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The Prehistory of Vertebrates, Especially Birds, on Tinian, Aguiguan, and Rota, Northern Mariana Islands

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Abstract—Recent excavations in caves and rockshelters on the islands of Tinian, Aguiguan, and Rota (Commonwealth of the Northern Mariana Islands) have yielded a history of vertebrates over the past 2500 years. Bones from these and other sites document these extinct or locally extirpated species of birds: Tinian: *Procelsterna cerulea*, *Gygis microrhyncha*, *Poliolimnas cinereus*, *Porzana* sp., *Gallirallus* sp., *Porphyrio* sp., cf. *Ducula oceanica*, *Collocalia vanikorensis*, *Acrocephalus luscinia*, *Cleptornis marchei;* Aguiguan: *Porzana* sp., *Gallirallus* sp.; and Rota: *Puffinus lherminieri*, *Procelsterna cerulea*, Anatidae new sp., *Megapodius laperouse*, *Porzana* sp., *Poliolimnas cinereus*, *Gallirallus* sp., cf. *Porphyrio* sp., *Gallinula chloropus*, *Gallicolumba* new sp., *Ducula oceanica*, Psittacidae new sp., *Collocalia vanikorensis*, *Myiagra* cf. *freycineti*, *Cleptornis marchei*, and *Erythura* new sp. The bones also portray the loss of nine populations of lizards, one of snake, and two of bats. It appears that chicken, dog, and pig, which occur prehistorically through much of Oceania, were not introduced to the Mariana Islands until after European contact. The only non-native, non-human vertebrate with good evidence of living prehistorically in the Mariana Islands is the Pacific Rat *Rattus exulans*, which nevertheless is absent in strata older than ca. AD 1000-1200. That flightless rails, especially *Gallirallus* spp., survived in the Mariana Islands for millennia after human arrival may be related to the lack of chicken, dog, and pig, combined with a 2000–2500 year delay in the introduction of *Rattus exulans*.

Introduction

Compared to most other island groups in Oceania, the modern status and distribution of resident birds are relatively well known in the Mariana Islands (Baker 1951, Jenkins 1983, Engbring & Pratt 1985, Engbring et al. 1986, Pratt et al. 1987, Reichel 1991, Reichel & Glass 1991, Craig et al. 1992a, Wiles et al. 1993). In much of Oceania, however, most indigenous populations and species of birds were lost to prehistoric human activities, including habitat alteration, direct predation, and predation from introduced vertebrates (Olson & James 1991, James &

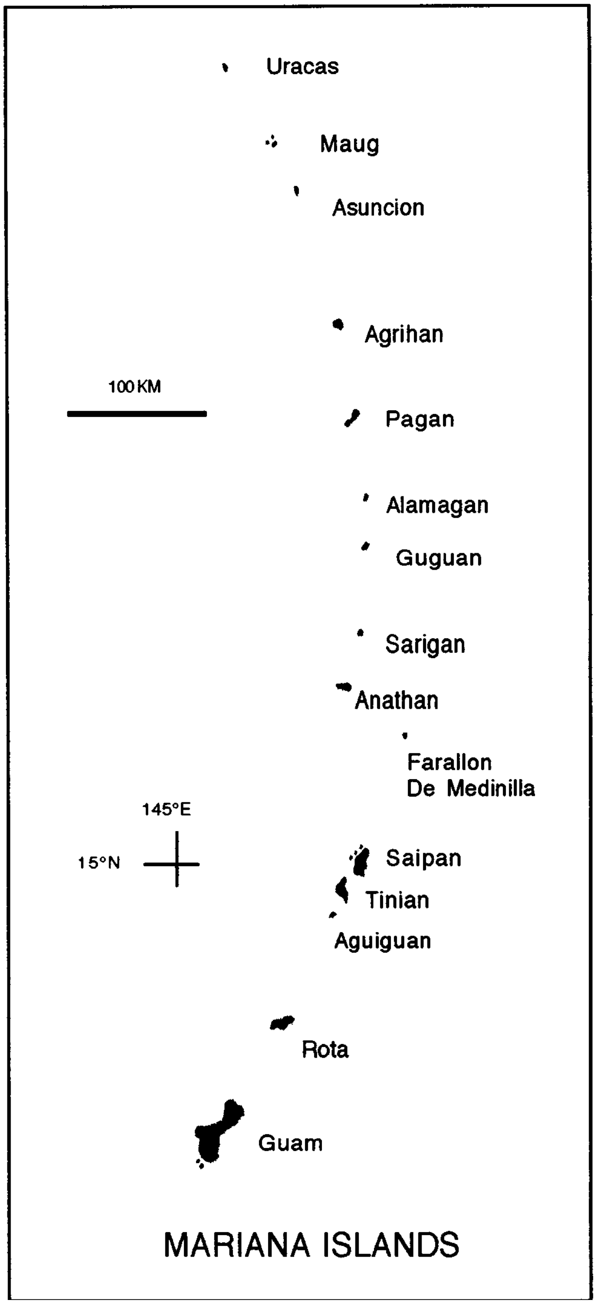

Figure 1. The Mariana Islands

Olson 1991, Steadman 1995). Because the birds that still survive on any Polynesian or Micronesian island are a subset of those that existed at first human contact, any assessment of the natural distribution of birds on tropical Pacific islands requires consideration of the prehistoric record, which is obtained by studying bones from archaeological (cultural) and paleontological (non-cultural) sites. The prehistoric record is much better developed in Polynesia than in Micronesia where the only previously published data on prehistoric birds are from Rota and Fais (Yap) (Steadman 1992, Steadman & Intoh 1994).

This paper presents and interprets paleoecological and biogeographic data from bones excavated on Tinian, Aguiguan, and Rota, three raised limestone islands in the Commonwealth of the Northern Mariana Islands (Fig. 1). The cultural context of the excavations, especially the abundant prehistoric pottery from certain sites, will be described along with stratigraphic and chronologic details in a separate paper being prepared by DWS and C. C. Bodner. The ages of the cultural sites do not exceed ca. 2500 years. Thus, given the fact that cultural sites as old as ca. 3500 years are known from Saipan and Rota (Craib 1993, Butler 1994, Amesbury et al. 1996), we are missing evidence of which species of birds were exploited by the very earliest inhabitants of the Mariana Islands.

Methods

Field Research

In consultation and collaboration with local biologists and other government officials, our field team (C. C. Bodner, S. R. Derrickson, J. D. Groves, D. S. Lee, DWS) visited Tinian (24 June–6 July), Aguiguan (6–15 July), and Rota (15–24 July) during 1994. We evaluated caves and rockshelters for bone deposits, eventually conducting excavations at nine sites (three on Tinian, two on Aguiguan, and four on Rota). The many caves and rockshelters on these uplifted limestone islands provide ideal settings for deposition of bones by both cultural and non-cultural means. Promising sites were tested, using standard paleontological/archaeological techniques to excavate and fine-screen sediments.

Laboratory Research

All bones were cleaned, curated, and identified by DWS except for human bone by S. C. Antón and amphibian and reptile bones by G. K. Pregill (see Pregill 1998). The fish bones have not been identified beyond being fish. The reptile bones are lumped as LIZARD or SNAKE in the main faunal tables. Rat bones were identified as either the prehistorically introduced Pacific Rat *Rattus exulans* (smaller) or the historically introduced Black Rat *Rattus rattus* (larger). Bat bones were identified to species for the Sheath-tailed Bat *Emballonura semicaudata* but only to genus for megachiropterans (*Pteropus* spp.), which have a long history of human exploitation in Micronesia (Wiles & Payne 1986, Wiles et al. 1989, 1997). Rail bones were identified only to genus for *Porzana*, *Gallirallus*, and *Porphyrio*, three genera with complex radiations of flightless and volant species in Oceania

(Steadman 1987, 1988, 1995, Olson & James 1991). The bird bones are housed in the Bird Collection of the Florida Museum of Natural History. Grayson (1984) has shown that, in zooarchaeological bone assemblages, the values for the number of identified bones (NISP) track the values for minimum number of individuals (MNI) represented by those bones. Therefore, in Tables 2–14 the numbers given for each taxon represent only NISP and not MNI.

