

Bird fauna of Niue Island in 1994-95

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Abstract An annotated checklist of the bird species of Niue Island in the southwest Pacific is provided from published and unpublished sources, and from observations during April-May, September, and December 1994. Results for common species were derived from five-minute counts, numbers seen per kilometre while travelling by motorcycle along roads, and single species surveys. The number of species on Niue is 31 (6 seabirds, 10 shorebirds, and 15 land birds). The common noddy (*Anous stolidus*) was confirmed as nesting on the island. Recommendations are made for the future management of the hunted Pacific pigeon (*Ducula pacifica*) and the scarce blue-crowned lory (*Vini australis*).

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INTRODUCTION

Little has been published about the bird fauna of Niue Island. The earliest records are those of Smith (1902), mentioning 18 species and noting the biology of each. In his book of the history and traditions of Niueans, Loeb (1926) described how several bird species were caught for food. From observations made during November 1968 and July-August 1969, Wodzicki (1971) extended the checklist to 19 species. He also discussed the affinities of the Niuean bird fauna with those of the neighbouring archipelagos of Samoa, Tonga and the Cook Islands. Kinsky & Yaldwyn (1981) made a detailed study of Niue's bird life in June 1971 and August-September 1972, with particular emphasis on the white-tailed tropicbird (*Phaethon lepturus*) and Pacific golden plover (*Pluvialis fulva*). D. Morrison spent nearly two years on Niue in 1979-80, and his observations of birds were published

by Child (1982). Subsequently, Gibb *et al.* (1989) published their records of birds seen during several visits in 1986-87. Recent work to determine the fossil avifauna of the island has revealed the former presence of three species, a megapode (*Megapodius pritchardii*), a large flightless night heron (*Nycticorax* sp.) and a flightless rail (*Gallirallus* sp.) (Worthy *et al.* 1998).

During our visits in 1994, there were varying opinions amongst the Niuean people about the status of several bird species. In particular, there was concern about numbers of the Pacific pigeon (*Ducula pacifica*), which is hunted, and seemed to be declining. The apparent decline of this species was of much concern to Niueans living on the eastern side of the island where it is a highly prized food. In addition, some small species, such as the blue-crowned lory (*Vini australis*) and spotless crane (*Porzana tabuensis*), were so rarely, if ever, seen that they were considered highly threatened and at the point of extinction. Thus, the Niuean Government was interested in having up-to-date information on the status,

distribution, and habitat requirements of each bird species. This paper reports our findings from studies carried out in 1994-95, and our recommendations for the conservation of some species.

STUDY AREA

Niue is a raised coral atoll in the south-central Pacific Ocean (19°S, 169°W). It is isolated, being about 480 km east of Tonga, 800 km west of the Cook Islands and 560 km south-east of Samoa. The island is 259 km² in area, roughly circular (18 x 21 km, Fig. 1) and formed of two terraces. A prominent lower terrace at 18-24 m a.s.l. encircles much of the island, and is about 1 km wide. At its inner margin there is a steep rise to a ridge crest or upper terrace at about 55 m a.s.l. in the east and 60-65 m a.s.l. in the west. From this upper encircling terrace, the land initially slopes down towards the island's centre, which is flat and about 30 m a.s.l. The lower terrace ends abruptly in most places in steep sea cliffs containing caves and deep chasms. Some parts of the coastline, particularly to the west and north, are fringed by a narrow wave-cut platform close to the shore; there are few beaches.

Niue Island may have been inhabited by Polynesians for about 2000 years (Walter & Anderson 1995), and the current population totals about 2,500. Alofi, on the western coast, is the administrative centre and port. In addition, there are 12 villages near the coast, connected by a 64 km perimeter road (Fig. 1).

The climate is tropical, with two distinct seasons: the hot or wet season from December to March, and the cool or dry season from April to November. Most rain falls during the wet season, often in torrential downpours. Average annual rainfall is 2180 mm. The average temperature is 27°C in January (wet season) and 24°C in July. There is no surface water (streams, ponds), except ephemeral pools after heavy rain, and droughts can be severe.

The soils of Niue are fertile but shallow (Lane 1994). As a result they are suitable only for the traditional "slash and burn" cropping techniques whereby garden areas are left fallow for up to ten years before being reused. As a result of this continuing practice of shifting agriculture, much of the island is now a mosaic of varying stages of regeneration, interspersed with cultivated gardens. There are also scattered coconut plantations and three experimental farms with some pasture.

The long-term conservation of Niue's fauna depends on the continued presence of habitats that existed before

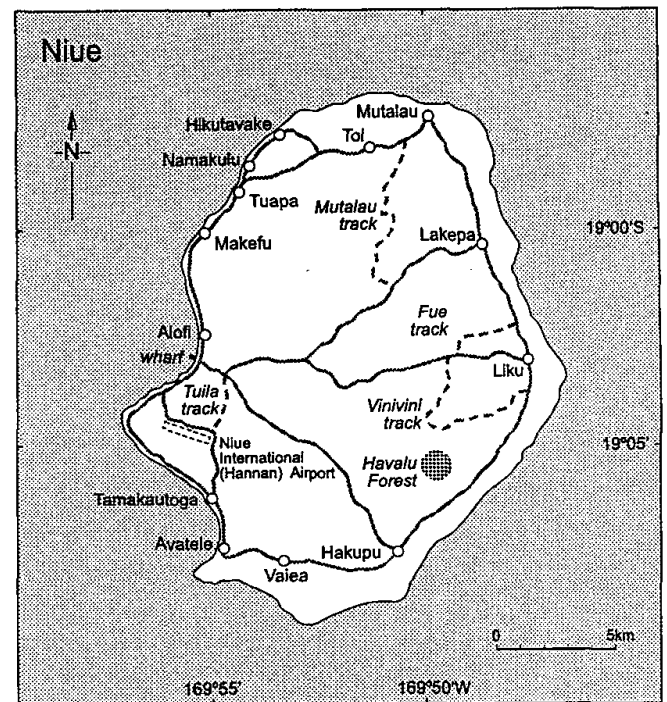


Fig. 1 Niue Island, showing the locations of villages, roads and the four tracks used for the 5-minute bird counts.

people colonised the island. The natural vegetation of the island consists of limited areas of rainforest, with a 20 m-high canopy, but most of it has been modified to some degree. Between 1966 and 1981 the area of "open" habitat increased by 144% from 3,200 to 7,800 ha (Lane 1994), largely as a result of land being cleared for agriculture. Open habitat, covering about 30% of the island in 1981, included bush gardens under cultivation, areas dominated by fou (*Hibiscus tiliaceus*) and "fernland", mostly *Nephrolepis hirsutula* (Lane 1994). A further 11.5% was covered by coastal forest, which included areas c. 50-1000 m from the coast, with generally good cover but where the trees were stunted by salt spray. This coastal forest on the eastern side of the island and on the encircling terrace at c. 60 m a.s.l. was mainly on makatea (rocky ground with many sharp coralline limestone pinnacles up to 5 m tall, and deep holes). Of the total land area, 46.2% was previously in cultivation and is now under regenerating forest. Just 12.3% of the island was covered by remnants of mature tropical rainforest (Lane 1994), concentrated in the triangular area delimited by the villages of Alofi, Lakepa, and Hakupu (Fig. 1). The largest block is the Havalu Forest (Fig. 1) containing a "tapu" area which people are forbidden to enter. No data exist to determine the habitat changes that have occurred since the last vegetation survey in 1981. However, with the establishment of an export taro

Table 1 Number of five-minute counts undertaken along three transects during visits to Niue Island in 1994.

| Transect | April | September | December |
|----------|-------|-----------|----------|
| Fue | 120 | 170 | 135 |
| Mutalau | 71 | 140 | 108 |
| Vinivini | 178 | 160 | 140 |

Table 2 The number of kilometres travelled along lower terrace, upper terrace and inland roads, and in total on Niue Island during three periods in 1994.

| | Roads | | | Total |
|-----------|---------------|---------------|--------|--------|
| | Lower terrace | Upper terrace | Inland | |
| April-May | 28.8 | 119.5 | 107.2 | 255.5 |
| September | 117.4 | 206.9 | 194.3 | 518.6 |
| December | 149.4 | 173.5 | 225.7 | 548.6 |
| Total | 295.6 | 499.9 | 527.2 | 1322.7 |

(*Colocasia esculenta*) market and the ready availability of bulldozers to clear land, it is likely that more areas of regenerating and mature rainforest have been cleared for cultivation since 1981.

