useful in distinguishing one from the other. Therefore I have used the name of the nearest village to identify caves. There is usually someone in each village who will know the whereabouts of the nearest cave, but they may not speak English and they may not be there when you want them. This means a lot of time can be spent in locating these caves. It is hoped that this paper will help solve some of these problems for future visitors and researchers.

In Samoa a person's name holds more importance than in European society and one of the reasons for this is

that knowing the names of your ancestral lineage is proof of land ownership. Knowing the names of the relevant persons who own land or are related to the land-owner where a cave is located, is important to gaining a guide and access, hence some names are included in Tables 2 & 3. More detailed directions to some caves are held by the author. It is foolish to try looking for these caves without permission and a guide.

Swiftlets nest in the twilight zones of some caves as well as the totally dark zones of most caves they inhabit. This study shows just how small some of the colonies became after the cyclone but also measures the subsequent rate of colony growth in those caves that were re-visited. In the census data the term “current nests” is used for nests that contain moist (shining) saliva. The majority of such nests contained an egg, a pink naked young or a black-feathered young. Particularly in some of the smaller colonies additional data are reported as ‘roost sites’. These were identified by the presence of dinner plate-sized guano deposits on the cave floor. These sites were considered current if they contained the white component of the bird’s faeces as it was determined that the white colour remained for only 1-2 weeks after defecation.



Green moss-lined nest containing one egg.

Results

The Bird

The White-rumped Swiftlet is mid-range in size for swiftlets. It is about 110 mm long and has a wingspan of 275 mm, of similar size to the Pacific Swallow (*Hirundo tahitica*), but weighs 9 g, 4 g less than the swallow. Detailed dimensions are given in Table 1. As with most Apodids, this species was found to forage for invertebrates over a wide area. They could be found at any part of the main islands, though they concentrated over forests more often than cleared, farmed or occupied land. Unlike the swiftlets on Borneo (Medway, 1962) which concentrated their populations in a few large caves and then flew long distances to cover the forests of the island, Samoan birds breed in a wide scatter of populations, at least some of which used to be large but

after the cyclones are all small. Harrison (1976) spent 350 hours, mostly in helicopters looking for swiftlets only to find that on some occasions “the great mass of birds [was] not visible within 10-25 miles” of their nesting cave at Niah, Borneo. Samoan birds in contrast, do not have to travel that minimal distance to cover the whole of even the largest island (Savai’i), and their colonies are scattered over both islands.

This reduction in travel time to feeding grounds is proposed as one reason that Samoan birds did not leave their colonies until after sunrise and had all returned well before sunset, despite their ability to echolocate. By contrast, swiftlets in Borneo started leaving prior to sunrise and the greatest rate of return was 56 minutes after sunset (Medway, 1962). Another reason for the shortened foraging time of the Samoan birds could

Table 1: Details of White-rumped Swiftlet measurements

	Mean	sd	Range	n
Weight	9.03 g	0.93	6.6-12.3 g	170
Wing	119.3 mm	2.54	111-125 mm	165
Outer Rectrix	53.7 mm	2.2	46-59 mm	116
Central Rectrix	48.0 mm	2.0	44-55 mm	108
Length	109.9 mm	2.19	107-114 mm	19
Wing Span	273.2 mm	9.3	254-291 mm	18
Culmen	4.4 mm			1
Exposed Culmen	3.85 mm	0.23	3.5-4.2 mm	13
Head	17.3 mm	5.9	18.6-21 mm	4
Mid Toe	5.6 mm	0.8	3.8-6.4 mm	13
Mid Claw	3.9 mm	0.6	3-5 mm	12
Tarsus	10.3 mm	0.4	9.7-11.2 mm	12

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be their smaller clutch size of just one. Birds from Fiji (Tarburton, 1986a,b) and Cook Island (personal observation, Dec. 1987 and Jan. 1988), leave their caves well before sunrise and most do not return to roost until after dark with some birds still returning at 11.30 pm. Both these swiftlets have broods of two.

Because caves are mostly difficult to find and there is no centralised caving or other body that might be interested in guiding ornithologists to these caves, I see value in recording the location of the caves I found as well as information about the cave and the location and size of the swiftlet colonies that inhabit them. The caves are described in the order in which I located them on each of the two islands (Tables 2 and 3).

Discussion

In the limestone caves of Queensland, Tonga and Fiji, the White-rumped Swiftlet nests in aggregations where the nests may sometimes be four deep on the cave wall (Smyth et al., 1980; Tarburton, 1986b, 1988a). This is the high density nesting strategy. They prefer elevated overhanging smooth surfaces where land-based mammalian and reptilian predators cannot reach the nests, and they mass their nests into a few of these areas. In the two caves that are used on Atiu in the Cook Islands, the nests are usually scattered metres apart, probably because their major predators are two species of crabs that can climb to almost all parts of those caves (Tarburton, 1990). These crabs appear to be best avoided by scattering the nest sites in a low density nesting strategy that reduces the chance of an individual nest being located and predated. The Samoan subspecies of the White-rumped Swiftlet is the only known population to utilize both high and low density nesting techniques. This may be due to the absence in some caves of really safe nesting surfaces with smooth rock overhangs that prevent predators such as rats, cats and pythons from reaching the nests. The varied behaviour may also result from the low population densities brought about by cyclones Val and Ofa, but this is less likely as reports prior to the cyclones did indicate high density nesting in some caves. Because some colonies nest on low ledges it is clear that predatory selection pressures have not forced all birds to roost in the ceilings of the tall caverns with smooth ceilings.

Some of the Samoan lava tube colonies inhabit caves with some of the smallest entrances I have found anywhere in the South Pacific. Samata-i-uta Sea Cave [38] and Falemauga Large Cave [4] also have the lowest ceilings beyond which I have found swiftlets nesting anywhere in the South Pacific.

Regarding the Polynesian Sheath-tailed Bat, I located only five individuals in 2 of the 41 caves surveyed in Samoa, and the population of 5 appeared to have declined to 2 over the 4 years I visited that cave. This

bat also disappeared from caves on Rota and three other Mariana Islands, and declined drastically in Fiji and American Samoa (Tarburton, 2002; Esselstyn et al., 2004; Uzzurum et al., 2006). It is possibly only common now on Palau & Aguiuan (Hutson et al., 2001; Esselstyn et al., 2004).

Subsequent to my studies and without knowing about them Greg Middleton (2003) visited caves in Samoa 19 June to 8 July 2002. Besides publishing his diary, maps and photos he recorded comments about the approximate size of swiftlet populations. These were either “occasional swiftlets” or “many swiftlets” or “swiftlet nests” and/or “guano”. By using these comments to compare with my data, we can make some general statements about the status of some of the colonies as for 2002.

