

## Extinct and Extirpated Birds from Aitutaki and Atiu, Southern Cook Islands<sup>1</sup>

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**ABSTRACT:** Six archaeological sites up to 1000 years old on Aitutaki, Cook Islands, have yielded bones of 15 species of birds, five of which no longer occur on the island: *Pterodroma rostrata* (Tahiti Petrel); *Sula sula* (Red-footed Booby); *Dendrocygna*, undescribed sp. (a large, extinct whistling duck); *Porzana tabuensis* (Sooty Crake); and *Vini kuhlii* (Rimatara Lorikeet). Of these, only *S. sula* and *P. tabuensis* survive anywhere in the Cook Islands today. The nearest record of any species of *Dendrocygna* is in Fiji. Aside from the aquatic species *Egretta sacra* (Pacific Reef-Heron) and *Anas superciliosa* (Gray Duck), the only native, resident land bird on Aitutaki today is the Society Islands Lorikeet (*Vini peruviana*), which may have been introduced from Tahiti. Residents of Aitutaki note that *Ducula pacifica* (Pacific Pigeon) and *Ptilinopus rarotongensis* (Cook Islands Fruit-Dove) also occurred there until the 1940s or 1950s. There is no indigenous forest on Aitutaki today. The bones from Aitutaki also include the island's first record of the fruit bat *Pteropus tonganus*. Limestone caves on the island of Atiu yielded the undated bones of six species of birds, three of which no longer exist there or anywhere else in the Cook Islands: *Gallicolumba erythroptera* (Society Islands Ground-Dove), *Ducula aurorae* (Society Islands Pigeon), and *Vini kuhlii*. Each of these species has been recovered from prehistoric sites on Mangaia as well. The limestone terrain of Atiu is mostly covered with native forest that supports populations of *Ducula pacifica*, *Ptilinopus rarotongensis*, *Collocalia sawtelli* (Atiu Swiftlet), and *Halcyon tuta* (Chattering Kingfisher). The survival of these land birds depends upon protection of Atiu's forests.

In 1987, THE ISLANDS OF Aitutaki and Atiu, Cook Islands (Figure 1), were surveyed for remains of prehistoric birds as part of a program to reconstruct the natural distribution of birds in eastern Polynesia, an area that has experienced much human-caused extinction. A primary goal of that survey was to compare prehistoric avian assemblages from these islands with those recently discovered on Mangaia (Steadman 1985, 1987, 1989), which is 385 km from Aitutaki and 215 km from Atiu. This paper presents those results and also analyses of collections of bird bones made

in 1989 by M. S. Allen as part of her archaeological study of the prehistoric subsistence and ecology of Aitutaki.

The physical environment and vegetation of Aitutaki (Figure 2) have been reviewed by Stoddart (1975). Classified as an "almost-atoll," Aitutaki has a land area of 18.05 km<sup>2</sup> and a maximum elevation of 124 m. No native forest exists on the main island of Aitutaki except for some degraded coastal forest near the airstrip. Most of the islets that surround the lagoon are forested in coastal associations that reflect varying degrees of human impact. The volcanic islets of Rapota and Moturakau support small patches of relatively undisturbed upland forest intermingled with coastal species.

The two most important sites for understanding the prehistoric distribution of birds on Aitutaki are the Ureia site (Bellwood 1978, Allen and Steadman 1990) and the Moturakau Rockshelter site (Allen and Schubel

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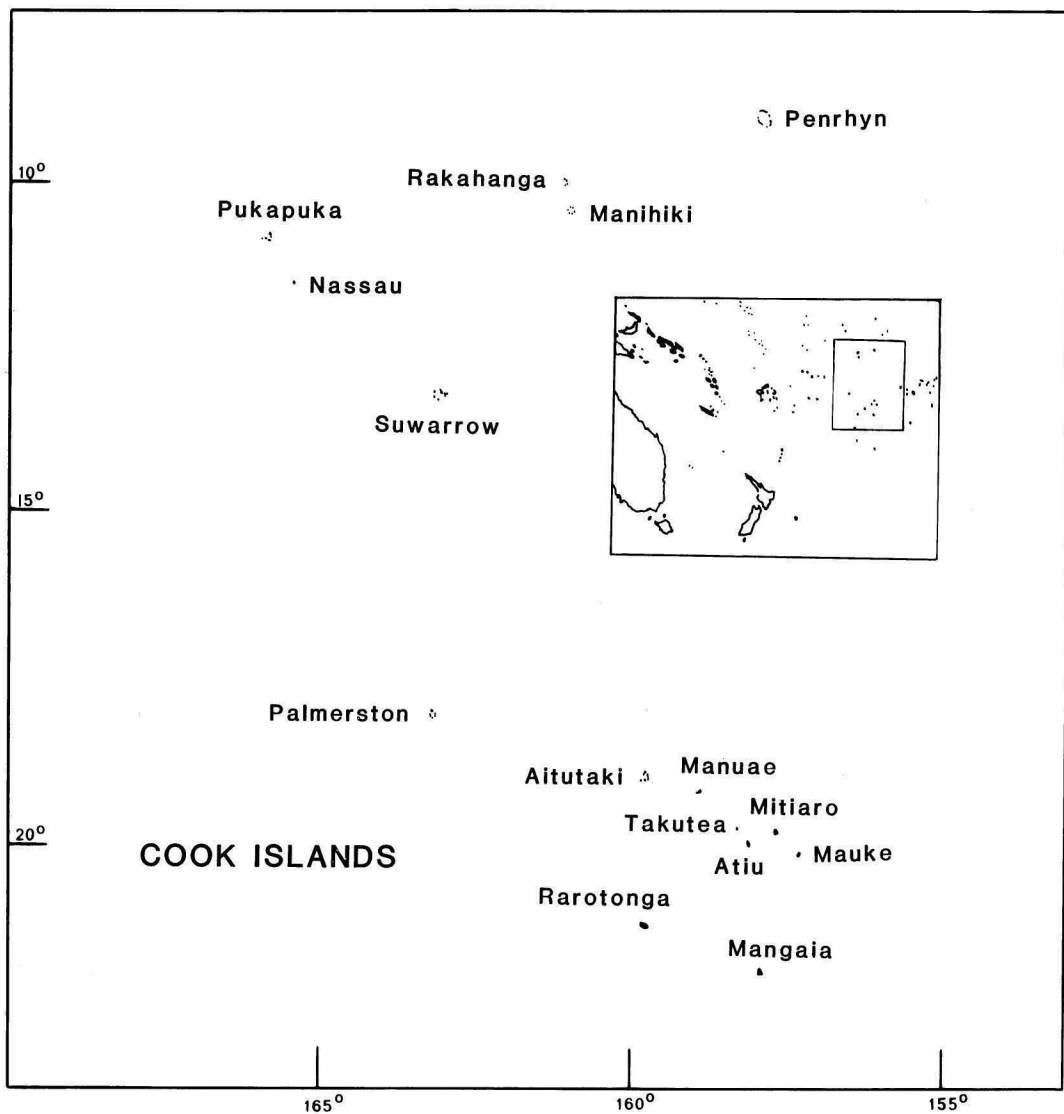


FIGURE 1. The Cook Islands.

1990). The Ureia site is a stratified sequence of calcareous sands just above sea level. It is about 100 m inland from the modern beach and is backed by a hill composed of volcanic bedrock and associated eroded soils. In 1987, M. S. Allen, S. E. Schubel, and I excavated 11 m<sup>2</sup> of sediment at Ureia to a depth of up to 2 m. Bones, artifacts, and other cultural features were concentrated in layers III, V,

and VII. The charcoal-based radiocarbon chronology of Ureia ranges from  $200 \pm 50$  yr B.P. (layer III) to  $1040 \pm 80$  yr B.P. (layer VII). Attempts to date the very small amounts of charcoal from strata below layer VII have not been successful.

M. S. Allen initiated the excavation of Moturakau Rockshelter site in 1987 (Allen and Schubel 1990) and greatly expanded the