The Sites and Their Faunas

TINIAN

On Tinian we worked in the Carolinas area, where earlier excavations had produced prehistoric bones of a rail *Gallirallus* sp. (Bodner & Welch 1992, Bodner 1993). The most important site in Carolinas is Railhunter Rockshelter, known also as site 131 or site 131/132. This small shelter is formed in an isolated block of limestone. The primary bone-bearing stratum (Layer II) dates to ca.

Table 1. Radiocarbon dates from prehistoric faunal sites, Northern Mariana Islands.[a]

Lab no.	Mass Carbon	Island	Site	Provenience	Age (yr BP)
CAMS-32971	1.55mg B-*Gallirallus*	TINIAN	Railhunter Rockshelter	TP6: I, 2	1880 ± 50
CAMS-32972	1.54mg B-*Gallirallus*	TINIAN	Railhunter Rockshelter	TP6: IIA, 5	2110 ± 60
CAMS-17394	1.00mg C	TINIAN	Railhunter Rockshelter	TP4: IIB, 7	2200 ± 60
CAMS-17389	0.91mg C	TINIAN	Railhunter Rockshelter	TP4: IIC, 8	2460 ± 60
CAMS-31063	0.87mg B-*Porzana*	TINIAN	Railhunter Rockshelter	TP4: III, 11	2420 ± 60
CAMS-17392	1.11mg C	AGUIGUAN	Pisonia Rockshelter	TP1: II, 5	540 ± 60
CAMS-32973	1.17mg B-*Rattus exulans*	AGUIGUAN	Pisonia Rockshelter	TP2: IIIB, 6	790 ± 50
CAMS-17390	1.09mg C	AGUIGUAN	Pisonia Rockshelter	TP1: IIIC, 15	1480 ± 60
CAMS-17403	0.82mg C	AGUIGUAN	Pisonia Rockshelter	TP1: IV, 16	1520 ± 60
CAMS-17393	0.97mg C	AGUIGUAN	Pisonia Rockshelter	TP1: IV, 16	1780 ± 70
Beta-36074	~12gm C	ROTA	Payapai Cave	TP2: II, 2	930 ± 70
CAMS-17397	1.31mg C	ROTA	Payapai Cave	TP3: III, 4	400 ± 60

[a]Accelerator-mass spectrometer dates (CAMS-xxx) were pretreated at University of Colorado Laboratory for Accelerator Radiocarbon Research and counted at Lawrence Livermore National Laboratory. The conventional date (Beta-36074) is from Beta Analytic Inc. B, bone; C, charcoal. Provenience abbreviations: TP, Test Pit; layers (natural stratigraphy) are in Roman numerals; levels (arbitrary sequence) are in Arabic numerals. yr BP, uncorrected radiocarbon years before present.

2400–2200 yr BP (Table 1). Layers I and III contain few bones but differ little in age from Layer II. Each Layer is distinctive sedimentologically. Layers I and especially II yielded abundant prehistoric pottery but no other type of prehistoric artifacts. There are major faunal differences between Layer II and the poorly stratified Layer I (Tables 2–4), the latter also yielding a mixture of prehistoric pottery and historic glass, gas masks, rusted iron, etc. Layer III lacks organic and cultural materials and probably was deposited immediately prior to human occupation of Railhunter Rockshelter.

Except for the lizards in Layer I and the entire fauna from Layer III, the vertebrate fauna from Railhunter Rockshelter is derived mainly from human

Table 2. Stratigraphic bone summary, Test Pits 4-6 combined, Railhunter Rockshelter (site 131), Tinian.[a]

	I	IIA	IIB	IIC	III	TOTAL
FISH	23	76	82	75	5	261
Bufo marinus (i)	8	-	-	-	-	8
LIZARD	12	23	19	11	10	75
SNAKE	-	-	2	-	-	2
Pteropus sp.	1	11	1	-	-	13
Emballonura semicaudata	-	-	1	-	-	1
Rattus exulans (i)	7	-	-	-	-	7
Rattus rattus (I)	3	-	-	-	-	3
Homo sapiens (i)	-	-	1	1	-	2
Canis familiaris (I)	1	-	-	-	-	1
LARGE MAMMAL (i)	-	-	2	-	-	2
Gallus gallus (I)	1	-	-	-	-	1
Sterna sp.	-	-	1	-	-	1
Anous stolidus	-	2	3	5	-	10
Anous minutus	-	1	2	-	-	3
Procelsterna cerulea	1	2	1	-	-	4
Gygis candida	1	11	4	4	-	20
Gygis microrhyncha	-	-	1	-	-	1
Pluvialis fulva	-	1	3	-	-	4
Megapodius laperouse	-	-	-	1	-	1
Poliolimnas cinereus	1	3	4	1	-	9
Porzana sp.	5	29	91	115	5	245
Gallirallus sp.	10	48	78	58	1	195
Rallidae sp.	-	3	2	3	1	9
Gallicolumba xanthonura	4	13	14	20	-	51
Ptilinopus roseicapilla	1	3	2	1	1	8
Acrocephalus luscinia	-	-	3	2	-	5
Myzomela rubrata	-	-	1	-	-	1
Aplonis opaca	1	1	5	7	-	14
Zosterops conspicillatus	-	1	-	-	-	1
Cleptornis marchei	1	-	-	-	-	1
Passeriformes sp.	1	6	3	4	1	15
BIRD sp.	8	66	97	71	7	249
TOTAL	90	300	423	379	31	1223

[a]Dry-sieving in the field (1.6 mm mesh). I, species introduced historically; i, species introduced prehistorically. The numbers represent the number of identified bones.

activities. Most bones in Layer II are burned, which is evidence of being cooked by humans. Railhunter Rockshelter is unique among cultural sites in Oceania in that, using careful techniques of fine-mesh sieving in the field, more bones were recovered of birds than of any other class of vertebrates (Table 2). Fish is by far the most abundant bone category in typical faunal assemblages across Micronesia and Polynesia. The implication is that the people who occupied this small, inland rockshelter more than two millennia ago hunted primarily birds, especially the rails from which we named the site. For the primary cultural/faunal strata (Layers II A-C), this trend holds up even when the sediments were wet-sieved with 1.6 mm mesh (13 fish bones vs. 38 bird bones; Table 3). When extremely fine-meshed

Table 3. Stratigraphic bone summary, Test Pit 4, Railhunter Rockshelter (site 131), Tinian.[a]

	I	IIA	IIB	IIC	III	TOTAL
FISH	9	3	8	2	1	23
LIZARD	173	4	3	2	23	205
SNAKE	1	-	-	-	43	44
Rattus exulans (i)	8	-	-	-	-	8
LARGE MAMMAL (i)	-	-	1	-	-	1
Megapodius laperouse	-	1	-	-	-	1
Porzana sp.	2	4	1	-	-	7
Gallirallus sp.	3	1	4	-	-	8
Rallidae sp.	4	-	1	-	-	5
Gallicolumba xanthonura	-	1	2	-	-	3
cf. *Ducula oceanica*	-	1	-	-	-	1
Collocalia vanikorensis	1	-	-	-	-	1
Rhipidura rufifrons	1	-	-	-	-	1
Aplonis opaca	-	-	2	-	-	2
Zosterops conspicillatus	1	-	-	-	1	2
BIRD sp.	6	8	8	3	2	27
TOTAL	210	22	30	7	70	339

[a]Wet-sieving in the field (1.6 mm mesh). i, introduced species. The numbers represent the number of identified bones.

