

## Evidence for year-round breeding of birds in the Samoan islands, in the context of the Australasian and South Pacific regions

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**Abstract** This paper summarises the variations in breeding periodicity in the Australasian - South Pacific region, including recent evidence contrary to previous knowledge. Birds shown to breed in the Samoan islands throughout the year are white-tailed tropicbird (*Phaethon lepturus*), white-rumped swiftlet (*Aerodramus spodiopygius*), buff-banded rail (*Gallirallus philippensis*), brown noddy (*Anous stolidus*), white tern (*Gygis alba*) and wattled honeyeater (*Foulchairo carunculata*). In addition, crimson-crowned fruit-dove (*Ptilinopus porphyraceus*), blue noddy (*Procelsterna caerulea*), cardinal honeyeater (*Myzomela cardinalis*) and Polynesian triller (*Lalage maculosa*) breed in at least 9 months of the year. The Samoan whistler (*Pachycephala flavifrons*) has been found breeding in 8 months and the Samoan starling (*Aplornis atrifusca*) in 7 months of the year.

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### INTRODUCTION

Reproduction in birds, as in all animals, takes place at the time of the year when it is biologically most advantageous for them to do so (Serventy & Warham 1971). Breeding periodicity allows birds and other organisms to synchronize breeding attempts with the most favourable ecological conditions under which to raise their offspring. In most of the world, ecological conditions vary seasonally and so impose an annual breeding schedule on their populations (del Hoyo *et al.* 1992). In the tropics however, seasons are not as distinct and annual breeding cycles may be longer than in temperate regions (Ricklefs 1966) or may not develop for a population or for individuals (Pyle *et al.* 2016).

The characteristic breeding cycles for some groups of birds have been known for some time; this is particularly the case for seabirds in which their colonial nature facilitates the collection of data regarding breeding seasonality. For instance, it has long been known that albatrosses nesting in temperate locations breed every second year even though the breeding site will have half the population breeding in it each year (Jouventin & Dobson 2002; Ratcliffe *et al.* 2008).

Regional variations have also been reported in seabirds. Serventy & Warham (1971) note that almost all species of seabirds in eastern and south-eastern Australia restrict their breeding to the spring and summer; whereas in north-western Australia, the predominant period of egg-laying is in the autumn and winter, and in south-western Australia spring and early summer egg-laying is the rule. In

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the intervening region, from the Lacedpede Islands in the north to Shark Bay, there are both autumn-breeding and spring-breeding populations on the same islands.

The incidence of tropical cyclones and strong winter winds, as well as upwelling ocean currents, each appear to have an effect on the seasonality of egg-laying in seabirds. Silver gulls (*Larus novaehollandiae*) in Western Australia are double brooded with an interval of about 4 months between layings (Nicholls 1964). When silver gulls are taken from south-eastern Australia where they are single brooded and held in captivity in south-western Australia, they become double brooded in synch with the local gulls (Nicholls 1964). In New Zealand, the nitrogen-rich upwellings off Kaikoura facilitate and control the timing and success of the breeding of red-billed gulls (*Larus novaehollandiae*) and Hutton's shearwaters (*Puffinus huttoni*) (Sherley 1992; Mills *et al.* 2008). During the breeding season, the relative availability of New Zealand krill (*Nyctiphanes australis*) was correlated positively with the Southern Oscillation Index and the frequency of occurrence of north-east winds which induce upwelling. Incursions of warm oceanic water, often induced by westerly winds which are characteristic of El Niño years, were associated with reduced euphausiid availability and reduced breeding success (Mills *et al.* 2008).

Less is known about the breeding seasons of tropical seabirds; but what is known often shows sub-annual breeding periodicity, rather than annual or biennial periodicity. Tropical seabirds known to breed every 6 months include swift terns (*Sterna bergii*) on Aldabra Atoll (Diamond & Prys-Jones 1986) and white terns (*Gygis alba*) on Christmas Island (Pacific) (Ashmole 1968). Those breeding every 7 to 8 months include white-tailed tropicbirds (*Phaeton lepturus*) on Ascension Island (Stonehouse 1962) and Aldabra Atoll (Prys-Jones & Peet 1980), and bridled terns (*Sterna anaethetus*) on Aldabra Atoll (Diamond & Prys-Jones 1986). Those breeding every 9 to 10 months include the Christmas shearwater (*Puffinus nativitatis*) on Pitcairn Islands (Brooke 1995), and Audubon's shearwater (*Puffinus lherminieri*) and swallow-tailed gulls (*Creagrurus furcatus*) on the Galapagos Islands (Snow 1965; Snow & Snow 1967). In Fiji, it has been shown that while the colony of black noddies (*Anous minutus*) on Vatu-i-Ra is occupied by birds throughout the year (Tarburton 1978), breeding takes place at 9 to 10-month intervals, and individual birds breed each second cycle (Tarburton 1987).

Small islands in the tropical South Pacific have less seasonal climate variation than most other places on earth (Steadman 2006). This means that along with the reliable year-round rainfall (except on a small part of large islands such as Savaii)

plants, invertebrates and vertebrates have greater possibilities of reproducing all year (Ricklefs 1966; Weimerskirch 2007). To prevent overpopulation there can be mechanisms to restrict that breeding period, to restrict the number of progeny or to reduce the number of breeders.