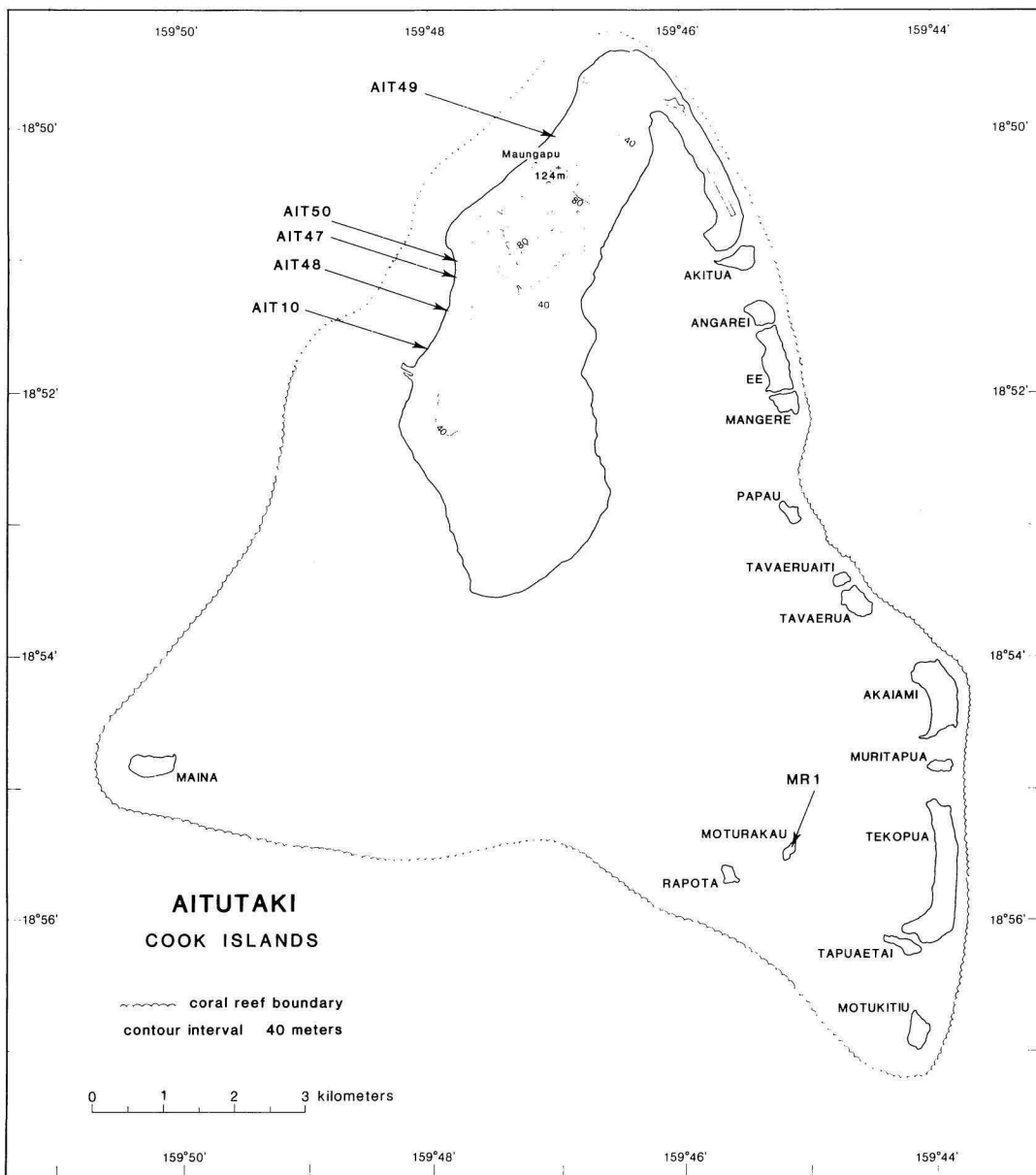


FIGURE 2. Aitutaki, showing archaeological sites mentioned in the text. AIT10 = Ureia site; AIT47 = Poana site; AIT48 = Mataki site; AIT49 = Aretai site; AIT50 = Hosea site; MR1 = Moturakau Rockshelter site.

excavations in 1989 (Allen 1991). Located on the islet of Moturakau, 5 km from the main island (Figure 2), this site is a well-protected, dry shelter that is 6.7 m wide and extends 2.8 m inside the dripline. The rockshelter was

formed by wave erosion of a cindery volcanic tuff formation. Based upon sea level studies from Mangaia (Yonekura et al. 1988), this erosion probably took place during the mid-to late Holocene high sea level stand dated at

about 4000–3400 yr B.P. A total of 16 m<sup>2</sup> of sediment, up to 1.8 m deep, has been excavated at Moturakau, revealing a stratified sequence of sandy layers that vary in organic content, weathered volcanic component, and density of cultural objects. The artifact assemblage features an excellent series of shell fish-hooks (Allen 1991). The 1987 excavations at Moturakau Rockshelter yielded <sup>14</sup>C dates on charcoal of 540 ± 70 yr B.P. from layer V, and 840 ± 80 yr B.P. from layer XIII, near the base of the shelter (Allen and Schubel 1990). Because the stratigraphy and chronology of the 1989 excavations at Moturakau do not correlate readily with those of 1987 (M. S. Allen, pers. comm.), I have not tabulated the bird bones from Moturakau stratigraphically.

Four other archaeological sites on Aitutaki have yielded bones of birds. These are Aretai, Poana, Mataki, and Hosea (Allen 1991), all located along the western coast of Aitutaki (Figure 2). Like Ureia, they are composed principally of sandy sediments. Based on present evidence, cultural occupations at these four sites, with the possible exception of Poana, date to less than 1000 yr B.P.

The vertebrate assemblages from each of the Aitutaki sites are dominated by fish bones (Allen 1991). Sea turtles (Cheloniidae) and lizards (Gekkonidae, Scincidae) are represented at most sites, while the mammals from Ureia include rat (*Rattus exulans*), dog (*Canis familiaris*), pig (*Sus scrofa*), human (*Homo sapiens*), and porpoise (Delphinidae), most of which occur at the other sites as well.

The Hosea site yielded a molar (TP1, zone E?) and wing phalanx (TP2) of *Pteropus tonganus* (Tongan Fruit-Bat, or Flying Fox), which has not been recorded previously from Aitutaki. In the Cook Islands today, *P. tonganus* is known only from Rarotonga and Mangaia, where it reaches the eastern limit of the species and the entire family (Krzanowski 1977, Wodzicki and Felten 1981, Steadman and Kirch 1990).

Atiu has a land area of 26.93 km<sup>2</sup> and a maximum elevation of 72 m. The island is encircled by a raised coralline limestone formation or *makatea*. The geology and topography of the *makatea* on Atiu have been de-

scribed by Marshall (1930), Wood and Hay (1970), and Stoddart et al. (in press). Inside the *makatea* is a late Tertiary volcanic formation with badly eroded soils that support villages, croplands, and fernlands with scattered nonnative trees. By contrast, most of the *makatea* on Atiu is blanketed by native forest with moderate to little human disturbance (Franklin and Merlin, in press; Franklin and Steadman, in press).

The extirpated birds from Atiu were reported briefly by Steadman (1989), without details of the sites or the bones themselves. The bone-bearing sites on Atiu consist of four caves in the *makatea* visited in 1987 (Figure 3). The first, Te Ana o Raka ("The Cave of Raka," Raka being a man's name), was visited on 21 September. This complex cave with many passages has at least eight entrances along an old trench in the reefal limestone. Flowstone formations, including large stalactites and stalagmites, are abundant and well developed in Te Ana o Raka. Most of the floor is dry but shows much evidence (old terraces, pools, aragonite nodules) of past water flow. Mana et al. (1984) provided a photograph of one of the human burials in Te Ana o Raka. We noted at least 10 human burials in this cave, including one in a dugout canoe.

The second cave, Ana Takitaki, was visited on 22 September. Like Te Ana o Raka, Ana Takitaki has numerous entrances and passages. This cave was described by Marshall (1930:67), who called it "Taketake," a variant spelling still sometimes used today. We found no human burials in Ana Takitaki. The aragonite nodules on the floor of Ana Takitaki, as in Te Ana o Raka, suggest a geochemical environment well suited for mineralization of bones. Ana Takitaki is the type locality and primary roosting and nesting site of the Atiu Swiftlet (*Collocalia sawtelli*). The word *takitaki* (or *taketake*) is an onomatopoeic Atiuan rendering of the sound made by the swiftlets as they echolocate in the cave's darkness. The main nesting area for the swiftlets is at least 200 m within the cave. There the floor is covered with moist, decomposing swiftlet guano, providing a poor



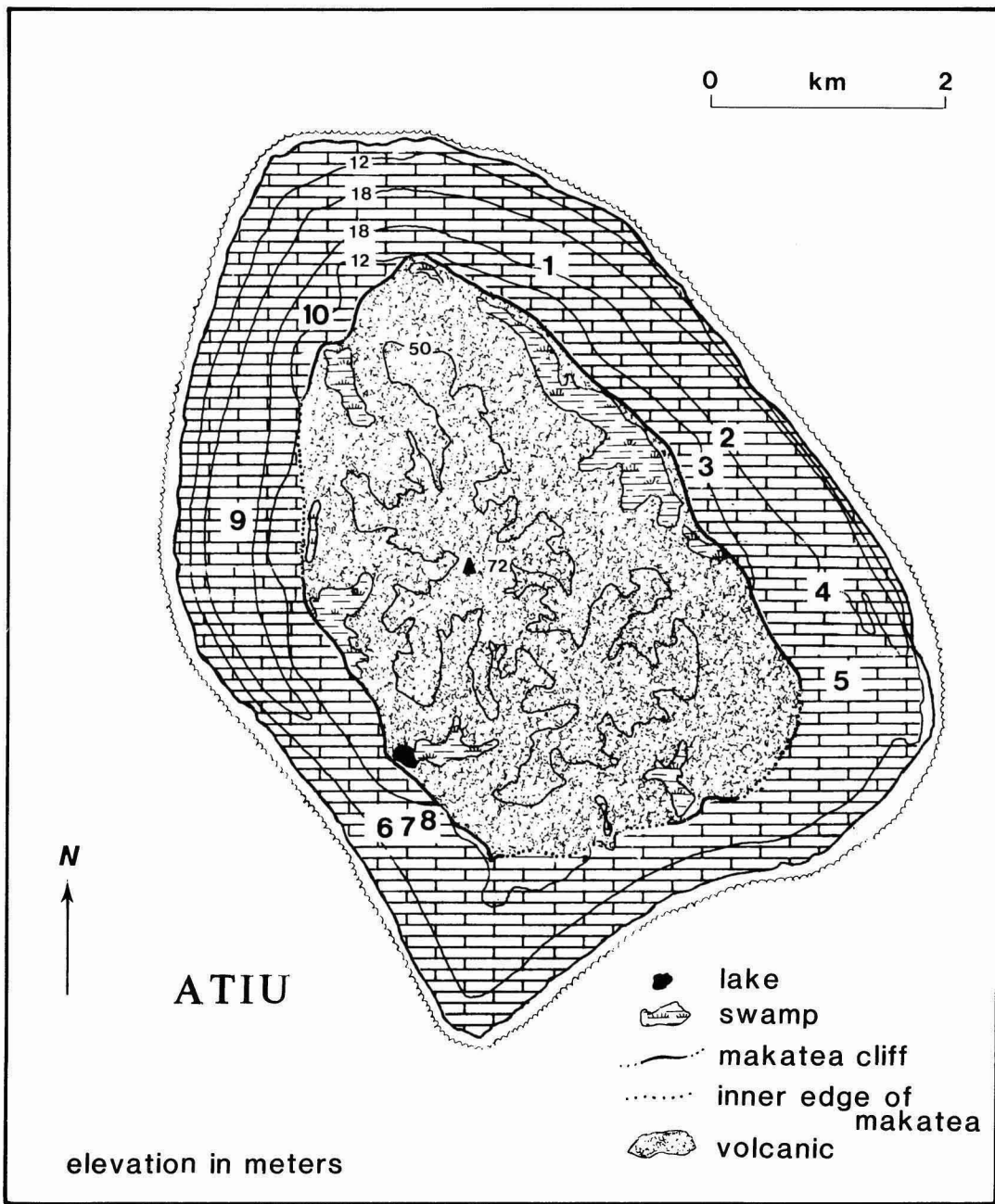


FIGURE 3. Atiu, showing caves mentioned in the text. 1, Te Ana o Raka; 2, Ana Angaangatai'ua; 3, Ana Vai Momoiri; 4, Ana Vaikaruru; 5, Ana Takitaki; 6, Ana Pau Atea; 7, Ana Vaitupuranga; 8, Ana Rimarau; 9, Te Ana o Kuekue; 10, Ana Vaiari.

setting for bone preservation. Ana Takitaki is featured in an Aituan legend as a place of refuge for a woman whose hiding ended happily when a kingfisher (*Halcyon tuta*) led her husband to her (Manu 1984).