Niue has a variety of introduced commensal mammals. Two species of rat are ubiquitous; the Kuma or Polynesian rat (*Rattus exulans*), introduced by the early Polynesian settlers, and the ship rat (*R. rattus*), which arrived between 1902 and 1925 (Smith 1902; Wodzicki 1971). Dogs (*Canis familiaris*) and cats (*Felis catus*) are common about villages, and feral cats are widespread over the island. Feral pigs (*Sus scrofa*) are present in some areas of forest.

METHODS

We made three visits to Niue: 22 April to 6 May (JRH); 16-30 September (RGP); 2-16 December 1994 (RGP & MHP). Trevor Worthy contributed observations made during archaeological surveys in 10 June to 1 July 1994 and 5 January to 3 February 1995 (Walter & Anderson 1995; Worthy *et al.* 1998).

Five-minute counts

Index counts of forest birds were made using the five-minute count technique (Dawson & Bull 1975). Count stations 200 m apart were marked along transects through forest, scrub, and open taro gardens. Each transect consisted of 20 count stations. So far as possible, each station was counted at least twice each day of recording, once in each direction to minimise bias which might result from counting certain stations at particular times of the

day. Counts were made during daylight away from the dawn and dusk hours when rapid changes in conspicuousness of birds could also have created bias. The counts were undertaken as much as possible during good weather, to minimise the effects of wind and rain on bird activity and conspicuousness. Five different observers participated in the survey.

The transects were established along vehicle tracks at three places on the island (Fig. 1). The Mutalau track ran north-south through the middle of the northern end of the island and traversed extensive open taro garden areas and small patches of remnant forest and scrub. The Fue track ran through a remnant of forest near Liku village and contained some garden clearings close to Liku village, whereas the Vinivini track traversed part of the most extensive remaining forest block on the island and was near the tapu area in Huvalu Forest. It also crossed a number of garden clearings. Table 1 summarises the number of counts undertaken along each of the transects.

Birds per kilometre

Whenever travelling by motorcycle or car along main roads by day, a record was kept of the number of each species seen, the kilometres travelled, and the section of road travelled (categorised as lower terrace, upper terrace, or inland). Observations were made during dry weather, and usually the speed was 30-40 km h⁻¹. We attempted to approximate the technique of Wodzicki (1971). Table 2 summarises the number of kilometres travelled along the three sections of road during each field-trip and in total.

Hunting

Whenever we were in the forest and unaccompanied by hunters we recorded all shot gun blasts heard so as to obtain an index of hunting effort. During the December field-trip, when the government-controlled hunting season was open for the Pacific pigeon, RGP accompanied two hunters to observe their hunting methods, and to record their success rate. Shot pigeons were measured and weighed. Measurements of tarsus length, head-bill length, bill length, bill depth, and bill width were made with vernier callipers (± 0.1 mm); wing and tail lengths were measured with a ruler (± 1 mm). Birds were weighed using "Pesola" scales (± 5 g), and foods in the crop were identified.

Single species surveys

1. Pacific golden plover (*Pluvialis fulva*) During the September visit, several counts of plovers were made at

specific sites, such as Liku village green. The total number of birds was calculated as the total of mean scores for all sites. A different method was used to determine the number of plovers in May and December. All known sites where Pacific golden plover were known to congregate, except exposed reefs, were visited on 1 May and 7 December, and the plovers counted.

2. Wandering tattler (*Tringa incana*) Wandering tattlers were counted along the Avatele-Tamakautoga reef (Fig. 1) on 13 December 1994. While walking along the reef at low tide, each wader was identified to species and counted as it flew back past the observer. Unfavourable on-shore winds during the subsequent week prevented the reefs between Alofi and Hikutavake from being surveyed.

ANNOTATED CHECKLIST OF NIUEAN BIRDS

The following checklist combines the results from our surveys of common species and incidental sightings of uncommon species during the three field trips in 1994, unpublished observations reported to us by a few people, the Ornithological Society of New Zealand's South-west Pacific Islands records, and published sources.

WEDGE-TAILED SHEARWATER *Puffinus pacificus* The wedge-tailed shearwater is abundant throughout the tropical and subtropical Pacific and Indian Oceans, breeding on at least nine island groups, including Fiji, Tonga and Samoa (Pratt *et al.* 1987). Four wedge-tailed shearwaters were collected from a colony near Namukulu village, Niue, in 1972-1974 and forwarded to the then National Museum of New Zealand (Kinsky & Yaldwyn 1981). Three birds seen by day in late November 1994, flying along the coast at Liku were possibly wedge-tailed shearwaters (S. Talagi pers. comm.). At night on 5 December 1994 at 2300 h a dark seabird, probably this species, was seen in a torch beam at Anaana Point (W. Tagalagi pers. comm.). Although a brief search was made for seabird burrows in the area, none was found. Shearwaters were frequently heard calling in flight at night over Alofi North during the first week of December 1994 (A. Lagaluga pers. comm.); one was heard calling in flight over Avatele on 13 December 1994 (RGP pers. obs.). T.H. Worthy (pers. comm.) saw three dark shearwaters, possibly wedge-tailed shearwaters, flying north off Mata Point in early February 1995. During the breeding season (October-May), shearwaters have been heard regularly from near Hakupu Village, but they have not been reported on the ground (M. Kulatea pers. comm.)

GIANT PETREL *Macronectes* sp. Bones of a specimen were found in Avatele village of a bird that landed there in September 1970 (Kinsky & Yaldwyn 1981), but we know of no further sightings of giant petrels on or about Niue Island.

RED-TAILED TROPICBIRD *Phaethon rubricauda* There is an unconfirmed report of this species being occasionally found on Niue Island and being much prized by Niueans (Smith 1902), presumably for its long red tail feathers.

WHITE-TAILED TROPICBIRD *Phaethon lepturus* The white-tailed tropicbird is almost pan-tropical in distribution (Pratt *et al.* 1987). This species was commonly seen flying between the sea and mature forest at any time of day during each of our visits. During September, tropicbirds regularly made steeply descending courtship flights. They were occasionally seen flying into or within forest as though searching for, or going to, nest sites, but we made no attempt to locate nests. A grounded fledgling, evident as such by its extensive mottled feathers over the crown, back and rump, and pink-grey bill and feet, was found shuffling along the Vinivini track on 11 December 1994.

Numbers of white-tailed tropicbirds seen per kilometre of road varied little between visits: 0.11, 0.08, and 0.10 km⁻¹ in May, September and December, respectively (Fig. 2). Tropicbirds were encountered more often along inland roads than lower and upper terrace roads in May, but greatest numbers were seen along upper terrace roads (mainly between Liku and Avatele) during September and December.