Watling (2001) uses information from the Whitney Expedition and his own observations to suggest that there is a distinct seasonal pattern in both breeding and moult for many south Pacific bird species. He points out that this seasonality is found in the majority of land birds in Fiji and Tonga, but less clearly in Samoa. Because the Samoan climate is almost aseasonal, it is tempting to agree with Dhondt (1976), that breeding is not restricted to 1 part of the year. Dhondt's assertion was based on his finding that buff-banded rails (*Gallirallus philipensis*) and Polynesian trillers (*Lalage maculosa*) were breeding in 6 to 8 months of the year. He only visited a white-rumped swiftlet (*Aerodramus spodiopygius*) colony once, but combining this with Ashmole's data (1963), he determined breeding in April, June and November, albeit in different years. Ashmole (1963) was able to make the generalisation that it is obvious that breeding is not restricted to 1 part of the year. She found banded rails breeding in March and August and white-rumped swiftlets breeding in February, April, June and November.

Banks (1984) noted that even though 1,300 specimens have been taken from American Samoa, the annual cycle remains incompletely known even for those few species with large samples of specimens. Largely this is due to the limited timing of collecting. Probably about the same number of specimens have been taken from Samoa (formerly Western Samoa) with similarly minimal information about the breeding seasons of the birds that breed there.

In 1985, the U.S. Fish & Wildlife Service organised a large survey of forest birds in American Samoa, but at the end of that they still claimed "little is known about life histories of forest birds" (Engbring & Ramsey 1989).

It has been shown that on Savaii, the largest island in the Samoan Archipelago, that the purple swamphen (*Porphyrio porphyrio*), flat-billed kingfisher (*Todiramphus recurvirostris*) and Samoan flycatcher (*Myiagra albiventris*) do not inhabit that island above 1,200 m (Pratt & Mittermeier 2016). What factor(s) restrict these birds? They also conclude that the Samoan woodhen (*Galinula pacifica*), a flightless rail, has been extinct for over 100 years and that recent "sightings" are mis-identifications. Steadman (2006) estimated that between 500–1,600 species of flightless rails inhabited Pacific islands prior to the first human colonization. However, not a single species survives on inhabited islands outside of New Zealand (Pratt

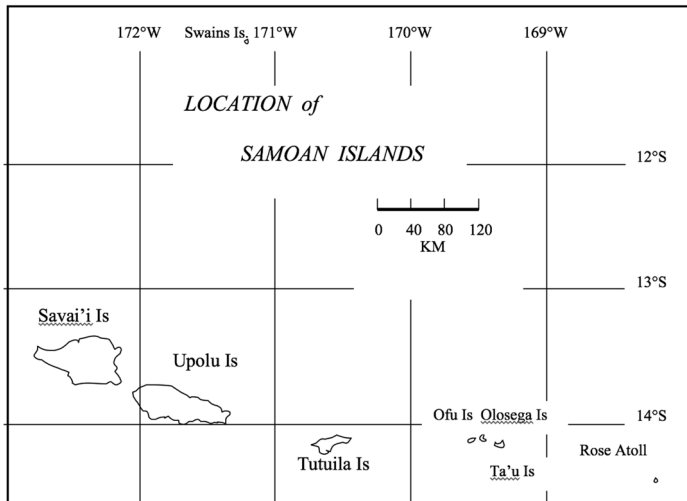


Fig. 1. Location of Samoan islands.

& Mittermeier 2016). It is too late to find out if they could or did breed all through the year.

Since I was to live on Upolu in Samoa for 4 years it was decided to start filling in some of the blanks in the breeding cycles of Samoan birds. Accordingly, this paper collates information from literature sources and field observations to provide an updated account of bird breeding activity on the Samoan islands.

## MATERIALS AND METHODS

Breeding data from the literature were compiled and added to my own field observations, made between January 1994 and December 1997, while locating and visiting 38 caves on the Samoan islands of Savai'i, Upolu and Tutuila, as well as doing over 400 1-hour censuses of seabird movements around the entire coast of Upolu.

To make headway on the bush birds, 35 trips were made up the walking track from Vailima, past the Robert Louis Stevenson memorial to the lookout on the west face of Mt Vaea, specifically to observe evidence for breeding. Mt Vaea is close to the capital of Samoa, Apia, on the island of Upolu. These walks were made between 1 July 1995 and 19 April 1997. One to 7 walks were made each month. Thus, while not evenly spread over the study period, the walks did add many data points to this paper.

Key indicators used to determine breeding included anatomical features (i.e. enlarged testes or ovaries), nests with contents (i.e. eggs, nestlings or brooding adults), breeding behaviours (i.e. seabirds landing in forests, courtship behaviour, copulation) or the presence of recently fledged birds.

Non-breeding indicators from specimens or captured birds are not recorded because it is too uncertain as to whether the individual was immature or in post-breeding condition. From looking at skins in all Australian and New Zealand Museums as well as live birds and the literature, I see there is also considerable variation in observer ability with regard to judging the age and seasonal status of skins – particularly in species new to most observers. It is also clear that in those species now known to breed all year that birds not in breeding condition do not preclude others from being in breeding condition.

Names and sequence of birds are taken from Christidis & Boles (2008) or if not included there, from the IOC Checklist (<http://www.worldbirdnames.org/ioc-lists/master-list-2/>).

## RESULTS

The location of the 8 main islands mentioned in this paper are shown in Fig. 1. The actual months of breeding for each species for which data was gained is shown in Table 1. Full details regarding the types of data used as evidence for breeding and the source of these observations are provided in Appendix 1.