The third cave to yield bones, Ana Vaitupuranga (*vai* = water; *tupu* = to grow, to come forth; *ranga* = to search out, to revenge; the combined meaning is unclear), was visited on 23 September. This cave is less complex but moister than the first two. A major section of Ana Vaitupuranga is virtually inaccessible because a deep pool of water surrounded by sheer walls blocks the entire passage. The only signs of possible human habitation were a few marine gastropods and a fragment of a stone adze on the floor. We saw only one human burial.

The fourth cave, Ana Pau Atea (*pau* = to be used up, consumed; *atea* = a wide, clear space; the combined meaning is unclear), also was visited on 23 September. This very large cave has many long, interconnected, complicated passages. As with Ana Vaitupuranga, one must descend a wall about 7 m to enter Ana Pau Atea. The scarcity of horizontal surfaces on the floor limits the potential for human habitation and bone deposition. We found a few remains of urchins, limpets, and marine gastropods, and one very degraded human burial.

Of the ca. 16 caves we explored on Aitu that did not yield any bird bones, most were unnamed, according to our informants. The exceptions were Ana Rima Rau ("Cave of a Thousand," named after 1000 people said to have been killed in a prehistoric battle and buried there; visited 23 September; described briefly in Mana et al. 1984); Ana Vaiari ("Sparkling Water Cave"; visited 24, 25 September, 2 October; see map and drawings of artifacts in Trotter 1974 and Mana et al. 1984); Te Ana o Kuekue (meaning uncertain, perhaps a man's name; visited on 25 September); Ana Vaikaruru (meaning unknown; visited 2 October); Ana Momoiri (*momo* = face, *iri* has many meanings; visited 2 October); and Ana Angaangatai'ua (*angaanga* = work, *tai* = seawater, *ua* has many meanings; combined meaning unknown; visited 2 October).

The archaeology of Atiu is not as thoroughly researched as that of Aitutaki. Gruning (1937) reported unnamed burial caves on Atiu. Duff (1971) plotted 31 prehistoric sites on Atiu, only one of which was excavated, and none of which included faunal remains. Although most of these sites were stone features, such as *marae* or scatters of coral gravel, they did include four caves with human burials (Ana Vaiari, Te Ana o Raka, Te Ana o Kuekue, and Te Ana o Kovi). Trotter (1974) surveyed the archaeology of Atiu during September 1969, listing five named caves (the four reported by Duff as well as Ana Pau Atea, which was called Ana Taketake by one of Trotter's informants). Trotter mapped and described the artifacts in Ana Vaiari in some detail.

#### MATERIALS AND METHODS

Data on the bird bones from Aitutaki and Atiu are summarized in Tables 1–3. Those from Aitutaki were recovered by sieving archaeological sediments through screens of 6-mm ( $\frac{1}{4}$ -in.) and 3-mm ( $\frac{1}{8}$ -in.) [and 1.5-mm ( $\frac{1}{16}$ -in.) at AIT10] mesh, while those from Atiu were collected from cave floors by hand with forceps. Identifications are based upon comparisons with skeletons from the National Museum of Natural History, Smithsonian Institution (USNM), the University of Washington Burke Museum (UWBM), the New York State Museum (NYSM), and The British Museum (Natural History) (BMNH). The bird bones are catalogued in the Fossil Bird Collection of UWBM. Measurements were taken with digital calipers with 0.01-mm increments, rounded to the nearest 0.1 mm.

Site acronyms for Aitutaki are as follows: AIT10 = Ureia site; AIT47 = Poana site; AIT48 = Matakai site; AIT49 = Aretai site; AIT50 = Hosea site; MR1 = Moturakau Rockshelter site. TP = excavated test pit (usually 1 m<sup>2</sup>). For AIT10, stratigraphic layers are designated by Roman numerals, while arbitrary excavation levels are designated by Arabic numerals: thus "VII/8" means layer VII, level 8; yr B.P. = adjusted radiocarbon (<sup>14</sup>C) years before present.

TABLE 1

STRATIGRAPHIC DISTRIBUTION OF IDENTIFIABLE BIRD BONES FROM 13 EXCAVATED 1-m<sup>2</sup> SQUARES AT THE UREIA SITE (AIT10), AITUTAKI

LAND BIRDS	I	II	III	IV	V	VI	VII	VIII	IX	X	TOTAL
*cf. <i>Dendrocygna</i> , undescribed sp.	—	—	1	—	—	—	—	—	—	—	1
<i>Anas superciliosa</i>	—	—	1	—	—	—	—	—	—	—	1
<i>Gallus gallus</i> (i)	1	—	13	6	17	1	1	—	—	1	40
* <i>Porzana tabuensis</i>	—	—	9	—	8	—	1	—	—	2	20
Total all species	1	0	24	6	25	1	2	0	0	3	62
Total native species	0	0	11	0	8	0	1	0	0	2	22
Total extirpated species	0	0	10	0	8	0	1	0	0	2	21

NOTE: Roman numerals represent natural stratigraphic layers, with I the shallowest and youngest and X the deepest and oldest. See text for chronologic information.

\* Extirpated species.

\*\* Extinct species.

i = introduced species.

TABLE 2

SUMMARY OF PREHISTORIC BIRDS FROM AITUTAKI

SPECIES	UREIA AIT10	ARETAI AIT49	POANA AIT47	MATAKI AIT48	HOSEA AIT50	MOTURAKAU MR1	TOTAL
<b>Seabirds</b>							
* <i>Pterodroma rostrata</i>	—	—	—	—	—	2	2
* <i>Sula sula</i>	—	1	—	—	—	—	1
<i>Fregata minor</i>	—	—	—	—	—	2	2
<i>Fregata ariel</i>	—	—	—	—	—	2	2
<i>Anous minutus</i>	—	—	—	—	—	1	1
<i>Anous stolidus</i>	—	—	1	—	—	10	11
<i>Gygis alba</i>	—	—	—	—	—	1	1
<b>Land Birds</b>							
<i>Egretta sacra</i>	—	—	—	—	—	12	12
*cf. <i>Dendrocygna</i> , undescribed sp.	1	—	—	—	—	—	1
<i>Anas superciliosa</i>	1	—	—	—	—	—	1
<i>Gallus gallus</i> (i)	40	—	—	3	4	26	73
* <i>Porzana tabuensis</i>	20	—	—	—	2	6	28
<i>Numenius tahitiensis</i> (m)	—	—	—	—	—	11	11
* <i>Vini kuhlii</i>	—	—	—	—	1	—	1
<i>Eudynamis taitensis</i> (m)	—	—	—	—	1	1	2
Total all species	62	1	1	3	8	74	149
Total native species	22	1	1	0	4	48	76
Total extirpated species	21	1	0	0	3	8	33
% extirpated of native species	95	100	0	—	75	17	44

NOTE: Numbers are the total number of bird bones from each site.

\* Extirpated species.

\*\* Extinct species.

i = introduced species; m = migrant species.

The modern status and distribution of birds on Aitutaki are taken from Holyoak (1980), who visited the island on 4–5 August 1973; Child (1981), who visited Aitutaki (including the offshore islets of Maina, Akaiami, Rapota, Moturakau, and Motukitii) on 30

August–3 September 1980; Taylor (1984), who visited the island on 26 November–2 December 1983; the collections and observations of C. D. Spaw on 21 October–3 November 1987; and my own observations from 2 November to 3 December 1987, which include

TABLE 3  
SUMMARY OF PREHISTORIC BIRDS FROM ATIU

LAND BIRDS	ANA VAITUPURANGA	ANA TAKITAKI	ANA PAU ATEA	TE ANA O RAKA	TOTAL
<i>Porzana tabuensis</i>	4	—	—	—	4
* <i>Gallinula erythroptera</i>	1	—	1	—	2
* <i>Ducula aurorae</i>	—	3	—	—	3
* <i>Vini kuhlii</i>	1	—	—	—	1
<i>Collocalia sawtelli</i>	—	28	—	1	29
<i>Halcyon tuta</i>	—	1	1	—	2
Total all species	6	32	2	1	41
Total native species	6	32	2	1	41
Total extirpated species	2	3	1	0	6
% extirpated of native species	33	9	50	0	15

NOTE: Numbers are the total number of identifiable bird bones from each cave site.

\* Extirpated species.

the entire main island and the islets of Maina, Rapota, and Moturakau. The modern status and distribution of birds on Atiu are taken from Holyoak (1980), who visited the island on 14–16 September 1973; Taylor (1984), who visited Atiu on 2–5 December 1983; and my own collections and observations (with C. S. Wood and J. Franklin) on 19 September–6 October 1987, which are reported in part by Franklin and Steadman (in press). Unless cited otherwise, the modern status and distribution of birds in the southern Cook Islands are taken from Holyoak (1980), who visited all islands during 22 July–5 August and 19 August–23 September 1973, and my own collections and observations on all islands except Manuae during 13 March–23 April 1984, 4–5 March, 28 May–13 June 1985, 15 September–7 December 1987, and 14 July–11 August 1989. Overall modern distributions of birds in the South Pacific are taken from Pratt et al. (1987). Prehistoric distributions are taken from Steadman (1989) and Steadman et al. (1990b), supplemented by the results of more recent research. Island group names are given the first time an individual island is mentioned.

