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Lizards from prehistoric sites on Ebon Atoll, Marshall Islands

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Abstract—A small collection of lizard bones was recovered during extensive archaeological excavations on Ebon Atoll, Marshall Islands. Most of the bones are from the large terrestrial skink *Eugongylus albofasciolatus*, the only lizard known in the literature from the atoll. The oldest bones date to 1560 + 70 years BP. Represented by a single bone each are the skink *Emoia* cf. *E. arnoensis* or *E. boettgeri*, the House gecko *Hemidactylus frenatus*, and the Oceanic gecko *Gehyra oceanica*. The House gecko was found in the oldest prehistoric strata, the Oceanic gecko in late prehistoric, and the *Emoia* in historic. Human settlement of the Marshall Islands occurred 2000 years BP following regression on-set of Mid-Holocene High (MHH) sea-level. Lizards probably did not begin colonizing the islands until this same time.

Introduction

Pacific island lizards occur on nearly every emergent piece of land that remains dry at high tide. Numerous species and populations, especially small geckos and skinks, probably reached their destinations as passive stowaways beginning with human settlement (Austin 1999, Case & Bolger 1991). Other species that colonized by natural dispersal from one island group to another typically have more circumscribed distributions. (Crombie & Pregill 1999, Crombie & Steadman 1987, Pregill 1993). Actual documentation of prehistoric and prehuman occurrences of lizards on Pacific islands comes from the bones preserved in archaeological (cultural) and paleontological (noncultural) sites. In most instances bone records date from about the mid-Holocene. In Micronesia, lizard fossils are known only from the Mariana Islands (Pregill 1998) and from a few late prehistoric sites in Palau (Pregill & Steadman 2000). Herein we discuss a small collection of lizard bones screened from prehistoric cultural deposits on Ebon Atoll, Marshall Islands.

Scattered across 2 million km^2 of ocean at the eastern limits of Micronesia, the Marshall Islands consist of 29 atolls, and five coral islands without lagoons. The islands are grouped in two roughly parallel alignments trending northwest-southeast over 1200 km between 4° and 12° latitude. There is a marked rainfall gradient from 900 mm in the dry north to about 4000 mm in the wet south. This

