

Terrestrial Vertebrates of the Ngerukewid Islands Wildlife Preserve, Palau Islands

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Abstract—A survey of terrestrial wildlife in the Ngerukewid Islands Wildlife Preserve of southwestern Palau detected one species of frog, 13 species of reptiles, 28 species of birds, and two species of bats. Fifteen species of native forest birds probably breed in the preserve but eight other species known from adjacent limestone islands in Palau are absent. The preserve supports relatively dense populations of Micronesian megapodes, Micronesian pigeons, Nicobar pigeons, and Micronesian fruit bats, all of which are hunted extensively elsewhere in Palau. Four active nesting mounds of megapodes were found in the preserve, with an additional two mounds present in the nearby Kmekumer Islands. Six species of seabirds are present, with brown noddies, black noddies, and bridled terns breeding in moderate numbers. Hawksbill sea turtles appear to nest regularly in the area but illegal egg collecting is a problem. Densities of skinks and geckos are low throughout the preserve. Only one introduced species of vertebrate, the greater sulfur-crested cockatoo, was recorded in the preserve, suggesting that the island group's original fauna is still largely intact.

Introduction

The Ngerukewid Islands Wildlife Preserve (NIWP) was established in 1956 to protect a segment of Palau's rich marine and terrestrial natural resources. More than 30 years later, the preserve remains the only officially designated protected area set aside for nature conservation in the Caroline Islands.

An important role of the NIWP has been to restrict hunting of wildlife, a common and widespread activity in the rest of Palau. The most sought after species include sea turtles, fruit bats, Micronesian pigeons, Nicobar pigeons, saltwater crocodiles, dugongs, and various types of land crabs (Brownell *et al.* 1981, Pratt *et al.* 1980, Pritchard 1981, Johannes 1981, Engbring & Pratt 1985, Wiles & Payne 1986). The eggs of sea turtles and Micronesian megapodes are also commonly collected. Although few data exist, overhunting has been implicated in reducing the populations of many of these species (Owen 1977, Pratt *et al.* 1980, Pritchard 1981, Brownell *et al.* 1981, Engbring & Pratt 1985, Wiles & Payne 1986). Most animals are taken for local use by residents, however, a thriving business in exporting fruit bats to Guam and Saipan exists (Wiles & Payne 1986). In 1987 alone, approximately 7,000 fruit bats were shipped to Guam (Wiles 1987a). Products made from hawksbill turtle shells are also widely available in Koror for purchase by tourists.

In general, Palau's wildlife has been poorly studied, particularly its reptiles and mammals. Even the distribution of many species is poorly documented within the archipelago. Many of the natural history studies of the islands have concentrated on birdlife. General information on the resident birds of Palau is available in several published accounts (Marshall 1949, Baker, 1951, Pratt *et al.* 1980, Engbring & Pratt 1985), and two

illustrated field guides to Palau's birds have been recently published (Pratt *et al.* 1987, Engbring 1988). None of these publications discuss birdlife in the Ngerukewid Islands. To our knowledge, an inventory of the terrestrial fauna in the NIWP has never been conducted. Previous work in the preserve apparently includes only a limited bird survey (J. Engbring, unpubl. data).

This study was part of a broader survey made from 5–15 January 1988 which examined the terrestrial and marine natural resources of the NIWP. Goals were to 1) determine the presence and relative abundance of terrestrial wildlife in the NIWP, particularly those species that are rare or declining elsewhere in Palau, and 2) identify known or possible threats to the preserve's fauna. In addition, the small islands located west of the preserve and collectively known as the Kmekumer Islands were briefly visited to determine the suitability of including them as part of the preserve.

Study Area

The Ngerukewid Islands ($7^{\circ}11'N$, $134^{\circ}16'E$), which are also known as the Seventy Islands, are located between the larger islands of Ngeruktabel and Peleliu in the Palau Islands. As part of the archipelago's famed "rock islands", these islands are formed of raised coral limestone and are steep, tall (up to 80 m elevation), and typically undercut along the waterline. The Ngerukewid Islands contain 37 islands, which range in size from 0.1 to 48.5 ha, and total 87.3 ha in land area. The NIWP comprises all but one of these islands. An additional 12 islands totalling 11.9 ha are present in the Kmekumer Islands, which lie about 1.5 km west of the NIWP. Both island groups are somewhat isolated from

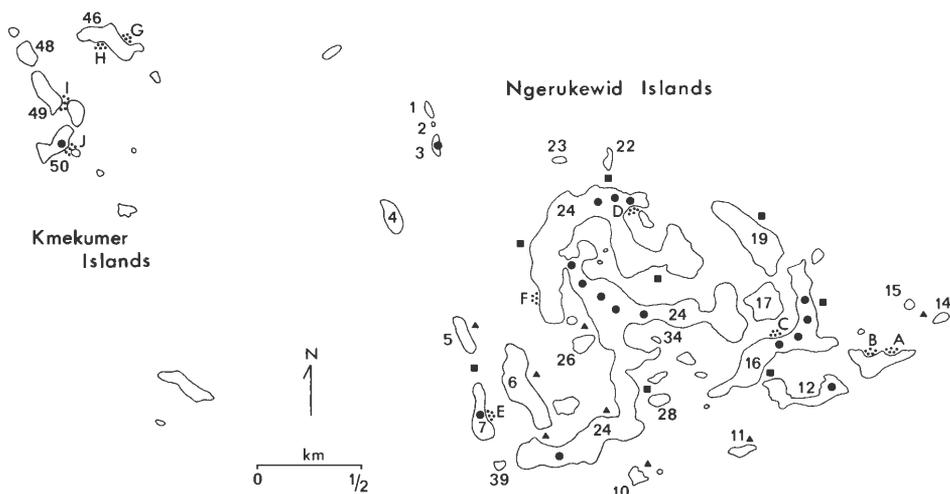


Figure 1. Locations of station counts for birds and bats in the Ngerukewid and Kmekumer Islands, Palau, in January 1988. Counts were conducted on land (closed circles), and by boat in the morning (closed triangles) and evening (closed squares). Islands are identified by numbers. Beaches are represented by dotted areas and identified by letters.

neighboring islands in Palau's lagoon, being 7.5 km west of Mecherchar Island and 5 km northeast of the small Ngemlis Islands.

Cole *et al.* (1987) gives a general description of the vegetation of Palau's limestone islands. A detailed account of the flora of the NIWP and nearby islands is in preparation by Manner & Raulerson. Limestone forest is the predominant plant community on these islands and occupies virtually all inland sites. Common tree and shrub species include *Intsia bijuga*, *Eugenia reinwardtiana*, *Pandanus* spp., *Cycas circinalis*, *Pouteria obovata*, *Dracaena multiflora*, *Glochidion* sp., *Aidia cochinchinensis*, and *Gulubia palauensis*. Forest development is greater on larger islands where trees may reach heights of 20–30 m. Shrubby halophytic-xerophytic vegetation occurs on vertical rock faces around the edges of all islands. *Bikkia palauensis*, *Pemphis acidula*, *Phyllanthus rupi-insularis*, *Capparis* sp., *Nepenthes mirabilis*, *Scaevola sericea*, and *Flagellaria indica* are present as are some limestone forest species.

Small patches of strand forest occur on 10 narrow sandy beaches, designated A–J, in the Ngerukewid and Kmekumer Islands (Figure 1). This habitat contains a number of species such as *Scaevola sericea*, *Hernandia sonora*, *Eugenia malaccensis*, *Barringtonia asiatica*, *Callophyllum inophyllum*, *Ficus* sp., *Pongamia pinnata*, *Intsia bijuga*, *Polyscias grandifolia*, and *Guettarda speciosa*. The preserve also contains two small areas of mangrove (*Rhizophora mucronata*), each less than 500 m² in size.

Methods

Station count surveys made by boat or on land were conducted to measure the relative abundance of birds and bats in the NIWP. Survey locations were chosen to give wide geographic coverage of the preserve (Figure 1) and include a variety of different sized islands. Surveys from a boat parked close to shore provided wide views of the outer forest canopy, the preserve's lagoon, and surrounding waters, and thus most animals were recorded visually. Land surveys were conducted in the forest and primarily sampled forest birds. Most of the birds detected during land surveys were heard rather than seen.