Table 4. Stratigraphic bone summary, Test Pit 4, Railhunter Rockshelter (site 131), Tinian.[a]

	I	IIA	IIB	IIC	III	TOTAL
FISH	4	16	45	3	-	68
LIZARD	54	1	-	-	-	55
SNAKE	2	-	-	1	-	3
Rattus exulans (i)	1	-	-	-	-	1
Gygis microrhyncha	-	-	1	-	-	1
Zosterops conspicillatus	1	-	-	-	-	1
Passeriformes sp.	-	-	1	-	-	1
BIRD sp.	2	1	1	1	-	5
TOTAL	64	18	48	5	0	135

[a]Wet-sieving in the laboratory (0.60 mm mesh). i, introduced species. The numbers represent the number of identified bones.

sieves (0.60 mm mesh) were used, however, a much greater relative abundance of very small fish bones is apparent (Table 4). Tiny lizard bones are especially common in the wet-sieved fraction of Layer I, where dark, organic sediments obscure small bones in dry-sieving operations.

Bones of the Pacific rat (*Rattus exulans*) are confined to Layer I. Human bones are the only evidence of introduced species in Layer II. (The category “LARGE MAMMAL” describes undiagnostic bone fragments that probably represent humans but could be from any other mammal that is dog-sized or larger.) Bones of the non-native cane toad (*Bufo marinus*), dog (*Canis familiaris*), and chicken (*Gallus gallus*) are confined to Layer I, which includes a mixture of both historic and prehistoric components. Although not recorded from Railhunter Rockshelter, the same is true for all records of the non-native pig (*Sus scrofa*) and goat (*Capra hircus*) from both Tinian and Aguiguan. With information currently in hand, the only non-native, non-human, terrestrial vertebrate for which there is solid evidence of living prehistorically in the Mariana Islands is *Rattus exulans.* The arrival of *R. exulans* on Tinian (and presumably elsewhere in the Mariana Islands) did not occur, however, until 1500–2500 years after human colonization.

The indigenous birds from Railhunter Rockshelter consist of six species of seabirds, one migrant shorebird, and 14 species of landbirds (Tables 2–4), including nine of the 10 species known to be extirpated on Tinian (see Biogeography and Conservation Implications).

A very different site on Tinian is Seabird Crevice, a deep, narrow fissure that is roofed over in some sections to form a cave. Seabird Crevice is developed along a circumferential joint in coralline limestone near the seaward-facing cliff below the terrace that supports Railhunter Rockshelter. The two sediment Layers at

Table 5. Stratigraphic bone summary, Test Pits 1-2 combined, Seabird Crevice, Tinian.

	I,1/2	II,2	II,3	II,4	II,5	II,6	TOTAL
FISH	3	-	3	8	2	-	16
Bufo marinus (i)	6	-	-	-	-	-	6
LIZARD	10	10	16	18	15	2	71
Pteropus sp.	1	-	-	-	-	-	1
Emballonura semicaudata	-	-	1	1	-	-	2
Rattus exulans (i)	65	33	15	36	2	2	153
Rattus rattus (i)	5	-	-	-	-	-	5
Canis familiaris (i)	-	-	2	-	-	-	2
Capra hircus (i)	1	-	-	-	-	-	1
Porzana sp.	-	-	1	1	1	-	3
Gallirallus sp.	-	1	-	3	-	-	4
Gallicolumba xanthonura	-	-	-	-	1	-	1
Collocalia vanikorensis	-	-	-	4	-	1	5
Aplonis opaca	3	-	-	-	-	-	3
BIRD sp.	4	2	3	4	3	1	17
TOTAL	99	46	41	75	24	6	291

[a]Dry-sieving in the field (1.6 mm mesh). i, introduced species. The numbers represent the number of identified bones.

Table 6. Stratigraphic bone summary, Test Pits 1-2 combined, Seabird Crevice, Tinian.[a]

	I,1/2	II,2	II,3	II,4	II,5	II,6	TOTAL
FISH	16*	4	7	12	4	4	47*
LIZARD	168	7	51	59	45	11	341
Rattus exulans (i)	234	36	64	19	8	-	361
Rattus rattus (i)	3	-	-	-	-	-	3
Gallicolumba xanthonura	1	-	-	-	-	-	1
Collocalia vanikorensis	7	-	2	6	4	-	19
Aplonis opaca	7	-	1	-	-	-	8
Passeriformes sp.	-	-	-	2	-	-	2
BIRD sp.	18	2	6	-	3	-	29
TOTAL	455*	48	131	98	64	15	811*

[a]Wet-sieving in the field (1.6 mm mesh). i, introduced species. * includes a single fish bone from a sediment sample. The numbers represent the number of identified bones.

Table 7. Stratigraphic bone summary, Test Pit 1, Golden Tooth Rockshelter, Tinian.[a]

	I,1	I,2	II,3	II,4	II,5	II,6	II,7	II,8	II,9	II,10	III,11	III,12	TOTAL
LIZARD	-	-	-	-	-	-	-	-	2	-	-	-	2
Emballonura semicaudata	-	-	-	-	-	-	-	1	1	-	-	-	2
Rattus exulans (i)	-	-	1	-	-	-	-	-	-	-	-	-	1
Capra hircus (i)	-	-	3	-	-	-	-	-	-	-	-	-	3
Porzana sp.	-	-	-	-	-	-	-	-	1	-	-	-	1
TOTAL	0	0	4	0	0	0	0	1	4	0	0	0	9

[a]Dry-sieving in the field (1.6 mm mesh). i, introduced species. The numbers represent the number of identified bones.

Seabird Crevice are loose, rubbly, poorly stratified, and poorly differentiated from each other. The surface and Layer I at Seabird Crevice contained historic materials from World War II (gas mask parts, rusted iron, glass, ammunition, unexploded grenade). Seabird Crevice yielded no pottery or other evidence of prehistoric human occupation. The site's name derives from how reminiscent it was of Te Rua Rere Cave, a similar joint-controlled crevice/cave on Mangaia (Cook Islands) that yielded abundant bones of seabirds (Steadman 1985). Ironically, not a single species of seabird was represented in the 1102 bones recovered at Seabird Crevice.