Birds shown to breed in the Samoan Islands throughout the year (Table 1) are white-tailed tropicbird, white-rumped swiftlet, buff-banded rail, brown noddy, white tern and wattled honeyeater (*Foulchairo carunculata*). In addition, crimson-crowned fruit-dove (*Ptilinopus porphyraceus*), blue noddy (*Procelsterna caerulea*), cardinal honeyeater (*Myzomela cardinalis*) and Polynesian triller (*Lalage*

**Table 1.** Months in which breeding has been observed in Samoan birds. \* = historical observation, # = data from this study.

Common Name	Scientific Name	J	F	M	A	M	J	J	A	S	O	N	D
Red-tailed tropicbird	<i>Phaethon rubricauda</i>					*	*	*	*	*	*	*	
White-tailed tropicbird	<i>Phaethon lepturus</i>	*	*	#	*	*	*	*	#	#	*	*	*
Crimson-crowned fruit-dove	<i>Ptilinopus porphyraceus</i>	*	*			*	*	*	*	*	*	*	*
Many-coloured fruit-dove	<i>Ptilinopus perousii</i>		*		*	*	*			*		*	*
Pacific imperial pigeon	<i>Ducula pacifica</i>				*			*	*	*			*
Tooth-billed pigeon	<i>Didunculus strigirostris</i>								*				
White-rumped swiftlet	<i>Aerodramus spodiopygius</i>	*	*	#	*	#	*	#	*	*	#	*	*
Tahiti petrel	<i>Pseudobulweria rostrata</i>				*	*		*			*		
Herald petrel	<i>Pterodroma heraldica</i>					*		*	*		*		
Audubon's shearwater	<i>Puffinus lherminieri</i>				*	*	*	*					*
Christmas shearwater	<i>Puffinus nativitatis</i>	*									*		
Great frigatebird	<i>Fregata minor</i>						*				*		*
Lesser frigatebird	<i>Fregata ariel</i>					*					*		*
Masked booby	<i>Sula dactylatra</i>					*	*		*		*	*	*
Brown booby	<i>Sula leucogaster</i>	*				*	*	*	*	*	*		*
Red-footed booby	<i>Sula sula</i>						*			*	*	*	*
Eastern reef egret	<i>Egretta sacra</i>									*	*		*
Purple swamphen	<i>Porphyrio porphyrio</i>	*					*	*				*	*
Buff-banded rail	<i>Gallirallus philippensis</i>	*	*	*	*	*	*	*	*	*	*	*	*
Spotless crane	<i>Porzana tabuensis</i>												*
Brown noddy	<i>Anous stolidus</i>	*	*	#	*	*	*	*	*	#	*	*	*
Black noddy	<i>Anous minutus</i>				*	*	*	*	*		*	*	*
White tern	<i>Gygis alba</i>	*	*	#	*	#	#	*	*	#	*	*	*
Blue noddy	<i>Procelsterna cerulea</i>	*		*		*	*	*	*	*	*	*	
Spectacled tern	<i>Onychoprion lunatus</i>										*	*	
Bridled tern	<i>Onychoprion anaethetus</i>								#		#		#
Sooty tern	<i>Onychoprion fuscatus</i>								*		*		*
Little tern	<i>Sternula albifrons</i>			*									
Black-naped tern	<i>Sterna sumatrana</i>					#						#	
Blue-crowned lorikeet	<i>Vini australis</i>	*					*						*
Eastern barn owl	<i>Tyto javanica</i>						#	*					*
Flat-billed kingfisher	<i>Todirhamphus recurvirostris</i>	*											
Collared kingfisher	<i>Todirhamphus chloris</i>	*	*	*	*	*	*				*	*	
Wattled honeyeater	<i>Foulehaio carunculatus</i>	*	*	#	*	#	*	*	#	#	*	*	*
Cardinal myzomela	<i>Myzomela cardinalis</i>			*	*	*	*	*	#	#	*	*	#
Mao	<i>Gymnomyza samoensis</i>		*										
Polynesian triller	<i>Lalage maculosa</i>	*	*	*	*	#	*	*	*	*	#		*
Samoan triller	<i>Lalage sharpei</i>		*					#	*		#		
Samoan whistler	<i>Pachycephala flavifrons</i>			#		#	#	#	#	#	#	#	
Samoan fantail	<i>Rhipidura nebulosa</i>			#	*		#				#		
Samoan flycatcher (broadbill)	<i>Myiagra albiventris</i>								*				

**Table 1 cont.** Months in which breeding has been observed in Samoan birds. \* = historical observation. # = data from this study.

Common Name	Scientific Name	J	F	M	A	M	J	J	A	S	O	N	D
Fiji shrikebill	<i>Clytorhynchus vitiensis</i>	*						*					
Pacific robin	<i>Petroica pusilla</i>	*					*	#	*	*	#		
Samoan white-eye	<i>Zosterops samoensis</i>					*							
Red-vented bulbul	<i>Pycnonotus cafer</i>	*	#					#	#	#	#	*	#
Island thrush	<i>Turdus poliocephalus</i>		*				*						*
Polynesian starling	<i>Aplonis tabuensis</i>	*		*				*	*		#		
Samoan starling	<i>Aplonis atrifusca</i>			*		*	*	*		*	*	*	
Jungle myna	<i>Acridotheres fuscus</i>												#
Common myna	<i>Acridotheres tristis</i>		*	*					#		#		#
Red-headed parrot-finch	<i>Erythrura cyaneovirens</i>							#		#	#		

*maculosa*) breed in at least 9 months of the year. The Samoan whistler (*Pachycephala flavifrons*) has been found breeding in 8 months and the Samoan Starling (*Aplornis atrifusca*) in 7 months of the year.