GREATER FRIGATEBIRD *Fregata minor* On 22 April 1994, 37 greater frigatebirds were seen hovering high over the western side of the island between Alofi and Hikutavake. This is the greatest number recorded at one time about Niue Island that we are aware of and was a source of some concern amongst local residents because they associated the appearance of frigatebirds with an imminent cyclone. Though none eventuated, weather conditions were somewhat unusual for that time of year, with a moderate westerly wind blowing instead of the usual southeasterly trades.

Two frigatebirds were seen flying together along the coast near Hakupu on 18 September 1994, but none was seen during the December trip. One was seen flying north above the lower terrace near Makapu Point, near Makefu, in January 1995 (T.H. Worthy pers. comm.).

WHITE-FACED HERON *Ardea novaehollandiae* Four sightings were made of an adult near Alofi during April-May 1980 (Child 1982).

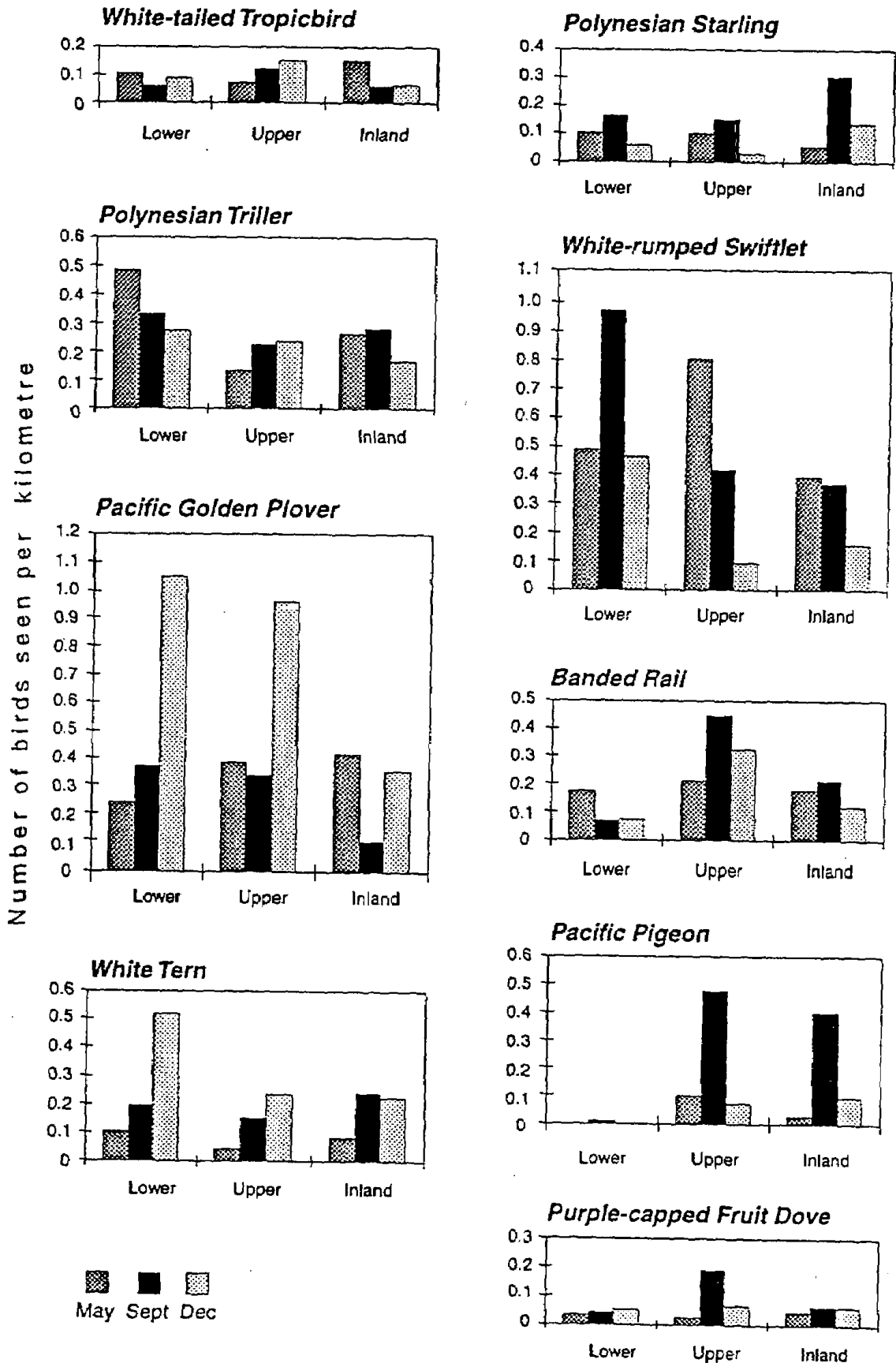


Fig. 2 Numbers of selected species seen km⁻¹ from lower terrace, upper terrace and inland roads travelled during the April-May, September and December 1994 field-trips, Niue Island.

REEF HERON *Egretta sacra* A grey-phase reef heron was seen on the island once in both April and July, and twice in October 1979 (Child 1982), and several times at Alofi in early 1980 (D. Christie pers. comm.). A reef heron that was very weak and unable to fly, was caught on a beach near Alofi on 20 October 1989 (C.R. Veitch pers. comm.).

NIUE NIGHT HERON *Nycticorax* n. sp. Fossil bones of this extinct large flightless heron were found in Anakuli Cave, Hakupu, in January 1995 (Worthy *et al.* 1998).

DUCK SPECIES *Anas* sp. A grey duck (*A. superciliosa*) or mallard (*A. platyrhynchos*) was seen at Liku on 12 June 1994. Apparently, ducks are seen only infrequently on Niue. For example, M. Kulatea (pers. comm.) recalled that his father once shot some.

FERAL FOWL *Gallus gallus* Feral fowl were heard occasionally, calling in bush gardens, both current and regenerating, as well as in the forest. They were seen on only 13 occasions during the 1323 km travelled along roads during the three visits. Few fowl were detected during the 5-minute count survey (means: 0.1 per count, April; 0.4, September; 0.2, December 1994). When individuals were seen they quickly ran or flew to cover, even up into the canopy. Broods of two to seven recently-hatched (< 1-week-old) chicks were seen in September 1994. At the same time 'domestic' fowl had broods estimated to be about a month old. One recently abandoned nest containing eight hatched and two unhatched eggs was found in a regenerating bush garden.

During the December 1994 trip, four broods of two to five recently-hatched chicks were seen, but none was seen that had hatched in September. In contrast, broods of domestic fowl in the villages were commonly of about four months of age, apart from an occasional newly-hatched brood.

NIUAFO'OU MEGAPODE *Megapodius pritchardii* Fossil bones of this megapode were found in Anakuli Cave, Hakupu, in January 1995 (Worthy *et al.* 1998). An extant population of the species occurs on Niuafo'ou Island, and possibly on Tafahi Island, in the Tongan group (Watling 1982).

BANDED RAIL *Rallus philippensis* The banded rail is resident on many islands free of mammalian predators from the Philippines to New Zealand, Palau and central Polynesia (Pratt *et al.* 1987). Banded rails on Niue were seen mainly along roads and tracks, especially after rain when they occasionally bathed in puddles. They were rarely heard calling. They were seen most often along roads in September (0.27 birds km⁻¹), as against 0.19

km⁻¹ in May and 0.17 in December, and were most evident along upper terrace roads (Fig. 2). In September and December, some adults were accompanied by one to three down-covered chicks that varied in size from recently hatched to half grown. D. Morrison saw chicks from mid March to late September 1980 (Child 1982).

Although the species is assumed to be relatively common (based on the road counts), they call infrequently, so they failed to figure significantly in the forest bird 5-minute count results; only one bird was recorded every 50 or so counts in each of the major habitats, though more commonly in the open country around the Mutalau track than in other areas.