The seabirds recorded from an archaeological site are considered to represent probable past breeding records because modern Polynesians take seabirds on land but not at sea. The presence of juvenile bones would be a

more certain indication of past breeding on an individual island.

#### SYSTEMATIC ACCOUNTS

#### Order PROCELLARIIFORMES Family PROCELLARIIDAE

#### *Pterodroma rostrata* Peale. Tahiti Petrel

MATERIAL. Aitutaki: UWBM 3035, 3036, tarsometatarsus, carpometacarpus, MR1, TP4.

REMARKS. *Pterodroma rostrata*, the largest petrel in the tropical South Pacific, has been reported from archaeological sites on Nuku Hiva, Ua Huka, and Tahuata (Marquesas), Huahine (Society Islands), Ofu (American Samoa), 'Eua (Tonga), New Caledonia, and Tikopia (Solomon Islands) (Steadman, in press). It survives today on none of these islands. This is the first record of *P. rostrata* from Aitutaki and the first certain record from anywhere in the Cook Islands. Holyoak (1980:11) reported seeing three individuals of *P. rostrata* at sea near Rarotonga in July and August 1973. Sight records of most South Pacific *Pterodroma* are not reliable. For example, *P. rostrata* is difficult to distinguish from *P. alba*. Modern breeding records of *P. rostrata* are from the Marquesas, Society Islands, American Samoa, and New Caledonia.

## Order PELECANIFORMES

## Family SULIDAE

*Sula sula* (Linnaeus). Red-footed Booby

MATERIAL. Aitutaki: UWBM 3000, humerus, Aretai Site, TP1.

REMARKS. This is the first record of *Sula sula* for Aitutaki. Within the southern Cook Islands, *S. sula* nests today only on Takutea, a small island (1.2 km<sup>2</sup>) off Atiu. *Sula sula* is widely but discontinuously distributed across tropical oceans today. It has been recorded from archaeological sites on Hiva Oa, Ua Huka, and Tahuata (Marquesas), Henderson (Pitcairn Group), Huahine, Ofu, Niuaotupapu (Tonga), and Tikopia and Anuta (Solomon Islands). These records, along with that from Aitutaki, indicate a more continuous distribution in the past.

## Family FREGATIDAE

*Fregata minor* (Gmelin). Great Frigatebird

MATERIAL. Aitutaki: UWBM 3167, 3169, synsacrum, humerus, MR1, TP15.

REMARKS. The only modern records of *Fregata minor* from Aitutaki are by Child (1981:30), who saw "odd individuals . . . over the lagoon each day" and a flock of 57 over Motukititi on 1 September 1980, and by C. D. Spaw, who collected one subadult female on Motukititi on 28 October 1987. I saw none during November–December 1987, although I did not visit Motukititi. Within the southern Cook Islands, *F. minor* breeds only on Takutea [and until 1907 on Palmerston (Burland 1964)], although it visits all other islands fairly regularly, especially after storms. Other archaeological records of this widespread seabird are from Fanning (Line Islands), Hiva Oa, Ua Huka, Huahine, Henderson, Lifuka (Tonga), Tikopia, and Anuta.

*Fregata ariel* (G. R. Gray). Lesser Frigatebird

MATERIAL. Aitutaki: UWBM 3170, manus phalanx, MR1, TP15; UWBM 3178, radius, MR1, TP6.

REMARKS. UWBM 3170 agrees in size with the manus phalanx in males of *Fregata ariel*, being smaller than that in females of *F. ariel* and in either sex of *F. minor* (Steadman et al. 1990b). UWBM 3178 agrees in size with the radius of a smallish female specimen (USNM 498436) of *F. ariel*. On Aitutaki, Holyoak (1980:19) saw "a few" *F. ariel* in 1973, Child (1981) did not record the species, and Taylor (1984) observed two males and a female on 1 December 1983. In 1987, I saw one adult female soaring over Moturakau on 16 November, an adult female and adult male soaring near the airstrip on 21 November, and one adult female soaring over the reef 1 km N of the Ureia site on 29 November and 1 December. Archaeological records of *F. ariel* are from Hiva Oa, Ua Huka, Huahine, Mangaia, 'Eua, Lakeba (Fiji), Tikopia, Anuta, and Makin (Kiribati).

## Order CHARADRIIFORMES

## Family LARIDAE

*Anous stolidus* Linnaeus. Brown Noddy

MATERIAL. Aitutaki: UWBM 3001, humerus, Poana site, TP4; UWBM 473, tibiotarsus, MR1, TP1; UWBM 3033, femur, MR1, TP4; UWBM 3041, ulna, MR1, TP5; UWBM 3152, ulna, MR1, TP6; UWBM 3155, radius, MR1, TP7; UWBM 3048, 3160, tibiotarsus, tarso-metatarsus, MR1, TP8; UWBM 3138, carpometacarpus, MR1, TP12; UWBM 3166, humerus, MR1, TP13; UWBM 3177, mandible, MR1, TP16.

REMARKS. *Anous stolidus* occurs regularly on Aitutaki today and might breed on Motukititi (Child 1981, Taylor 1984; specimen data from birds collected on 28 October 1987 by C. D. Spaw). Nevertheless, it is less common on Aitutaki than on most or all other islands in the southern Cooks. This very widespread and often common tern has been recovered in archaeological sites virtually throughout Polynesia.

*Anous minutus* Boie. Black Noddy

MATERIAL. Aitutaki: UWBM 3134, humerus, MR1, TP11.

REMARKS. *Anous minutus* probably is less common on Aitutaki than *A. stolidus*. It probably nests in low numbers on Motukitiu (Child 1981). On 27 November 1983, Taylor (1984) saw three over the Aitutaki lagoon and five resting on a sandspit on Tekopua Islet. I observed *A. minutus* twice in 1987 (two off Moturakau on 16 November and one over the reef 1 km N of the Ureia site on 29 November). Within the southern Cook Islands, *A. minutus* nests on, or at least visits, Atiu, Takutea, Ma'uke, and Mitiaro. Other Polynesian archaeological records of this widespread tern are from Ua Huka, Tahuata, Huahine, Tikopia, and Mussau (Papua New Guinea).

*Gygis alba* (Sparman). Common Fairy-Tern

MATERIAL. Aitutaki: UWBM 3151, ulna, MR1, TP6.

REMARKS. This distinctive tern is the most common seabird on and near Aitutaki today, although it is less common on Aitutaki than on most nearby islands. It breeds on Moturakau [eggs and young noted commonly in *Calophyllum* trees in May 1989 (M. S. Allen, pers. comm.)], Motukitiu, and perhaps other islets (Child 1981). *Gygis alba* is widely distributed in the Cook Islands and most of Polynesia, both today and in archaeological sites. The bone from Aitutaki agrees in size with that of *G. alba* rather than the smaller *G. microrhyncha*, which has been reported from an archaeological site on Mangaia (Steadman and Kirch 1990).

Order CICONIIFORMES

Family ARDEIDAE

*Egretta sacra* (Gmelin). Pacific Reef-Heron

MATERIAL. Aitutaki: UWBM 3042, 3043, synsacrum, femur, MR1, TP5; UWBM 3144, tarsometatarsus, MR1, TP6; UWBM 3145, 3147–3149, four vertebrae, MR1, TP6; UWBM 3126, vertebra, MR1, TP7; UWBM 3161, pedal phalanx, MR1, TP8; UWBM 3133, tibiotarsus, MR1, TP11; UWBM 3136, carpometacarpus, MR1, TP11; UWBM 3172, tibiotarsus, MR1, TP15.

REMARKS. *Egretta sacra* is fairly common on Aitutaki today, where it feeds in shallow water in the lagoon and inside the fringing reef. Correlated with differences in their foraging, Rohwer (1990) noted a statistically significant difference in the distribution of color morphs of *E. sacra* on Mangaia in November–December 1987. He observed two dark and six white birds on the windward side of the island, and eight dark, one white, and one pied bird on the leeward side. My sightings of *E. sacra* on Aitutaki in November–December 1987 consisted of nine dark and one white birds on the leeward coast or calm lagoon, with no birds seen on the windward side. This corroborates Rohwer's (1990) observations on Mangaia. Surveying Aitutaki's shorelines, Child (1981) reported 26 dark, 17 white, and 4 pied herons on a single day in August–September 1980. Unfortunately, leeward versus windward was not recorded. These high numbers suggest that there is a nesting colony of *E. sacra* somewhere on Aitutaki (almost certainly on an offshore islet), the whereabouts of which remains unreported. Surveying a major section of Aitutaki's leeward coast, Taylor (1984) observed 17 dark, 7 white, and 1 pied herons on 27 November 1983. Other archaeological records of *E. sacra* are from Nuku Hiva, Ua Huka, Huahine, Ofu, 'Eua, Lakeba, and Rota (Mariana Islands).

Order ANSERIFORMES

Family ANATIDAE

Subfamily DENDROCYGNINAE

cf. *Dendrocygna*, undescribed species. Extinct whistling duck

MATERIAL. Aitutaki: UWBM 15, complete terminal phalanx of pes digit 3, AIT10, TP5, III/3.