Between 1994-97 and 2002 it appears that White-rumped Swiftlets declined in Malololelei [7] and Letui [22] Caves; were still present in Anaseuao [19], O le Pupu Pu'e [1] and Aopo [24]; and had increased in Tafatafa [2], Satuiatua [32], Salamumu #2 [10], & Salamumu #3 [16]. Middleton visited three caves that I did not, and found many swiftlets in each of them. These were Tapueleele, Leos Cave at Patamea, and Short Peoples Cave at Paia.

Acknowledgements

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References

- Armstrong, J.S. 1932: *Hand-list to the birds of Samoa*. John Bale, Sons & Danielsson: London.
- ASF (Australian Speleological Federation) 1999: Survey Grades. http://www.caves.org.au/m_stdsurv.html (accessed January 2011)
- Beck, R.H. (n.d.): Extracts from the journal of Rollo H. Beck (1924), pages 20-21 in *Unpublished journals of the Whitney South Sea Expedition*, Vol. F: American Museum of Natural History, NY.
- Blockstein, D. 1987: Unpublished moult and measurement data collected from Ofiso Plantation & Aopo Caves Savai'i.
- Correia, J. (n.d.): Journal of Jose Correia (1924), page 172 in *Unpublished journals of the Whitney South Sea Expedition*, Vol. N: American Museum of Natural History, NY.

- Crossin, R. & Seibel, D. 1986: Unpublished summary of collecting information on skin tags in the University of Kansas, Museum.
- Dhont, A. 1976: Bird observations in Western Samoa. *Notornis*, **23**: 29-43.
- Elmqvist, T., Rainey, W.E. & Pierson, E.D. 1994: Effects of Tropical Cyclones Ofa and Val on the Structure of a Samoan Lowland Rain Forest. *Biotropica*, **26**: 384-391.
- Enbring, J. & Ramsey, F.L. 1989: *A 1986 survey of the forest birds of American Samoa*. U.S. Fish & Wildlife Service. 145pp.
- Epila-Otara, J.S. 1996: *The effects of cyclone Val on the vegetation of Western Samoa*. IRETA U.S.P. 40pp.
- Esselstyn, J. A., Wiles, G. J. & Amar, A. 2004: Habitat use of the Pacific sheath-tailed bat (*Emballonura semicaudata*) on Aguiuan, Mariana Islands. *Acta Chiropterologica* **6**: 303-308.
- Freeman, J.D. 1943: The Seuao Cave. *J. of the Polynesian Soc.*, **52**: 101-109.
- Freeman, J.D. 1944: The Falemaunga Caves. *J. of the Polynesian Soc.*, **54**: 86-97.
- Grant, G.S. 1993: Sheath-tailed Bats – Tutuila's rarest mammal. In Craig, P., P. Taril, G. Grant, J. Craig, & D. Itano. *American Samoa: Natural History and Conservation Topics*, **1**: 51-52. Dept. Of Marine & Wildlife Resources. Amer. Samoa.
- Harrison, T. 1976: The food of *Collocalia* swiftlets (Aves, Apodidae) at Niah Great Cave in Borneo. *Journal of the Bombay Natural History Society*, **71**: 375-393.
- Hutson, A.M., Mickleburgh, S.P. & Racey, P.A. 2001: *Microchiropteran bats: global status survey and conservation action plan*. IUCN/SSC Chiroptera Specialist Group, International Union for the Conservation of Nature and Natural Resources, Gland. 259 pp.
- Iliffe, T.M. & Sarbu, S. 1990: Anchialine caves and cave fauna of the South Pacific. *NSS News*, **48**: 88-96.
- Lyons, J. 1997: Anaseuao Cave. *The Utah Caver* **9**: 105-106.
- Lim, C.K. & Cranbrook, Earl of, 2002: *Swiftlets of Borneo. Builders of edible nests*. Natural History Publications (Borneo), Kota Kinabalu. 171 pages.
- Medway, L. 1962: The swiftlets of Niah Cave, Sarawak Part 2. Ecology and the Regulation of Breeding. *Ibis* **104**: 228-245.
- Middleton, G. 2003: The lava caves of Samoa – A preliminary investigation. *J. Sydney Speleological Society*, **47**., 79-96.
- Muse, C. & Muse, S. 1982: *The birds and birdlore of Samoa*. Walla Walla Pioneer Press: Walla Walla.
- Ollier, C.D. & Zariello, P. 1979: Pe'ape'a Lava Cave, Western Samoa. *Trans. Brit. Cave Res. Assoc.*, **6**: 133-142.
- Peale, T.R. 1848: United States Exploring Expedition during the years 1838-1842, under the command of Charles Wilkes, USN. pages 176-178 in *Mammalia and Ornithology*, Vol. VIII. New York Museum of Natural History, Philadelphia.
- Smyth, D.H., Pecotich, L. & Roberts, J.R. 1980: Notes on the distribution and breeding of the Grey Swiftlet, *Aerodramus spodiopygius*. *The Sunbird*, **11(1)**: 1-21.
- Tarburton, M.K. 1986a: The food of the White-rumped Swiftlet (*Aerodramus spodiopygius*) in Fiji. *Notornis*, **33**: 1-16.
- Tarburton, M.K. 1986b: Breeding of the White-rumped Swiftlet in Fiji. *Emu*, **86**: 214-227.
- Tarburton, M.K. 1988a: Breeding Biology of the White-rumped Swiftlet at Chillagoe. *Emu*, **88**: 202-209.
- Tarburton, M.K. 1988b: Calls of the White-rumped Swiftlet. *Notornis*, **35**: 77-83.
- Tarburton, M.K. 1990: Breeding Biology of the Atiu Swiftlet in the Cook Islands. *Emu*, **90**: 175-179.
- Tarburton, M.K. 1994: The diet of the White-rumped Swiftlet (*Aerodramus spodiopygius*) in Queensland's savanna. *Avocetta*, **17**:125-129.
- Tarburton, M.K. 2002: Demise of the Polynesian Sheath-tailed Bat *Emballonura semicaudata* in Samoa. *Micronesica*, **34**: 105-108.
- Tarburton, M.K. 2009: The breeding biology of the White-rumped Swiftlet (*Aerodramus spodiopygius*) in Samoa. *Corella*, **33**: 1-6.
- Utzurum, R.C.B., JO Seamon, & KS Saili. 2006: A comprehensive strategy for wildlife conservation in American Samoa. Department of Marine and Wildlife resources. Pago Pago. As accessed 18 Nov 2007 at www.wildlifeactionplans.org/pdfs/action_plans/as_action_plan.pdf
- Whitmee, S.J. 1875: List of Samoan birds, with notes on their habits & c. *Ibis*, **5**: 436-447.