The bone assemblage from Seabird Crevice is dominated by lizards and rats (Tables 5, 6). Bones of *Rattus exulans* occur throughout the sequence whereas those of *R. rattus* occur only in Layer I. The presence of *R. exulans* bones in the lowest levels of Layer II suggests that the entire bone assemblage at Seabird Crevice is not older than that of Layer I at Railhunter Rockshelter. The two dog bones from upper Layer II (Table 5) indicate that even this layer has an historic as well as prehistoric component. The fish bones may be from prey items of seabirds. In spite of not yielding bones of seabirds, Seabird Crevice would have been an ideal roosting and nesting site for shearwaters and petrels before the arrival of rats on Tinian. Tropicbirds and terns also might have contributed fish

Table 8. Stratigraphic bone summary, Test Pits 1-3, Pisonia Rockshelter, Aguiguan.[a]

	I	II	III	IV	IV-V	V	TOTAL
FISH	8	31	105	1404	95	126	1769
LIZARD	2	2	6	121	12	42	185
Pteropus sp.	-	-	1	5	-	-	6
Rattus exulans (i)	10	2	19	-	-	-	31
Homo sapiens (i)	-	-	1	14	1	10	26
Sus scrofa (i)	2	-	-	-	-	-	2
Capra hircus (i)	1	-	-	-	-	-	1
LARGE MAMMAL (i)	-	-	-	1	1	15	17
Phaethon lepturus	-	-	-	-	-	1	1
Fregata ariel	-	-	-	1	-	-	1
Anous stolidus	2	-	-	12	1	1	16
Gygis candida	-	-	-	5	-	1	6
Pluvialis fulva	-	-	-	4	22	2	28
Megapodius laperouse	-	-	-	10	-	-	10
Porzana sp.*	1	4	9	149	19	17	199
Gallirallus sp.	-	-	5	197	21	16	239
Rallidae sp.	-	-	4	156	54	14	228
Gallicolumba xanthonura	5	-	2	105	11	14	137
Ptilinopus roseicapilla	-	-	-	9	1	-	10
Columbidae sp.	-	-	-	82	1	12	95
Aplonis opaca	-	-	1	11	-	1	13
Myzomela rubrata	-	-	-	1	-	-	1
Zosterops conspicillatus	-	-	-	2	-	1	3
Cleptornis marchei	-	-	-	-	1	-	1
Passeriformes sp.	-	1	-	4	1	-	6
BIRD sp.	-	-	12	451	50	69	582
TOTAL	31	40	165	2780	254	344	3613

[a]Dry-sieving in the field (1.6 mm mesh). i, introduced species. * two species may be represented. The numbers represent the number of identified bones.

bones. Bones of the Sheath-tailed Bat *Emballonura semicaudata* and Island Swiftlet *Collocalia vanikorensis* probably were deposited through natural mortality within the cave, which would have been a suitable roost site for these two extirpated species.

The third site tested on Tinian is Golden Tooth Rockshelter, so called because of two gold-lined human incisors that were lying on the surface of the site. Like nearby Seabird Crevice, Golden Tooth Rockshelter lies at the upper edge of the escarpment above the first marine terrace. In spite of seemingly suitable sediments (dry, silty), few bones were found at Golden Tooth Rockshelter (Table 7). The transition from historic to prehistoric times is difficult to discern in the absence of pottery or radiocarbon dates but probably lies within Layer II, i.e., below the goat bones (II,3) but above the single bone of *Porzana* sp. (II,9).

AGUIGUAN

Previous archaeological work on this uninhabited island was limited to one surface survey in 1990 (Butler no date). After exploring much of Aguiguan for

Table 9. Stratigraphic bone summary, Test Pit 1, Pisonia Rockshelter, Aguiguan.[a]

	I	II	IIIA	IIIB	IIIC	IV	V	TOTAL
FISH	-	-	-	-	2	13	-	15
LIZARD	-	-	-	-	-	3	-	3
Rallidae sp.	-	-	-	-	-	1	-	1
Gallicolumba xanthonura	-	-	-	-	-	1	-	1
BIRD sp.	-	-	-	-	-	7	-	7
TOTAL	0	0	0	0	2	25	0	27

[a]Sediment samples, wet-sieved in lab (0.60 mm mesh). i, introduced species. The numbers represent the number of identified bones.

Table 10. Stratigraphic bone summary, Test Pit 3, Payapai Cave, Rota.[a]

	I	II	III	TOTAL
FISH	37	-	26	63
LIZARD	62	57	1351	1470
SNAKE	-	-	7	7
Pteropus sp.	2	6	16	24
Emballonura semicaudata	16	39	272	327
Rattus exulans (i)	26	15	7	48
Puffinus lherminieri	4	5	8	17
Phaethon lepturus	10	1	-	11
Procelsterna cerulea	2	-	5	7
Gygis candida	2	-	1	3
Pluvialis fulva	-	-	1	1
Heteroscelus sp.	-	-	1	1
Egretta sacra	53	7	-	60
Megapodius laperouse	2	1	1	4
Gallicolumba xanthonura	1	-	6	7
Gallicolumba new sp.	-	-	3	3
Ducula oceanica	-	-	2	2
Columbidae sp.	-	-	3	3
Collocalia vanikorensis	-	3	-	3
Aplonis opaca	39	14	42	95
Myzomela rubrata	-	1	3	4
Zosterops conspicillatus	1	-	7	8
Erythrura new sp.	-	1	-	1
Passeriformes sp.	1	4	13	18
BIRD sp.	187	45	193	435
TOTAL	445	199	1965	2609

[a]Dry-sieving in the field (1.6 mm mesh). i, introduced species. The numbers represent the number of identified bones.

several days, we excavated Pisonia Rockshelter, a deeply stratified human habitation site formed beneath an undercut limestone wall along a trail to the rugged north coast. The site lies about 250 m inland from the north-central coast, in the vicinity of Butler's site number 7. Pisonia Rockshelter is named for the immense *Pisonia grandis* tree growing at its edge. Layer I is historic in age, as evidenced by pig bones and lack of pottery. Layers II-IV are pottery-rich, prehistoric cultural deposits spanning more than a millennium (Table 1). Layer V may be partly pre-human in age, based on a sharp decline in pottery content, lack of charcoal, and scarcity of burned bones.

More than 3600 bones were recovered from Pisonia Rockshelter (Tables 8, 9). Bones are scarce in Layers I-III, with those of fish and rat being the most common. In Layer IV, bones of fish and birds become abundant while those of rats disappear from the record. Layer IV yielded 2779 (77%) of the 3613 total bones dry-sieved from Test Pits 1-3 (Table 8). In a small wet-sieved sample from Test Pit 1, Layer IV yielded 25 of 27 (93%) bones (Table 9). The lower percentage of bones from Layer IV in dry-sieved Test Pits 1-3 is because many bones actually from Layer IV are subsumed in the category "IV-V" in Table 8, these being from a loose area of the excavation wall that had to be salvaged in such a way that Layers IV and V could not be distinguished. Essentially all non-human bones from Layer IV are burned, providing clear evidence of human cookery. The bones identified as human or LARGE MAMMAL from Layers IV-V may all be derived from prehistorically disturbed human burials. These bones, unlike the others, are not in a midden context.

That snares were the primary way to capture birds in prehistoric times is suggested by the abundance of rail bones from Pisonia Rockshelter, along with the much higher numbers of dove bones that represent understory species (*Gallicolumba xanthonura*) rather than canopy species (*Ptilinopus roseicapilla*). These circumstances are similar to those at Railhunter Rockshelter on Tinian.

Rota

We worked primarily at Payapai Cave in the Alaguan region, where a small excavation (Test Pits 1 and 2; <1m^3 of sediment) in February 1990 had produced 300+ identifiable bird bones (Steadman 1992). The new excavations at Payapai Cave increased the bird bone sample and expanded the chronological range of the excavated deposits. Test Pit 3 (Tables 10, 11) adjoined the original Test Pits 1 and 2. Test Pit 4 (Tables 12, 13) was closer to the cave's immense entrance. As with Test Pits 1-2, neither new excavation yielded human artifacts, even though the abundant wood charcoal recovered probably was from human-set fires. A new

Table 11. Stratigraphic bone summary, Test Pit 3, Payapai Cave, Rota.[a]

	I	II	III	TOTAL
FISH	8	-	-	8
LIZARD	2	3	34	39
Emballonura semicaudata	-	-	4	4
Rattus exulans (i)	2	-	-	2
Egretta sacra	1	-	-	1
Collocalia vanikorensis	-	-	1	1
TOTAL	13	3	39	55

[a]Sediment samples, wet-sieved in lab (0.60 mm mesh). i, introduced species. The numbers represent the number of identified bones.