REMARKS. This unusual record was noted briefly in Allen and Steadman (1990). Here are the verifying details. In identifying UWBM 15 (Figure 4), the terminal pedal phalanges of every family of Indo-australian bird were examined. Within the Anatidae, phalanges of the following species were examined:

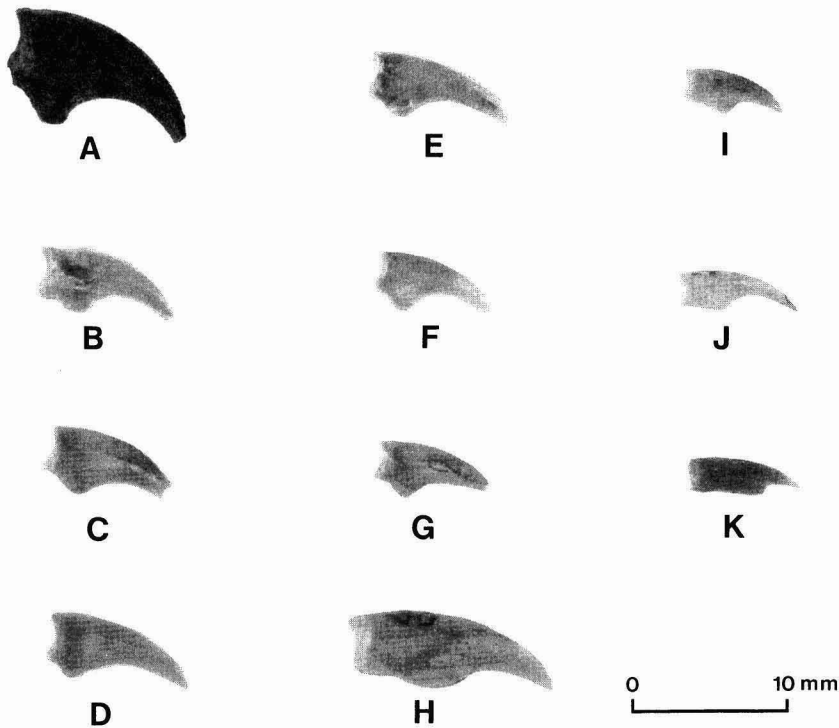


FIGURE 4. Terminal phalanx of digit 3 of *Dendrocygna* (A–G) and other anatids (H–K), in lateral aspect. A, *Dendrocygna* sp., Aitutaki, UWBM 15. B, C, *D. arborea*, captive, USNM 345010. D, *D. arborea*, Dominican Republic, USNM 226455. E, *D. autumnalis*, Texas, USNM 224796. F, *D. autumnalis*, Brazil, USNM 345767. G, *D. arcuata*, captive, USNM 226488. H, *Branta canadensis*, Wyoming, NYSM 30. I, *Aix sponsa*, ?New York, NYSM 1038. J, *Anas clypeata*, Texas, NYSM 1485. K, *Bucephala clangula*, New York, NYSM 1354.

Anseranatinae—*Anseranas semipalmatus*;  
 Dendrocygnae—*Dendrocygna guttata*, *D. eytoni* (2), *D. bicolor* (12), *D. arcuata* (4), *D. javanica* (2), *D. viduata* (15), *D. arborea* (3), *D. autumnalis* (13), *Thalassornis leuconotus*;  
 Anserinae—*Cygnus olor*, *Anser albifrons*, *A. caerulescens*, *Branta canadensis*, *Cereopsis novaehollandiae*, *Stictonetta naevosa*;  
 Tadorninae—*Cloephaga picta*, *Tadorna tadorna*, *T. radjah*, *Neocheilus jubatus*;  
 Anatinae—*Malacorhynchus membranaceus*, *Nettapus auritus*, *Anas clypeata*, *A. fulvigula*, *A. discors*, *A. superciliosa* (2), *A. gibberifrons*, *A. acuta*, *Hymenolaimus malacorhynchus*, *Aix sponsa* (3), *A. galariculata*, *Cairina moschata*, *C. scutulata*, *C. hartlaubi*, *Plectropterus gambensis*, *Marmaronetta angustirostris*, *Amazonetta brasiliense*, *Chenonetta jubata*, *Aythya americana*, *A. collaris*;  
 Merginae—*Melanitta*

*fusca*, *M. nigra*, *Bucephala albeola*, *B. clangula*, *Clangula hyemalis*, *Somateria mollissima*, *Mergus cucullatus*;  
 Oxyurinae—*Oxyura "maccoa"* (= *O. punctata*), *Heteronetta atricapilla*.

UWBM 15 resembles the terminal phalanx of *Dendrocygna* rather than that of all other birds because of the following combination of characters: (1) in lateral aspect, highly curved dorsal and ventral surfaces; (2) in distal aspect, highly rounded dorsal and ventral surfaces; (3) presence of bifurcated lateral grooves; (4) in proximal aspect, convex lateral margins of articular surface; (5) well-developed ventral knob; and (6) pointed distal end. Within the Anatidae, UWBM 15 is referred to *Dendrocygna* because of characters outlined in Table 4. In these characters, the terminal phalanges of *Thalassornis* (the only



TABLE 4  
 CHARACTERS OF THE TERMINAL PHALANX, DIGIT 3, OF THE SUBFAMILIES OF ANATIDAE (FOLLOWING MAYR AND COTTRELL 1979)

CHARACTER	UWBM 15	DENDROCYGNINAE	ANSERANATINAE	ANSERINAE	TADORININAE	ANATINAE	MERGINAE	OXYURINAE
1. Overall shape in lateral aspect	deep proximally, tapering quickly to a distal point	deep proximally, tapering quickly to a distal point	medium depth proximally, tapering gradually	shallow proximally, tapers gradually	shallow proximally, tapers gradually	shallow proximally, tapers gradually	shallow proximally, tapers gradually	shallow proximally, tapers gradually
2. Curvature of dorsal and ventral surfaces in lateral aspect	highly curved	highly to medium curved	gradually to medium curved	gradually curved	gradually curved	gradually curved	gradually curved	gradually curved
3. Shape of articular surface in proximal aspect	depth much greater than width	depth much greater than width	depth = width	depth = width	depth = width	depth = width	depth = width	depth = width
4. Curvature of dorsal surface in distal aspect	narrowly rounded	narrowly rounded	medium rounded	broadly rounded	broadly rounded	medium rounded	medium rounded	narrowly rounded
5. Curvature of ventral surface in distal aspect	narrowly rounded	narrowly rounded	medium rounded	flattened to broadly rounded	flattened to broadly rounded	narrowly rounded to unrounded	narrowly rounded to unrounded	narrowly rounded
6. Lateral grooves	clearly bifurcated	clearly bifurcated	clearly bifurcated	unbifurcated to clearly bifurcated	unbifurcated to poorly bifurcated	unbifurcated to poorly bifurcated	unbifurcated to poorly bifurcated	clearly to poorly bifurcated

NOTE: See *Materials and Methods* for species examined within each subfamily.



TABLE 5

MEASUREMENTS (IN mm) OF THE TERMINAL PHALANX, DIGIT 3, OF *Dendrocygna*, WITH MEAN, RANGE, AND SAMPLE SIZE

SPECIES	TOTAL LENGTH	PROXIMAL DEPTH	DEPTH OF ARTICULAR FACET	WIDTH OF ARTICULAR FACET	DEPTH AT BIFURCATION OF LATERAL CANAL
cf. <i>Dendrocygna</i> , undescribed sp.	14.1	8.1	5.3	3.8	5.4
Aitutaki, Cook Is. (U)	1	1	1	1	1
<i>D. guttata</i>	8.7	3.6	2.5	2.3	2.4
Captive (F)	1	1	1	1	1
<i>D. eytoni</i>	9.6	4.3	2.8	2.7	3.2
Captive (M)	1	1	1	1	1
<i>D. bicolor</i>	10.5	4.6	2.9	2.4	2.8
Florida, Louisiana, Texas,	9.9–11.7	4.3–4.9	2.7–3.4	2.3–2.6	2.5–3.2
California, Bechuanaland,	5	7	7	7	7
captive (2F, 4M, U)					
<i>D. arcuata</i>	8.6	4.1	2.8	2.4	2.7
Captive (2F, M, U)	8.0–9.4	4.0–4.2	2.6–2.9	2.2–2.6	2.5–3.0
	3	4	4	4	4
<i>D. javanica</i>	8.4	3.7	2.3	2.1	2.1
Thailand (2F)	8.2–8.7	3.7	2.1–2.5	2.1	1.8–2.4
	2	2	2	2	2
<i>D. viduata</i>	9.4	4.1	2.7	2.4	2.7
Brazil, Cameroon, Sudan,	8.2–10.2	3.4–4.8	2.3–2.9	2.0–2.7	2.3–3.1
captive (6F, 6M)	11	11	12	11	10
<i>D. arborea</i>	10.3	5.1	3.4	2.8	3.7
Dominican Republic, captive	9.6–10.9	4.5–5.5	3.3–3.5	2.7–3.0	3.3–4.0
(2F, M)	3	3	3	3	3
<i>D. autumnalis</i>	9.5	4.5	3.0	2.4	3.1
Texas, Mexico, Brazil, captive	8.1–10.1	4.1–5.1	2.7–3.3	2.1–2.5	2.6–3.7
(2F, 6M, 2U)	7	10	10	10	10

F = female, M = male, U = sex unknown.

other genus of *Dendrocygninae*) resemble those of other anatids more than those of *Dendrocygna*.

The Aitutaki specimen is assumed to represent the terminal phalanx of digit 3, which is larger than any other terminal phalanx, although it possibly could represent that of digit 2 or digit 4. UWBM 15 is much larger than those in all living species of *Dendrocygna* (Table 5). It most closely resembles the terminal phalanges of *D. arborea* and *D. autumnalis* in overall shape and proportions, particularly in characters 1, 2, 4, and 5 (Table 4). These characters may represent a complex of features related to perching in trees. Within the "Anatinae," a questionably monophyletic assemblage, the *Dendrocygna*-like condition of the characters in Table 4 is approached, but not attained, in *Aix sponsa*, *Nettapus auritus*, and *Chenonetta jubata*, and is slightly

approached in *Aix galericulata*, *Cairina moschata*, *C. scutulata*, *C. hartlaubi*, and *Plectropterus gambensis*. All of these species, unlike most species of Anatinae, regularly perch in trees (Delacour 1959). Thus, their approach to the *Dendrocygna*-like condition of the terminal phalanx, which reaches an extreme in *D. arborea*, *D. autumnalis*, and the Aitutaki specimen, may be a convergent feature related to perching. The Aitutaki specimen is the first record of an extinct anatid from eastern Polynesia. Extinct anatids are common in the late Holocene fossil deposits of the Hawaiian Islands, although nearly all of these species are flightless and presumably endemic to the Hawaiian region (Olson and James 1982a, b, in press).