During station counts, all birds and bats seen or heard during a 10-minute period (8 minutes at evening boat stations) were recorded. A total of 41 station counts were conducted, 17 on land and 24 on water. Land counts were conducted from 0700–1000 hrs, with six single counts made at widely scattered locations in the preserve and three transects of three to four stations each performed on two larger islands (Figure 1). Data were partially pooled and analyzed in nine groups. For boat counts, a series of eight stations in a single transect was surveyed on two evenings from 1600–1800 hrs for a total of 16 stations. An additional two transects of four stations each were completed from a boat in the morning from 0700–1000 hrs. Results are reported as frequency of occurrence, number, and aggregate average number of birds observed per forest station, boat station, and for all stations combined. The aggregate average is the mean of all transect averages (i.e., the sum of the transect averages for a given species divided by the number of transects).

Lizards and snakes were surveyed by walking slowly through a site and counting the number of animals seen on the ground, on tree trunks and branches, under the flaking bark of dead trees, in the crowns of *Pandanus* trees, and on rock outcrops. Observations frequently took place during other activities such as walking between station counts and the

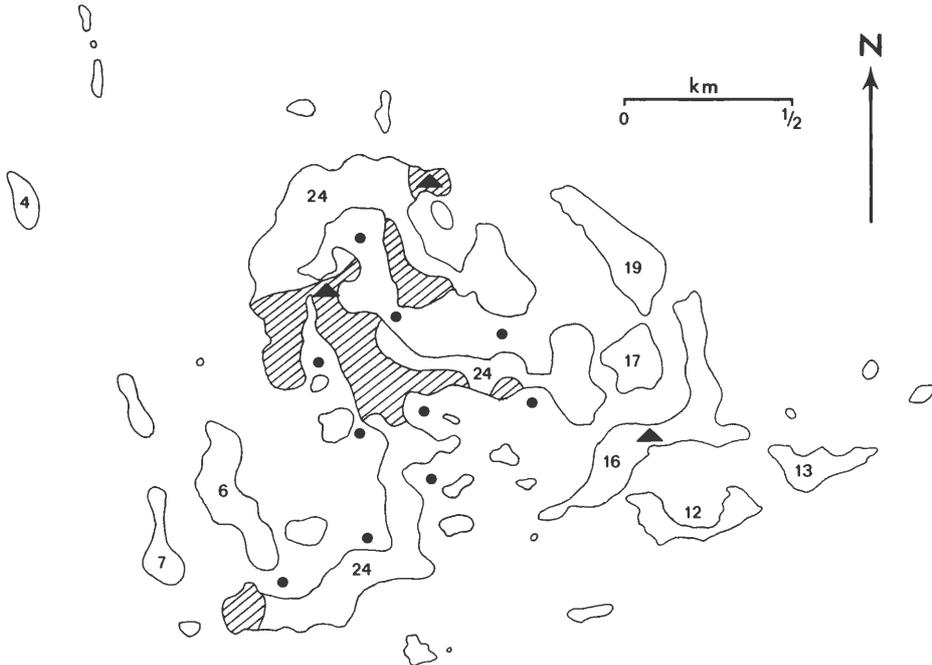


Figure 2. Distribution of Palau frogs (cross-hatched area), locations of survey stations for frogs and Palau owls made by boat (closed circles), and location of trapping sites (closed triangles) in the Ngerukewid Islands Wildlife Preserve, Palau, in January 1988.

setting of traps. Most observations were made during the day when skinks were active, however, searches were also conducted at night between 1900 and 2300 hr to look for geckos. Animals were collected whenever possible to obtain positive identifications. Skinks were caught by shooting them with a heavy rubber band while geckos were captured by hand. Specimens were sent to the National Museum of Natural History (USNM), Washington, D.C. for identification and deposit.

The occurrence of Palau frogs and Palau owls was determined by listening for their calls during four nights spent in the preserve. Because Palau owls readily respond to tape-recorded calls, we played calls several times each night to incite responses from nearby birds. On one evening from 1930–2130, a survey for owls and frogs was conducted by boat around Island 24 and neighboring islands. The survey consisted of 10 stations spread 200–300 m apart (Figure 2). Tape-recorded owl calls were played for 2 min at each station and were followed by a silent period of 8 min to listen for owl responses and the singing of Palau frogs.

Trapping for small mammals and reptiles was conducted at three locations. These were on the northern end of Island 24 near Beach D, in the center of Island 24 north of the tallest hill, and on Island 16 near Beach C (Figure 2). Twelve stations spread about 20 m apart were established along a transect at each location. Each station had one rat trap, one

mouse trap, and two 10 × 23 cm sticky traps, one set on the ground and a second placed in an elevated position such as on a tree trunk, among the leaves of a *Pandanus* tree, or on a rock outcrop. Traps were set at 1500 hr and were visited the next day at 1100 hr, a schedule that allowed both nocturnal and diurnal animals to be sampled.

Twelve underwater transects were surveyed by marine biologists associated with the NIWP study and provided data on the abundance of marine reptiles and mammals. Additional information about wildlife in the Ngerukewid Islands was gathered during incidental observations made outside of structured surveys.

Survey results are presented as species accounts which are listed in taxonomic order. Scientific names follow those used by R. I. Crombie (pers. comm.) for amphibians and reptiles, by Pratt *et al.* (1987) for birds, and by Honacki *et al.* (1982) for mammals.

The qualitative descriptions of a bird's status is based on its relative abundance and frequency of occurrence on station counts. A bird species was considered abundant if it occurred on more than 50% of the station counts in numbers greater than an aggregate average of 1.0 birds/station. Those species recorded on 20–50% of the stations and having an aggregate average of 0.2–1.0 birds/stations were regarded as common. Uncommon species occurred on 5–20% of stations with an aggregate average of 0.1–0.2 birds/station. A species was classified as rare if it was detected on less than 5% of the stations at an aggregate average of less than 0.1 birds/station. Incidental sightings and other subjective appraisals of abundance were used for certain species (e.g., the silent Nicobar pigeon and highly vocal Palau fruit-dove) that were not equally detectable on station counts.

A similar classification system was used to describe the relative abundance of frogs and reptiles. Species are referred to as common if they were found in a habitat at rates greater than one individual/hour. Those that were observed at rates of 0.10–1.00 individuals/hour were classified as uncommon. Rare species were found at rates of less than 0.10 animals/hour.

The use of "N", "C", and "S" in association with Island 24 in the text refers to the northern, central, and southern portions of that island, respectively.

Species Accounts

Palau Frog, *Platymantis pelewensis*

This species is endemic to Palau and is widespread and common throughout most of the archipelago (Owen 1977). We detected animals in limestone forest on Island 24N, C, S but not on any other island. Their distribution on Island 24 was patchy (Figure 2), with calling not heard on large portions of the island. Densities of singing frogs varied greatly across the island, with only a few animals vocalizing at some sites and large numbers doing so at other locations.

Calling began at nightfall and continued at least until midnight. In Koror, frogs were heard singing prior to dawn, thus calling probably lasts through the entire night. In the preserve, individuals called from sites located on the ground or in low vegetation such as in *Pandanus*. The cryptic dark brown coloration of frogs made them difficult to see even though singing was loud and sometimes performed from exposed perches.

Metamorphosis in *P. pelewensis* has been described by Atoda (1950). Larva develop

Table 1. Numbers observed and observation rates (number/hour) of frogs and reptiles in limestone forest and strand forest in the Ngerukewid and Kmekumer Islands, Palau.

Key to habitats: L = limestone forest, S = strand forest.

Time period	Habitat	Total search-ing effort (hrs)	<i>Platymantis pelewensis</i>		<i>Cryptoblepharus poecilopleurus</i>		<i>Lamprolepis smaragdina</i>		<i>Eugongylus</i> sp.		Skink sp. 1		Skink sp. 2	
			no.	no./hr.	no.	no./hr.	no.	no./hr.	no.	no./hr.	no.	no./hr.	no.	no./hr.
day	L	55	0	0	0	0	5	0.09	12	0.22	3	0.05	1	0.02
day	S	8	0	0	20	2.50	7	0.88	0	0	0	0	0	0
night	L	9	12	1.30	0	0	0	0	0	0	0	0	0	0
night	S	1	0	0	0	0	0	0	0	0	0	0	0	0
Total		73	12		20		12		12		3		1	

entirely within their eggs and do not experience a free-swimming tadpole stage in their developmental cycle. This adaptation explains the ability of Palau frogs to colonize limestone islands, where sources of standing freshwater are absent except perhaps for those held in tree cavities or among the leaf nodes of *Pandanus*.

Hawksbill Sea Turtle, *Eretmochelys imbricata*, and Green Sea Turtle, *Chelonia mydas*

Hawksbill sea turtles occur primarily inside Palau's lagoon, while green sea turtles are mostly found outside the lagoon's fringing reef (Pritchard 1981, Owen 1977). A substantial amount of turtle hunting and egg collecting occurs in Palau and is undoubtedly the cause of a gradual decline in hawksbill numbers from 1949 to the late 1970s (R. P. Owen, in Pritchard 1981). Current trends in sea turtle populations in Palau are not known.