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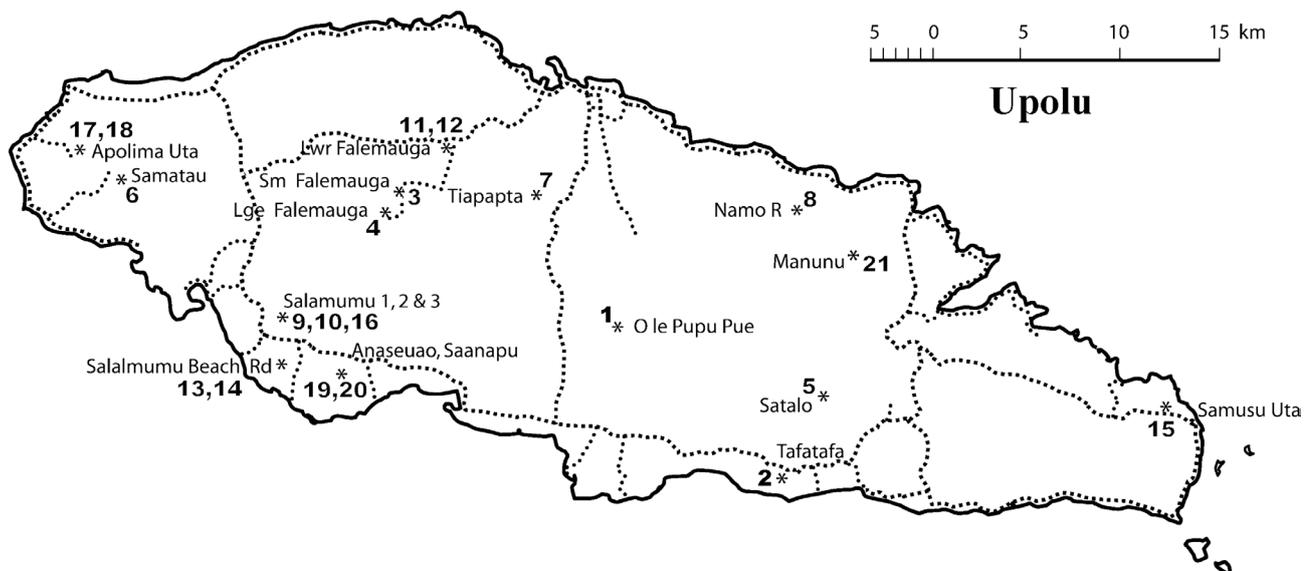
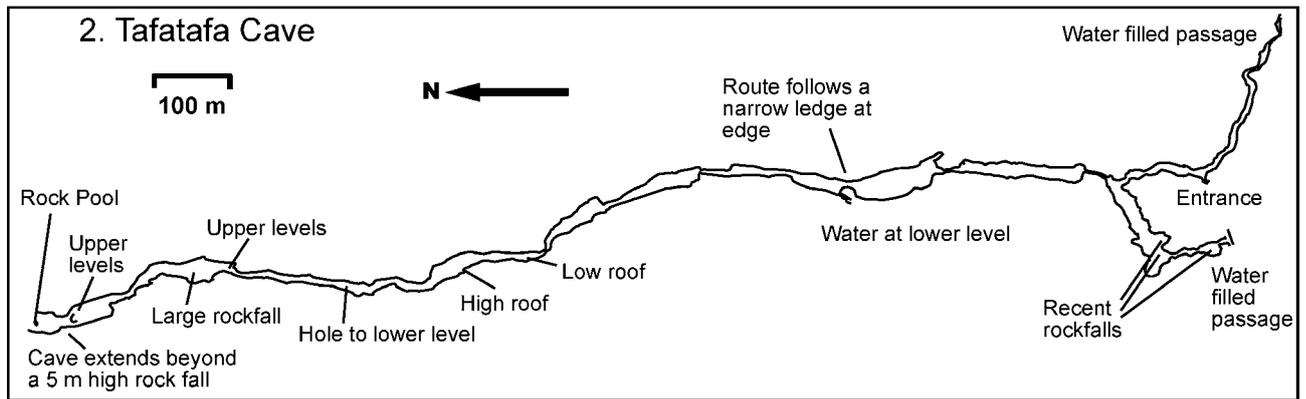


Table 2: Site descriptions – UPOLU

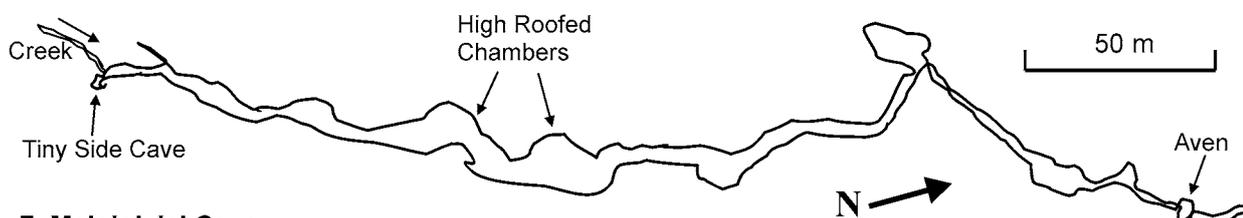
Cave	Location and Access	Cave Description	Colony Information
1. O le Pupu Pu'e	The best-known cave on Upolu, often shown to overseas visitors by the National Parks staff and guides, (available through the National Parks Department). Located in the O le Pupu Pu'e National Park on the north side of the main road. Access via a track (two hours walk) or Government Beef Farm (45 min walk). See also map in Ollier and Zarriello (1979).	A branch of the Tafitoala River runs through this cave and after heavy rain can make it dangerous to enter. At the upstream end the cave is up to 7 m high and 15m wide and the deep pools can be waded carefully on the left hand side. There are 4 "daylight" openings, the third and the last can be used to exit. There is one 40 m long anabranch. The total length is about 650 m.	6.3.1994 – 9 nests in current use, all before the third daylight opening and none close together. 31.3.1994 – 23 birds mist and hand netted (DC & MT); total colony size estimated at about 27 birds. 14.10.1996 – increase to 72 nests; all were still located before the third daylight opening. Although Middleton (2003) mentions that he saw his first White-rumped Swiftlet in this cave he gave no indication of how many were encountered.
	<p>1. O le Pupu Pu'e Cave</p>		
2. Tafatafa	The entrance is a 1.5m hole behind the Tafatafa Village shop (now derelict, Middleton, 2003). Permission to enter the cave is obtained from the owner David Peterson at Matareva Beach. Visited by Iliffe & Sarbu (1990) and Middleton (2003).	This is a 1.8km long branching tube. To the right is a 400m conventional lava tube; the diameter decreases and it fills with water. The left is more complex. The first 100m is a small tube which descends to a 70x10m chamber. To the far left, a climb up to a very loose passage leads to another chamber. The immediate right is a 0.5m high, 10m long wet duck or crawl (depending on water level) opening into a large passage, which bends left and narrows before a chamber with fallen rock. On the far side, a negotiable but narrow ledge on the right wall allows access to more cave. See map on next page...	27.5.1994 – 1 nest downstream (to the right) of the entrance, (now destroyed); 9 nests in use to the left. 20.12.1994 – increased number of nests to 13. 6.8.1997 – increased number of nests to 18 Large swiftlet guano piles in the tube beyond the ledge were estimated to be about 5-8 years old. The former large colonies in this section of the cave had been reduced to one nest only, on my last visit in 1997. Even though Middleton (2003) did not visit all of the cave he recorded many swiftlets at 2 sites indicating that the colony has increased significantly.