The only resident duck in eastern Polynesia today is *Anas superciliosa*. The Aitutaki specimen is the first record of *Dendrocygna* from

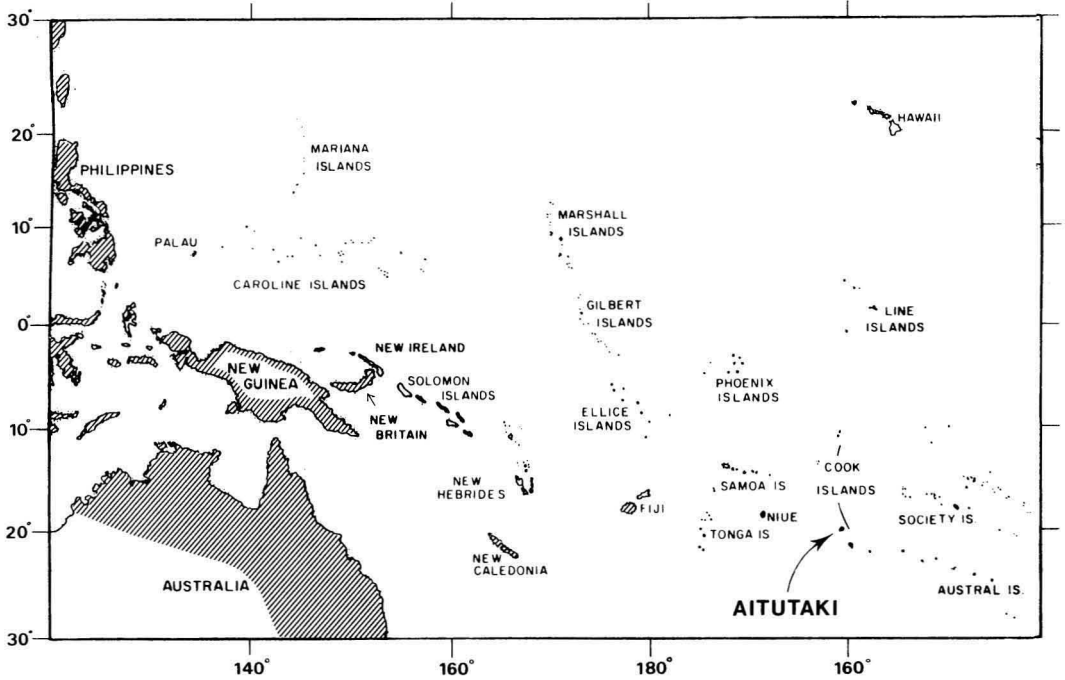


FIGURE 5. The tropical Pacific, showing the modern distribution of *Dendrocygna* in relation to Aitutaki. The cross-hatching represents the modern combined ranges of *D. guttata*, *D. eytoni*, and *D. arcuata*, the latter including New Caledonia and Fiji.

Polynesia, except for the unrelated (human-aided?) colonization of Hawaii by *D. bicolor* within the past decade (Pratt et al. 1987:94). The record of *Dendrocygna* nearest to Aitutaki is of *D. arcuata* from Fiji (Viti Levu and possibly Vanua Levu), where it probably was resident, based upon two nineteenth-century BMNH specimens collected by J. D. Macdonald (Gray 1859:54) and a questionable sight record in 1959 (Watling 1982:69). I examined these Fijian specimens in 1990 and found them indistinguishable from specimens of *D. arcuata* from the Philippines, Australia, and New Caledonia.

On the Reva River of Viti Levu in 1857, Macdonald (1857:236) reported that "wild ducks were to be seen in flocks on every low part of land or sand-bank. The natives distinguished two kinds, viz. Nga ndamu (red), and Nga loa (black). The former is a wilder species than the latter, and not so frequently met with. It stands up, with its head

erect, and utters a peculiar sharp cry in flight. Dagwell knocked down six of the Nga loa in two shots; but the others were too shy, and took wing before the necessary approach could be made." From this description, there is little doubt that "nga loa" is *Anas superciliosa* and "nga ndamu" is *Dendrocygna arcuata*. Layard (1875:30) noted that *D. arcuata* was common "in the marshes on the west coast of Viti Levu; it is called by the planters the 'mountain duck'; and they say it comes from the interior."

Aside from Fiji, the range of *Dendrocygna arcuata* extends from Java, Borneo, and the Philippines to New Guinea, New Britain, northern Australia, and formerly New Caledonia, but the species is absent from the Solomon Islands and Vanuatu (Mayr 1945:53, Mayr and Cottrell 1979:428, 429; Figure 5 herein). The only other species of *Dendrocygna* from the Papuan region are *D. guttata* and *D. eytoni*, neither of which has

colonized islands more remote from New Guinea than New Britain (Mayr and Cottrell 1979:428, Beehler et al. 1986:69–70).

It is difficult to speculate on how extensive the natural range of the extinct *Dendrocygna* may have been. Within the Cook Islands, the current absence of this species from the prehistoric records of Mangaia and Atiu (Steadman 1985, 1989; Steadman and Kirch 1990) may be an artifact of the incompleteness of the records. The only bit of evidence I can find about Polynesian anatids that might pertain to the Aitutaki *Dendrocygna* is from the field journal of James Morrison, a boatswain's mate on the infamous *Bounty*, who visited Tahiti from September 1789 until March 1791 (Derscheid 1939). Morrison noted that "the Mountains produce birds of Different kinds unknown to us, among which are a large bird nearly the size of a Goose, which is good food; they are never seen near the Sea nor in the low lands" (Derscheid 1939:757). Morrison knew birds well enough to distinguish the various species he saw on Tahiti, and Derscheid provided logical evidence that Morrison's large bird was probably an indigenous goose. The extinct *Dendrocygna* from Aitutaki was certainly large enough to be regarded as a goose rather than a duck and thus might be similar to the bird noted by Morrison.

Although often called "tree ducks," most species of *Dendrocygna* inhabit various freshwater habitats and rarely if ever perch or nest in trees. Therefore, most modern authors refer to these species as "whistling ducks," based upon their vocalizations. Nevertheless, *D. arborea* and *D. autumnalis*, the claws of which most closely resemble the Aitutaki fossil, are more arboreal and terrestrial than their congeners (Delacour 1954:43, 47; Johnsgard 1978:20–23). Thus it is likely that the extinct whistling duck of Aitutaki also was largely arboreal and nonaquatic.

*Dendrocygna arborea* inhabits only the West Indies, while *D. autumnalis* is widespread on the Neotropical mainland. None of the indigenous birds of Polynesia (outside of Hawaii) is known to be derived from New World species. The large species of *Dendrocygna* from Aitutaki probably is no

exception, although additional specimens are needed before anything substantial can be said of its relationships within *Dendrocygna*.

The Aitutaki specimen of *Dendrocygna* documents another occurrence in eastern Polynesia of an avian genus that no longer exists in this region. Other recently discovered dramatic range extensions include extinct boobies (*Papasula*), swampheens (*Porphyrio*), cuckoo-doves (*Macropygia*), and flycatchers (*Myiagra*) from the Marquesas (Steadman 1988, 1989; Steadman et al. 1988). Previously, the first was known only from the Indian Ocean, the second unknown east of Niue, the third not found east of Vanuatu, and the fourth unknown east of Samoa.

#### *Anas superciliosa* Gmelin. Gray Duck

MATERIAL. Aitutaki: UWBM 3013, coracoid, AIT10, TP12, Feature 4.

REMARKS. This duck is uncommon and local on Aitutaki today, inhabiting the lagoon and shallow reef waters. The largest flock I saw in 1987 was nine birds on 14 November. The lack of discernible geographic variation in all oceanic populations of *Anas superciliosa*, which are united under the name *A. s. pelewensis*, as well as its absence from early archaeological deposits, suggests that this species may have colonized much of Oceania within the past several thousand years (Steadman et al. 1990b). The only other archaeological records of *A. superciliosa* are from Mangaia and Tikopia.

#### Order GALLIFORMES

#### Family PHASIANIDAE

#### *Gallus gallus* (Linnaeus). Chicken

MATERIAL. Aitutaki: 73 specimens, representing most major skeletal elements, UWBM 3, 4, 10, 12, 13, 24–26, 31, 452, 453, 455, 456, 458–463, 466–469, 3002–3004, 3009–3012, 3014–3024, 3026–3032, 3034, 3037–3040, 3046, 3050, 3051, 3053, 3124, 3125, 3127, 3129, 3137, 3140, 3141, 3143, 3153, 3156, 3165, 3171, 3173–3176; specimens from AIT10 and MR1 compiled in Tables 1 and 2; specimens from other sites are as follows:

Mataki—three bones from TP1; Hosea—two bones from TP4 (zones E, G), two bones from TP5 (zone E).

REMARKS. Bones of *Gallus gallus* occur throughout the cultural strata at both AIT10 and MR1, although they are most common in layers III–V at AIT10 (Table 1) and in the upper levels of MR1. The presence of chicken bones in early strata suggests that neither of these sites represents the initial human colonization of Aitutaki (Allen and Steadman 1990). At Tangatatau Rockshelter (MAN-44) on Mangaia, chicken bones are absent in the lowest layer but become common in middle strata (Steadman and Kirch 1990). Chickens occur on Aitutaki and most other Polynesian islands as domesticated and/or feral populations. Their bones are found in archaeological sites nearly throughout Polynesia, with the single exception of Henderson Island (Schubel and Steadman 1989).