NIUE RAIL *Gallirallus* n. sp. Fossil bones of this extinct flightless rail were found in Anakuli Cave, Hakupu, in January 1995 (Worthy *et al.* 1998).

SPOTLESS CRAKE *Porzana tabuensis* The spotless crake occurs on the Philippines and Australia, and east to virtually every island group in central and southeastern Polynesia (Pratt *et al.* 1987). On 6 December 1994 a tape-recording of spotless crake calls from New Zealand was broadcast at dusk (1820-1900 h) five times along the south side of Niue airport in habitat most characteristic for the species. No crake responded to the taped calls by calling or coming into view. The last confirmed sighting of the species was in 1969 when crakes were seen near the airport runway while it was being built (Kinsky & Yaldwyn 1981).

PURPLE SWAMPHEN *Porphyrio porphyrio* In June 1994, purple swamphens were regularly seen along the Hakupu-Alofi road in the middle of the island and on the road between Lakepa and Mutalau. In September, the species was seen or heard on 15 occasions, and usually just one bird was seen at a time (83%, $n=12$). One sighting was of a juvenile. All birds were either in current or regenerating bush gardens, or on the tracks (Tuila, Vinivini, Mutalau and Fue) adjacent to them. Even fewer swamphens were seen ($n=7$) or heard ($n=2$) in December, each sighting being of a single bird. As well as along the Fue, Tuila, and Mutalau tracks, birds were twice seen on the Hakupu-Liku road, and one was heard calling near the airport.

Purple swamphens were detected rarely during the 5-minute count study; those encountered were in garden plots.

PACIFIC GOLDEN PLOVER *Pluvialis fulva* The Pacific golden plover is a common non-breeding visitor to southern and southeastern Asia, New Guinea, Australia, New Zealand and islands of the western and central Pacific Ocean (Kinsky & Yaldwyn 1981). At a mean of 0.48 birds

Table 3 Numbers of Pacific golden plover at various sites on Niue Island, 1994.

| Sites | 1 May | 25 Sept | 7 Dec |
|---------------------------------------|-----------|------------|------------|
| Alofi south to airport (lawns + road) | 1 | 1 | 4 |
| Fualahiu | 0 | - | 8 |
| Niue Sports Ground | 37 | 42 | 8 |
| Airport - lawns | 5 | 9 | 12 |
| - runway | 0 | 9 | 99 |
| Alofi south lawns | 0 | 0 | 12 |
| Tamakautoga to Alofi south | 0 | 4 | 0 |
| Tamakautoga | 2 | 1 | 8 |
| Avatele | 2 | 16 | 19 |
| Niumaga (Island style) | 0 | 2 | 7 |
| Vaiea and farm paddocks from road | 4 | 14 | 22 |
| Hakupu | 1 | 6 | 28 |
| Hakupu to Liku | 0 | 1 | 3 |
| Liku | 4 | 30 | 71 |
| Lakepa | 10 | 26 | 47 |
| Mutalau | 4 | 4 | 14 |
| Toi | 1 | 8 | 9 |
| Vaipapahi Farm | 0 | 8 | 9 |
| Hikutavake | 0 | 2 | 5 |
| Namukulu | 0 | 3 | 3 |
| Hio (VJ's) | 0 | - | 1 |
| Tuapa | 0 | 4 | 7 |
| Palaha | 0 | 0 | 1 |
| Avaiki (Sails) | 1 | 0 | 0 |
| Makefu | 1 | 5 | 6 |
| Alofi north lawns and road | 1 | 16 | 11 |
| Paliati High School | 0 | 15 | 16 |
| Alofi central | 0 | 0 | 2 |
| Primary School | 0 | - | 6 |
| Museum and hospital | 0 | - | 3 |
| TOTAL | 74 | 226 | 441 |

km⁻¹, this species was the most frequently seen from roads on Niue. Most plover were on lawns, such as village greens, school playgrounds, and around homes. They foraged on these lawns, even when the grass was taller than themselves. Other foraging habitats were the margins of sealed and unsealed roads (including those with adjacent forest or overhead canopy), bush gardens with open ground between taro plants, beaches and reefs. Numbers at some sites, particularly village greens, were quite consistent from day to day. Disputes between foraging individuals were frequent, giving the impression that individuals defended foraging areas. Moderate numbers of Pacific golden plover were seen foraging, bathing, and preening on reefs at low tide. Numbers of roosting plover increased at a few sites from midday onwards, particularly on the airport runway and at the quarries at either end. The largest flock seen was of 184 birds roosting on the runway at 1600 h on 21 September 1994. The largest flock seen by D. Morrison in 1979-80 was 116 at the airport in November 1979

(Child 1982). In 1994, small flocks (5-15 birds) were seen leaving the airport between sunset and dusk; where they flew to and whether any remained at the airport overnight was not determined. Similarly, birds left Avatele green about dusk, but individuals were occasionally heard there, apparently calling in flight, up to three hours after sunset.

Some of the birds in September retained much of the black breeding plumage, but by December all were in non-breeding plumage. From counts of the species it is evident that numbers increased from May to December (Table 3), as is expected for a species that breeds in the Northern Hemisphere. The trip totals are minimum numbers, and there were probably 250-300 in September, and at least 500 on the island in December. The seasonal increase in plover numbers was less evident from the numbers seen per kilometre on roads; May (0.38 birds km⁻¹), September (0.26 km⁻¹) and December (0.78 km⁻¹) (Fig. 2), although they were more common in the latter month. In May, the number of plover was lowest on lower terrace roads and highest on inland roads, but the trend reversed in the later months (Fig. 2).

TURNSTONE *Arenaria interpres* One to three turnstones were seen on seven occasions in September foraging over the Niue Sports Club grounds ($n=4$), roosting on the airport runway or adjacent gravel ($n=2$), or foraging on Utuko Reef, Alofi. The only sighting in December was when two birds flew on to the airport runway. They were quickly forced into flight by a few Pacific golden plover that had been roosting there. The largest turnstone flocks recorded on Niue were of 10 birds on each of 25 November 1979 and 15 December 1979 (Child 1982).

SANDERLING *Calidris alba* D. Morrison saw single birds foraging on the reef at Alofi on 4 and 5 December 1979, and on the airport runway on 19 October 1980 (Child 1982).

PECTORAL SANDPIPER *Calidris melanotos* The only recorded sighting of this species on Niue was of two birds on the airport runway in September 1972 (Kinsky & Yaldwyn 1981).

EASTERN CURLEW *Numenius madagascariensis*. One eastern curlew was seen on the airport runway in September 1972 (Kinsky & Yaldwyn 1981).

BRISTLE-THIGHED CURLEW *Numenius tahitiensis* A bristle-thighed curlew was collected from Niue Island in November 1963 (Wodzicki 1971). Small numbers, usually singletons, were seen by D. Morrison in October 1979, the largest group being of four birds at the airport (Child 1982).

EASTERN BAR-TAILED GODWIT *Limosa lapponica* A specimen was collected on Niue in late December 1972 (Kinsky & Yaldwyn 1981).

WANDERING TATTLER *Tringa incana* Wandering tattlers were seen foraging on reefs exposed at low tide, and along the beach-cliff margin once the incoming tide had covered the reefs. Individuals defended sections of reef from other tattlers, with interlopers being vigorously chased in flight from the area. In addition, up to 14 tattlers were regularly seen foraging at the Niue Sports Club grounds in September 1994, even when it was low tide at the coast. D. Morrison saw 21 tattlers at the airport in November 1979, and noted that the species was present on Niue throughout the year (Child 1982).