Cave	Location and Access	Cave Description	Colony Information
3. Falemauga – Small Cave (Wendt's)	This cave is on Dr Wendt's property on the north side of the University of the South Pacific's farm "Lalonea". His permission is needed to visit it.	The cave entrance is a 3m high, 4m wide opening in the bottom of a 5m deep slump. The cave narrows to 1x2m and then enlarges to 2m before narrowing and sloping down to a larger terminal chamber.	11.9.1994 – 24 active nests scattered the full length of the cave. This cave was censused monthly for 2 years (1994- 1996) and the colony size remained constant. On my last visit (27.10.1997) there were 31 active nests indicating a slight increase.
<p>3. Small Falemauga Cave: Wendt's</p> <p>Scale: 100 m</p> <p>North Arrow: N</p>			
4. Falemauga – Large Cave	Located on "Lalonea", the University of the South Pacific farm property. Permission obtained at the Alafua Campus. It is a 300m walk to the cave entrance: a large hole about 14m across with a steep slope into the large lava tube.	190m inside, the cave levels off and narrows where the soft mud is shoulder deep. This can only be crossed on the far left if there has not been any heavy rain for about 2 weeks. The cave is 545m long, reducing to a 0.5m high crawl at 265m from ~13m in height. It terminates in rubble and unstable roof. Just inside the entrance is a stone sleeping platform.	11.9.1994 – at least 57 nests prior to the crawl. 9.7.1997 – 49 nests before the crawl and 33 after it; a total of 82 nests. This decline in nests before the crawl illustrates the variation that can occur in these colonies. From rat tracks in the mud and the pile of flight feathers at the crawl, it was evident that rats were catching swiftlets at the crawl and were the likely cause for the decline..
<p>4. Large Falemauga Cave: Lalonea</p> <p>Scale: 100 m</p> <p>North Arrow: N</p> <p>Labels: Friable roof, lots of rubble, Half metre high crawl, 1.6m deep soft mud, Steep walk-in entrance</p>			
5. Satalo Cave	David Peterson (Matareva beach) is the best guide. A track to the village heads inland 750m east of a concrete culvert on the round-island road. A total walk of 1.7 km. The cave is 50m below 2 arches and behind a waterfall, access is via the right bank.	Water does not currently flow through the cave so the guano can be quite deep. The cave is only about 60m long and is nowhere totally dark.	Prior to the cyclones the 2 arches were covered with swiftlet nests (D. Peterson, pers com.) 15.9.1994 – 28 nests on the arches. The total number of nests was 103, many of which were less than 3m from the floor.
<p>5. Satalo Cave</p> <p>Scale: 10 m</p> <p>North Arrow: N</p> <p>Labels: 15 m Waterfall, Cave, Archways, Creek</p>			
6. Samatau Cave	About 5-6 km along the road heading inland, 250m east of Samatau SDA Church, Access permission and guidance from Mr Asaua Fitu at the single house.	The cave is 43m long with the ceiling not far above head height.	12.12.1994 – 9 active nests all in the twilight zone.

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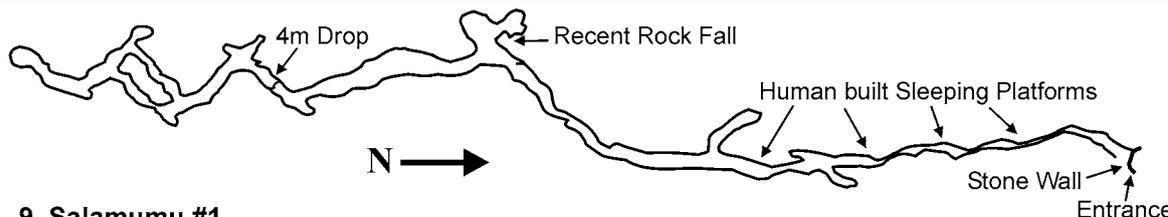
Cave	Location and Access	Cave Description	Colony Information
7. Malololelei (Tiapapata) Cave	Permission should be gained from the Methodist Church Office, above the Methodist Bookshop on Beach-Front Road, Apia. The best guide is Moi who lives on the main Cross-Island Road at Afiamalu. Middleton (2003) mapped this cave.	The creek flows through the cave. The main cave passage averages ~6m in height with several larger chambers (roof height maximum ~ 9m). 40m before the cave ends and ~280m from the walk-in entrance, is a spectacular 10m high smooth-walled aven (daylight opening) with tree ferns providing a picturesque second entrance for the swiftlets and insectivorous bats. The cave extends significantly beyond the collapse pit (Middleton, 2003) but the passage can be full of mud from about 40m beyond the pit. Just to the right of the obvious 10m diameter main entrance is a small squeeze into a 10m long cave (Tiny Side Cave). Labeled "hole 2.5m up wall" by Middleton (2003) on his map.	Tiny Side Cave – 1 occupied nest 1m from the floor, each visit. In the main cave, nests from 3-8m above the cave floor appear sporadically on suitable parts of the walls of the main cave from about 30m inside until 20m before the spectacular opening at the far end. No nests occurred after that opening during the period of my visits. 28.5.1995 & 1.10.1995 – 83 nests 16.11.1997 – 108 nests Sadly Middleton (2003) only mentions swiftlets just inside the entrance to this cave. There used to be a lot more further in.