Inspection of beaches for nesting evidence during this study revealed five sets of turtle tracks on Beaches E, F, G, and I (Figure 1). We did not identify the species of turtle making these tracks but suspect that they were made by nesting hawksbill turtles. Each of the nests or nesting attempts showed signs of having been visited by people whose intent was to collect eggs. At each nest site, we observed small holes made with a stick to probe the sand for eggs, or holes dug by hand to remove eggs that were present.

The Ngerukewid Islands are a favored nesting area of hawksbills (Johannes 1981, T. Remokt, pers. comm.) and the species is known to nest widely on small beaches of other limestone islands in the Palau (Pritchard 1981). Each of the beaches in the Ngerukewid and Kmekumer Islands is probably used by nesting turtles. The lengths of these beaches at high tide levels ranged from 30–115 m (mean = 62.7 m). The four beaches with nesting activity were among the smallest in the area, averaging 43.0 m in length.

Nesting has been recorded in all months of the year for hawksbill turtles in Palau although peak activity occurs in July and August (Pritchard 1981). Hawksbills are reported to come ashore to nest most often around new and full moons (Johannes 1981). The five nesting efforts observed in this study occurred approximately between 6–13 January, a period that was 3–10 days after the full moon.

Sea turtles were not observed on any of the underwater transects in the NIWP. How-

Table 1.
(continued)

Time period	Habitat	Total searching effort (hrs)	<i>Gekko</i> sp.		<i>Lepidodactylus</i> sp. 1		<i>Lepidodactylus</i> sp. 2		Unidentified <i>Lepidodactylus</i>		<i>Candoia carinata</i>		<i>Dendrelaphis lineolatus</i>	
			no.	no./hr.	no.	no./hr.	no.	no./hr.	no.	no./hr.	no.	no./hr.	no.	no./hr.
day	L	55	0	0	4	0.07	0	0	2	0.04	0	0	2	0.04
day	S	8	2	0.25	0	0	1	0.13	0	0	0	0	0	0
night	L	9	2	0.22	0	0	0	0	0	0	0	0	0	0
night	S	1	0	0	0	0	0	0	0	0	0	0	0	0
Total		73	4		4		1		2		0		2	

ever, incidental sightings of turtles occurred twice during other routine activities. A large turtle, probably a green sea turtle, was observed on the south side of the preserve near Island 28 (C. Birkeland, pers. comm.), and a medium-sized unidentified turtle was seen in shallow water along the west shore of Island 24N.

Salt Water Crocodile, *Crocodylus porosus*

This species of crocodile is common in mangroves and estuaries in Palau (Owen 1977). The NIWP does not support a resident population of salt water crocodiles and sightings of these animals are apparently extremely rare. A single large crocodile reportedly lived in the preserve for an unknown length of time in the 1960s or early 1970s (Beki Madrasau, pers. comm. to J. Engbring), but aside from this, records from recent years are lacking. Two small clumps of mangroves exist in the NIWP but are too small to support crocodiles permanently.

Snake-eyed Skink, *Cryptoblepharus poecilopleurus*

The status of *C. poecilopleurus* in Palau is not known. This species is generally restricted to shoreline habitats on other Pacific islands (McKeown 1978, Schwaner 1980, Wiles, pers. observ.). In our survey, this small skink was recorded only at Beach H in the Kmekumer Islands, where it was common in strand forest (Table 1). These lizards were conspicuous on tree trunks and logs, but frequently sought shelter under leaf litter when pursued. Their abundance at this location contrasted greatly with the low densities of other lizards residing in the preserve. Thorough searches of other beaches failed to find additional populations of *C. poecilopleurus*, and it is unlikely that the species occurs within the present boundaries of the NIWP.

Green Tree Skink, *Lamprolepis smaragdina*

These distinctive bright green and black skinks are common throughout Palau (Owen 1977), but were uncommon in the NIWP. This species had the widest distribution of any lizard noted in the study, being recorded on Islands 12, 16, 24, 46, and 50 (Table 2), but

Table 2. Occurrence (x) of frogs and reptiles in the Ngerukewid and Kmekumer Islands, Palau, based on sightings and collected specimens made during the survey.

Species	Island									
	4	7	12	13	16	24	34	46	49	50
<i>Platymantis pelewensis</i>						x				
Sea turtles		x				x			x	x
<i>Cryptoblepharus poecilopleurus</i>								x		
<i>Lamprolepis smaragdina</i>			x		x	x		x		x
<i>Eugongylus</i> sp.					x	x		x		
Skink sp. 1			x			x				
Skink sp. 2	x									
<i>Gekko</i> sp.						x		x		
<i>Lepidodactylus</i> sp. 1	x				x		x			
<i>Lepidodactylus</i> sp. 2								x		
Unidentified <i>Lepidodactylus</i>						x				x
<i>Candoia carinata</i>				x						
<i>Dendrelaphis lineolatus</i>						x				
<i>Laticauda colubrina</i>				x		x				

Table 3. Capture rates of small mammals and reptiles, Ngerukewid Islands Wildlife Preserve, Palau.

	Rat trap	Mouse trap	Sticky traps	
			Ground	Elevated
No. of trap nights	36	36	36	36
No. of animals captured	0	0	3 ^a	0
No. of captures/trap night	0.00	0.00	0.08	0.00

^a Three *Eugongylus* sp. were captured.

was not numerous at most locations. *Lamprolepis smaragdina* is primarily arboreal and was almost always found on the trunks and branches of large trees in both limestone and beach strand forest. The species appears to be more common in strand forest where observation rates were slightly higher than in limestone forest (Table 1). It was particularly abundant at Beaches C and H. Green tree skinks were somewhat gregarious with several animals sometimes foraging within a meter of each other in the same tree.

Eugongylus sp.

Eugongylus sp. is the largest species of skink in Palau, but its status and distribution are poorly known. The Palau population of this species has been incorrectly referred to as *E. mentovarius* by other authors (Dryden & Taylor 1969, Owen 1977), but additional taxonomic study is needed to establish this skink's correct identity (R. I. Crombie, pers. comm.).

Individuals (including USNM 284418, 284419) were noted only in limestone forest

on Islands 16, 24, and 46. Rates of observations and captures in sticky traps (Tables 1 and 3) suggest that *Eugongylus* sp. is uncommon in the NIWP. Typically, animals were not seen until they were flushed by the close approach of an observer, whereupon they fled hastily to the nearest limestone crevice or hole. These skinks foraged inconspicuously in leaf litter during the day and were captured only in sticky traps. They may have been attracted to traps to feed on large wingless crickets (*Stonychophora* sp. nov.) caught during the night.

Unidentified Skinks

The NIWP contained at least two other species of small skinks that escaped capture for identification. Sightings of these animals occurred in limestone forest (Table 1). Two blackish skinks (referred to as skink sp. 1 in Tables 1 and 2) were observed on the forest floor on Island 24N while another was found under dead palm fronds lying on the ground on Island 12. A fourth small skink (referred to as skink sp. 2 in Tables 1 and 2), this one having a golden back and brown flanks, was discovered in the crown of a *Pandanus* tree on Island 4. These few sightings indicate that both species are rare in the preserve.

Gekko sp.

Previous authors have referred to this species as *Gekko vittatus* (Dryden & Taylor 1969, Owen 1977), but a more recent examination indicates that it should be distinguished as a separate species that is as yet undescribed (R. I. Crombie, pers. comm.). Its status in Palau is unknown. A large conspicuous gecko, it was recorded at only two locations and appears to be rare in the NIWP (Table 1). Two animals (USNM 284396, 284397) were found on the prop roots and leaves of *Pandanus dubius* in limestone forest on Island 24N. Two others (USNM 284398, 284399) were captured together during the daytime under the peeling bark of a large dead tree in strand forest at Beach H.

Lepidodactylus spp.

Two similar species of small geckos of the genus *Lepidodactylus* were recorded in the survey, with both appearing to represent previously undescribed species (R. I. Crombie, pers. comm.). These are referred to here as *Lepidodactylus* sp. 1 and *Lepidodactylus* sp. 2. Four individuals of *Lepidodactylus* sp. 1 (USNM 284400–284403) were found in *Pandanus* crowns and under flaking tree bark in limestone forest on Islands 4, 16, and 34. One individual of *Lepidodactylus* sp. 2 (USNM 284404) was caught under the loose bark of a large tree in strand forest on Island 46. Two other geckos of this genus were seen in *Pandanus* crowns in limestone forest on Islands 24C and 50 but escaped capture. Surprisingly, none of the geckos were found at night; all were discovered in their daytime hiding spots (Table 1).