On 13 December 1994, wandering tattlers along the reef at low tide from Avatele to its furthest extent north of Tamakautoga (3.15 km) were counted. The total was 20 tattlers (mean 6.3 km⁻¹). Inclement weather prevented us completing the survey along other reefs of the western and northern coasts. However, we estimate that the length of suitable reefs was 8.65 km; extrapolating from the count would give an estimated total population of 55 wandering tattlers. On the few occasions we visited the eastern side of Niue Island, no tattlers were seen. However, T.H. Worthy (pers. comm.) saw two birds on the Hakupu wave platform in January 1995.

SOUTHERN BLACK-BACKED GULL *Larus dominicanus* A juvenile black-backed gull was at Alofi Wharf on 11 June 1994 just after a cyclone had passed through the region. The bird was seen nearby several times during the following two weeks.

COMMON NODDY *Anous stolidus* The common nobby is widely distributed throughout the tropical Atlantic, Indian and Pacific Oceans (Kinsky & Yaldwyn 1981). Common noddies were seen regularly each day on Niue, with over 100 sightings in May, 79 in September, and 158 in December. Most sightings were of noddies flying over mature rainforest along the Vinivini, Fue, and Mutalau tracks (81% of sightings in September and 87% of those in December). The rest were of birds seen flying to and from inland sites over the coastal ring road. Of 34 noddies seen while travelling along roads, 62% were along the upper terrace roads (0.042 birds km⁻¹, mainly along the east coast), as against 15% seen along lower terrace roads of the west coast (0.017 birds km⁻¹) and 23% along inland roads (0.015 km⁻¹).

About 80% of sightings were of single birds and 1% were of four or five birds. During September, two to more noddies were heard occasionally calling and seen

apparently displaying to each other, but such possible displays were not recorded in December. A nesting noddy was found on 3 December 1994 along the Fue track. The nest of twigs was in a branch fork at about 15 m of a sparsely leaved tree. There was only one other site, along the Vinivini track, where a noddy seemed to be attempting to land in the forest. This contrasts with our observations of white-tailed tropicbirds and white terns, which were regularly seen flying in under the canopy, and the latter species often perched on branches. There are no other published records of common noddies nesting on Niue Island, although the number of birds we saw suggests that it nests there relatively commonly.

WHITE TERN *Gygis alba* This species is pan-tropical in distribution (Pratt *et al.* 1987). During September and December, white terns were seen frequently each day foraging just offshore or flying over forest from the coast to inland sites of Niue. Pairs and groups of three to five terns were often seen flying about as though involved in courtship. Occasionally individuals or pairs of terns flew into the forest and perched on branches under the canopy. No incubating adults or chicks were seen, but in December adults were regularly seen flying inland, each carrying a fish, indicating that chicks were present.

The number of white terns seen from roads increased from 0.1 km⁻¹ in May, to 0.2 in September, and 0.3 in December. In May and September, similar numbers of terns were seen along the three types of roads, but in December twice as many were seen from the lower terrace roads as from upper terrace and inland roads (Fig. 2).

PACIFIC PIGEON *Ducula pacifica* The Pacific pigeon occurs from the Bismarck Archipelago east through the tropical central Pacific (Pratt *et al.* 1987). Counts of Pacific pigeons seen while travelling along roads on Niue were similar in May and December (0.06 birds km⁻¹), but sightings were over five times as numerous in September (0.34). Most pigeons were seen along upper terrace and inland roads, with very few seen along the lower terrace roads each visit (Fig. 2).

Pacific pigeons were commonly seen or heard calling in forest each day during each trip, particularly along the Fue and Vinivini tracks. In September, they were often seen singly or in flocks of up to six birds, flying east in the morning or returning in the evening over the coastal road between Liku and Vaiea. These birds were feeding on oota (*Linociera vitiense*) fruit (J. Mamaia pers. comm.). Other foods in September were the fruit of toi (*Alphitonia zizyphoides*) (RGP pers. obs.) and kanumea (*Planchonella*

Table 4 Weights (g) and measurements (mm) of six adult and 10 juvenile Pacific pigeons shot by hunters in December 1994, Niue Island. HBL is head + bill length.

| Date | Age | Weight | Wing | Tail | Tarsus | HBL | Bill | | |
|-----------------------------|-------|--------|------|------|--------|------|--------|-------|-------|
| | | | | | | | length | depth | width |
| Tuila Forest | | | | | | | | | |
| 6 th | Juv | 440 | 240 | 140 | 30.3 | 67.2 | 29.8 | 9.9 | 10.4 |
| 6 th | Juv | 380 | 227 | 130 | 34.7 | 65.2 | 22.7 | 9.1 | 9.3 |
| 6 th | Adult | 445 | 250 | 160 | 36.8 | 65.4 | 19.9 | 9.5 | 10.0 |
| 6 th | Adult | 390 | 238 | 135 | 33.8 | 64.0 | 25.3 | 8.8 | 8.1 |
| Tuila Road | | | | | | | | | |
| 7 th | Juv | 425 | 240 | 137 | 36.6 | 65.8 | 25.0 | 9.4 | 9.2 |
| 7 th | Juv | 380 | 233 | 135 | 33.8 | 63.4 | 24.4 | 8.6 | 8.4 |
| 7 th | Adult | 405 | 240 | 144 | 33.0 | 63.8 | 27.7 | 9.2 | 8.7 |
| 7 th | Juv | 370 | 230 | - | 34.3 | 65.1 | 24.6 | 9.1 | 9.3 |
| 7 th | Juv | 440 | 240 | 145 | 35.8 | 67.3 | 25.0 | 8.0 | 8.8 |
| 10 th | Adult | 405 | 230 | 145 | 33.3 | 63.4 | 23.3 | 8.5 | 9.5 |
| 10 th | Juv | 440 | 235 | 137 | 35.2 | 63.0 | 24.1 | 8.7 | 8.8 |
| 10 th | Juv | 360 | 235 | 127 | 33.6 | 64.2 | 22.7 | 8.5 | 9.2 |
| 10 th | Adult | 435 | 243 | 142 | 34.3 | 64.9 | 25.9 | 9.4 | 11.1 |
| North Vinivini Track | | | | | | | | | |
| 13 th | Juv | 450 | 235 | 137 | 36.3 | 67.1 | 24.8 | 8.6 | 9.0 |
| 13 th | Juv | 385 | 224 | 134 | 34.9 | 65.5 | 24.3 | 9.0 | 9.0 |
| 13 th | Adult | 445 | 232 | 130 | 33.9 | 65.3 | 25.7 | 8.4 | 9.0 |
| Mean | | | | | | | | | |
| | Adult | 421 | 239 | 143 | 34.2 | 64.5 | 24.6 | 9.0 | 9.4 |
| | Juv | 407 | 234 | 136 | 34.6 | 65.4 | 24.7 | 8.9 | 9.1 |
| | Total | 412 | 236 | 138 | 34.4 | 65.0 | 24.7 | 8.9 | 9.2 |

samoensis), and kafika (*Syzygium inophylloides*) flowers (J. Mamaia pers. comm.).

Twice each in September and December, Pacific pigeons were seen performing a brief display flight, which involved the birds clapping their wings over the back a few times during take-off, rising in the air by one to two metres to stall with wings and tail spread, and then returning to the canopy. No birds were seen carrying nest material, nor were any nests found. One juvenile was seen, identified by the lack of a prominent black cere at the base of the upper mandible, which is characteristic of adult birds (Pratt *et al.* 1987).