Table 12. Stratigraphic bone summary, Test Pit 4, Payapai Cave, Rota.[a]

	I	II	III	TOTAL
FISH	2	1	26	29
LIZARD	1	13	58	72
Pteropus sp.	3	-	1	4
Emballonura semicaudata	13	32	57	102
Rattus exulans (i)	1	-	-	1
Phaethon lepturus	7	2	1	10
Egretta sacra	1	-	-	1
Aplonis opaca	2	-	1	3
Zosterops conspicillatus	-	-	1	1
Passeriformes sp.	-	-	2	2
BIRD sp.	2	1	-	3
TOTAL	32	49	147	228

[a]Dry-sieving in the field (1.6 mm mesh). i, introduced species. The numbers represent the number of identified bones.

radiocarbon date on wood charcoal from Test Pit 3 (Layer III, level 4) is about 500 years younger than one from Test Pit 2 (Layer II, level 2). This suggests that the massive wood charcoal deposit (Layer II) in Test Pits 1-3 either represents a long time interval or that a very old tree was the source of charcoal for the older radiocarbon date. That bones of *Rattus exulans* occur throughout Test Pit 3 (Table 10) corroborates the late prehistoric age (<1000 yr BP) for this deposit.

Over 50% of nearly 3000 bones from Test Pits 3 and 4 are of lizards (Tables 10–13). The fish bones at Payapai Cave probably represent the prey of shearwaters, tropicbirds, terns, and herons that have nested or roosted in the cave. The former presence of Sheath-tailed Bats *Emballonura semicaudata* is evidenced by abundant bones as well as guano deposits in the rear of the cave.

Smaller, less controlled excavations near the rear of Payapai Cave produced 1300+ additional bones, mostly lizards (Table 14). These unstratified sediments lack an absolute chronology but probably date to within the past millennium.

In the same limestone cliff as Payapai Cave is another vertical, joint-controlled solution feature dubbed “Crevice 150m N of Payapai Cave.” The non-cultural, unstratified, lizard-dominated faunal assemblage (Table 14) is similar to that of Payapai Cave. Aside from lizards, this site yielded many bones of *Emballonura semicaudata* and a small but important set of passerine bones.

Table 13. Stratigraphic bone summary, Test Pit 4, Payapai Cave, Rota.[a]

	I	II	III	TOTAL
FISH	15	12	25	52
LIZARD	2	3	1	6
SNAKE	-	-	1	1
Collocalia vanikorensis	-	-	1	1
TOTAL	17	15	28	60

[a]Sediment samples, wet-sieved in lab (0.60 mm mesh). i, introduced species. The numbers represent the number of identified bones.

Between Payapai Cave and the last site, in the same cliff, is a very protected site known as Alaguan Rockshelter. In spite of its dry, powdery sediment, this site yielded few bones (Table 14). The sediments had been disturbed by (prehistoric?) digging and filling associated with human burials. Given the low bone yield and the impossibility of maintaining stratigraphic or chronological control, we quit excavating Alaguan Rockshelter after only two small test pits.

The fourth site that we tested on Rota is As Matmos Cliffside Cave on the northeast coast. This shallow, dry cave has small pockets of non-cultural, unstratified, bone-rich sediment. In spite of its proximity to the sea, only one bone of a seabird was found at this site (Table 14). Perched just above the short, windward forest canopy, this cave is an ideal roost for an avian predator, perhaps a species of *Accipiter, Falco, Tyto,* or *Asio.* Such predators probably were responsible for depositing most bones here as well as at Payapai Cave and Crevice 150m N of Payapai Cave.

Table 14. Bone summary from unstratified minor sites, Rota.[a]

	PCSB	CNPC	AR	AMCC
FISH	178	14	2	46
LIZARD	1072	485	-	234
Varanus cf. *indicus* (i?)	-	6	-	10
SNAKE	15	-	-	10
Pteropus sp.	-	-	4	5
Emballonura semicaudata	17	54	1	2
Rattus exulans (i)	10	11	-	7
Rattus rattus (i)	-	-	1	-
Phaethon lepturus	-	2	1	-
Puffinus lherminieri	-	-	-	1
Anous stolidus	-	-	1	-
Egretta sacra	-	-	2	-
Megapodius laperouse	-	-	-	3
Porzana sp.	-	-	1	1
Gallicolumba xanthonura	-	1	-	2
Gallicolumba new sp.	-	-	-	1
Ptilinopus roseicapilla	-	-	-	2
Collocalia vanikorensis	-	-	-	1
Myiagra cf. *M. freycineti*	-	2	-	-
Aplonis opaca	-	3	-	18
Myzomela rubrata	-	3	-	3
Zosterops conspicillatus	1	-	-	2
Cleptornis marchei	-	-	-	2
Erythrura new sp.	-	1	-	1
Passeriformes sp.	4	3	-	8
BIRD sp.	4	2	-	151
TOTAL	1301	587	13	510

[a]PCSB, (Scott Bauman samples 1, 2) at rear of Payapai Cave: (wet-sieving in the lab, 0.60 mm mesh); CNPC, Crevice 150 m N of Payapai Cave (dry-sieving in the field, 1.6 mm mesh); AR, Alaguan Rockshelter (dry-sieving in the field, 1.6 mm mesh); AMCC, As Matmos Cliffside Cave (dry-sieving in the field, 1.6 mm mesh); i, introduced species. The numbers represent the number of identified bones.

Table 15. Faunal summary by site, Tinian and Aguiguan. Presence or absence of bones.[a]

	TINIAN			AGUIGUAN	
	RR	SC	GTR	MS	PR
FISH					
Osteichthyes sp. Small boney fish	X	X	-	-	X
AMPHIBIANS					
Bufo marinus (I) Cane toad	X	X	-	-	-
REPTILES					
Gekkonidae sp., Scincidae sp. Small lizards	X	X	X	-	X
Serpentes sp. Small snake	X	-	-	-	X
MAMMALS					
Pteropus sp. Flying fox	X	X	-	-	X
Emballonura semicaudata Sheath-tailed Bat	X	X	X	-	-
Rattus exulans (i) Pacific Rat	X	X	X	-	X
Rattus rattus (I) Black Rat	X	X	-	-	-
Homo sapiens (i) Human	*X*	-	-	-	*X*
Canis familiaris (I) Dog	X	X	-	-	-
Sus scrofa (I) Pig	-	-	-	-	X
Capra hircus (I) Goat	-	X	X	-	-
BIRDS					
Gallus gallus (I) Chicken	X	-	-	X	-
Phaethon lepturus White-tailed Tropicbird	-	-	-	-	X
Fregata ariel Lesser Frigatebird	-	-	-	-	X
Sterna cf. *S. fuscata/lunata* Sooty/Gray-backed Tern	X	-	-	-	-
Anous stolidus Brown Noddy	X	-	-	X	X
Anous minutus Black Noddy	X	-	-	-	-
Procelsterna cerulea (e) Blue-gray Noddy	X	-	-	-	-
Gygis candida Common Fairy-Tern	X	-	-	-	X
Gygis microrhyncha (e) Little Fairy-Tern	X	-	-	-	-
Pluvialis fulva Pacific Golden-Plover	X	-	-	-	X