Pacific Island Boa, *Candoia carinata*

This snake is common throughout Palau (Owen 1977), but appeared to be rare in the NIWP with only one *C. carinata* recorded during the survey. A single reddish brown boa was observed in a *Hernandia* tree at Beach B. In the Solomon Islands, individuals of this species exhibit great variation in appearance with colors ranging from a striking pale gray

with darker patterning along the back to dark brown with faint markings (McCoy 1980). This degree of variation has also been noted in specimens from Palau.

Palau Tree Snake, *Dendrelaphis lineolatus*

Dendrelaphis lineolatus is common in the Palau archipelago (Owen 1977), but appears to be rare in the NIWP (Table 1). It was recorded only in limestone forest on the slopes of the tallest hill in the center of Island 24, where two sightings were made and one shed skin was found. Both sightings and the finding of the skin occurred on the ground. This small slender snake is widely recognized in Palau as being fast and agile in its movements. Owen (1977) noted that they are often found climbing in shrubs and low trees.

Banded Sea Snake, *Laticauda colubrina*

Sea snakes are common residents in Palau's waters (Owen 1977), but appeared to be uncommon in the NIWP, with none sighted along any of the marine survey transects. However, sea snakes were found three times on shore sleeping in well-shaded resting spots located just above the high tide mark. In the first case, two snakes (one was large and the other was small) lay coiled together in a sandy-bottomed crevice below a limestone outcrop at the edge of Beach D. The largest animal remained at the site for at least 24 hours while the second snake departed during the night. One week later, the same apparent two snakes were again present at this location at 1030 hr, an indication that *L. colubrina* may return repeatedly to favored sleeping sites. At Island 13, a single sea snake was discovered sleeping at 1600 hr in a limestone cavity in the island's undercut. *Laticauda colubrina* is both diurnal and nocturnal and normally forages on shallow reef flats near rocky shorelines (McCoy 1980). *Laticauda* is the only genus of sea snake that comes ashore to lay eggs.

Audubon's Shearwater, *Puffinus lherminieri*

Audubon's shearwaters occur commonly in Palau's limestone islands, where they roost at night and nest (Pratt *et al.* 1980, Engbring 1988). During the day, they feed on the open ocean outside the central lagoon and are rarely seen from land. This species was not recorded in our survey. During four nights spent in the NIWP, no individuals were seen nor were their distinctive calls heard. Shearwaters were not noted on two early evening boat counts conducted on the west side of the preserve. These stations provided good viewing points to watch for birds returning to the preserve from the direction of the barrier reef to the west.

White-tailed Tropicbird, *Phaethon lepturus*

White-tailed tropicbirds are common in most of Palau and are frequently seen flying over islands singly or in small loose groups (Engbring 1988). Tropicbirds were uncommon in the NIWP, with an estimated 8–10 birds present during the study. This species was recorded at 5% of all stations (Table 4). The largest number of birds seen at once was a group of four soaring over Island 24 and the adjacent lagoon. One active nest with a large fledgling(s) was found in limestone forest on Island 24C. The nest was 8 m high in the cavity of a large hollow tree on a hillside.

Table 4. Results of bird and bat surveys in the Ngerukewid and Kmekumer Islands, Palau, expressed as percent frequency of occurrence, total number of individuals recorded, and aggregate average number of individuals recorded per station. Species are listed in order of abundance as determined by the aggregate average number recorded per station.

Species	% frequency of occurrence			Total number recorded ^a			Aggregate average		
	Land	Boat	All	Land	Boat	All	Land	Boat	All
Birds									
Micronesian starling	94.1	75.0	82.9	41	53	94	2.41	2.06	2.30
Palau fruit-dove	64.7	58.3	61.0	31	29	60	1.49	1.19	1.40
Micronesian honeyeater	76.5	54.2	63.4	25	24	49	1.35	1.03	1.25
Mangrove flycatcher	82.4	54.2	65.9	25	24	49	1.19	1.06	1.15
Brown noddy	41.2	70.8	58.5	13	56	69	0.64	2.00	1.06
Black noddy	47.1	87.5	70.7	10	63	73	0.49	2.22	1.02
Noddy spp.	0.0	37.5	22.0	0	86	86	0.00	2.69	0.83
Island swiftlet	0.0	58.3	34.1	0	61	61	0.00	2.22	0.68
Micronesian pigeon	41.2	41.7	41.5	11	14	25	0.73	0.53	0.67
Collared kingfisher	47.1	50.0	48.8	12	18	30	0.62	0.78	0.67
Caroline Islands white-eye	5.9	25.0	17.1	3	30	33	0.08	1.09	0.39
Common fairy-tern	5.9	45.8	29.3	1	25	26	0.04	1.16	0.38
Bridled tern	0.0	45.8	26.8	0	38	38	0.00	1.19	0.37
Micronesian megapode	29.4	16.7	22.0	7	5	12	0.29	0.22	0.27
White-eye spp.	11.8	8.3	9.8	3	8	11	0.26	0.25	0.26
Palau fantail	11.8	0.0	4.9	3	0	3	0.33	0.00	0.23
Morningbird	11.8	8.3	9.8	3	2	5	0.19	0.09	0.16
Dusky white-eye	0.0	16.7	9.8	0	11	11	0.00	0.41	0.13
White-tailed tropicbird	5.9	4.2	4.9	1	1	2	0.04	0.03	0.04
Pacific reef-heron	0.0	12.5	7.3	0	3	3	0.00	0.09	0.03
Tattler spp.	0.0	8.3	4.9	0	2	2	0.00	0.09	0.03
Black-naped tern	0.0	4.2	2.4	0	2	2	0.00	0.06	0.02
Nicobar pigeon	0.0	4.2	2.4	0	1	1	0.00	0.03	0.01
Bats									
Micronesian fruit bat	0.0	91.7	53.7	0	119	119	0.00	4.25	1.31
Pacific sheath-tailed bat	0.0	8.3	4.9	0	5	5	0.00	0.16	0.05

^a The average number of individuals recorded per station can be calculated by dividing the total number recorded per survey type by the number of stations conducted per survey type: land surveys—17 stations, boat surveys—24 stations, all surveys—41 stations.

Pacific Reef-Heron, *Egretta sacra*

Reef-herons are common throughout Palau (Engbring 1988). They were widespread but uncommon in the NIWP. Reef-herons were primarily observed from the boat, and were recorded at 12% of the boat stations at an aggregate average of 0.09 birds/station (Table 4.) A total of 19 observations was made (Table 5) and represented an estimated population of 6–8 birds. Birds occurred solitarily or in groups of two or three. Gray and white color phases were noted in about equal numbers. Birds preferred to forage in shallow water, particularly on beaches and sand flats exposed at low tides, rather than along

Table 5. Total observations of birds and bats on various islands in the Ngerukewid and Kmekumer Islands, Palau, by island. Numbers include survey data plus incidental records.

Species	Island													
	1	2	3	4	5	6	7	10	11	12	13	14	15	
Island size (ha)	0.2	<0.2	0.4	1.2	1.0	5.0	1.7	0.6	0.5	3.0	2.5	0.4	0.2	
Birds														
White-tailed tropicbird	1													
Pacific reef-heron						1								
Rufous night-heron														
Micronesian megapode						3	1				6			
Lesser golden-plover			1											
Common sandpiper							1							
Tattler sp.													1	
Black-naped tern			2		10									
Bridled tern	1	2	2		5					2	6			
Brown noddy				4		2		1			10			
Black noddy	3		4						1	10	5		3	
Common fairy-tern					5	6	3	2	2					
Nicobar pigeon										1				
Palau fruit-dove					2	6				3	6			
Micronesian pigeon					1	1	1				3			
Gr. sulphur-crested cockatoo														
Island swiftlet					2	9	3			1	4			
Collared kingfisher				1	2	4				5				
Micronesian kingfisher												1		
Cicadabird												1		
Morningbird					1		1			2	6	1	1	
Mangrove flycatcher					1	3	4		2	1				
Palau fantail														
Micronesian starling			6			1	6	1		11	13	1	1	
Micronesian honeyeater	1		4	1	5	8	6	1		5	2			
Caroline Islands white-eye						5					12			
Dusky white-eye											7			
White-eye spp.					3		4				10			
Bats														
Micronesian fruit bat	2		2	3		8	2	2		4	2	4		
Pacific sheath-tailed bat							4				12			

the steep limestone undercuts of most islands. Although not determined, it is likely that the species breeds in the preserve or on nearby islands.