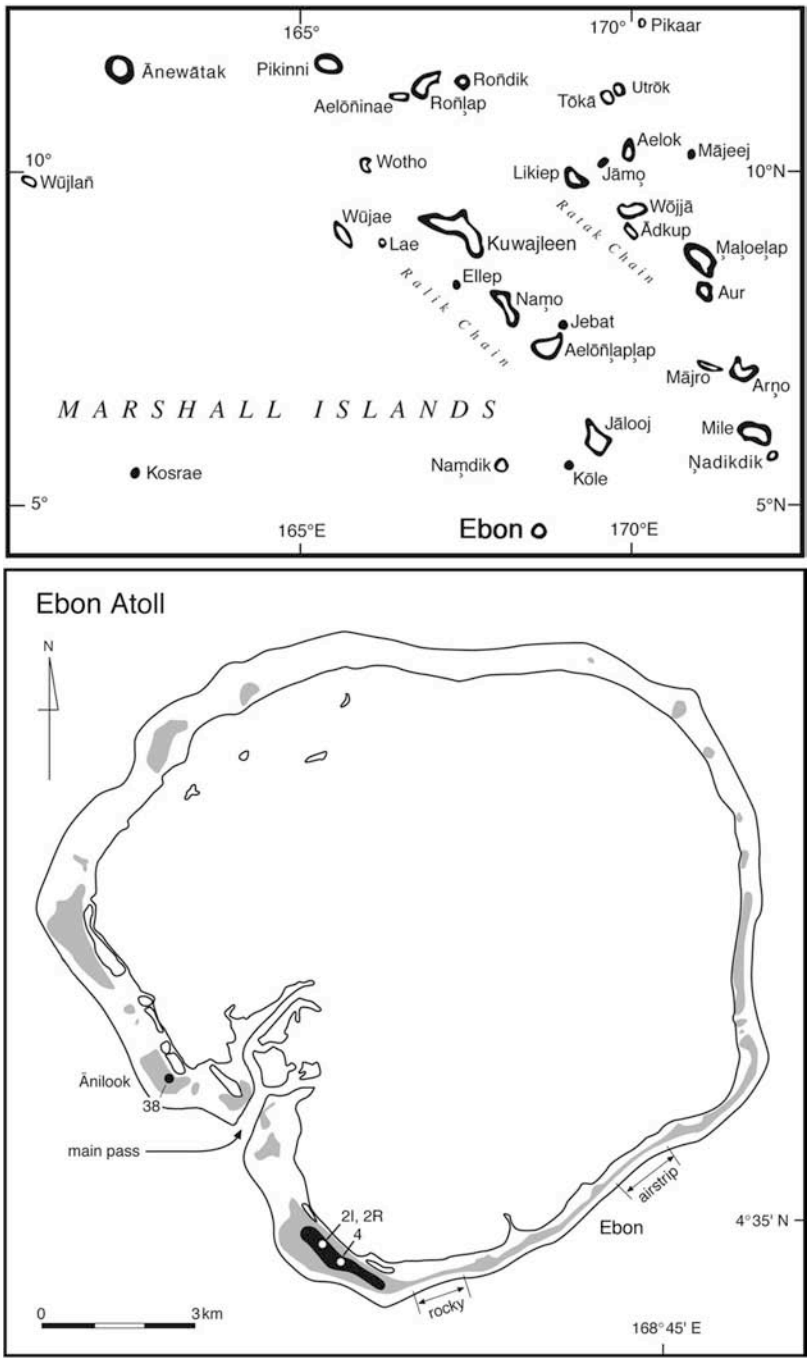

Figure 1. The Marshall Islands (top) and Ebon Atoll (below) showing locations of bone-bearing deposits described in the text.

precipitation trend not only influenced the distribution of plants and animals, but also the density of prehistoric human settlement (Weisler 2001a; Williamson & Sabath 1982). Recent archaeological studies of the Marshall Islands document human colonization and settlement of the archipelago at around 2000 BP (Riley 1987, Shun & Athens 1990, Weisler 1999a, 2000, 2001b). Since 1993, a multi-disciplinary project has been examining human colonization of these small, dispersed landmasses and the historical transformations of atoll societies (Weisler 2001a). Excavations have been conducted throughout the archipelago (Weisler 1999b, 2001b, 2002). On Ebon Atoll, nearly 28,000 bones were recovered, among which were 18 lizard bones representing four species.

Other than species lists for a few islands and atolls (e.g., Lamberson 1987, Marshall 1951), no comprehensive checklist of the Marshall Island lizard fauna has been published. There are no endemic species. Museum records reflect an opportunistic and sporadic history of collecting, and only one species, *Eugongulus albofasciolatus*, has been taken from Ebon Atoll (Schnee 1902). Most of the species recorded in the Marshalls are geckos and skinks widespread in the Pacific, for example *Leptodactylus lugubris, Hemidactyus frenatus, Gehyra oceanica, Emoia cyanura* and *Lipinia noctua*. Others, such as *Lamprolepis smaragdina* and *Perochirus ateles*, range erratically through the Carolines and Marianas (Crombie & Pregill 1999).

Materials and Methods

The southernmost of the Marshall Islands, Ebon Atoll ranks 14th in land area at 5.75 km^2 and consists of 16 islets that surround a lagoon 12 km wide (Fig 1). Nineteen prehistoric sites including middens, horticultural areas (aroid pit systems) and a trail were inventoried. Five habitations were test excavated, totaling 64 m^2 (Weisler 2002). Sediment was screened through 6.4 mm dry and wet sieves. Sediment colors were designated using the Munsell Soil Color Charts (1994 edition). Most of the food bones were fish, but also present were dog, bird, toothed whale and sea turtle. Probable non-food bones were those of rat, mouse, and lizard. Stratigraphy and age determinations of the lizard bones are described below and listed in Table 1. Radiocarbon age determinations were calibrated after Stuiver & Reimer (1993) and Reimer et al. (2004).