## DISCUSSION

Muse & Muse (1982) predicted that the white-tailed tropicbird, the buff-banded rail, the Pacific robin (*Petroica multicolour*) and cardinal honeyeater will be found to breed throughout the year. This paper adds credence to each of these suggestions, though only the first 2 are fully confirmed. The same authors also claimed that the Polynesian triller bred throughout the year but gave no evidence for the statement. This study found Polynesian trillers breeding in 2 of the remaining 3 months – so are now almost certain to be found breeding in all 12 months of the year. This study has also shown that 4 unpredicted species nest in each month of the year: white-rumped swiftlet, brown noddy, white tern and wattled honeyeater.

With seabirds, there is the possibility in Polynesia of having a breeding period of less than 12 months. This non-annual breeding regime has been found in black noddies in Fiji where the colony has an 8 to 10-month breeding cycle (Tarburton 1987), with individuals breeding every 20 months. This means the colony has eggs every 10 months and can look deserted diurnally at the time they had eggs the previous year. At sunset however, the noddies that are not on migration to the Solomon Islands will mass offshore and come ashore to roost each night of the year. A similar regime is possible for sooty terns (*Onychoprion fuscatus*) on Rose Island where eggs were observed in October 1975, whereas in October the following year 4,300 fledglings were

recorded (Sekora 1974 & 1976 in Amerson *et al.* 1982). This is further supported by the recording of breeding birds in May 1974 (Amerson *et al.* 1982). A sub-annual breeding cycle could also explain the breeding dates given for the brown noddy in American Samoa by Amerson *et al.* (1982), whereas they interpret their data as probably signalling breeding throughout the year. Separate colonies may also not be synchronised with each other so we need to be aware of the dangers of mixing data from different sea-bird colonies.

Bridled terns, breeding on Penguin Island in Western Australia breed out of the tropics then migrate to “winter” in the tropics in the Celebes Sea (Dunlop & Johnstone 1994). However, Samoan bridled terns stay in the tropics to breed on the 2 stacks off O-Le-Pupu Pue National Park (Tarburton 2001).

The concept of individual birds not participating in breeding even though the colony might be breeding is also worth consideration. Tarburton (2009) has shown that white-rumped swiftlets breed throughout the year (*contra* Whitmee 1875) at most colonies in Samoa, yet individual pairs in that colony usually breed only once a year. If food levels are continually reasonably high but insufficient for all to breed all the time, then pairs can share them throughout the year. This is in contrast to 1 pair of buff-banded rails on Upolu producing 5 broods in 1 year (Robinson 1995). Even though the swiftlets in Samoa breed all year, there is an obvious peak in September.

Amerson *et al.* (1982) suggest many-coloured fruit-doves (*Ptilinopus perousii*) breed in the southern winter, but from this paper it is now clear that they breed in all 4 seasons. The same authors also suggest that the collared kingfisher “probably



breeds in the southern summer". This paper shows that to be true – but this kingfisher also breeds up to at least June – the Austral winter.

Turning from seabirds to landbirds, Pyle *et al.* (2015) found in American Samoan birds that while there was broad overlap between moult and breeding at the population level, there was very little at the individual level. They suggest that while moult may take precedence over breeding, that tropical landbirds appear to be capable of suspending moult to breed when environmental conditions shift to favour successful reproduction. Much further study is needed to understand why so many Samoan bird species are breeding all year round.

I would be very wary of claiming too much for the family of crested terns I observed in Vaiusu Bay 27 July 1997. The 2 adults were accompanied by a juvenile with 75% of the body covered with brown flecking. The juvenile concerned was very like illustration #4 on Plate 36 in Higgins & Davies (1996). This does not prove breeding in Samoa as banded birds in Australia have been found up to 575 km from their natal colony 19 days after fledging, and over 1,000 km away within 7 weeks of fledging (Higgins & Davies 1996). We just do not know whether this species will take their fledglings over the sea as readily as they do along the Australian coast, but vagrants do turn up in New Zealand (Higgins & Davies 1996).

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**Appendix 1.** Specific evidences for breeding given for species recorded in this study and in literature, covering named Samoan islands. \*Key to evidence: ASol = adult soliciting; AFF = adult flying with food; BP = brood patch; CNM = carrying nest material; E = egg; ES = egg shells; EOvi = egg in oviduct; F = fledgling departing; FB = fledgling begging; FF = flying with fish in bill; FFI = feeding fledgling; FI = fledgling(s) seen; FLA = seabird flying over major island - not coral bar; diurnal; GE = gonads enlarged; GNE = gonads not enlarged; Hd = heard in burrow; Juv = juvenile; N = "nesting" reported; NA = parents tending nest; NB = adult brooding; NBI = nest building; NDF = nest defence behaviour; NI = nestling; NP = nest prospecting; NS = repeated trips to one site; Nt = nest; OE = ovary enlarged; PC = pair courting; R = runner; RB = runner, in black down; Sbl = seabird landing in forest/tree; TE = testes enlarged.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
Red-tailed tropicbird	Nt											x		Rose	Morrell & Aquilani 2000
Red-tailed tropicbird	NB					x	x	x	x	x	x	x	x	Rose	Amerson <i>et al.</i> 1982
Red-tailed tropicbird	FI												x	Swain's	Amerson <i>et al.</i> 1982
Red-tailed tropicbird	E												x	Rose	Amerson <i>et al.</i> 1982
Red-tailed tropicbird	NI												x	Rose	Amerson <i>et al.</i> 1982
White-tailed tropicbird	NI												x	Upolu	Armstrong 1932
White-tailed tropicbird	NS												x	Upolu	Armstrong 1932
White-tailed tropicbird	Fla													Upolu	Yaldwyn 1952
White-tailed tropicbird	FI												x	Tutuila	Clapp & Sibley 1966
White-tailed tropicbird	OE												x	Tutuila	Clapp & Sibley 1966
White-tailed tropicbird	OE												x	Tutuila	Banks 1984
White-tailed tropicbird	NI, TE													Tutuila	Banks 1984
White-tailed tropicbird	FI												x	Tutuila	Banks 1984
White-tailed tropicbird	FI													Tutuila	Dunmire 1960
White-tailed tropicbird	FI													Tutuila	Banks 1984
White-tailed tropicbird	FI													Ofu	Dunmire 1960
White-tailed tropicbird	Oe													Ta'u	Dunmire 1960
White-tailed tropicbird	FLa													Swains	Clapp 1968
White-tailed tropicbird	FLa													Upolu	This study
White-tailed tropicbird	FLa													Tutuila	This study
White-tailed tropicbird	PC													Upolu	This study
White-tailed tropicbird	Sbl													Upolu	This study
White-tailed tropicbird	FLa													Savai'i	This study
White-tailed tropicbird	NP													Upolu	This study
White-tailed tropicbird	NI													Upolu	This study
White-tailed tropicbird	E													Upolu	This study
Crimson-crowned fruit-dove	E													Upolu	Armstrong 1932