Rufous Night-Heron, *Nycticorax caledonicus*

This species is a common resident in much of Palau (Engbring 1988). Its preferred feeding and roosting areas include mangroves and tidal flats (Pratt *et al.* 1987). Rufous night-herons were rare in the NIWP. A single bird was observed on three occasions near the small patch of mangroves on Island 24C, where it roosted during the middle of the day. Another night-heron seen on Island 24S was probably the same individual.

Table 5.
(continued)

Island															
16	17	19	22	23	24N	24C	24S	26	28	34	39	46	48	50	Total
7.9	2.5	5.2	0.4	0.2	20.3	18.6	9.6	1.0	0.5	<0.2	0.4	2.7	1.0	2.0	
1					2	4									8
5					3	9					1				19
						1	1								2
8					7	17	4					1		2	49
															1
															1
		1	1			1	1								5
			2		2		2								18
		1	1	1	21				3						45
13		5	2	1	35	19	4							3	99
8	1	5		3	34	4	4							3	88
2					6		9	1	1						37
1					6	2	3					1			14
27	1		1		22	46	12						1		127
8		1			11	25	9					2			62
						6	4					2	2		14
33		6	1	1	36	2	4				3	8			113
11	1	1			14	11	2	1				2		1	56
1					3										5
															1
2					6	4	3								27
21		2	1		19	21	9	1	1			6		4	96
						5	4								9
59	4	3	1		20	36	11	3	4			5		5	191
30	4	1			26	7	16		1	1		5			124
33					10	7	9					3			79
11	1				3	2	2					7			33
3			3		6	20	16								65
61	4	7	1		66	8	15					3		1	195
6					5										27

Osprey, Pandion haliaetus

This species is a rare visitor to Palau and Micronesia (Engbring 1988, Pratt *et al.* 1987). Ospreys have been previously recorded in the NIWP, with a single bird observed by J. Engbring (pers. comm.) in August 1985. None were seen during this survey of the preserve.

Micronesian Megapode, Megapodius laperouse

Micronesian megapodes are common on the coralline islands south of Koror but uncommon to rare on Koror, Arakabesan, and Babeldoab (Pratt *et al.* 1980). Megapodes

were found to be common in the NIWP. They were recorded on 29% of the forest stations at an aggregate average of 0.29 birds/station (Table 4). Megapodes were noted on nine islands, each of which was larger than 2 ha in size (Table 5). Birds were encountered as individuals or pairs foraging on the ground, and we frequently heard pairs duetting.

A rough estimate of the number of Micronesian megapodes in the Ngerukewid Islands was determined from densities of birds recorded on two islands. Three pairs of birds were noted on Island 16 (density of 0.76 birds/ha), and four birds were detected on Island 13 (density of 1.60 birds/ha). These density figures may be somewhat conservative as additional birds may have gone undetected on both islands. Data from other islands were inconclusive but were generally similar. An extrapolation of density estimates for the eight islands in the NIWP that were larger than 2 ha gives a population estimate of 57–121 birds, with an additional 7–15 birds on the four largest islands in the Kmekumer Islands. These figures total 64–136 megapodes for both island groups. We believe that a more conservative figure of 60–90 birds at a density of 69–103 birds/km² is a reasonable population estimate for these islands, and that 50–80 birds occur in the preserve.

Ten nest mounds of megapodes were discovered in the two island groups, of which six appeared to be active. Nine mounds occurred in strand forest behind sandy beaches. These included two active mounds each at Beaches E and H, one active mound at Beach C, and single inactive mounds at Beaches B, D, H, and J (Figure 1). Mounds on beaches were typically constructed of sand with small amounts of organic matter mixed in. A single active mound was also found in limestone forest on a hillside on Island 24C at an elevation of about 50 m. It was built entirely of leaf litter and detritus. It is possible that other mounds of this second type exist in the preserve, although their occurrence is apparently rare in the rest of Palau (Pratt *et al.* 1980). The presence of at least six active nest mounds indicates that there is an average of one mound per 10–15 birds in these islands.

We observed birds visiting mounds on three occasions. In all three instances, individual birds rather than pairs approached the mounds. In one case, a bird appeared to fly in from an adjacent island to reach Beach E. Megapodes have been observed to fly several kilometers between islands elsewhere in Palau (Pratt & Bruner 1978). Individuals in the NIWP probably show little aversion to flying to neighboring islands to reach nest mounds.

Lesser Golden-Plover, *Pluvialis dominica*

Lesser golden-plovers are common migrants to Palau (Engbring 1988), but only one bird was recorded in our survey of the NIWP. It was seen on Island 4 in a small opening below a grove of *Casuarina litoria*. Plovers favor open fields and tidal flats, two types of habitat that are almost entirely lacking in the preserve.

Common Sandpiper, *Actitis hypoleucos*

This species is a common migrant in Palau and uses a wide variety of habitats near water (Engbring 1988). One common sandpiper was recorded on Beach E in the survey.

Tattlers, *Heteroscelus* sp.

Two species of tattler, the Siberian tattler (*H. brevipes*) and wandering tattler (*H. incanus*), occur as migrants in Palau. Both have similar winter plumages and are difficult

to distinguish in the field. The Siberian tattler is the more common of the two species in Palau (Engbring 1988). Five sightings of unidentified tattlers were made in the NIWP including two individuals observed on boat surveys (Table 4). Several of the sightings were probably of the same individuals, and overall, just 2–3 birds may have been in the preserve during the survey. All birds foraged at the water's edge under the rocky undercuts of islands. They were easily detected when flushed by passing boats.

Black-naped Tern, *Sterna sumatrana*

This species is a widespread resident of the Palau archipelago, being most common from southern Babeldoab to Pelelieu (Engbring 1988). In the NIWP, black-naped terns were uncommon with an estimated 6–8 pairs present. This species was observed on one boat station and was not recorded on any forest counts (Table 4). Birds always occurred in pairs and breeding is suspected in the preserve. Pairs were generally solitary and typically roosted 3–10 m high on vertical rock faces above the water.

Bridled Tern, *Sterna anaethetus*

Bridled terns are common residents in Palau's high limestone islands from Koror to Mecherchar (Engbring 1988). This seabird was common in the NIWP, but numbered far fewer than black noddies or brown noddies. Bridled terns were recorded only at boat stations; they were seen at 46% of those stations and occurred at an aggregate average of 1.19 birds/station (Table 4). This species normally roosts and nests in small colonies on cliffs (Engbring 1988). In the NIWP, bridled terns were seen in small groups of 6–10 birds sitting on rock faces over water. Moderate numbers of birds remained in the preserve during the day, with larger numbers returning at dusk from the direction of the western barrier reef.

Brown Noddy, *Anous stolidus*

This species is abundant in Palau and occurs widely from Kayangel to Pelelieu (Engbring 1988). Brown noddies were abundant in the NIWP and were observed at 71% of the boat stations at an aggregate average of 2.00 birds/station (Table 4). Moderate numbers of noddies used the preserve during the day with large numbers of birds arriving at dusk, flying in from the direction of the outer edge of the lagoon at dusk. These terns are pelagic feeders, foraging mainly outside Palau's barrier reef (Engbring 1988, Pratt *et al.* 1987).

Brown noddies nest year-round in Palau (Engbring 1988). During the survey, two active nests were found in limestone forest on the hillsides of Island 24S, C. One nest was 9 m high in a tree and was constructed of dead leaves placed atop several branches. It was hidden in thick foliage and held a single egg. The second nest was 10 m high in the cup of an aerial *Asplenium nidus* fern and contained a fully feathered nestling. We also observed a number of birds picking floating twigs off the surface of calm waters between islands, presumably to use as nesting material.

Black Noddy, *Anous minutus*

The black noddy is found throughout Palau and is considered to be the most abundant tern in the archipelago (Engbring 1988). This species was also the most abundant seabird

on station counts made in the NIWP. It occurred on 87% of the boat counts at an aggregate average of 2.22 birds/station (Table 4). We observed flocks of 20–30 birds feeding in the shallow reef flats immediately adjacent to the islands of the preserve, with concentrations of hundreds of birds further out in the lagoon.

This species breeds throughout the year and commonly nests in vegetation overhanging water (Pratt *et al.* 1980). In this survey, a pair of active nests were found in *Bikkia* shrubs leaning out over water on Island 13. Adults sat on each nest but we did not determine whether eggs or young were present.

Common Fairy-Tern, *Gygis alba*

This species is common on most islands in the Palau archipelago (Engbring 1988). Fairy-terns were also common in the NIWP and were recorded on 46% of the boat counts at an aggregate average of 1.16 birds/station (Table 4). They were almost always seen flying alone or in small groups among the islands of the preserve. Engbring (1988) reported that these birds are commonly associated with inland and coastal forests on islands, where they roost and nest.