7. Malololelei Cave

8. Namo River Cave	A rock overhang on the true right bank, 30 minutes walk up river from Solosolo Village. The owner (Liasi) lives in the fale by the east side of the bridge across the Namo River, edge of Solosolo and is happy to show visitors if he sees you have a genuine interest.	The two big cyclones caused landslips that half filled the cave so the roof is now just above head height.	26.5.1995 – 2 active nests and white droppings at 3 other sites indicating a colony of about 7 birds; 6 were circling the entrance.
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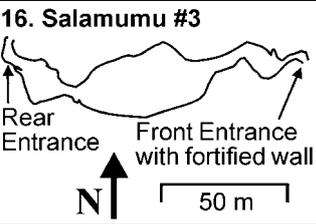
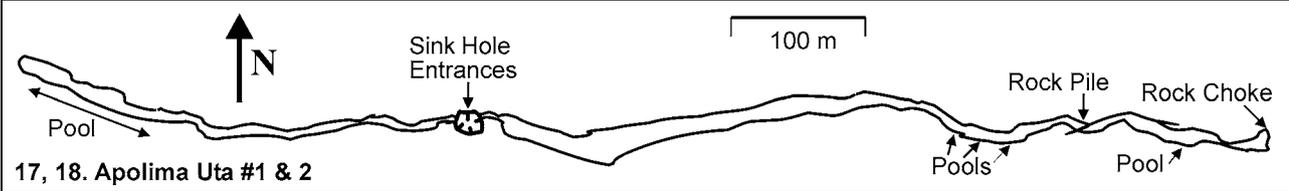
9. Salamumu #1 Cave	The lady owning the cave lives 250m west of the cave on the inland side of the road near a wide car park. Mapped by Iliffe & Sarbu (1990) and visited by Middleton (2003).	The natural entrance is 2 x 3m and has been infilled by a solid stone wall with a narrow opening. Inside there are extensive stone sleeping bunks and mollusc remains indicating past occupancy. One stone axe head was found and was taken by David Butler to the Environment Department. Short extensions occur left and right after the highest sleeping platform. The cave is a complex tube and the main tube extends for 1.5km, although Iliffe & Sarbu (1990) mapped 3487 m. Cave surveyed and mapped 25.6.1995 by M. Tarburton, K Tarburton, D. Butler.	1,000 very old swiftlets nests clearly pre-dating the cyclones estimated.. 1.6.1995 – 1 swiftlet, 1 current nest, 2 birds roosts. 25.6.1995 – 2 active nests and 1 dead nestling on the cave floor.
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9. Salamumu #1

Cave	Location and Access	Cave Description	Colony Information
10. Salamumu #2 Cave	This cave is 40m from the land owners' home and is one third full of their rubbish and when I pointed out three swiftlets flying into the cave entrance they could not believe birds would nest in there.	A small cave which tracks under the road and at right angles to it, but does not open on the south side. Traversing the rubbish pile poses a hazard.	1.6.1995 – 3 widely spaced nests in current use. Middleton (2003) recorded lots of swiftlets and their guano so this colony appears to have increased. I wonder if flies from the rubbish provide extra food to the swiftlets. They do eat flies (Tarburton 1986a, 1994).
11, 12. Falemaunga Caves	These caves are located on Kitona's property and he can usually be found in the Apia Market. Steve Brown of Ecotours Samoa can also gain permission and lead people to it. These caves were surveyed and mapped by Freeman in 1943 and later visited by Middleton (2003). Map published in Freeman (1944).	There are 2 caves at this site. A large opening on the south side of the collapse 180m long, descending then climbing until closure. A small opening on the north side of the collapse leads through 680m of lava tube, with large variations in passage height. The cave contains an old Polynesian Sheath-tailed Bat roost site. Freeman's (1943) archaeological dig is still evident in an anabranch of the cave just before the terminus.	6.7.1995 – The shorter cave with the large opening contained 51 nests and the longer cave (small opening) contained 11 nests and 4 individual roost sites.
<p>11,12. Lower Falemauga Caves</p>			
13, 14. Salamumu Beach Road Caves	The entrance is in a collapse and access is via a 3m climb down a live tree. Tua, who lives next to a very large fig on the Upolu Island ring road 200m west of the lady who owns the Salamumu caves, can guide to these caves.	One cave opens to the SW and the other to the SE from the bottom of the collapse. Both caves are very muddy. The SE cave has two trends and the right hand one crosses under the SW cave and ends in knee-deep mud.	17.3.1996 – The SW cave contained 8 nests in current use and 6 additional roosting sites, while the SE cave contained 3 active nests and 1 roost site.
<p>13, 14. Salamumu Beach Road Caves</p>			
15. Samusu Uta Waterfall Cave	Opposite a Roman Catholic Church 3km west of Samusu, lives Tauga Tinu who can guide to this rock overhang. The site is 1km closer to Samusu on the road side and 4-6m from the waterfall (depending on river flow).	This is a lava overhang near the waterfall in a very moist environment.	19.5.1996 – 3 active nests in a well-lit situation where liverworts and mosses grow very close to the nests.