## Appendix 1. cont.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
Crimson-crowned fruit-dove	NI						x							Upolu	Armstrong 1932
Crimson-crowned fruit-dove	Ge	x	x				x	x	x	x	x	x	x	Tutuila, Manu'a	Banks 1984
Crimson-crowned fruit-dove	Juv	x	x					x	x	x	x	x	x	Tutuila, Manu'a	Banks 1984
Crimson-crowned fruit-dove	TE						x							Tutuila	Clapp & Sibley 1966
Crimson-crowned fruit-dove	NI						x							"Samoa"	Ripley & Birkhead 1942
Crimson-crowned fruit-dove	NB	x												Upolu	This paper
Crimson-crowned fruit-dove	NI						x							Unspecified	Ashmole 1963
Crimson-crowned fruit-dove	TE						x							Tutuila	Amerson <i>et al.</i> 1982
Crimson-crowned fruit-dove	TE						x							Tutuila	Clapp & Sibley 1966
Many-coloured fruit-dove	NL	x										x	x	Tutuila, Manu'a	Banks 1984
Many-coloured fruit-dove	GE											x	x	Tutuila, Manu'a	Banks 1984
Many-coloured fruit-dove	TE						x							Tutuila, Manu'a	Banks 1984
Many-coloured fruit-dove	TE, OE											x		Tutuila	Amerson <i>et al.</i> 1982
Pacific pigeon	E										x	x	x	Upolu	Whitmee 1875
Pacific pigeon	OE													Tutuila	Banks 1984
Pacific pigeon	TE												x	Upolu	Layard 1876
Tooth-billed pigeon	R										x			Not given	Ashmole 1963
Tooth-billed pigeon	Juv										x			Upolu	Armstrong 1932
White-rumped swiftlet	NI												x	Upolu	Whitmee 1875
White-rumped swiftlet	Nt												x	Ta'u	Banks 1984
White-rumped swiftlet	Nt													Ofu	Banks 1984
White-rumped swiftlet	E													Upolu	Armstrong 1932
White-rumped swiftlet	NI													Upolu	Armstrong 1932
White-rumped swiftlet	E, N, BP													Upolu	Dhondt 1976
White-rumped swiftlet	E													Upolu	Ollier <i>et al.</i> 1979
White-rumped swiftlet	E, NI													Upolu	Amerson <i>et al.</i> 1982
White-rumped swiftlet	NB													Tutuila	Engbring & Ramsey 1989
White-rumped swiftlet	N													Tutuila	Bellingham & Davis 1988
White-rumped swiftlet	E, NI													Upolu	Tarburton 2009
White-rumped swiftlet	TE, PC													Upolu	Amerson <i>et al.</i> 1982; Banks 1984
Tahiti petrel	SbL													Ta'u	Amerson <i>et al.</i> 1982
Tahiti petrel	Hd, Fla, N													Ta'u	Engbring & Ramsey 1989

Appendix 1. cont.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
Tahiti petrel	NB						x							Tutuila	Engbring & Ramsey 1989
Tahiti petrel	Fla, N						x							Olosega	Engbring & Ramsey 1989
Herald petrel	Fla, N			x			x							Ta'ū	Pyle <i>et al.</i> 1990
Herald petrel	NI						x							Ta'ū	Pyle <i>et al.</i> 1990
Herald petrel	OE			x										Ta'ū	Pyle <i>et al.</i> 1990
Herald petrel	SbL								x					Ta'ū	Amerson <i>et al.</i> 1982
Audubon's shearwater	Nt											x		Ta'ū	Banks 1984
Audubon's shearwater	SbL			x			x							Ta'ū	Amerson <i>et al.</i> 1982
Audubon's shearwater	NI					x								Ta'ū	Engbring & Ramsey 1989
Audubon's shearwater	FLa, N						x							Tutuila	Engbring & Ramsey 1989
Christmas shearwater	SbL	x												Ta'ū	Amerson <i>et al.</i> 1982
Great frigatebird	Nt					x								Rose	Amerson <i>et al.</i> 1982
Great frigatebird	NI						x							Rose	Amerson <i>et al.</i> 1982
Lesser frigatebird	E		x											Rose	Amerson <i>et al.</i> 1982
Lesser frigatebird	Nt		x											Rose	Amerson <i>et al.</i> 1982
Masked booby	E, NI												x	Rose	Banks 1984
Masked booby	E			x			x							Rose	Amerson <i>et al.</i> 1982
Masked booby	NL					x								Rose	Amerson <i>et al.</i> 1982
Brown booby	TE, OE													Rose	Banks 1984
Brown booby	E, TE													Rose	Banks 1984
Brown booby	TE		x											Ofu	Banks 1984
Brown booby	NI									x				Fanuatapu	Child 1979
Brown booby	NI													Ofu(Nu'utele)	Amerson <i>et al.</i> 1982
Brown booby	E													Rose Tutuila	Amerson <i>et al.</i> 1982
Brown booby	NI													Ofu(Nu'utele) Olosega	Amerson <i>et al.</i> 1982
Brown booby	NI													Ofu(Nu'utele) Olosega	Amerson <i>et al.</i> 1982
Brown booby	NI													Ofu(Nu'utele) Olosega	Amerson <i>et al.</i> 1982
Brown booby	NI													Tutuila	Engbring & Ramsey 1989
Brown booby	NI													Olosega	Engbring & Ramsey 1989
Red-footed booby	NI, E													Off E Upolu, Nu'utele?	Armstrong 1932
Red-footed booby	E													Rose	Banks 1984
Red-footed booby	Nt, E, NI													Rose	Amerson <i>et al.</i> 1982