Megapodius laperouse Micronesian Megapode	X	-	-	-	X
Poliolimnas cinereus (e) White-browed Crake	X	-	-	-	-
Porzana sp. (E/e) crake	X	X	X	-	X
Gallirallus sp. (E) rail	X	X	-	X	X
Gallicolumba xanthonura White-throated Ground-Dove	X	X	-	-	X
Ptilinopus roseicapilla Marianas Fruit-Dove	X	-	-	-	X
cf. *Ducula oceanica* (e) Micronesian Pigeon	X	-	-	-	-
Collocalia vanikorensis (e) Island Swiftlet	X	X	-	-	-
Rhipidura rufifrons Rufous Fantail	X	-	-	-	-
Acrocephalus luscinia (e) Nightingale Reed-Warbler	X	-	-	-	-
Aplonis opaca Micronesian Starling	X	X	-	-	X
Myzomela rubrata Micronesian Honeyeater	X	-	-	-	X
Zosterops conspicillatus Bridled White-eye	X	-	-	-	X
Cleptornis marchei (e) Cleptornis	X	-	-	-	X
Total species of birds	22	5	1	1	14
Total species of landbirds	14	5	1	1	9
Total species of E or e landbirds	7	3	1	1	2

[a]RR, Railhunter Rockshelter; SC, Seabird Crevice; GTR, Golden Tooth Rockshelter; MS, Miscellaneous sites (sites 75, 98, 105, 117, 138 of Bodner and Welch 1992, Bodner 1993); PR, Pisonia Rockshelter. E, extinct species; e, species extirpated on Tinian; I, species introduced historically; i, species introduced prehistorically.

Biogeography

The faunas from all sites are summarized in Tables 15–18. The richest sites in Tinian and Aguiguan are primarily cultural in origin whereas all sites on Rota are primarily or exclusively non-cultural. The cultural sites are characterized by having more large birds (seabirds, megapodes, rails, columbids), whereas the non-cultural sites feature many more lizards, small bats, and passerines. Each island has one site with a very rich vertebrate assemblage. In terms of species richness of birds, Railhunter Rockshelter (Tinian) and Payapai Cave (Rota) stand out, with Pisonia Rockshelter (Aguiguan) and As Matmos Cliffside Cave (Rota) being of intermediate richness.

The reptile bones from all three islands are dominated by geckos and skinks, including all six species of geckos presently known from the Marianas, and four

Table 16. Site summary, Rota. Presence or absence of bones.[a]

	PC	CNPC	AR	AMCC	OS
FISH					
Osteichthyes sp. Small boney fish	X	X	X	X	X
AMPHIBIANS					
Bufo marinus (I) Cane toad	-	-	-	-	X
REPTILES					
Gekkonidae sp. Gecko	X	X	-	X	X
Scincidae Skink	X	X	-	X	-
Varanus cf. *indicus* (I/i) Monitor lizard	-	X	-	X	-
Serpentes sp. Small snake	X	-	-	X	-
MAMMALS					
Pteropus sp. Flying fox	X	-	X	X	X
Emballonura semicaudata Sheath-tailed Bat	X	X	X	X	-
Rattus exulans (i) Pacific Rat	X	X	-	X	-
Rattus rattus (I) Black Rat	-	-	X	-	X
BIRDS					
Puffinus lherminieri (e) Audubon's Shearwater	X	-	-	-	-
Phaethon rubricauda Red-tailed Tropicbird	X	-	-	-	-
Phaethon lepturus White-tailed Tropicbird	X	X	X	-	-
Anous stolidus Brown Noddy	X	-	X	-	-
Procelsterna cerulea (e) Blue-gray Noddy	X	-	-	-	-
Gygis candida Common Fairy-Tern	X	-	-	-	-
Pluvialis fulva Pacific Golden-Plover	X	-	-	-	-
Heteroscelus sp. Tattler	X	-	-	-	-
Egretta sacra Pacific Reef-Heron	X	-	X	-	-
Anatidae new sp. (E) Flightless duck	X	-	-	-	-
Megapodius laperouse (e) Micronesian Megapode	X	-	-	X	-
Porzana sp. (E/e) Crake	-	-	X	X	-
Poliolimnas cinereus (e)	X	-	-	-	-

White-browed Crake					
cf. *Porphyrio* sp. (E/e)	X	-	-	-	-
Swamphen					
Gallinula chloropus (e)	-	-	-	-	X
Common Moorhen					
Gallicolumba xanthonura	X	X	-	X	-
White-throated Ground-Dove					
Gallicolumba new sp. (E)	X	-	-	X	-
Extinct large ground-dove					
Ptilinopus roseicapilla	X	-	-	X	-
Mariana Fruit-Dove					
Ducula oceanica (e)	X	-	-	-	-
Micronesian Pigeon					
Psittacidae new sp. (E)	X	-	-	-	-
Extinct parrot					
Collocalia vanikorensis (e)	X	-	-	X	-
Island Swiftlet					
Myiagra cf. *M. freycineti* (E)	X	X	-	-	-
Guam Flycatcher					
Aplonis opaca	X	X	-	X	X
Micronesian Starling					
Myzomela rubrata	X	X	-	X	-
Micronesian Honeyeater					
Zosterops conspicillatus	X	-	-	X	-
Bridled White-eye					
Cleptornis marchei (e)	-	-	-	X	-
Cleptornis					
Erythrura new sp. (E)	X	X	-	X	-
Extinct parrot-finch					
Total species of birds	24	6	4	11	2
Total species of landbirds	16	5	2	11	2
Total species of E or e landbirds	10	2	1	6	1

[a]PC, Payapai Cave; CNPC, Crevice 150 m N of Payapai Cave; AR, Alaguan Rockshelter; AMCC, As Matmos Cliffside Cave; 0S, Other sites (unnamed caves 1-3 of Steadman 1992). E, extinct species; e, species extirpated on Rota; I, species introduced historically; i, species introduced prehistorically.

of the six species of skinks (Pregill 1998; Table 18 herein). From Aguiguan are six species (four geckos, two skinks, one snake) previously unknown from the island. On all three islands are bones of an extinct gecko that cannot be referred to any genus known from Micronesia. The most abundantly occurring species of lizards are the gecko *Perochirus ateles* and the skink *Emoia sleveni*, both of which have much more restricted ranges in the Marianas today. Three species of lizards, the geckos *Gehyra oceanica* and *G. mutilata*, and the monitor *Varanus indicus*, are restricted to historic rather than prehistoric strata. The blind snake *Ramphotyphlops braminus* occurs in both prehistoric and pre-cultural strata, demonstrating that it is indigenous.