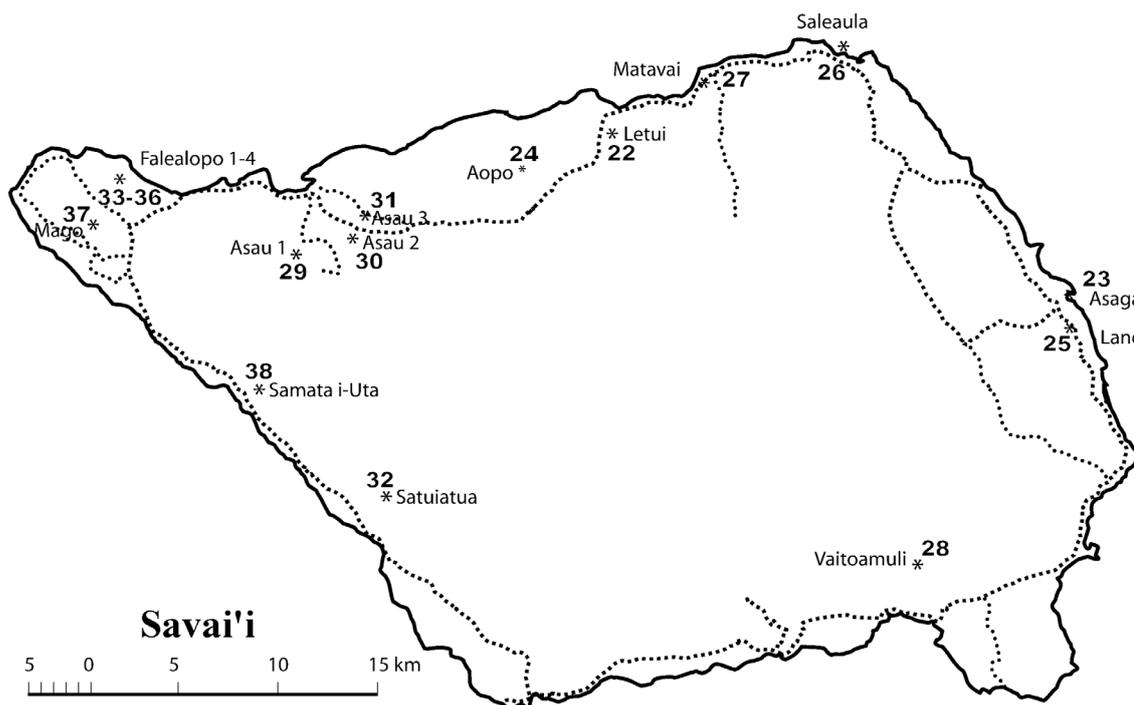
Samoa Cave Swiftlets

Cave	Location and Access	Cave Description	Colony Information
16. Salamumu #3 Cave	<p>The small entrance is 100 m NW of Salamumu #2 Cave. This is the cave Middleton (2003) called Salamumu II.</p> <p>16. Salamumu #3</p> 	<p>This cave has historically been used for human habitation, presumably during times of warfare. The entrance has been blocked with natural stones to allow access only through a narrow slit. There are human sleeping platforms throughout much of the length of this short cave. There were several sections of guano sludge.</p>	<p>1.6.1995 – Although there were only 12 nests in use the areas of old guano indicated that there was a large colony here prior to the cyclones. Middleton (2003) noted there were lots of swiftlets, demonstrating the recovery of this colony.</p>
17. Apolima Uta #1	<p>A few metres before the Apolima Uta Village sign, which is possibly now used in a nearby shed (Middleton 2003), on the round island road, turn inland for 2.5 km. The 15 m diameter sink-hole containing the entrance can be seen 20 m off the road to the left.</p>	<p>This cave has a large opening (5 m diameter) in the collapse and heads seaward (west) for 300 m. The cave has several chambers 10 m wide and 10 m high and much of it contains water deepening closer to the coast. There are some white and coloured calcite formations and in one pool a 9-10 cm long thin minnow-like white fish with darkish fins and no eyes was observed.</p>	<p>12.11.1996 – 8 active nests.</p>
 <p>17, 18. Apolima Uta #1 & 2</p>			
18. Apolima Uta #2	<p>The entrance to this cave is in the same collapse as Apolima Uta #1 Cave. Entrance mostly covered with Mile-a-minute creeper.</p>	<p>The entrance is ~1 m diameter. The cave is a 600 m long straight passage about 5 m in diameter. At 100 m is a 150 m section of knee-deep very sticky mud. At 150 m after the mud are 3 clean pools of water before a collapse, followed by another pool and a high rock pile that ends in a choke.</p>	<p>12.11.1996 – 2 two active nests in this cave, 65 m apart. This entrance is one of the smallest I have known swiftlets to use anywhere. There were 2 or 3 red-stained domes, below which were the fine red-brown guano remains that confirmed former use by the Sheath-tailed Insect Bat.</p>
19. Anaseuao Cave #1	<p>A sign for this “tourist” cave was erected in 1997 on the round island road near the village of Saanapu. The people in the nearest fale on the seaward side of the road will find a suitable guide. The entrance is 1.5 km from the road.</p>	<p>The cave has clean smooth rock and extends 700 to 800 m towards the road. It has 2 branches extending for 100 m and 300 m, with very low ceilings. The cave has calcite flowstone over wall rock, which has traditionally been called the King of Samoa’s throne. This name comes from the incident referred to in the name of the cave where the local village people were chased into the cave and trapped in there by a large fire lit over the entrance by an opposing village. When all seemed lost an old talking Chief of the trapped group came to the entrance and pleaded continuously all day in an oratory that so impressed the opponents that they released the trapped group. John Lyons returned to this cave on 6 occasions and mapped it thoroughly (Lyons 1997). Subsequently Middleton visited this cave and resurveyed it (2003). An earlier description had been made (Freeman 1943) with a more elaborate (and possibly more accurate) telling of the name origin.</p>	<p>25.11.1996 – 13 nests in current use Several protrusions from the ceiling showed the red discolouration characteristic of Sheath-tailed bat roosts. Middleton (2003) shows two sections of cave as having scattered swiftlet nests in 2002, so it would appear this colony has not increased very much since the cyclones.</p>

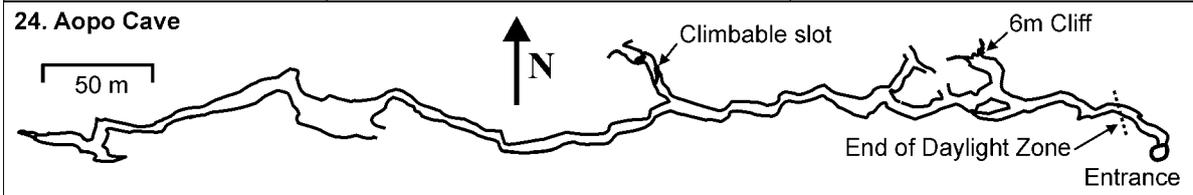
Cave	Location and Access	Cave Description	Colony Information
20. Anaseuao cave #2	The entrance is located on the seaward side of the same collapse where Anaseuao Cave #1 begins.	The cave is 80-100m long and is much larger in cross-section than the longer cave.	25.11.1996 – There were no current nests but the remains of about 12 pre-cyclone nests were counted.
21. Manunu cave	This cave is on the south bank of the Falefa River near the village of Manunu.	Only 45m long, both ends open into the river bank and has no truly dark zone. The overhang is lava that has been eroded into and exposed by the river.	24.11.1997 – 20 current nests in spite of its being close to the village.

Table 3: Site descriptions – SAVAI'I

Cave	Location and Access	Cave Description	Colony Information
22. Letui Tourist Cave	This cave is 12m off the inland side of the round island road, 60m west of a rectangular water tank, about 1km west of Letui. The tank and cave entrance are sometimes hidden by creepers but at other times every pebble is visible and signs advertise its tourist potential.	The 3-8m deep collapse leads to an 85m cave that runs under the road. This dry cave averages 3m in diameter. The overhangs on the south side of the collapse do not lead to any other caves. Middleton (2003) reports that it has been fitted with electric lights; probably not a helpful addition for the swiftlets that breed (bred?) there.	25.2.1994 – 1 current but empty nest. However, 20 birds came in to roost at sunset. 7.7.1994 – 15 active nests and 3 active roost sites. 12.2.1995 – 3 nests in use. 5.10.1997 – 8 nests and 3 roost sites. Middleton (2003) did not report any swiftlets or their nests, just guano, but without comment on its age.