## Appendix 1. cont.

Species	Evidence*	Month												Location	Source	
		J	F	M	A	M	J	J	A	S	O	N	D			
Red-footed booby	Nt												x	Tutuila, Poa (off Tutuila)	Amerson <i>et al.</i> 1982	
Eastern reef egret	E													x	Rose	Banks 1984
Eastern reef egret	E, Nt												x	Rose	Amerson <i>et al.</i> 1982	
Eastern reef egret	TE												x	Ofu	Banks 1984	
Purple swamphen	TE								x						Ofu	Banks 1984
Purple swamphen	OE												x	Tutuila	Banks 1984	
Purple swamphen	E	x												Tutuila	Banks 1984	
Purple swamphen	GE	x										x		Tutuila, Tau, Ofu,	Banks 1984	
Purple swamphen	N, E	x										x		Tutuila, Tau, Ofu,	Banks 1984	
Buff-banded rail	RB						x							Upolu	Armstrong 1932	
Buff-banded rail	Juv												x	Upolu	Armstrong 1932	
Buff-banded rail	OE												x	Tutuila	Clapp & Sibley 1966	
Buff-banded rail	OE, TE	x												Tutuila	Banks 1984	
Buff-banded rail	R	x											x	Tutuila	Banks 1984	
Buff-banded rail	R													Savai'i	Green 1965	
Buff-banded rail	R, RB	x												Upolu	Dhondt 1976	
Buff-banded rail	ES													Upolu	Dhondt 1976	
Buff-banded rail	E												x	Upolu	Dhondt 1976	
Buff-banded rail	Juv												x	Upolu	Dhondt 1976	
Buff-banded rail	Cop												x	Upolu	Dhondt 1976	
Buff-banded rail	RB												x	Upolu	Dhondt 1976	
Buff-banded rail	R	x												Upolu	Robinson 1995	
Buff-banded rail	R													Savai'i	Reed 1980	
Buff-banded rail	R, RB	x												Upolu	This study	
Buff-banded rail	ES													Upolu	This study	
Buff-banded rail	E													Upolu	This study	
Buff-banded rail	Juv													Upolu	This study	
Buff-banded rail	Cop													Upolu	This study	
Buff-banded rail	R													Upolu	This study	
Buff-banded rail	R, GE													Upolu	Banks 1984	
Spotless crane	N													Ta'u	Banks 1984	
Brown noddy	Nt, NDf	x												Nu'tutele, Upolu	Steve Brown <i>pers. comm.</i>	
Brown noddy	N													Tutuila	Clapp & Sibley 1966	
Brown noddy	NB													Tutuila	Clapp & Sibley 1966	
Brown noddy	NI													Tutuila	Dhondt 1976	
Brown noddy	OE, BP													Swain's	Clapp 1968	
Brown noddy														Swain's	Clapp 1968	

## Appendix 1. cont.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
Brown noddy	EOvi												x	Swain's	Clapp 1968
Brown noddy	NI, N				x									Swain's	Clapp 1968
Brown noddy	BP, GE	x												Swain's	Clapp 1968
Brown noddy	NI	x			x								x	Tutuila	Amerson <i>et al.</i> 1982
Brown noddy	NI								x					Ofu	Amerson <i>et al.</i> 1982
Brown noddy	NI								x					Ta'u	Amerson <i>et al.</i> 1982
Brown noddy	N	x					x							Rose	Amerson <i>et al.</i> 1982
Brown noddy	NI						x							Swain's	Amerson <i>et al.</i> 1982
Brown noddy	FLa	x	x	x	x	x	x	x	x	x	x	x	x	Upolu	This study
Brown noddy	FLa													Upolu	This study
Brown noddy	SbL	x	x	x	x	x	x						x	Tutuila	This study
Brown noddy	CNM													Upolu	This study
Brown noddy	FLa													Upolu	This study
Brown noddy	NB	x			x	x	x	x	x					Savai'i	This study
Brown noddy	E													Upolu	This study
Brown noddy	NL													Upolu	This study
Brown noddy	PC													Upolu	This study
Black noddy	NB													Swain's	Clapp 1968
Black noddy	NB													Swain's	Clapp 1968
Black noddy	NB, NL													Swain's	Clapp 1968
Black noddy	NB													Swain's	Banks 1984
Black noddy	NB													Rose	Banks 1984
Black noddy	N													Tutuila	Amerson <i>et al.</i> 1982
Black noddy	N													Ta'u	Amerson <i>et al.</i> 1982
Black noddy	N													Swains	Amerson <i>et al.</i> 1982
Black noddy	N, E													Rose	Amerson <i>et al.</i> 1982
Black noddy	N													Ta'u	Amerson <i>et al.</i> 1982
White tern	E, BP													Swain's	Engbring & Ramsey 1989
White tern	BP													Swain's	Clapp 1968
White tern	NS													Swain's	Clapp 1968
White tern	NB													Tutuila	Clapp 1968
White tern	GE, NB													Rose, Ta'u	Banks 1984
White tern	E, Nt													Rose	Banks 1984