Lizard bones were identified with the aid of comparative skeletons borrowed from Museum collections: San Diego Natural History Museum, SDSNH; National Museum of Natural History Smithsonian Institution, USNM.

Results

The following site descriptions are based on Weisler (2002).

SITES 2I AND 2R.

These two sites are part of a nearly continuous 2-km long habitation and horticultural system along the broadest width of Ebon islet. Some of these sites were partially recorded earlier by Rosendahl (1987). The sites consisted of sever-

Table 1. Lizard bones, provenance, and associated radiocarbon age determinations, Ebon Atoll.

Taxon	Element	Site	Unit	Layer/ Spit	Depth Below Surface (cm)	Lab Number	Conventional Age	Calibrated at 2 Sigma
Emoia cf. E. boettgeri or *E. arnoensis*	lt pelvis	2I	2	I/1	0-10			
Geyra oceania	frontal	2I	7	IA/1	0-12			
Eugongylus albofasciolatus	frontal	2I	15	IA/1	0-10			
Eugongylus albofasciolatus	frontal	2I	16	IA/1	0-10			
Eugongylus albofasciolatus	lt mandible	2I	16	IA/1	0-10			
Eugongylus albofasciolatus	lt articular	2I	16	IA/1	0-10			
Eugongylus albofasciolatus	frontal	2I	16	IA/4	30-37			
Eugongylus albofasciolatus	femur	2I	16	IA/4	30-37			
Eugongylus albofasciolatus	parietal	2I	18	IB/13	126-180	92126	870 ± 60 BP	1036-1260
Eugongylus albofasciolatus	rt dentary	2I	19	IC/10	90-100	92127	750 ± 50 BP	1177-1384
Eugongylus albofasciolatus	lt pelvis	2R	3	IA/1	0-11			
Eugongylus albofasciolatus	frontal	2R	5	IA/1	0-12			
Eugongylus albofasciolatus	lt ang surangular	2R	6	IA/1	0-10			
Eugongylus albofasciolatus	sacrum	4	5	IB/9	81-95	92132	1420 ± 110 BP	409-869
Eugongylus albofasciolatus	rt maxilla	38	3	IA/6	48-65*	92134	1560 ± 70 BP	349-641
Hemidactylus frenatus	frontal	38	6	IA/1	0-10	92134	1560 ± 70 BP	349-641
Eugongylus albofasciolatus	rt dentary	38	7	IA/1	0-10	92134	1560 ± 70 BP	349-641
Eugongylus albofasciolatus	femur	38	7	IA/1	0-10	92134	1560 ± 70 BP	349-641

Lab number preceded by Beta-. Calibrated after Stuiver & Reimer (1993) and Reimer et al. (2004).

* Bones were recovered in a combustion feature within Layer IA.

al low earthen habitation mounds, scatters of fragmented food shellfish, prehistoric shell tools, and aroid pits extending up to 600 m inland that currently are used to grow Giant Swamp Taro (*Cyrtosperma chamissonis*). Twenty-six 1-m^2 units were excavated, from which lizard bones occurred in nine.

The bones were recovered from prehistoric cultural layers in black (2.5Y2/0) gravely sand with combustion features. Artifacts included coral abraders, *Tridacna* shell adze fragments, hammerstones, worked pearlshell and *Conus* beads, along with abundant bone of other vertebrates (fish) and shellfish. Possibly the bone of *Gehyra oceanica* (Table 1) was deposited in the early historic period. The bones of *Eugongylus albofasciolatus* from units18 and 19 were retrieved at greater depths associated with prehistoric radiocarbon age determinations calibrated between the 11th and 14th centuries AD (Beta-92126 and -92127; Table 1).

A bone of a smaller skink found in historic age strata (Site 2I, unit 2/1) came from a moderate size species approximately 75-80 mm snout-vent length. It represents a species of the large, diverse genus *Emoia,* possibly *E. boettgeri* or *E. arnoensis*,

SITE 4

Situated 500 m southeast of site 2R along Ebon islet, site 4 is marked by dense concentrations of surface artifacts and food shellfish. A single bone of *Eugongylus albofasciolatus* was recovered from unit 5 Layer IB (dusky red [2.5YR3/N3] sandy gravel) along with bones of fish, bird, Pacific rat, and sea turtle. Prehistoric artifacts included a pearlshell fishhook tab and worked shell. Layer IB is associated with a radiocarbon age determination calibrated to the 5th to 9th centuries (Beta-92132).