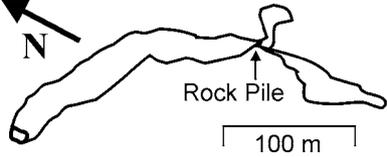
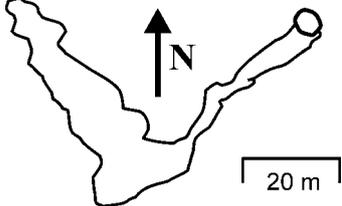
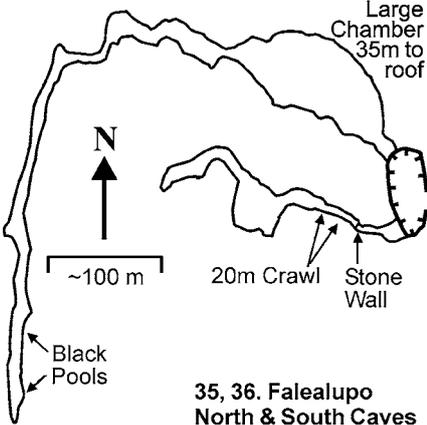


Samoa Cave Swiftlets

Cave	Location and Access	Cave Description	Colony Information
23. Asaga Cave (Ana o le Imoa.)	The entrance is 300m seawards of the edge of the weathered lava flow. Access is through the coconut plantation on the north. Tugilima from the Asaga School can guide. Middleton (2003) obtained a guide who was not able to find this cave, instead taking him to the less significant Ana Sumu the Fish Cave, a frequent problem.	The 2m diameter entrance is to a tube of similar dimensions until it opens into a 5m high, 20m wide chamber for 170m after which it narrows. The cave ends with the 1m high tunnel being filled with water. On the 5.10.97 visit it was observed from debris in the ceiling crevices that the whole of the entrance tunnel had been filled with water and that freshly sprouting coconuts had been distributed throughout much of the length of the cave.	27.2.1994 – 3 nests in current use and a partly constructed nest at the end of the large section; one old nest and 6 -7 birds were observed in flight. 8.7.1994 – 5 nests in use 5.10.1997 – 4 nests in use. There were 3 roost sites on the last visit indicating that probably most birds had survived the recent flooding of the cave.
24. Aopo Cave	The cave is a walk 400m along the "track" before turning right and 200m into the bush, 2km along a road to the north of the western end of Aopo Village. To visit this cave one needs to pay 5 Tala to the Pulenuu at the Aopo Village. He will organise a guide whom you will drive to where the vehicle is parked before the walk.	This extensive cave has a frequently-connected lower and upper tube system. The easiest place to descend to the lower passage is at the climbable slot (see map). Much of the cave is clean rock although it ends in mud pools. Middleton (2003) mapped part of this cave but ran out of time to locate the climbable slot and get to the end of the cave. His map is more accurate than my sketch map.	27.6.1996 – Most of the 120 nests in current use were in the upper tube. Middleton (2003) recorded many swiftlets (nests?) so presumably this colony is doing well.
<p>24. Aopo Cave</p> 			
25. Lano Cave (Ana o le Malie)	It can be reached in a conventional vehicle. Taea Apineru from the Lano village showed the cave to me, but this is one of the few caves where most people could guide you.	The cave opening and much of the passage is large as it extends northwards under the road. It is 630m long and has 3 large holes in the floor. The first 2 are climbable to an experienced and fit person, though the second had a very bad smell from a huge volume of decaying matter. The third hole is 13-15m deep and is vertical on the near side. The far side is near vertical and gives access to a 3m diameter tube that opens to daylight 13 metres further on. Evidence of large logs with branches and other flood debris indicating recent flooding in this section.	26.2.1994 – at least 42 nests in use ranging between 7.2 to 13m above the cave floor. The sub-colonies were spaced widely throughout the length of the cave, with most in the totally dark section.
26. Saleaula Cave (Church Cave)	Referred to as Church Cave by Middleton (2003). On a track that runs inland on the south side of the AOG Church 3km south of Saleaula Village. The entrance is on a ridge.	The 2m diameter entrance opens to a 50m long cave with some boggy patches, exposed tree-roots, and a roof height ranging between 1.4 to 3m. 26. Saleaula Cave	10.7.1994 – 8 active nests, all in the twilight zone, 2 partly built nests and 4 roost sites. The innermost part of the cave is too low for swiftlets to use for nesting. Middleton (2003) did not report any swiftlets or nests.

Cave	Location and Access	Cave Description	Colony Information
27. Matavai Water Cave	This cave is well known by all Matavai Village residents as it is on the edge of the village and is used for washing. It is best to seek permission from the villagers as ownership of the cave is disputed and we found it was better to have paid somebody than nobody if a dispute erupts.	There are two large openings. The one to the right is the shortest and used for village bathing and washing. The one to the left has knee to waist-deep water in the entrance but 120m of dry cave extends behind the water.	10.7.1994 – Only 2 currently active nests were located in the left cave, though the village guide said there had been many before the cyclones.
28. Vaitoamuli Cave	This cave is difficult to find and as ownership is clear, it is best to contact the owner (Iulio Malaesala) directly. His fale is in the centre of the village on the coastal side behind a tomb that has black stones in white cement. Alternatively the resident American Deputy Principal (David Brindisi) and his Samoan wife who live in the cyclone-fenced school houses right by the main road, can organise permission for you. The cave is approximately 2 km inland.	The cave is relatively large and we did not reach the end. The cave is over 632m long and extends at least 160m past the second and larger roof collapse although decreasing in size. Inside the entrance, the cave forks; the south-east branch to the right does not go very far, the north-west trend is the one that leads to the main cave.	11.7.1994 – 62 active nests all in total darkness, 1 nest behind the second rock fall. No swiftlet nests in the south-east branch. The 20 swiftlets flying in this area appeared to be there because they were flushed into the rear of the cave and not because they were travelling to distant nests.
29. Asau #1 Cave	The cave is some 5-8km inland at about 600-700m altitude. The best guides are Petau Ofisa and his wife Naoupu who live in a green-roofed fale 1km along the vehicle track opposite the Harbour turnoff from the Asau-Aopo road (the old road to Aopo),	The cave opening is 1.5m in diameter with a 3m climb down to a narrow (averaging 1m in width) short cave of just 30m.	11.2.1995 – 3 active nests and 3 roost sites in the twilight zone.
30. Asau #2 Cave	The cave is 500m along the track from Asau #1 cave on the seaward side and 8m from the track. The cave was discovered by observing the circling and diving swiftlets near Asau #1 cave.	The opening is 3m high and 6m wide but there are sections in the cave that are up to 10m in height, along with some very narrow and other broad sections. It extends for 220 metres.	11.2.1995 – 29 active nests were grouped into several favourable locations, well out of reach of humans and in totally dark sections of the cave.
31. Asau #3 Cave	This cave was also discovered by noticing the circling and diving swiftlets. The entrance is 3km below Asau #1 Cave and inside the arc made by the west branch off the main track. It is 15-18m from the track and not obvious. Petau was surprised to find this cave but should remember where it is.	The cave passage is 60m long, 5-8m wide but averages only 1.8m in height.	11.2.1995 – all 17 nests in current use were low due to the low profile of the cave. Their presence in these numbers suggests that they are not disturbed.