During December, pigeons flew west across the Tuila track (Fig. 1) in the morning and back east in the late afternoon and evening. These regular movements of pigeons were used to advantage by hunters, it being the hunting season (December-February). Most evenings, except Sundays, when the weather was suitable, one to ten hunters stationed themselves along the Tuila track to shoot pigeons flying overhead. Foods from the crops of the Tuila track birds, identified by the hunters, were

flowers and fruit of pualiki (*Ficus obliqua*), and fruit of pua (*Fagraea berteriana*), ata (*Ficus scabra* or *F. tinctoria*), and ovava (*Ficus prolixa*). Food of pigeons from along the Vinivini track, ascertained by observing foraging birds and examining the crop contents of three shot birds, was le (*Macaranga seemannii*) fruit. Table 4 shows the age, weight, and measurements of all 16 Pacific pigeons examined. Of the 16, plus a further three seen, eight (42%) were adults (bulbous cere, red-crimson feet, red eye) and 11 (58%) were juveniles (flat or slightly bulbous cere, black-brown to black-red feet, brown-red eye). There were no significant differences in the measurements between adults and juveniles. Five adults and seven juveniles were in moult, replacing their body, wing, and/or tail feathers. None of the adults had brood patches, indicating that they were not nesting.

The results of the 5-minute bird counts indicate several facets of the life history of the species. An apparent change in conspicuousness of the Pacific pigeon between April (mean=1.5 birds count⁻¹) and in September (2.1 count⁻¹) and December (2.0 count⁻¹) was consistent with an

increase in the population after breeding. There were consistent differences between the transect counts, with the Vinivini line exhibiting the greatest concentrations of birds (mean=3.2 birds count⁻¹ in December), and the Mutalau Track the lowest (0.5 count⁻¹ in December).

Even though the hunting season was officially from 1 December to 29 February, gun shots were heard occasionally during other months. It is likely that most were of shots fired at pigeons. During 40.2 hours spent in forest habitats during April, and 56.9 hours during September, 25 shots (1/1.6 h) and 5 shots (1/11.4 h) were heard, respectively. This compares with 38.5 hours spent in forest habitats during December, not in the company of hunters, when 19 shots were heard (1/2.0 h). According to several Niueans, April-June is one period when Pacific pigeons are usually in good condition and so people are keen to hunt them.

PURPLE-CAPPED FRUIT DOVE *Ptilinopus porphyraceus* This species is widely distributed and common on the Caroline Islands, Wallis and Futuna, Samoa, the outlying islands of Fiji, Tonga and Niue (Pratt *et al.* 1987). Purple-capped fruit doves were seen and heard frequently each day on Niue, most frequently along roads during September (0.11 birds km⁻¹), almost twice as often as during December (0.06 km⁻¹) and three times as often as during May (0.03 km⁻¹). In general, doves were seen at a similar rate along the three categories of road during each trip, except in September when three to four times as many doves were evident along upper terrace roads than elsewhere (Fig. 2). Although we did not find any purple-capped fruit dove nests, juveniles (lacking the purple cap) were seen in December 1994, indicating recent nesting.

The 5-minute count results show a substantial increase in the number of doves seen or heard from April (mean=0.8 birds count⁻¹) to September (1.8 count⁻¹), peaking in December (2.3 count⁻¹). In April and September, double the number were counted along the Mutalau transect than along the other two transects, but in December similar numbers were recorded along each transect.

BLUE-CROWNED LORY *Vini australis* The blue-crowned lory is endemic to and widespread in central Polynesia (Pratt *et al.* 1987). Because lories had been sighted infrequently for many years on Niue, we made a point of visiting sites where the species had been seen previously. On 20 June 1994, six lories were seen and others heard at the roadside at the northern end of the Vinivini track where the birds were feeding in an area of 2-3 m high yellow-flowering legume, possibly pigeon pea (*Cajanus cajan*),

growing over an old bush garden. There was one possible sighting of a lory flying across the road in September about 1 km south of Liku. During December, lories were seen eight times, all along the Vinivini track. One to four blue-crowned lories were seen five times in a legume patch at the junction of the road and Vinivini track where they seemed to be feeding on the legume and from the flowers of kafika. The other three observations were of birds at a bush garden 3 km south along the track. In addition, there were two reports of lories being seen occasionally at bush gardens near the south end of the Mutalau track during November-December 1994. Lastly, two lories were seen in a mango (*Mangifera indica*) tree in Alofi opposite the wharf on 14 December 1994 (M. Kulatea pers. comm.).

The blue-crowned lory was recorded infrequently during the 5-minute bird counts; most were counted in April, when an average of one bird was recorded about every 10 counts. The birds were evenly distributed along the Fue and Vinivini tracks.

LONG-TAILED CUCKOO *Eudynamis taitensis* Cuckoos were seen or heard on three occasions during September and three in December 1994. All the birds were in mature rainforest along the Vinivini ($n=4$), Mutalau, and Fue tracks. Usually, birds were seen briefly or gave their distinctive alarm call when disturbed, but on 15 December 1994 one bird was heard calling at irregular intervals for 15 minutes during which another cuckoo called nearby. Good views of the prominently spotted back and upper wing surfaces of one bird on 21 September 1994 showed it to be a juvenile. The presence of cuckoos on Niue in December, two months after the species has reappeared in New Zealand, suggests that immature birds may remain on Niue during their first summer.

Long-tailed cuckoos were rarely heard during the course of the 5-minute counts; they were relatively silent on Niue, in contrast to their often highly vocal behaviour in New Zealand during the breeding season.

BARN OWL *Tyto alba* On several occasions in June 1994 between the hours of 2100 and 2300, a barn owl was seen from the Hakupu-Alofi road. Owls were seen eight times in September, and twice in December (including one road kill). Of the nine sightings of live birds, eight were in the late afternoon or evening, the ninth was of a bird foraging at 0820 h on 24 September 1994 in bright sunlight. The owls were seen at widely separated locations in mature rainforest, foraging over rank pasture about the airport, and flying through villages.

WHITE-RUMPED SWIFTLET *Collocalia spodiopygia* The white-rumped swiftlet is distributed from Australia and

Melanesia, as far east as Samoa, being present on islands with caves (Pratt *et al.* 1987). Swiftlets were seen frequently each day foraging along roads and tracks, and over bush gardens, usually below canopy level. In calm weather they also foraged above the canopy. Individuals may have used the same foraging site from day to day because swiftlets were invariably seen at particular count stations most times they were visited. Few swiftlets were detected during the 5-minute count survey, the mean number per count varying from 0.1 in April to 0.2 in December 1994. No nest sites were checked during the September and December visits.

White-rumped swiftlet sightings along roads declined from trip to trip: 0.6 birds km⁻¹ in May, 0.5 km⁻¹ in September and 0.2 km⁻¹ in December. During the May trip, swiftlets were most evident along upper terrace roads, but in September and December they were seen more frequently along lower terrace roads (Fig. 2).

T.H. Worthy (pers. comm.) saw small numbers of swiftlet nests in several caves during his archaeological survey, including in Avaiki, Palaha, Talava, Anatoloa, Ulupaka, Maselula, Vehokaho, Vaopula, Makato Chasm and Taupala. In 1979, nests in caves at Avaiki contained young in August, and eggs and young in November (Child 1982).

KINGFISHER SPECIES *Halcyon* sp. There was an unconfirmed sighting of a kingfisher in 1990 (S. Talagi pers. comm.).

POLYNESIAN TRILLER *Lalage maculosa* The Polynesian triller is widely distributed in the south-west Pacific, from the Santa Cruz Islands eastwards to Samoa, Tonga and Niue (Kinsky & Yaldwyn 1981), with the subspecies *whitmeei* being endemic to Niue. Trillers were commonly seen and heard on Niue in all habitats during each trip. Territorial disputes, involving chasing and loud song, were frequent in September and December. Although no triller nests were found, adults were seen occasionally carrying food and feeding fledglings in September and December. The first adult in wing and tail moult was seen on 10 December 1994.