Table 17. Prehistoric records of native resident birds from the Northern Mariana Islands. Data from Steadman (1992, this report, other unpublished data). Modern status of seabirds is from Reichel (1991).[a]

	Tinian	Aguiguan	Rota
SEABIRDS			
Puffinus lherminieri	-	-	e
Audubon's Shearwater			
Phaethon rubricauda	-	-	X
Red-tailed Tropicbird			
Phaethon lepturus	-	X	X
White-tailed Tropicbird			
Fregata ariel	-	e	-
Lesser Frigatebird			
Sterna cf. *S. fuscata/lunata*	X/e	-	-
Sooty/Gray-backed Tern			
Anous stolidus	X	X	X
Brown Noddy			
Anous minutus	X	-	-
Black Noddy			
Procelsterna cerulea	e	-	e
Blue-gray Noddy			
Gygis candida	X	X	X
Common Fairy-Tern			
Gygis microrhyncha	e	-	-
Lesser Fairy-Tern			
LANDBIRDS			
Egretta sacra	-	-	X
Pacific Reef-Heron			
Anatidae new sp.	-	-	E
Flightless duck			
Megapodius laperouse	X	X	e
Micronesian Megapode			
Gallirallus spp.	E	E	E**
Guam-like rails			
Porzana spp.	E/e	E/e*	E/e
Crakes			
Poliolimnas cinereus	e	-	e
White-browed Crake			
Porphyrio sp.	E/e**	-	E/e
Swamphen			
Gallinula chloropus	-	-	e
Common Moorhen			
Gallicolumba xanthonura	X	X	X
White-throated Ground-Dove			
Gallicolumba new sp.	-	-	E
Extinct large ground-dove			
Ptilinopus roseicapilla	X	X	X
Mariana Fruit-Dove			
Ducula oceanica	e	-	e
Micronesian Pigeon			
Psittacidae new sp.	-	-	E

Extinct parrot			
Collocalia vanikorensis	e	-	e
Island Swiftlet			
Myiagra cf. *M. freycineti*	-	-	E
Guam Flycatcher			
Rhipidura rufifrons	X	-	-
Rufous Fantail			
Acrocephalus luscinia	e	-	-
Nightingale Reed-Warbler			
Aplonis opaca	X	X	X
Micronesian Starling			
Myzomela rubrata	X	X	X
Micronesian Honeyeater			
Zosterops conspicillatus	X	X	X
Bridled White-eye			
Cleptornis marchei	e	X	e
Cleptornis			
Erythrura new sp.	-	-	E
Extinct parrot-finch			
SEABIRDS			
Number of bones	40	24	176
Total species	5	4	6
Total extant species	3-4	3	4
Total extirpated species	2-3	1	2
LANDBIRDS			
Number of identified bones	647	944	474
Total species	15	9	20
Total extant species	6	7	6
Total extinct/extirpated species	8	2	14

[a]E, extinct species; e, extirpated species (survives elsewhere); X, prehistoric record of locally extant species; -, no prehistoric record; * two species may be represented; ** from sites other than those decribed herein.

The Sheath-tailed Bat *Emballonura semicaudata* occurs in three sites on Tinian and four of five sites on Rota. It survives on neither island today (Lemke 1986). The prehistoric status of Flying Foxes (*Pteropus* spp.) awaits species-level identification; bones occur on all three islands, where *P. mariannus* survives in low numbers (Wiles et al. 1989).

Among migratory shorebirds, the Pacific Golden-Plover *Pluvialis fulva* is most frequent in prehistoric contexts, just as it dominates the modern shorebird fauna (Stinson et al. 1997a). Much as with landbirds, the prehistoric seabird bones from the Marianas document various extirpated populations. Many more such losses are expected as additional bone assemblages are studied. The most noteworthy prehistoric seabird records thus far are the Audubon's Shearwater from Rota, and various terns/noddies from Tinian and Rota. These records often include bones of non-volant juveniles, thereby indicating local breeding popula-

Table 18. Summary of squamate reptiles from fossil sites on Tinian, Aguiguan, and Rota, Mariana Islands.

	Tinian		Aguiguan	Rota			
	RR	SC	PR	PC	CNPC	AMCC	Total
GEKKONIDAE							
Gehyra mutilata	3	2	-	-	-	-	5
Gehyra oceanica	2	3	-	1	-	-	6
Hemidactylus frenatus	2	5	5*	-	-	-	12
Lepidodactylus lugubris	3	-	-	3	-	-	6
Nactus pelagicus	4	13	2*	-	-	2	21
Perochirus ateles	16	6	10*	77*	7*	5*	121
Gekkonidae gen. sp. unk.	4*	-	4*	-	6*	2*	16
Gekkonidae spp.	9	6	6	3	-	-	24
SCINCIDAE							
Cryptoblepharus poecilopleurus	1	-	-	-	-	-	1
Emoia cf. *caeruleocauda*	3	2	-	4	-	2	11
Emoia slevini	19	8	19*	9	10	3	68
Lipinia noctua	-	-	-	2*	-	-	2
Scincidae spp.	5	2	-	-	-	-	7
VARANIDAE							
Varanus cf. *indicus*	-	-	-	-	1	1	2
TYPHLOPIDAE							
Ramphotyphlops braminus	4	3	2*	2	-	1	12
Total MNI	75	50	48	101	24	16	314
Total species	11	8	6	7	4	7	13
Total * species	1	0	6	2	2	2	-

Numbers = MNI (minimum number of individuals). RR, Railhunter Rockshelter; SC, Seabird Crevice. PR, Pisonia Rockshelter. PC, Payapai Cave; CNPC, Crevice North of Payapai Cave; AMCC, As Matmos Cliffside Cave. *, taxon previously unrecorded from that island. Note that, for any given provenience, the number of reptile bones identified by Gregory K. Pregill is typically less than the number reported in Tables 2-14. This is because most of the reptile bones are undiagnostic to the level of genus or species. Data are based mostly upon highly diagnostic bones of the skull and mandible. From Pregill (1998).

tions. The Blue-gray Noddy *Procelsterna cerulea* and Least Fairy-Tern *Gygis microrhyncha* are unknown in the Marianas except for bone records.

The prehistoric landbirds include several extinct species and range extensions of locally extirpated species. A flightless duck (Anatidae new sp.) is known only from one juvenile coracoid from Rota. Bones of the Micronesian Megapode occur in the major sites on all islands. This species is extirpated on Rota, extremely rare (a few individuals) on Tinian, and survives on Aguiguan.

Sites on each island yielded bones of "Guam-like" rails (*Gallirallus*, species-level identification undetermined), thus demonstrating that each island was inhabited by rails closely related to the Guam Rail *Gallirallus owstoni*, which survives now only in captivity (Witteman et al. 1991, Haig & Ballou 1995). (On Rota, bones of *Gallirallus* are from Mochong, an open calcareous sand site excavated by J. L. Craib independently of this study. Also, bones of *Gallirallus* have been found in the Chalan Piao archaeological site on Saipan, excavated by Micronesian Archaeological Research Services. Similarly, the only record of *Porphyrio* from Tinian is based on bones I have identified from Unai Chulu, another open calcareous sand archaeological site excavated by Paul H. Rosendahl, Ph.D., Inc.)

At least five species of rails (in the genera *Gallirallus, Porzana, Poliolimnas, Porphyrio, Gallinula*) have been extirpated on Rota (Steadman 1992). If the fossil record of rails were complete, each island probably would be found to have sustained a species in each of these genera. As with *Gallirallus*, species-level systematics of the various forms of *Porzana* and *Porphyrio* have not yet been reconciled. The extinction of various populations of rails is due to predation from nonnative vertebrates as well as habitat changes, whether to forests or wetlands (Engbring & Pratt 1985, Savidge 1987, Stinson et al. 1991, Steadman 1995).

The large, extinct species of *Gallicolumba* from Rota is the first extinct ground-dove from Micronesia. Other large, extinct species of ground-doves are known from New Caledonia and Polynesia (Steadman 1997). Bones of the Micronesian Pigeon (*Ducula oceanica*) from Tinian and Rota suggest that this large frugivore, now absent from the Marianas, once lived through much or all of the island group. Given its modern occurrence in Palau, Yap, Chuuk, Pohnpei, etc., it is logical that *D. oceanica* once lived in the Mariana Islands.

The extinct parrot from Rota (Steadman 1992) is still known only from a single tibiotarsus that is not diagnostic at the generic level. The Island Swiftlet *Collocalia vanikorensis* was lost on Tinian and Rota within the past several decades. Across the Pacific, bones of *Collocalia* tend to be scarce or absent in cultural sites; this probably explains their absence from Pisonia Rockshelter on Aguiguan.