Nicobar Pigeon, *Caloenas nicobarica*

In Palau, Nicobar pigeons range from Babeldoab to Peleliu, where they vary from being uncommon to rare (Pratt *et al.* 1980, Engbring 1988). This species was uncommon in the NIWP. It was recorded only once on station counts (Table 4), but 2–3 birds per day were encountered during other field work. Most sightings were of pigeons flushed from the ground in limestone forest or of birds flying high overhead between islands. This species was recorded on five widespread islands, most of which were large (Table 5). Pratt *et al.* (1980) suggested that Nicobar pigeons may be more common in Palau than believed and can be overlooked because of their secretive habits and quiet behavior. We had similar observations and concluded that the species may be more common in the NIWP than indicated by survey data.

Palau Fruit-Dove, *Ptilinopus pelewensis*

Palau fruit-doves are abundant and widely distributed in Palau (Pratt *et al.* 1980, Engbring 1988). They were the second most abundant bird in the NIWP as determined by count data, and were recorded on 61% of all stations at an aggregate average of 1.40 birds per station (Table 4). Fruit-doves were noted most frequently on larger islands and appeared to avoid small islands with scrubby forests (Table 4 and 5). Most of our records were of calling birds. One instance of a fruit-dove feeding on the flowers of *Intsia bijuga* in strand forest was noted.

Micronesian Pigeon, *Ducula oceanica*

These large pigeons occur from Babeldoab to Peleliu with densities varying widely among islands (Pratt *et al.* 1980). Micronesian pigeons were widespread and common throughout the NIWP and occurred on 41% of all station counts (Tables 4 and 5). They were recorded in slightly greater numbers on forest stations than from the boat. As with the other fruit-eating doves, this species was usually found on the larger islands with tall forest and an abundance of fruit-producing trees.

Greater Sulphur-crested Cockatoo, *Cacatua galerita*

Cockatoos were introduced to Palau in the 1940s and have established populations in the limestone islands (Engbring 1988). Cockatoos are rare in the Ngerukewid and Kmekumer Islands with two pairs of birds recorded during the survey. None were observed during station counts. One pair was seen and heard repeatedly on Island 24C, S, usually in the vicinity of the largest hill in the center of the island. A second pair of cockatoos was seen flying between Islands 46 and 48, and probably made use of Islands 49 and 50 as well. We are certain these few birds represent the entire population of the two island groups. This species is easily detected because of its loud calls and habit of flying above the forest canopy.

Elsewhere in Palau, cockatoos feed on the hearts of two species of endemic palms and are responsible for killing large stands of these trees (Engbring 1988). In the NIWP, damage to the palm *Gulubia palauensis* was quite noticeable and extensive in 1977–1979 (J. Engbring, pers. comm.), but was rarely noted in our survey. This palm is common at present. This may indicate that populations of cockatoos in the Ngerukewid Islands have declined significantly during the last decade, perhaps because they are actively sought for pets.

Palau Owl, *Pyrhogaux podargina*

The Palau owl is a common forest resident on Palau's major islands as well as on many smaller limestone islands (Engbring 1988). Surprisingly, owls were not detected during the survey and appear to be absent from the NIWP. No birds responded to tape-recorded calls during the night-time survey of Island 24 and surrounding islands, nor were owls heard calling from any other island during four nights spent in the preserve.

Island Swiftlet, *Aerodramus vanikorensis*

This species is abundant on most islands in Palau (Pratt *et al.* 1980, Engbring 1988). In the NIWP, swiftlets occurred in moderate numbers and were considered to be common to abundant. They were recorded only at boat stations, occurring at 58% of these counts with an aggregate average of 2.22 birds/station (Table 4). While foraging, birds typically flew silently over the forest canopy, thus none were recorded on counts made on land. Birds were present throughout the preserve (Table 5).

A small colony of swiftlets was found on Island 24N in a cave that was also used as a roost by about 200 Pacific sheath-tailed bats. A description of this and other caves visited in the survey is included in the species account for Pacific sheath-tailed bats. The cave contained 13 swiftlet nests, many of which were visited by birds, perhaps indicating that eggs or young were present. Ten of the nests occurred in a faintly lit room that was also used by the bats and was next to the entrance. The remaining nests were located deeper in the cave in nearly complete darkness.

A second large cave on Island 16 and several small caves elsewhere in the preserve did not contain swiftlets or guano. On several islands, birds were regularly seen flying near rock overhangs above the water. Closer examination revealed that none of these sites had nests. We observed swiftlets foraging in the preserve until dark, indicating that the population is resident and does not commute to caves on distant islands. The bulk of the swiftlet population probably roosts in one or more undiscovered caves in the preserve.

Collared Kingfisher, Halcyon chloris

The collared kingfisher is the larger of Palau's two kingfishers and is common throughout the island chain (Pratt *et al.* 1980, Engbring 1988). It is most abundant in coastal areas but also occurs in savanna and forested uplands on a few islands (Pratt *et al.* 1980). This species was common in the NIWP and exhibited a strong association with areas next to water. It was recorded on 49% of all stations with an aggregate average of 0.67 birds/station (Table 4). A number of birds were seen flying between islands or perched on exposed branches over water. Sightings were distributed throughout the preserve (Table 5).

Two inactive nests were found on Island 24C. Both were located near the water's edge in termite mounds attached to tree trunks or roots. The nests were 1–2 m above the ground at 5–15 m elevation.

Micronesian Kingfisher, Halcyon cinnamomina

In Palau, *H. cinnamomina* ranges from Babeldoab to Peleliu, with its abundance varying from common to uncommon (Pratt *et al.* 1987, Engbring 1988). During this survey, kingfisher calls that differed slightly from those of *H. chloris* were heard on five occasions, all incidental to station counts. These were probably given by Micronesian kingfishers although the identities of the birds involved were never confirmed visually. The calls were heard on Islands 24N, C, 16, and 13. All occurred in tall upland limestone forest inland from the shoreline.

Palau's two species of kingfishers typically segregate themselves by habitat with *H. chloris* avoiding the deep forests that are preferred by *H. cinnamomina* (Pratt *et al.* 1980). We believe that a small population of Micronesian kingfishers lives in the NIWP and that the species can be considered as uncommon. Because these birds are somewhat retiring in their habits, their abundance may have been somewhat underestimated. *Halcyon cinnamomina* probably occurs on most of the preserve's larger elevated islands with well-developed forest.

Cicadabird, Coracina tenuirostris

Cicadabirds are widespread but uncommon in Palau (Pratt *et al.* 1980). This species was rare in the NIWP, with only one bird recorded during the survey. A female was seen on Island 13 as it moved slowly through the forest canopy above Beach B. No birds were recorded on station counts. It is possible that a small breeding population of cicadabirds exists in the preserve and that other individuals were overlooked. Typically, these birds are difficult to detect because of their inconspicuous behavior and preference for foraging in tree tops (Engbring 1988, Pratt *et al.* 1987).

Morningbird, Colluricincla tenebrosa

Morningbirds occur commonly from Babeldoab to Peleliu (Pratt *et al.* 1980, Engbring 1988). Survey data suggested that this species was uncommon in the NIWP. It occurred at only 12% of forest stations at an aggregate average of 0.19 birds/station (Table 4). Morningbirds were rarely heard during the survey, thus nearby individuals may have gone unrecorded on station counts. We encountered birds more often while hiking through the preserve and suspect that this species is slightly more common than indicated here. It

probably occurs at moderate densities on most islands in the NIWP. Pratt *et al.* (1980) reported that morningbirds are most vocal before dawn and often follow an observer silently.

This species is a solitary skulker that feeds slowly and deliberately in the forest understory (Pratt *et al.* 1980). In the NIWP, individuals or pairs commonly foraged on the ground or less than a meter high in understory vegetation. On a number of occasions, we witnessed a possible courtship display in pairs of adults that consisted of one bird rapidly fluttering its wings in front of its companion in a manner similar to that performed by begging juveniles of many other bird species.

Mangrove Flycatcher, *Myiagra erythrops*

The mangrove flycatcher ranges from Babeldoab to Peleliu and is common in all types of forest, especially mangroves (Pratt *et al.* 1980, Engbring 1988). Flycatchers were abundant and well distributed in the NIWP. They were found on 82% of the forest counts at an aggregate average of 1.19 birds/station (Table 4). This species occurred primarily in higher quality limestone forest but was also observed in strand forest and on small islands with scrubby limestone forest. Birds foraged at a variety of heights, ranging from the understory to the upper canopy.