## Appendix 1. cont.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
White tern	AFE, NBI											x		Upolu,	Child 1979
White tern	FF	x			x									Upolu,	Dhondt 1976
White tern	N, E											x		Rose	Amerson <i>et al.</i> 1982
White tern	SbL	x												Tutuila	Dunnire 1960
White tern	PC	x												Ta'u	Dunnire 1960
White tern	FLa	x	x	x	x	x	x	x	x	x	x	x	x	Upolu	This study
White tern	FF	x	x	x	x	x	x	x	x	x	x	x	x	Upolu	This study
White tern	SbL	x										x		Upolu	This study
White tern	PC	x	x	x	x	x	x	x	x	x	x	x	x	Upolu	This study
White tern	FLa	x	x	x	x	x	x	x	x	x	x	x	x	Tutuila	This study
White tern	FF													Tutuila	This study
White tern	NI											x		Upolu	This study
White tern	FLa		x											Savai'i	This study
White tern	NB						x	x	x				x	Upolu	This study
White tern	E								x					Upolu	This study
White tern	PC												x	Savai'i	This study
Blue noddy	NI												x	Tutuila	This study
Blue noddy	NB													Tutuila	Clapp & Sibley 1966
Blue noddy	GE	x												Tutuila	Banks 1984
Blue noddy	NB													Tutuila, Aunu'u,	Banks 1984
Blue noddy	N													Ofu	Dhondt 1976
Blue noddy	Nt													Tutuila	Amerson <i>et al.</i> 1982
Blue noddy	N													Tutuila	Amerson <i>et al.</i> 1982
Blue noddy	N													Aunu'u	Amerson <i>et al.</i> 1982
Blue noddy	N													Ofu (Nu'utele)	Amerson <i>et al.</i> 1982
Blue noddy	N													Ta'u	Amerson <i>et al.</i> 1982
Blue noddy	N													Olosega	Amerson <i>et al.</i> 1982
Blue noddy	N													Tutuila	Amerson <i>et al.</i> 1982
Blue noddy	N													Nu'u'loa & Nu'utele	McAllan & Hobcroft 2005
Spectacled tern	FI													Sand, Rose	Amerson <i>et al.</i> 1982
Bridled tern	E, NB													Upolu	This study
Bridled tern	Juv													Upolu	This study
Sooty tern	OE													Rose	Banks 1984
Sooty tern	E													Rose	Amerson <i>et al.</i> 1982

## Appendix 1. cont.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
Sooty tern	FI												x	Rose	Amerson <i>et al.</i> 1982
Little tern	Juv			x										Upolu	This study
Black-naped tern	FFI											x		Upolu	This study
Black-naped tern	F, Juv				x									Upolu	This study
Blue-crowned lorikeet	GE (4)	x										x		Tutuila	Banks 1984
Blue-crowned lorikeet	GnE 64)	x										x		Tutuila	Banks 1984
Blue-crowned lorikeet	GnE					x								Ofu	Banks 1984
Eastern barn owl	OE								x					Ta'u	Banks 1984
Eastern barn owl	NS											x		Upolu	Armstrong 1932
Eastern barn owl	F							x						Upolu	This study
Flat-billed kingfisher	F	x												Upolu	Armstrong 1932
Collared kingfisher	NI			x										Tutuila	Clapp & Sibley 1966
Collared kingfisher	NI	x												Olosenga	Banks 1984
Collared kingfisher	GE, NI									x				Tutuila, Manu'a	Banks 1984
Collared kingfisher	NI		x											Tutuila, Manu'a	Banks 1984
Collared kingfisher	NI	x												Tutuila	Banks 1984
Wattled honeyeater	FI								x					Upolu	Amerson <i>et al.</i> 1982
Wattled honeyeater	GE	x	x		x				x		x	x		Upolu	Armstrong 1932
Wattled honeyeater	NBI	x								x				Tutuila, Manu'a	Banks 1984
Wattled honeyeater	CNM		x											Upolu	Dhondt 1976
Wattled honeyeater	BP		x		x									Upolu	Dhondt 1976
Wattled honeyeater	FFI								x					Upolu	Dhondt 1976
Wattled honeyeater	FB									x				Ofu?	Dhondt 1976
Wattled honeyeater	FB, FFI								x		x			Upolu	Engbring & Ramsey 1989
Wattled honeyeater	NIDf									x				Upolu	This study
Wattled honeyeater	FB		x						x		x	x		Upolu	This Study
Cardinal myzomela	TE		x		x						x	x		Upolu	This study
Cardinal myzomela	FI		x		x					x	x	x		Tutuila	Banks 1984
Cardinal myzomela	BP												x	Tutuila	Banks 1984
Cardinal myzomela	Juv													Upolu	Dhont 1976
Cardinal myzomela	GE													Upolu	Dhont 1976
Cardinal myzomela	FB													Tutuila	Amerson <i>et al.</i> 1982
Cardinal myzomela														Tutuila	Engbring & Ramsey 1989