The prehistoric bones document a number of range extensions for living species of passerines, none of which truly is endemic to a single island. Extinction of island populations has led to a distributionally artificial situation where, for example, the Tinian Monarch *Monarcha takatsukasai* has been shown not to be endemic to Tinian but to have occurred historically on Saipan (Peters 1996). Similarly, the Guam Flycatcher *Myiagra freycineti* is not endemic to Guam but once lived on Rota. The Nightingale Reed-Warbler *Acrocephalus luscinia*, known in the non-volcanic Marianas from Guam, Aguiguan, and Saipan (Reichel et al. 1992), occurred prehistorically on Tinian. The enigmatic Cleptornis *Cleptornis marchei* has been thought to be endemic to Saipan and Aguiguan (with an illogical absence on Tinian). Bones of *C. marchei* occur, however, on Tinian and Rota. Lastly, from Rota are several diagnostic bones of an extinct, large species of parrot-finch (*Erythrura* new sp.) that undoubtedly lived on other islands as well. The nearest congeneric species is *E. trichroa* in Palau, Chuuk, Pohnpei, and Kosrae (Pratt et al. 1987:316).

The sites on Rota have produced the richest prehistoric assemblage of landbirds (20 species). These data show that, until only centuries ago, Rota was inhabited by at least 14 species of landbirds that no longer occur on the island. If the fossil record were complete, the natural (= minimal or no human impact) landbird fauna of Rota would be in the range of 30–35 species, as opposed to the 10 species that live there today. I do not believe that Rota had an unusually rich avifauna or that it has been subjected to more extinction than Tinian or Saipan; it simply has a better fossil record. Before human impact, most or all of the volant species or superspecies of Mariana Island landbirds must have occupied all five limestone islands (Guam north through Saipan). Flightless genera probably were endemic to single islands, but had representatives on each island.

The full assemblage of landbirds on any one island in the Marianas probably included at least one species in most or all of these genera that are known today or prehistorically from at least one island in the group: *Egretta* (reef-herons), *Ixobrychus* (bitterns), *Anas* (dabbling ducks), *Megapodius* (megapodes), *Gallirallus* (rails), *Porzana* (crakes), *Poliolimnas* (crakes), *Gallinula* (moorhens), *Porphyrio* (swamphens), *Gallicolumba* (ground-doves), *Ptilinopus* (fruit-doves), *Ducula* (imperial pigeons), *Cacatua/Eclectus* (cockatoo/parrots), *Collocalia* (swiftlets), *Halcyon* (kingfishers), *Corvus* (crows), *Monarcha* (monarchs), *Myiagra* (flycatchers), *Rhipidura* (fantails), *Acrocephalus* (reed-warblers), *Aplonis* (starlings), *Myzomela* (honeyeaters), *Zosterops* (white-eyes), *Cleptornis* (cleptornis; relationships uncertain), and *Erythrura* (parrot-finches).

Note that this list includes nine genera of passerines. Before human impact, all indigenous species of passerines from the Marianas probably co-existed on each limestone island (Guam through Saipan). This is worth considering when interpreting the modern foraging strategies of various species of small passerines (Craig 1989, 1990, 1992b, Craig et al. 1992b) where species that are naturally sympatric have not co-existed for centuries because of human-caused extirpations.

As the fossil record in the Mariana Islands improves, it is likely also to include species in genera now living elsewhere in Micronesia (Palau, Yap, Truk, or Pohnpei), perhaps such as *Nycticorax* (night-herons), *Rallina* (crakes), *Caloenas* (“Nicobar” pigeons), *Trichoglossus* (lorikeets), *Otus* (*Pyrrhoglaux*) (small scops-like owls), *Coracina* (cuckoo-shrikes), *Pitohui* (morningbirds), *Rukia/Megazosterops* (large white-eyes), and *Cettia* (bush-warblers). Other genera that might turn up would include the predatory birds that presumably were involved in concentrating bones in roost sites such as As Matmos Cave or Cave 150m North of Payapai Cave. These possibly would include *Accipiter* (hawks), *Falco* (falcons), *Tyto* (barn-owls), or *Asio* (eared owls).

Conservation Implications

Many surviving populations and species of Pacific island landbirds are at risk of extinction, including megapodes, rails, pigeons, parrots, kingfishers, and passerines. Translocation and/or re-introduction (with or without captive breeding) may be the only way to save certain species (Franklin & Steadman 1991, Witteman et al. 1991). Prehistoric data reveal the natural distributions of species and thus provide a sound biogeographic framework for recovery programs of endangered species. Before any such actions should be taken, consideration should be given to the extent and species composition of forests (i.e., Chandran et al. 1992, Craig 1992a), the presence of various non-native vertebrates, and whether current human activities are likely to be compatible with the establishment of new avian populations (Franklin & Steadman 1991).

Based on my field experience on Saipan, Tinian, Aguiguan, Rota, Guam, and many other islands in Oceania, today's environmental conditions on uninhabited Aguiguan (see Craig 1992c, Craig et al. 1992a) are much better than those on any other limestone island in the Marianas. Aguiguan's relatively favorable attributes for the survival of translocated birds include: no permanent human population; no Brown Tree Snakes (*Boiga irregularis*), feral cats, dogs, pigs, or cattle; presence of the Pacific Rat *Rattus exulans* rather than the Black Rat *R. rattus* (neither rat is desirable, but *R. exulans* is less destructive to birds than *R. rattus*); more forested; and difficulty of human access (including no wharf), which means that brown tree snakes, black rats, and feral cats are less likely to become established. The feral goats and chickens on Aguiguan should be eliminated.

The discovery of "Guam-like" rails (*Gallirallus*, not yet identified to species, but similar overall to *G. owstoni*) on Saipan, Tinian, Aguiguan, and Rota shows that a representative of this species-group once lived throughout the non-volcanic Mariana Islands. The behavior and ecology of the Guam Rail (see Jenkins 1979, 1983) probably are not very different from those of the extinct species of *Gallirallus* from other islands in the Marianas. Saipan, Tinian, and Rota, with their many existing and potential environmental problems, are not as well suited for the establishment of a wild population of Guam Rails as Aguiguan. With the failure of repeated and labor-intensive efforts since 1990 to establish the Guam Rail on Rota, I cannot see the logic of continuing to focus on Rota rather than Aguiguan for translocation of this endangered species. Sadly, it probably is just a matter of time before the Brown Tree Snake becomes firmly established on Saipan, Tinian, and Rota, with a likelihood of devastating the avifaunas as it did on Guam (Savidge 1987).

Aside from Guam Rails, the Micronesian Pigeon should be a translocation candidate on Aguiguan if adequate food is present. Even though its bones have not been found there yet, Micronesian Pigeon bones are already known from Rota and Tinian, on either side of Aguiguan. Thus it is highly likely that this pigeon once occupied Aguiguan as well. The same logic could apply to the White-browed Crake, but this species may be of less conservation concern.

The record of vertebrates in the Mariana Islands still is very incomplete. Expanded excavations on Tinian, Aguiguan, and Rota would increase the number of species of birds known from each of these islands. If combined with new data from Saipan and Guam, two islands whose prehistoric faunas remain virtually unknown, a fairly comprehensive picture of the natural distribution of birds in the non-volcanic Mariana Islands would emerge. This picture would fundamentally change how we evaluate distributions of vertebrates in these abused islands. The improved concepts would help to guide conservation biologists who struggle to save the parts of the fauna that are left.

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