Order GRUIFORMES  
Family RALLIDAE

*Porzana tabuensis* (Gmelin). Sooty Crake

MATERIAL. Aitutaki: 28 specimens, representing most major skeletal elements, UWBM 1, 2, 5, 6, 8, 9, 11, 17–19, 21–23, 27, 29, 30, 32, 464, 3006, 3008, 3025, 3044, 3045, 3052, 3123, 3157–3159; specimens from AIT10 and MR1 compiled in Tables 1 and 2; there are also two bones from Hosea (TP1, zone E?; TP2, zone E). Atiu: UWBM 35, 36, humerus, ulna, Ana Vaitupuranga, 20 m from vertical entrance; UWBM 63, 64, tibiotarsus, pedal phalanx, Ana Vaitupuranga, edge of talus cone at vertical entrance.

REMARKS. *Porzana tabuensis* no longer occurs on Aitutaki, where the numerous archaeological bones represent the only record of the species. This widespread, small rail still is common in freshwater wetlands on Atiu. It has been found in prehistoric sites on Mangaia, Huahine, 'Eua, and New Caledonia.

This and other rails are easily caught in snares, which may explain why they often are common in archaeological sites. On Aitutaki,

the snares used for *P. tabuensis* may have been similar to, but smaller than, those described by Te Rangi Hiroa (1927:317–318, 344) for catching chickens. With bones recorded in the upper strata of both Ureia and Moturakau Rockshelter, the loss of *P. tabuensis* on Aitutaki probably occurred within the past two centuries. A major factor in this loss may have been the infilling of Aitutaki's limited freshwater marshes (Allen and Steadman 1990) and perhaps the historic introduction of cats (*Felis domesticus*) and black rats (*Rattus rattus*).

Order CHARADRIIFORMES  
Family SCOLOPACIDAE

*Numenius tahitiensis* (Gmelin). Bristle-thighed Curlew

MATERIAL. Aitutaki: UWBM 3047, 3049, 3162–3164, tarsometatarsus, scapula, three pedal phalanges, MR1, TP8; UWBM 3128, humerus, MR1, TP9; UWBM 3130, 3131, tibiotarsus, femur, MR1, TP10; UWBM 3132, scapula, MR1, TP10; UWBM 3139, ulna, MR1, TP12; UWBM 3168, ulna, MR1, TP15.

REMARKS. This large migrant shorebird is found regularly in low numbers today throughout eastern Polynesia and the Cook Islands. On Aitutaki, Child (1981) saw five on Motukititi on 1 September 1980 and two near the airstrip on 2 September 1980. Two were collected by C. D. Spaw on Maina Islet on 22 October 1987. Surprisingly, I saw none during November–December 1987. Other archaeological records of *Numenius tahitiensis* are from Ua Huka, Huahine, Henderson, Mangaia, Ofu, and Tikopia.

Order COLUMBIFORMES  
Family COLUMBIDAE

*Gallicolumba erythroptera* (Gmelin). Society Islands Ground-Dove

MATERIAL. Atiu: UWBM 43, humerus, Ana Vaitupuranga, 15 m from vertical entrance; UWBM 386, tibiotarsus, Ana Pau Atea, 50 m from entrance.

REMARKS. These two bones provide the first record of *Gallicolumba erythroptera* from

Atiu. The species occurs commonly in prehistoric sites on Mangaia (Steadman 1989), where it also is unknown in modern times. The range of *G. erythroptera* has been much reduced since human arrival in Polynesia. It survives only on an unknown number of islands in the Tuamotu Group (Collar and Andrew 1988: 63). Within the Society Islands, *G. erythroptera* has been lost from Tahiti in historic times and Huahine in prehistoric times (Steadman and Pahlavan, in prep.).

*Ducula aurorae* (Peale). Society Islands Pigeon

MATERIAL. Atiu: UWBM 40–42, associated coracoid, radius, carpometacarpus, Ana Takitaki, on ledge near first entrance.

REMARKS. Bones of *Ducula aurorae* may be distinguished from those of *D. pacifica* as follows: coracoid is larger, with twenty-five flatter lateral surface of shaft; and carpometacarpus is larger, with more elongate extensor process. This endangered species survives only on Tahiti (Society Islands) and Makatea (Tuamotu Islands). A much wider prehistoric distribution of *Ducula aurorae* is indicated by prehistoric records from Henderson (Steadman and Olson 1985), Mangaia, and Huahine. As with *Gallicolumba erythroptera*, the Atiu record of *D. aurorae* corroborates that from Mangaia and suggests that both of these columbids may have been found throughout the southern Cook Islands in prehistoric times.

Order PSITTACIFORMES  
Family PSITTACIDAE

*Vini kuhlii* (Vigors). Rimatara Lorikeet

MATERIAL. Aitutaki: UWBM 3007, femur, Hosea site, TP1, zone E?. Atiu: UWBM 419, ulna, Ana Vaitupuranga, deep in cave.

REMARKS. Bones of *Vini kuhlii* are larger than those of *V. peruviana* (Steadman and Zariello 1987; Steadman and Pahlavan, in prep.), which occurs today on Aitutaki. Whether *V. peruviana* is indigenous or introduced to Aitutaki is unresolved (duPont 1976: 95, Holyoak 1980:35, Child 1981, Taylor 1984, Pratt et al. 1987:207). The earliest

record of *V. peruviana* on Aitutaki was seven specimens collected on 21 November 1899 (Townsend and Wetmore 1919:159, 193). By noting that *V. peruviana* is commonly kept as a pet on Aitutaki, Townsend and Wetmore (1919) provided a basis for doubting that it is indigenous.

The only surviving indigenous population of *V. kuhlii* is on Rimatara, Austral Islands, which is the first major island east of Mangaia. The first Cook Island record of *V. kuhlii* was a bone found in a cave on Mangaia (Steadman 1985). Numerous additional bones of *V. kuhlii* were found in an archaeological site on Mangaia in 1989 (Steadman and Kirch 1990). With the discovery of this species in prehistoric deposits on Atiu and Aitutaki as well, it is likely that *V. kuhlii* rather than *V. peruviana* was the indigenous small parrot in the Cook Islands. This seems particularly probable since the plumage of *V. kuhlii* is largely red while that of *V. peruviana* includes no red feathers. The Rarotongan word *kura* means “red, scarlet, glowing or crimson, or ornaments with red feathers” as well as “a native bird with scarlet plumage, now extinct on the island of Rarotonga” (Savage 1980: 122). The *kura* (syn. *moomoo*) was related to the *kuramoo* [*V. peruviana*] of Aitutaki and survived into the nineteenth century on Atiu and Ma’uke (Savage 1980:122). Even after red parrot feathers were difficult or impossible to secure, the headdress of a chief on Aitutaki was called *pare kura* because of its traditional red feathers (Te Rangi Hiroa 1927:91–92). The only red feathers available in modern times have been the tail feathers of *Phaethon rubricauda*, the Red-tailed Tropicbird.

Order CUCULIFORMES  
Family CUCULIDAE

*Eudynamis taitensis* (Sparrman). Long-tailed Cuckoo

MATERIAL. Aitutaki: UWBM 3005, vertebra, Hosea site, TP1; UWBM 3154, tarsometatarsus, MR1, TP7.

REMARKS. This migratory species is an uncommon but regular visitor to the Cook Islands. Child (1981) recorded two cuckoos

on 31 August and one on 1 September 1980. The only cuckoo I saw in 1987 was on 28 November. The probable cause of this relative scarcity is that most individuals of *Eudynamis taitensis* migrate to New Zealand to breed during the austral summer. Other archaeological records of *E. taitensis* are from 'Eua, Tikopia, Anuta, and New Caledonia.

Order APODIFORMES  
Family APODIDAE

*Collocalia sawtelli* Holyoak. Atiu Swiftlet

MATERIAL. Atiu: UWBM 37, ulna, Te Ana o Raka, near entrance; UWBM 44–48, 420–423, coracoid, four ulnae, manus phalanx, three tibiotarsi, Ana Takitaki, 40 m from entrance; UWBM 49–62, 424–427, six coracoids, six ulnae, two radii, two carpometacarpi, two tibiotarsi, Ana Takitaki, 100 m from entrance; UWBM 38, ulna, Ana Takitaki, 120 m from entrance.

REMARKS. We found *Collocalia sawtelli*, regarded as an endemic species, to be common on Atiu in 1987, foraging during the day over both open and forested terrain. This small swift roosts and nests in at least three caves on Atiu. The largest colony is deep within Ana Takitaki, the type locality (Holyoak 1974, Holyoak and Thibault 1978 [called "Cave of the Kopeka" by Taylor (1984)]). We did not attempt to count the nests or birds systematically, but we roughly estimate that 200 to 400 swiftlets inhabit Ana Takitaki. The ulna from Te Ana o Raka is the first record of *C. sawtelli* from that cave, where we did not notice any nests during our single day of exploration. On 23 September 1987 we saw five *C. sawtelli* flying into an inaccessible section of Ana Vaitupuranga, the resident swiftlet population of which is unknown.

*Collocalia sawtelli* probably is not truly endemic to Atiu. On Mitiaro in 1987, Mr. Tiki Tetava told me that "an old man" had told him that the *kopeka* of Atiu (= *C. sawtelli*) used to live on Mitiaro. Compared to Atiu, Mitiaro has very few caves, which would increase the vulnerability of swiftlets. It seems likely that *C. sawtelli* also once occurred in the

caves of Ma'uke and Mangaia, although evidence is lacking.

Order CORACIIFORMES  
Family ALCEDINIDAE

*Halcyon tuta* Gmelin. Chattering Kingfisher

MATERIAL. UWBM 34, carpometacarpus, Ana Pau Atea, 30 m from entrance; UWBM 39, coracoid, Ana Takitaki, big room.