Palau Fantail, *Rhipidura lepida*

Fantails are widespread and common in a variety of forest types in Palau (Engbring 1988, Pratt *et al.* 1987). This species was rare in the NIWP. It was found only in limestone forest on Island 24C, S, where a total of two pairs and a solitary bird were noted. Three individuals were detected on two (12%) forest counts for an aggregate average of 0.33 birds/station (Table 4). The conspicuous behavior of these birds makes it doubtful that many were overlooked during the survey. The presence of paired birds indicates that breeding probably occurs in the preserve.

Micronesian Starling, *Aplonis opaca*

Micronesian starlings are widely distributed in Palau and are considered to be the most abundant forest bird in the archipelago (Baker 1951, Pratt *et al.* 1980). Starlings were also the most common bird in the NIWP, being present on 83% of all station counts with an aggregate average of 2.30 birds per station (Table 4). Starlings inhabited limestone and strand forests throughout the preserve, and were one of the few bird species that used small islands (Table 5). Birds were frequently seen flying in small flocks between islands. Individuals were observed feeding on *Ficus* fruit.

Micronesian Honeyeater, *Myzomela rubrata*

The Micronesian honeyeater occurs throughout Palau and is common and conspicuous near forest edges, openings, and in other disturbed habitats (Pratt *et al.* 1980, Engbring 1988). This species was abundant in the NIWP, occurring on 63% of all stations at an aggregate average of 1.25 birds/station (Table 4). We commonly found honeyeaters in tall undisturbed forest and recorded them more frequently inside the forest than from boat stations (Table 4). Honeyeaters also made frequent use of strand forest and occurred regu-

larly on small islands with poor forest. Birds were often noted chasing each other at high speeds through the canopy and even between islands. One bird was seen feeding on flowers of *Gulubia palauensis*.

Caroline Islands White-eye, *Zosterops semperi*

This species is common on most islands from Babeldoab to Peleliu (Pratt *et al.* 1980, Engbring 1988). Caroline Islands white-eyes can be classified as common in the NIWP even though they were recorded on only 17% of all stations at an aggregate average of 0.39 birds/station (Table 4). The species was detected more frequently during boat counts than at forest stations (Table 4). Unidentified white-eyes, some of which may have been *Z. finschii*, occurred at an additional 10% of the stations (Table 4). *Zosterops semperi* was seen only on islands that were larger than 2.5 ha in size (Table 5), suggesting that it has a preference for tall forests with closed canopies.

This species is gregarious and associated in flocks of 5–15 birds. Birds foraged in the upper canopy and were constantly in motion, making individuals in flocks difficult to observe and identify as they flew overhead. Birds were seen feeding avidly on the flowers of *Aidia racemosa*.

Dusky White-eye, *Zosterops finschii*

Dusky white-eyes are common to abundant throughout most of Palau and frequent most habitats (Pratt *et al.* 1980). They were uncommon in the NIWP and were identified at 10% of all stations with an aggregate average of 0.13 birds/station (Table 4). Dusky white-eyes were recorded only on boat counts as they foraged in the forest canopy with flocks of *Z. semperi*. As with *Z. semperi*, dusky white-eyes were noted only on larger islands (Table 5).

Micronesian Fruit Bat, *Pteropus mariannus pelewensis*

Although fruit bats in Palau have been heavily hunted over the past 15 years for local use and as an exported food item, this species was apparently still common in much of the archipelago in the mid 1980s (Wiles & Payne 1986). Fruit bats were abundant and widely distributed in the NIWP. They occurred on most islands (Table 5) and were often noted flying between islands. Fruit bats were not recorded on forest counts, but were abundant on boat counts (92%) where they occurred at an aggregate average of 4.25 bats per station (Table 4). Bats became more active in the late afternoon, with moderate to large numbers of animals seen feeding from 1600 to darkness (at about 1830).

An estimate of the number of Micronesian fruit bats in the NIWP was determined from the number of bats seen on the two sets of evening counts made from the boat. Approximately 33% of the preserve was surveyed on this transect, with 43 and 55 bats observed on the two nights, respectively. An extrapolation of this data for the whole preserve yielded a population estimate of 131–168 fruit bats occurring at a density of 150–192 bats/km². The reliability of estimating the sizes of bat populations from station count data has never been verified and the accuracy of our estimate is difficult to assess. During such counts, some individuals may be tallied more than once as they fly about, while others may not be counted at all if they do not fly and are not seen. Our estimate of 130–170 bats in the preserve seems reasonable given the frequency with which bats were sighted.

Although *P.m. pelewensis* is reported to congregate in colonies during the day (Perez 1968, C. Kittelng, pers. comm. to J. Engbring), all of the bats seen in this survey roosted solitarily or in small groups of 2–4 animals. Colonies of other taxa of *Pteropus* are typically noisy and readily visible, which aids in their detection (Wiles 1987b). The steep hillsides of the NIWP provided ideal terrain for locating bat roosts. After 10 days of field work, we are confident that no fruit bat colonies were present in the preserve.

Ten to 12 female fruit bats were observed in flight with attached young during the study. Young of this size probably ranged in age from a few days to perhaps 4–6 weeks old, indicating that births occurred sometime between late November and early January.

Most species of *Pteropus* have diverse diets of fruit, nectar, pollen, and sometimes leaves (Marshall 1985). In the NIWP, fruit bats were noted to feed on the fruits of *Ficus* sp., *Pandanus tectorius*, and *Cycas circinalis*, the flowers of *Intsia bijuga* and *Gulubia palauensis*, and the leaf stems of *Artocarpus mariannensis*. Several observations of bats visiting the flowers of *Gulubia palauensis* suggest that it is a favored food. Elsewhere in southern Palau, we recorded feeding on the fruit of *Eugenia malaccensis*, *Terminalia cattapa*, *Neisosperma oppositifolia*, and *Mangifera indica*.

Intsia bijuga was heavily in bloom during the survey and large numbers of fruit bats were attracted to its flowers. Up to five bats were commonly seen foraging in single trees at once. On one occasion at dusk, a bat was observed successfully defending an area of tree crown with many flower clumps. The bat fully extended its wings forward and clapped them rapidly several times at other bats flying close overhead. Wing clapping was audible to observers 15 m below on the ground. Several other bats were feeding as close as 5 m away in the same tree but no defense was directed at them. The defending bat flew off after about 8 min, having fed at many flower clumps. Gould (1978) and Wiles, Engbring & Falanruw (in prep.) have observed similar defense of food resources by other *Pteropus*.

Palau Fruit Bat, *Pteropus pilosis*

This species of bat is endemic to Palau and is much larger than *P. m. pelewensis*. Only two specimens have ever been collected, both prior to 1874 (K. F. Koopman, pers. comm.), and the species may now be extinct. No noticeably large fruit bats were noted in the NIWP during this survey. All of the fruit bats observed were believed to be *P. m. pelewensis*.

Pacific Sheath-tailed Bat, *Emballonura semicaudata*

This small insectivorous bat is considered to be abundant throughout Palau (Owen 1977). Data gathered in this study indicate that sheath-tailed bats are uncommon in the NIWP. Bats were seen flying at dusk on only two of the four nights spent in the preserve and were never recorded in large numbers (usually 4–5 animals per location) at twilight. They were recorded at two of the 24 boat stations and occurred at an aggregate average of 0.16 bats per station (Table 4). Bats began to emerge from roosts near sunset with initial sightings occurring at 1810 and 1726 hrs. Future efforts to study sheath-tailed bats at night with mist nets or harp traps may reveal that these animals are more common than indicated here. Bats were seen on Islands 7, 13, 16, and 24, an indication that the species forages widely in the preserve.

Two fairly large caves were inspected for sheath-tailed bats during the survey. One

cave with a colony of about 200 *E. semicaudata* was discovered on Island 24. It had two chambers, each estimated to be 25–30 m long, 5–15 m wide, and 3–10 m tall. Both chambers had exterior entrances. The bats resided in only one small dimly lit room that was located just inside one of the entrances. This room was approximately 5 m long, 3 m wide, and 5–6 m tall. The bats were spread over most of the ceiling, with animals roosting 10 cm or more from neighbors. All bats appeared to hang from the open ceiling rather than inside crevices. The room was shared with a small number of island swiftlets which had built about 10 nests that were distributed across the ceiling. Nearly all bats took flight immediately when an observer entered the room. The cave did not have large accumulations of fresh guano, but deposits of extremely soft soil were found in some places on the cave's floor and had probably formed from decomposed guano. The cave showed no signs of having been visited by people.

A second large cave, which was located on Island 16, did not contain sheath-tailed bats or guano. It had a main room that was about 75 m wide and 30 m long with several smaller chambers branching off and appeared to be of appropriate size for bats. Small caves that were a few meters long were found on several other islands but never contained bats.