This species was seen at a similar rate along roads each trip: 0.23 birds km⁻¹ in May, 0.27 km⁻¹ in September, and 0.22 km⁻¹ in December. Similarly, there was no marked variation in the rate of triller sightings between the three categories of roads each trip (Fig. 2). In total, slightly more Polynesian trillers were seen along lower terrace roads (0.32 birds km⁻¹), than along the upper terrace (0.21 km⁻¹) and inland roads (0.23 km⁻¹).

Trillers were consistently common (2.5-3.0 birds each

5-minute count) along each of the transects and during each trip.

POLYNESIAN STARLING *Aplonis tabuensis* This species is widely distributed from the Santa Cruz Islands east to Fiji, Wallis and Futuna, Tonga, Samoa and Niue (Pratt *et al.* 1987). The subspecies *brunnescens* is endemic to Niue. Polynesian starlings were seen and heard regularly each day. Starlings were encountered in forest and shrub habitats, but not in grassland or in bush gardens at an early stage of cultivation. Most Polynesian starlings foraged over trunk, branch and leaf surfaces, alive or dead, as though searching for invertebrates. Some starlings were also seen once feeding on the flesh of a ripe pawpaw (*Carica papaya*) fruit in a bush garden.

The species was seen nearly three times as frequently along roads in September (0.2 birds km⁻¹), as in May (0.1 km⁻¹) and December (0.1 km⁻¹). Although the differences were not great, in May there were about twice as many sightings of starlings along lower and upper terrace roads as seen along inland roads, but the reverse in September and December (Fig. 2).

Polynesian starlings were nesting during each trip. In May, at least three broods of fledglings were seen being fed by their parents. Birds were observed building nests at two separate sites in early December. Thus, the nesting season extended from at least March to January. Of five nest sites, three were in tall, dead, hollow coconut palm (*Cocos nucifera*) trunks, one was in a hollow portion of a dead tree trunk, and one was in a curled-up piece of bark, which formed a horizontal tube lodged in the branches of a dead tree. All these sites were in current or regenerating bush gardens.

Starlings were detected at about 2.5 birds per 5-minute count along each of the three transects during each visit.

DISCUSSION

The list of birds confirmed as being or having been present on Niue Island includes 31 species, including three known from fossil material only (Worthy *et al.* 1998), of which 18 were seen during the course of this study. Six are sea birds (3 breeding, 1 possibly breeding, 2 vagrant), 10 are shorebirds (2 migrant, 8 vagrant) and 15 are land birds (3 extinct, 10 breeding, 1 possibly breeding, 1 migrant). In addition, there have been unconfirmed sightings of the red-tailed tropicbird, and three birds of unknown species (a species of *Anas*, *Halcyon*, and *Macronectes*). The *Anas* species was probably the grey duck which is widely distributed in the South Pacific, including Fiji, Samoa,

Tonga, and the Cook Islands, although it is nowhere common (Watling 1982). The *Halcyon* species was probably the collared kingfisher (*Halcyon chloris*) since it breeds on the nearby major island groups of Tonga, Samoa, and Fiji (Gibb *et al.* 1989). The species of *Macronectes* could have been either the southern (*Macronectes giganteus*) or the northern giant petrel (*M. halli*) because juveniles of both wander widely. No doubt the list will be extended, particularly by migrant and vagrant seabirds and shorebirds, if and when more intensive bird-watching is carried out throughout the year.

The relatively small number of species presently known to breed on Niue Island (13 species), compared with the number of confirmed breeding species on Tonga (36 species), Samoa (44) and the southern Cook Islands (28) (Gibb *et al.* 1989), results from several factors. These factors include the island's relatively recent geological origin, its small size, relative isolation (the closest land is the Vava'u Group of the Tongan Islands c. 430 km away) and the lack of habitat variety, especially of freshwater and estuarine habitats. A notable feature of the Niuean bird fauna is that it includes only one introduced species, the feral fowl. This contrasts with other Pacific island groups, such as Fiji and Samoa, where several introduced species have established, sometimes to the detriment of the native fauna and agricultural crops (Watling 1982; Gibb *et al.* 1989).

Cats and rats (Polynesian rat and Norway rat (*Rattus norvegicus*), have caused a major decline in the breeding population of the wedge-tailed shearwater on Kermadec Island (Marchant & Higgins 1990). The Polynesian rat preys on the eggs of the little shearwater (*Puffinus assimilis*) (Booth *et al.* 1996), and was responsible for the low breeding success of four species of gadfly petrel (*Pterodroma* spp.) on the Pitcairn Islands in 1991-92 (Brooke 1995). Therefore, it is probable that the same predators have had a similar impact on the shearwater population of Niue. Although shearwaters were seen and heard in flight during December 1994, a search of the sites near Vaiea and Namukulu villages, where nesting wedge-tailed shearwaters were found in the 1970s (Kinsky & Yaldwyn 1981), would be needed to determine whether the species still nests on the island. Such a search would need to be made during the nesting season in December-May (Marchant & Higgins 1990).

In contrast to the burrow-nesting of the wedge-tailed shearwater, the arboreal nesting of the white-tailed tropicbird, white tern and common noddy seems to have enabled these species to fledge sufficient young on Niue

in the presence of cats, Polynesian rats and ship rats to enable these seabirds to maintain their populations. Similarly, King (1973) found that the populations of ground-nesting seabird species on several island groups in the central Pacific Ocean were more vulnerable to introduced mammalian predators, particularly rats (*Rattus* spp.), than tree-nesting species.

It seems from the number seen flying over Niue during each trip that reasonable numbers of white-tailed tropicbirds still inhabit the island, even though the area of mature forest in which it nests has been much reduced. Estimating how many pairs nest on Niue would be impractical because of the difficulty of finding nests in the forest. However, monitoring the nesting success of some pairs over several years would be useful, so as to determine whether they can nest successfully in the presence of ship rats and maintain their population. Ship rats are known to take white-tailed tropicbird eggs on Christmas Island (Marchant & Higgins 1990).

Since we saw white-tailed tropicbirds on 124 occasions while travelling 1323 kilometres along roads (0.09 birds km⁻¹), it is surprising that Wodzicki (1969) saw only one during his 1072 kilometres travelled. Similarly, he saw no white terns, but we saw the species on 285 occasions. One possible reason why Wodzicki saw so few seabirds was that he did his counts from a Landrover, which may have restricted his field of view, particularly of birds flying overhead. Our counts were made mainly from motorcycles.

It is possible that the spotless crane was overlooked during this study because of its secretive habits and similar appearance to young banded rail. However, adults and young are particularly vulnerable to cats, and possibly to rats (*Rattus* spp.) as well (Marchant & Higgins 1993). To establish whether the species is still present or not, it would be necessary to play taped spotless crane calls during early morning or late afternoon at a number of sites in different habitat types.

Adult Pacific golden plover migrate from the southern Pacific region, including Niue, to Siberia and western Alaska to nest in late April-May, and return in August-September (Kinsky & Yaldwyn 1981). The estimates of 250-300 plover in September and at least 500 in December suggest that not all birds had reached Niue by late September in 1994. Kinsky & Yaldwyn (1981) estimated there were 250-300 plover present during late August 1972, but that numbers had increased to about 500 birds by 10 September. This could indicate a higher population in 1972 or a later arrival in 1994. Since Pacific golden

plover inhabit mainly lawns, paddocks and roads, the increased area of open habitat on Niue over the past 28 years (Lane 1994) should have favoured this species.