## Appendix 1. cont.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
Cardinal myzomela	FB, FFI					x							x	Upolu	This study
Cardinal myzomela	NI				x									Upolu	This study
Cardinal myzomela	FI								x				x	Upolu	This study
Cardinal myzomela	CNM, NS					x								Upolu	This study
Cardinal myzomela	NS								x				x	Upolu	This study
Mao	TE		x											Tutuila	Mayr 1932; Banks 1984
Polynesian triller	AFF			x										Upolu	Dhondt 1976
Polynesian triller	NI				x									Upolu	Dhondt 1976
Polynesian triller	JB, FFI													Upolu	Dhondt 1976
Polynesian triller	JB		x											Upolu	Dhondt 1976
Polynesian triller	E													Upolu	Dhondt 1976
Polynesian triller	NI					x								Unspecified	Ashmole 1963
Polynesian triller	NB								x					Upolu	Ollier <i>et al.</i> 1979
Polynesian triller	FFI												x	Upolu	Ollier <i>et al.</i> 1979
Polynesian triller	FFI				x									Upolu	This study
Polynesian triller	FI								x					Upolu	This study
Polynesian triller	FB								x				x	Upolu	This study
Polynesian triller	NI												x	Upolu	This study
Polynesian triller	AFF												x	Upolu	This study
Polynesian triller	NBI													Upolu	This study
Polynesian triller	Nt, NS												x	Upolu	This study
Samoan triller	E, N, NB													Upolu	Dhondt 1976
Samoan triller	FFI													Upolu	Ollier <i>et al.</i> 1979
Samoan triller	E, N													Savaii	Reed 1980
Samoan triller	FB, FFI												x	Upolu	This study
Samoan whistler	FFI, FB												x	Upolu	This study
Samoan whistler	FB												x	Upolu	This study
Samoan fantail	FFI													Upolu	Dhondt 1976
Samoan fantail	FB												x	Upolu	This study
Samoan fantail	FFI													Upolu	This study
Samoan broadbill	NBI													Savai'i	Reed 1980
Fiji shrikebill	NI, E													Ta'u	Beck, <i>vide</i> Banks 1984

Appendix 1. cont.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
Fiji shrikebill	E						x							Ta'u	Engbring & Ramsey 1989
Fiji shrikebill	NI	x												Ofu	Banks 1984
Pacific robin	E		x											Upolu	Armstrong 1932
Pacific robin	FI	x												Upolu	Muse & Muse 1982
Pacific robin	E						x							Upolu	Muse & Muse 1982
Pacific robin	FFI													Upolu	Dhondt 1976
Pacific robin	FI													Upolu	Ollier <i>et al.</i> 1979
Pacific robin	NI													Savai'i	Reed 1980
Pacific robin	FFI													Upolu	This study
Pacific robin	NBI													Upolu	This study
Pacific robin	GE													Savai'i	Beck, fide Armstrong 1932
Samoan white-eye	N	x												Upolu	Goodman 1969 in Dhont 1977
Red-vented bulbul	E													Upolu	This study
Red-vented bulbul	FI													Upolu	This study
Red-vented bulbul	PC													Upolu	This study
Red-vented bulbul	FFI													Tutuila	This study
Red-vented bulbul	FFI													Upolu	This study
Island thrush	FI													Upolu	This study
Island thrush	TE													Upolu	Armstrong 1932
Island thrush	E													Upolu	Armstrong 1932
Polynesian starling	FI													Upolu	Green 1965
Polynesian starling	OE													Upolu	Armstrong 1932
Polynesian starling	TE, BP													Tutuila	Clapp & Sibley 1966
Polynesian starling	NI													Tutuila	Banks 1984
Polynesian starling	BP													Tamalingi, Upolu	Child 1979
Polynesian starling	FB, FFI													Savai'i	Reed 1980
Samoan starling	FFI													Upolu	This study
Samoan starling	TE													Upolu	Armstrong 1932
Samoan starling	TE													Tutuila	Clapp & Sibley 1966
Samoan starling	GE, Ny													Tutuila, Olosega	Amerson <i>et al.</i> 1982
Samoan starling	NBI													Tutuila, Olosega	Amerson <i>et al.</i> 1982
Samoan starling	AFF													Savai'i	DuPont 1972
Samoan starling	CNM													Upolu	Dhondt 1976
Samoan starling	CNM													Upolu	Dhondt 1976

## Appendix 1. cont.

Species	Evidence*	Month												Location	Source
		J	F	M	A	M	J	J	A	S	O	N	D		
Samoan starling	NA											x		Upolu	Ollier <i>et al.</i> 1979
Samoan starling	AFF					x								Tutuila	Engbring & Ramsey 1989
Samoan starling	CNM									x				Upolu	This study
Samoan starling	NBI									x				Upolu	This study
Samoan starling	NS									x				Upolu	This study
Jungle myna	E												x	Upolu	This study
Jungle myna	NI												x	Upolu	This study
Common myna	FFI													Upolu	Dhondt 1976
Common myna	Juv													Upolu	Dhondt 1976
Common myna	NDf													Upolu	This study
Common myna	FI													Upolu	This study
Common myna	NI													Upolu	This study
Red-headed parrot-finch	E, NB													Upolu	This study
Red-headed parrot-finch	FFI													Upolu	This study
Red-headed parrot-finch	NI													Savai'i	This study