Other caves probably exist in the NIWP. A tight flock of 12 bats suddenly appeared over Island 13 and fed briefly one afternoon at 1500 hr. Their roost, which was never discovered, was possibly disturbed by other members of the survey party working near the hill top.

Small Mammals

Small mammals that have been introduced to Palau include the musk shrew (*Suncus murinus*), house mouse (*Mus musculus*), and four species of rats (*Rattus* spp.) (Owen 1977). Most of these animals are commensal with man, but the Polynesian rat (*R. exulans*) and the roof rat (*R. rattus*) have established populations in forested areas (Owen 1977).

Rodents and shrews appear to be absent from the NIWP. Trapping was conducted on Islands 16 and 24N, C, with no animals captured during a combined total of 144 trap nights using rat, mouse, and sticky traps (Table 3, Figure 2). This effort was not extensive enough to prove conclusively that small mammals are absent from the preserve. However, the lack of any small mammal sightings by members of the terrestrial survey team during the study supports this conclusion. In contrast, rats were so numerous on Ulong and Eudelchol, two other limestone islands in southern Palau, that observers could see several animals within minutes of going ashore on each island.

Dugong, *Dugong dugon*

Aerial surveys of Palau's lagoon in 1977–1978 and 1983 estimated that only a small population of perhaps 50 dugongs remains in Palau (Brownell *et al.* 1981, Rathbun *et al.* 1988), although this figure is regarded as too low by some Palauans. Heavy dugong poaching was reported in both studies, causing Brownell *et al.* (1981) to predict that Palau's dugong population would become extinct by the year 2000 if illegal hunting continues.

Dugongs were not observed in this study. There are no documented sightings of dugongs in the NIWP, although several animals were seen in the general vicinity of the Ngerukewid Islands during the surveys of Brownell *et al.* (1981) and Rathbun *et al.*

(1988). Dugongs may occasionally enter the preserve, although they probably do not remain for extended periods because only one small seagrass bed is present (S. Wilkins, pers. comm.). Animals are known to use daytime loafing areas near reefs, patch reefs, or shipwrecks far from extensive seagrass beds (Brownell *et al.* 1981), and thus, the lack of seagrass in an area may not be a reliable indicator of dugong use.

Discussion

The ecology of most islands in Micronesia has been altered to varying extents through habitat modification and the introduction of numerous animal and plant species. Neither of these factors has occurred to a significant degree in the NIWP, making it probably one of the least disturbed terrestrial ecosystems remaining in Micronesia. Only one introduced vertebrate, the greater sulphur-crested cockatoo, was recorded. All six species of small mammals introduced to Palau appear to be absent. Because of its pristine condition, the preserve is highly deserving of its protected status and provides a valuable control site with which to evaluate the faunas of other Palauan islands modified by man and alien organisms. Future efforts to manage the NIWP should strive to protect and preserve the area's present natural conditions.

Excluding introduced species, the fauna of the Palau Islands is comprised of one species of amphibian, approximately 32 species of reptiles, 136 species of birds, and four species of mammals (Owen 1977, Engbring 1988, R. I. Crombie, pers. comm.). Forty-five species of native birds breed in the archipelago with 24 of these classified as forest species. Our study indicates that the NIWP contains one amphibian, 13 species of reptiles (plus an additional species, *Cryptoblepharus poecilopleurus*, in the Kmekumer Islands), 29 species of birds, and two, or possibly three, species of mammals. Twenty-three kinds of birds are thought to breed in the preserve, 15 of which are native forest birds.

Interestingly, a number of birds that occur elsewhere in Palau's heavily forested limestone islands were not detected in the NIWP. These included the Audubon's shearwater, yellow bittern (*Ixobrychus sinensis*), banded crane (*Rallina eurizonoides*), Palau ground-dove (*Gallicolumba canifrons*), Palau owl, jungle nightjar (*Caprimulgus indicus*), Palau bush-warbler (*Cettia annae*), giant white-eye (*Megazosterops palauensis*), and blue-faced parrotfinch (*Erythrura trichroa*). The absence of these species may be related to several causes. Biogeographical factors, such as the preserve's small land mass and isolation from neighboring islands, perhaps play a role in the absence of some forest-dwelling birds. Limestone forests in the NIWP are more poorly developed than on the larger islands of Mecherchar and Ngeruktabl, and may lack necessary resources required by some bird species. Also, the preserve's forests may be more susceptible to drought. During 1983, an El Niño year of severe drought, vegetation in the NIWP appeared much drier and browner than on larger neighboring islands (J. Engbring, pers. comm.). A lack of freshwater wetlands, mudflats, and large areas of mangroves or exposed tidal reef flats greatly limits the value of the NIWP for waterbirds and migrant shorebirds.

Most birds and bats were distributed throughout the NIWP. Although survey design and time limitations did not allow a critical appraisal of habitat associations, we noted a general trend of greater species diversity on larger islands within the preserve where for-

ests were taller and more complex than on smaller islands supporting meager forest. Both species of pigeons and white-eyes, fruit-doves, megapodes, Micronesian kingfishers, and fruit bats preferred large islands, probably because of better food resources and protective cover.

Six species of seabirds reside in the preserve, with the black noddy, brown noddy, and bridled tern being particularly common. Although no large breeding colonies of seabirds are present, such as those reported for black noddies on the remote Fanna and Helen Islands southwest of Palau (Engbring 1988), the isolated and uninhabited nature of the preserve makes it a highly suitable location for seabirds to breed in moderate numbers.

Densities of lizards and snakes were generally low throughout the NIWP and adjacent islands. Lizard sightings were infrequent in limestone forest, occurring at rates of less than one animal per hour for each species (Table 1). Low capture rates of lizards on sticky traps corresponded with the low numbers of observations (Table 3). Although comparative data for other islands in Palau are lacking, lizard densities are much lower in the Ngerukewid Islands than on certain other islands in Micronesia, such as Rota and Tinian in the Marianas and Ulithi Atoll near Yap (Wiles, pers. observ.).

As with some birds, reptiles and frogs were not distributed uniformly in the NIWP. Larger islands generally had greater numbers of species present than did smaller islands (Table 2). Many of the islands in the preserve are less than a hectare in size and do not offer well-developed forest to sustain diverse lizard populations. Forests on larger islands tend to have greater plant diversity and size variation, and beach strand forest is present on some of these islands.

Overall rates of lizard observations were slightly higher in strand forest, but this is somewhat biased by the inclusion of data from Beach H, where densities were noticeably higher. Other strand areas had small lizard populations. The greater lizard densities and diversity of Beach H may have been related to its size. It was the largest beach in the study area, being approximately 3,500 m² in size, whereas nine other beaches averaged 620 m² (maximum area = 1,100 m²). At several large beach strands visited outside the study area on the islands of Euidelchol and Ngercheu, shrink populations were noticeably high, further indicating that large beaches may typically support high populations of lizards.

The small variety of reptiles in the Ngerukewid and Kmekumer Islands is possibly related to several factors including chance extinctions, the relative isolation of these islands from large neighboring islands, the small total land area of the island group, the predominance of a single habitat on the islands, and past drought conditions. Limestone forest comprises about 99% of the land area on these islands, with strand forest being the only other terrestrial habitat. However, until additional faunal surveys are conducted, it may be premature to conclude that the reptile fauna of the Ngerukewid Islands is relatively depauperate in comparison with other limestone islands in southern Palau. Further studies will undoubtedly expand the known distributions of many reptiles in the preserve and clarify biogeographical relationships.

Collecting of turtle eggs and the catching of coconut crabs (*Birgus latro*) are two major forms of hunting that presently occur in the preserve. The amount of hunting of birds and fruit bats with pellet guns was difficult to determine. This type of gun is the only weapon that can be legally used for hunting in Palau at present. We found no recent evi-

dence of hunting of fruit bats or birds with shotguns, which are illegal but probably still widely used (Wiles & Payne 1986). Only two shotgun shells, both badly rusted and probably at least 10 years old, were discovered in the preserve. Hunting parties were not encountered during the survey, a possible indication that few hunters visit the preserve. Relatively high densities of pigeons and fruit bats inhabit the preserve, which is further evidence that extensive hunting for these animals does not take place. These species appear to be more numerous in the preserve than on many of Palau's other islands (J. Engbring, pers. comm.). Some collecting of megapode eggs may occur in the preserve, as it does elsewhere in archipelago (Owen 1977, Pratt *et al.* 1980), but no direct evidence of this was found. If the NIWP is to maintain its current role as a sanctuary for Palauan wildlife, including species heavily hunted elsewhere, control of illegal hunting must be a high priority in management efforts.

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