It seems likely that most Pacific golden plover roost at night on the coast where the very rough terrain may offer them protection from cats and dogs; M. Kulatea (pers. comm.) reported finding plover at such sites at night. A study of wintering American golden plover (*Pluvialis dominica*) on Oahu, Hawaii, showed that the birds left their feeding grounds near sunset to roost on an offshore island, and returned about 30 minutes before sunrise (Johnson *et al.* 1981). The same observers also reported that about half the birds had territories in which they fed, preened, and loafed by day. These territorial plover vigorously defended their territories from interlopers in the same manner as Pacific golden plover on Niue.

Adult wandering tattlers migrate north to nest in Alaska and northwest Canada from April to August, with immatures remaining on Niue (Child 1982, Kinsky & Yaldwyn 1981, Pratt *et al.* 1987). Our preliminary estimate of 55 birds in December 1994 was determined from surveying a small section of Niue's reefs. A more extensive survey, including both eastern and western reefs, would be required to determine how many tattlers visit the island. With regard to future surveys, it is of note that some wandering tattlers foraged on the Niue Sports Club grounds in September 1994. They also foraged there at a time of day when they might otherwise have been taking advantage of low tide on the reefs, supposedly their favoured habitat (Pratt *et al.* 1987).

Wodzicki (1971) and T.H. Worthy (pers. comm.), from discussions with Niueans, reported that the common noddy nested on Niue. In contrast, Kinsky & Yaldwyn (1981) concluded that the species had only been seen roosting in trees. But given that the noddy is resident and relatively common on Niue (Wodzicki 1971; Kinsky & Yaldwyn 1981; Gibb *et al.* 1989), and that it breeds on many islands in the south-central Pacific (Watling 1982), it was not surprising that we found a pair nesting. We saw several common noddies each day flying to and from mature forest, so it is likely that several other pairs were nesting at the same time.

Because we saw and heard many Pacific pigeons each day during all three trips, and 62% of the 16 shot birds examined were juveniles, it appears that the species was common and had recently bred successfully. The greater rate of sightings of pigeons along roads in September than during the other trips probably resulted from the birds

being more conspicuous as they flew across the ring road to and from south-eastern coastal sites. This species and other members of the genus are known to be very mobile in search of seasonally available fruits, even to the extent of flying between islands (Goodwin 1970; Watling 1982).

Notwithstanding an apparently high hunting pressure, including outside the legal hunting season, Niue has a relatively dense population of Pacific pigeons (1.5-2.0 birds 5-minute count⁻¹) compared with other central Pacific islands where JRH has observed them. For example, in Western Samoa, before Cyclone Val, a maximum of 0.5 birds per 5-minute count were recorded at the site where it was most abundant; in most habitats the figure was much lower, with a mean of 0.15 pigeons per count (Park *et al.* 1992). Other large pigeons occur in Samoa but in total they still did not reach the abundance of Pacific pigeons on Niue. Because pigeons are an important traditional hunting resource, research on the species is desirable, on which to base management aimed at maintaining the population at a sustainable level. The long-term future of the population can only be assured if it is not over-hunted. An initial step would be to assess the population size and trends, and study the species' biology (such as habitat requirements, foods, breeding season, and nesting success). Unfortunately, there is little detailed information about its biology, either on Niue or from anywhere else in the region.

One way to maintain a healthy Pacific pigeon population would be to ensure that it is not hunted during the nesting season. The little information available from hunters and autopsies of birds they had shot suggests that the species nests at least from April to August. Pigeons shot later in the year were often in moult and did not have brood patches (pers. obs.; Kinsky & Yaldwyn 1981). Although more precise information is required, the legal hunting season (December-February) does not seem to overlap with the nesting season. However, if the amount of illegal hunting we observed in April-May 1994 is usual then it will have a major impact on the long-term viability of the pigeon population, particularly if the area of mature forest continues to decline as well.

One form of management of the Pacific pigeon that may work would be to monitor its numbers a few months before the start of each hunting season and, depending on the results, change the length of the hunting season or the number of cartridges allowed to each registered hunter accordingly. The 5-minute count method of monitoring bird populations represents the most efficient means of obtaining the information. The first step would be to

establish permanent count sites, such as the three transects used during this study, and an additional transect along the Tuila track, which is in a popular hunting area.

In addition, the long-term conservation of the Pacific pigeon would be helped by retaining as much as possible of the remaining mature forest. Our results strongly suggest that the tapu area in Huvalu Forest provides a sanctuary where birds can feed and nest in the absence of human predation, but are still vulnerable to predation by rats and cats. Ultimately, to ensure that the pigeon is not over-hunted may mean the declaration of more sites where no hunting is allowed.

Our few sightings of blue-crowned lorries and the few recent sightings reported to us by locals suggest that only a small population remains. Its present rarity is in contrast to its abundance in the 1940s and 1950s when it was snared and shot for food (M. Kulatea pers. comm.). Several reasons were suggested to us for the dramatic decline of the lory. That it has declined to such low numbers while most other forest bird species have remained relatively common suggests that hunting by people, impacts of cyclones on its habitat, and the reduction in forest area are unlikely to have been major causal factors. Other possible causes are an introduced disease, honeybees competing with it for nectar, or predators taking eggs and chicks.

There is so little information about the blue-crowned lory on Niue that we are unable to determine which, if any, of these possible factors has brought about the decline. However, some information is available about the species from observations elsewhere in the Pacific. Gill (1995) found that there were good numbers of the blue-crowned lory on Futuna Island, but that it was absent from Wallis Island. Both islands have Polynesian rats and Norway rats (*Rattus norvegicus*), but only Wallis is known to have ship rats. Similarly, information from Tongan islands (D. Rinke pers. comm.) illustrates that the species is unable to survive and breed successfully on islands with ship rats, while populations are sustaining themselves well even on small islands from which that rat species is absent. Although the year when ship rats were inadvertently introduced to Niue is not known, the obvious decline of the lory during the 1950s-60s (M. Kulatea pers. comm.) occurred after the arrival of the ship rat during 1902-25 (Wodzicki 1971). Ship rats are agile climbers and are known predators of birds' eggs and young in New Zealand (Innes 1990). Hole-nesting birds are particularly vulnerable to such predators because occasionally a parent bird is killed in the nest with its

eggs or chicks, being unable to escape past the predator entering via a narrow hole (Hicks & Greenwood 1989). As a result of its predations, the ship rat has caused the extinction of bird species on several islands that were previously rodent-free (Innes 1990). For example, within three years of the ship rat reaching Big South Cape Island, New Zealand, five forest bird species went extinct on the island and four others declined in numbers (Innes 1990).

We consider the Niue population of the blue-crowned lory to be endangered and that it will be extinct in a few years if remedial action is not taken. Given its rarity, there may be little opportunity or time to determine what has brought the species to such low numbers. Therefore, it would be prudent to take some birds or young into captivity to ensure the species survives on the island. In addition, because predation at nests by rats seems the most likely cause of the lory decline, a programme of rat control using toxic baits in stations on a 100 m grid prior to and during the nesting season may enhance the status of the wild population. Such "mainland island" methods have been successful in improving the status of forest bird species in New Zealand (Innes *et al.* 1999; Saunders 1999). Such a double-action programme has been used to conserve the green parrot (*Cyanoramphus novaezelandiae cookii*) on Norfolk Island (Hicks & Greenwood 1989). Interestingly, although there were a number of reasons for the decline of the green parrot, the most important was found to be predation of adults, eggs, and chicks by ship rats. The presentation of poison baits for rats on Niue would have to ensure they were not accessible to coconut crabs (*Birgus latro*), an important traditional food source, and banded rails. An alternative method of protecting nesting lorries from predation would be to place metal bands above and below nests to prevent access by rats, and to provide predator-proof artificial nest boxes.

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