Samoa Cave Swiftlets

Cave	Location and Access	Cave Description	Colony Information
<p>32. Satiutua Cave. (Ana Ole Sau; Cave of the Breezes)</p>	<p>Also known as Ana Ole Sau; Cave of the Breezes (Middleton, 2003). The cave entrance is 2.5km from the primary school and up the inland slope. Mate and her sons manage the Beach Resort in Satiutua village and I can recommend their service as well as that of Mate's brother Tauia Lepua in guiding one to the cave.</p>	<p>The entrance is the lower end of a 500m long lava tube and bifurcates appear ~100m in. The right branch was initially dark (Middleton, 2003, shows it reaches a gorge) and the left one surfaced at the 500m point. The cave is dry and easily traversed. Middleton (2003) visited and surveyed this cave.</p>	<p>3.10.1997 – The right branch contained 14 current nests and the left branch 43, totalling 62. The colony has suffered predation from a Barn Owl (Lulu) judging from a Barn Owl feather just inside the entrance, near a large pile of swiftlet flight feathers, which I estimate came from 30-40 birds. That so many birds survived the cyclone may be explained by whatever the explanation is for the survival of a large colony of Tongan Fruit Bats (<i>Pteropus tonganus</i>) that roost just east of here. Middleton's (2003) map records many swiftlets (presume nests?) suggesting this colony may have increased.</p>
<p>33. Falealupo #1 Cave</p>	<p>This cave is west of the Falealupo School on the opposite side of the road and the best guide is Tapu Aeaeanu, a teacher from the school. Tapu's friend (Seumamutafa Fetui) can also act as a guide to the caves in this area.</p>	<p>The cave tube extends 300m to a rock pile that reaches the roof but does not block the passage completely. To the right over the pile is a 100m extension, and to the left is a 20m extension. The cave up to the rock pile was still littered from human occupation during cyclones.</p>	<p>4.10.1997 – 16 current nests were found before the rock fall and 1 in each extension, totalling 18 nests. Most were in the totally dark zone.</p>  <p>33. Falealupo #1 Cave</p>
<p>34. Falealupo School Cave</p>	<p>About 100m from the school house, past a very large fig that having survived both cyclones succumbed to a fire in 1996. The area was mostly weeds such as Mile-a-minute and sensitive plant.</p>	<p>This 100m cave has a small cross section but is fairly wide where it branches to the right.</p> 	<p>4.10.1997 – 10 active nests were found in this cave indicating that the birds are not molested.</p>
<p>35. Falealupo South Cave</p>	<p>This cave is on land owned by Lagolago and its entrance is south past the school and west of Lagolago's fale. This cave entrance is in the south end of a linear collapse.</p>	<p>The cave is 225m long but a man-made ceiling-to-floor wall of stones has been built 30m into the cave where the roof is only 1m from the floor. This obscures the way into a 20m crawl to a larger chamber where villagers used to hide from their enemies.</p>	<p>4.10.97 – the first 2 of the 15 nests were in twilight but the rest were well inside beyond the low difficult crawl. I suspect the birds have another route into the large chamber.</p>  <p>35, 36. Falealupo North & South Caves</p>

Cave	Location and Access	Cave Description	Colony Information
36. Falealupo North Cave	The entrance to this cave is in the north end of the same linear collapse referred to above. Same access arrangements as for Falealupo South Cave.	This ~320m or more long cave is the mirror image in shape to Falealupo South Cave. It initially has a 13m high roof and a wide chamber that narrows to end in black coloured pools of water.	4.10.1997 – The first nest was 25m inside and 35m from the floor while the last was only 2m off the floor. There were at least 14 current nests, the majority of them difficult to discern due to height except from the floor faecal remains.
37. Mago Cave	A well-known cave on the south part of the loop road. The entrance is 100m off the road opposite owner's (Vaogo Setu) fale. The same guides from Falealupo (see above) can guide. Asking for the landowner or the cave helps location. Entrance fee 10 tala/vehicle charged.	This cave has a large cross-section with five collapses in the early section. The first, second and fourth collapses are free climbable but the others are roof daylight. The cave ends 420m beyond the last collapse and 412m from a stone wall.	4.10.1997 –The first two nests were in the twilight and 85m apart. The other 16 nests were all in complete darkness, one of which was unusual for Samoan nests in that it was totally self supporting (at 5.8 metres above the floor), rather than being on a ledge or protuberance.
38. Samata-i-uta Sea Cave	The cave is right on the 38m high sea cliff edge of the village. The landowner (Esau Tilo) is the best guide. It is best to ring Faifeau on 56036 and ask for Esau; then call back 5-10 min later to speak to Esau. Esau charges 5 tala for access.	The cave entrance is 20m from the top of the cliff and during the cyclones the entrance and first third of the cave passage received substantial coral sand deposits. There is no protective reef on this part of the island. The cave is about 250m long with an average height of 2m. There are 3 low points in the cave; 99cm, 40cm and 37cm in height. It is normally a very dry cave except in very high seas.	7.11.1997 – 3 nests were found, 1 beyond the 99 cm low point. A partly-built nest was at a height of 1.44 m. A roost site was at 1.41 m above the floor. This cave and the swiftlet colony have significance to this village and they name their cricket team <i>Ana Pe'a pe'</i> to commemorate both. In spite of this the men that accompanied me including the owner did not venture very far into the cave, citing the presence of spirits for their reticence.
<p>The map shows the layout of 38. Samanta-i-Uta Cave. On the left, 'Ocean cliffs' are indicated with a jagged line. A north arrow points upwards. A scale bar below the map indicates 50 meters. The cave passage is shown as a long, narrow, slightly irregular line extending to the right. Three points along this passage are marked with arrows and labeled 'Low Points'.</p>			