REMARKS. *Halcyon tuta* (the endemic subspecies *H. t. atiu*) is locally common in forested and partially forested areas of the *makatea* on Atiu. It is either absent or extremely rare in the eroded volcanic terrain of central Atiu because of near total forest clearance (Franklin and Steadman, in press). *Halcyon tuta* also occurs on Ma'uke (endemic subspecies *H. t. mauke*) and various of the Society Islands. The related kingfishers from Mangaia and the Tuamotu Islands are distinctive enough to be classified usually as separate species, *H. mangaia* and *H. gambieri*. Other archaeological records of the *Halcyon tuta* species-group are from Huahine and Mangaia.

DISCUSSION

Of the 20 species of birds represented in the prehistoric sites on Aitutaki and Atiu, only two species, the rail *Porzana tabuensis* and the parrot *Vini kuhlii*, are shared by both islands. This low level of similarity is due to several factors, none of which is related to potential biogeographic differences between the two islands. First, the sites on Aitutaki are open sand deposits, with the exception of Moturakau Rockshelter. All of the sites on Atiu are limestone caves that virtually lack sedimentation. Second, the sites on Aitutaki are on or near the coast, while those on Atiu are in upland forests up to 1.5 km from the ocean. As a result, only the Aitutaki sites contained a variety of seabirds and shorebirds. Third, the relative abundance of chicken bones in the Aitutaki faunas is because, unlike on Atiu, the sites on Aitutaki represent human habitation



sites, even though some of the deposits probably derive from very short-term habitation.

### *Aitutaki*

The most significant discoveries among the bird bones from the Ureia site were those of the giant, extinct whistling duck (cf. *Dendrocygna*, species unknown) and the Sooty Crake (*Porzana tabuensis*). The single terminal phalanx of cf. *Dendrocygna* is distinct from that of other types of waterfowl as well as all other families of birds. Although the specimen from Aitutaki is an inadequate basis for describing a new species, it is much larger than in any modern species of *Dendrocygna* and undoubtedly represents an extinct, undescribed species. *Dendrocygna* is previously unknown and unsuspected for eastern Polynesia. Fiji and New Caledonia are the localities nearest to Aitutaki where a living species of *Dendrocygna* has been recorded, although the nearest extant populations are in Australia, New Guinea, and New Britain. *Porzana tabuensis*, also recovered from the Moturakau Rockshelter, has not been recorded previously from Aitutaki, although modern records of this small rail exist from Atiu, Mitiaro, and Mangaia. The other extirpated birds represented by bones are the Tahiti Petrel (*Pterodroma rostrata*) from Moturakau Rockshelter, Red-footed Booby (*Sula sula*) from Aretai site, and Rimatara Lorikeet (*Vini kuhlii*) from the Hosea site.

The modern vegetation of Aitutaki includes no areas unmodified by people (Stoddart 1975), and this probably has been the case for many hundreds of years. Although a  $^{14}\text{C}$  date of  $1040 \pm 80$  yr B.P. from AIT10 is the oldest available from Aitutaki, it is likely that much of eastern Polynesia has been occupied for 1500 to 2000 years (Kirch 1986, Steadman and Kirch 1990). Thus, Aitutaki may have been inhabited for up to a millennium earlier than the oldest radiocarbon date. That species of birds were lost on Aitutaki is no surprise. It is much more shocking that the large, extinct *Dendrocygna* survived on Aitutaki as long as it did. While the extinct species of waterfowl (*moa-nalo*) of Hawaii were flightless (Olson and James, in press), more bones

are needed to determine if the extinct whistling duck of Aitutaki was volant. The only other indigenous bird represented at AIT10 is *Porzana tabuensis*, a small rail that also is extinct on Aitutaki.

Compared to other islands in eastern Polynesia with archaeological records of birds, particularly nearby Mangaia (Steadman 1985, 1987, 1989; Steadman and Kirch 1990), the low number (two) of extinct or extirpated species recovered at AIT10 suggests that many of the native birds already were lost on Aitutaki by the time cultural deposition began at AIT10. This idea is reinforced by the lack of bones of pigeons, doves, parrots, and flightless rails at AIT10, as well as the abundance of chicken bones (49% of all bones).

The modern avifauna of Aitutaki is depauperate. The small parrot *Vini peruviana* is the only surviving land bird that might be indigenous. Various authors have indicated that *V. peruviana* may have been brought to Aitutaki from the Tuamotu or Society islands. I have found no solid evidence for this except that the prehistoric records of *V. kuhlii* from Mangaia, Atiu, and Aitutaki suggest that *V. kuhlii* was indigenous to the southern Cook Islands. Whether *V. kuhlii* and *V. peruviana* could have co-existed is unknown.

Some older people on Aitutaki recall the uncommon and localized presence there of the rupe (Pacific Pigeon, *Ducula pacifica*) and kukupa (Cook Islands Fruit-Dove, *Ptilinopus rarotongensis*) until the 1940s or early 1950s. No specimens of either of these columbids have ever been taken on Aitutaki, although this island had been very poorly collected for birds before 1987. (Like the other southern Cook Islands, Aitutaki was not visited by the otherwise fairly exhaustive Whitney South Sea Expedition in the 1920s and 1930s. D. T. Holyoak's collections and observations in 1973 were based upon less than 24 hr on Aitutaki.) The amount of suitable habitat on Aitutaki in the twentieth century for *D. pacifica* and *P. rarotongensis* must have been very limited and undoubtedly was greatly reduced when the airport was made in 1942. Commercial citrus groves were developed on Aitutaki in the 1950s, with heavy use of pesticides (T. Tuakura, pers. comm.). It was

also about this time that *Acridotheres tristis*, the Common Myna, was introduced. This aggressive pest now is abundant everywhere on the island. Thus, the poorly documented final demise of columbids on Aitutaki, perhaps like that of *Dendrocygna*, probably was related to forest clearing and predation from humans. Secondary factors might include pesticides, competition from the Common Myna, disease, and predation from rats and cats.

The much greater variety of birds at Moturakau Rockshelter versus all of the sites on Aitutaki proper indicates that in pre-historic times, just as today, shorebirds and seabirds were scarcer along the coasts of Aitutaki proper than on or near the off-shore islets. Human impact accounts for this difference.

### Atiu

The surviving land bird fauna of Atiu is in much better condition than that of Aitutaki. This is because much of the rugged limestone *makatea* of Atiu is unsuited for agriculture or human habitation and therefore is mostly forested with indigenous trees (Franklin and Merlin, in press). During September–October 1987, *Ducula pacifica* and *Ptilinopus rarotongensis* both were common in relatively undisturbed *makatea* forest. Franklin and Steadman (in press) classified nearly 40% of Atiu's total land area as "good to very good" habitat for *D. pacifica* and "fair to very good" habitat for *P. rarotongensis* (Table 6). Much of the island is also well suited for

*Halcyon tuta atiu*. *Collocalia sawtelli* feeds over the entire island but is vulnerable to disturbances of its nesting sites in caves. Unfortunately, the introduced Common Myna, *Acridotheres tristis*, is extremely abundant on Atiu in all habitats except undisturbed forest. The long-term impact of *A. tristis* on indigenous land birds is poorly understood (Steadman et al. 1990a).

At least two factors explain the scarcity of bird bones, including the lack of seabird bones, in Atiuan caves compared to Mangaian caves. First, each of the ca. 20 caves explored on Atiu, except Te Ana o Raka, Ana Vaitupuranga, Ana Takitaki, and Ana Pau Atea, exhibit two or more of these features in most or all of their passages: small; humid; few horizontal surfaces on the floors to act as catchment basins; and intercepts the water table. These features result in physical and geochemical environments that are unfavorable for deposition and long-term preservation of bones. For the four caves just named, however, there seems to be little about the physical or geochemical environment that would prohibit bone preservation, which brings us to the second scarcity factor: the virtual lack of human habitation in Atiuan caves. Although human burials often are present (usually with rather poor preservation of bones), the caves on Atiu, unlike many on Mangaia, lack evidence of long-term pre-historic occupation such as kitchen middens. The Atiuan with whom we worked consistently told us that, unlike the early Mangaian, their ancestors did not live in

TABLE 6

AVAILABLE HABITAT FOR LAND BIRDS ON ATIU, COOK ISLANDS, EXPRESSED AS % OF TOTAL LAND AREA

SPECIES	0 NOT USED	1 VPOOR	2 POOR	3 FAIR	4 GOOD	5 VGOOD
<i>Anas superciliosa</i>	86.9	1.1	2.1	7.8	0	2.1
<i>Porzana tabuensis</i>	94.6	0	1.1	0	2.1	2.1
<i>Ptilinopus rarotongensis</i>	30.2	22.7	7.6	18.6	0	20.8
<i>Ducula pacifica</i>	27.1	15.9	17.6	0	18.6	20.8
<i>Halcyon tuta</i>	21.7	11.9	21.2	5.8	33.0	6.4

NOTE: Habitat suitability classes are defined as follows: 0 (not used) = never used for feeding or nesting; 1 (very poor) = limited or no feeding, no nesting; 2 (poor) = occasional feeding, little or no nesting; 3 (fair) = mainly feeding, uncommon nesting; 4 (good) = regular feeding and nesting; 5 (very good) = preferred nesting sites, abundant food. Data from Franklin and Steadman (in press).



caves. On Mangaia, caves were inhabited only by defeated tribes who were hiding from their enemies. Compared to at least some of the inhabited Mangaian caves, I noticed that the Atiuan caves have entrances that would be difficult to defend from attack.

The chronology of extinction on Atiu is poorly known. Each of the three species of extirpated birds from Atiu (*Gallicolumba erythroptera*, *Ducula aurorae*, *Vini kuhlii*) is known as well from the stratified, well-dated Tangatatau Rockshelter site on Mangaia, where they did not survive beyond ca. 700 yr B.P. (Steadman and Kirch 1990). Assuming a similar time of human arrival on Atiu and Mangaia, the bones from Atiu probably are at least 700 yr old, particularly considering that the *makatea* region of Atiu is smaller in area and somewhat less rugged than on Mangaia.

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