SITE 38

Seven 1-m^2 units were excavated in this habitation and horticultural site located on the lagoon half of Enilok islet. Lizard bones (*Eugongylus albofasciolatus* and cf. *Hemidactylus frenatus*) were recovered from three units, all from Layer IA the main prehistoric cultural layer of the site. Also recovered was abundant evidence of *Pinctada* pearlshell fishhook manufacture, bones of fish and sea birds, and large fragments of food shellfish. An earth oven in this layer had a calibrated age spanning the 4th to 7th centuries A D (Beta-92134).

Discussion

Of the 18 lizard bones recovered, 15 are those of the skink *Eugongylus albofasciolatus* (Table 1). Compared with most Pacific island lizards, *E. albofasciolatus* is a comparatively large species (adults to ca. 145 mm snout-vent length), a fact that accounts for its dominance among the lizard bones screened from large-mesh sieves. This skink is a terrestrial, generally secretive species of dense cover (Buden 1996a,b). The crowns of posterior teeth, we note, are large and blunt, which in other lizards is associated with a durophagus diet (Pregill

1984). Marshall (1951) in fact reported snails in stomach contents of three specimens. *Eugongylus albofasciolatus* is known elsewhere in the Marshall Islands from Arno Atoll and Jaliut Atoll. In the Caroline Islands it occurs in Pohnpei (incuding Ant, Mokil, Oroluk, Pingelap) Chuuk (Namoluk) and Yap (Ifalik).

The single bone of a smaller skink is tentatively referred to either *Emoia boettgeri* or *E. arnoensis*. Both of these species occur in the Marshall Islands (Marshall 1951, Brown & Marshall 1953) and parts of the Carolines (Brown 1991).

A single bone each of the Oceanic gecko, *Gehyra oceanica*, and the smaller House gecko *Hemidacylus frenatus* were screened from Sites 2I and 38, respectively. The frontal bone of *Gehyra* is a distinctive element (Pregill 1993). The bone was recovered from a late prehistoric/early historic layer probably dating to around the 17th century. *Gehyra oceanica* is widely distributed in Oceania. Micronesian populations are distinguishable from those in Polynesia both morphologically and by proteins (Beckon 1992, Fisher 1997). In Polynesia its distribution corresponds with patterns of early human settlement, whereas in Micronesia it appears to be a more recent adventive (Beckon 1992, Pregill 1998). Elsewhere in Micronesia this species is known as a fossil only from the northern Mariana Islands. Those fossils were confined to historic age strata that, along with other evidence, indicate that it was also a late arrival to the islands (Pregill 1998).

The single frontal bone of the smaller gecko is unremarkable. Among Pacific geckos of comparable size (ca. 50-60 mm svl), the bone most closely corresponds with that of *Hemidactylus frenatus*. The frontal of *Nactus pelagicus* is long and narrow, whereas that of *Perochirus ateles* is proportionately broader with upturned supraorbital margins (Pregill, 1993). *Hemidactylus frenatus* is a quintessential "house lizard" that was introduced widely throughout the Pacific in historic times. In Polynesia, introductions occurred primarily since WWII (Case et al. 1994), but in Micronesia the house gecko apparently has a deeper history. In the northern Marianas it was recovered from early prehistoric strata (Pregill 1998), and the Ebon Atoll fossil was from a layer dated to the 4th to 7th centuries AD.

COLONIZATION AND HOLOCENE SEA LEVELS

The bone record for Ebon Atoll documents the prehistoric presence of at least three species of lizards (*Eugongylus albofasciolatu, Emoia* cf. *E. boettgeri* or *E. arnoensis, Hemidactylus frenatus*). The bone sample, however, is insufficient to suggest confidently when the actual earliest colonization might have been. On low-lying islands and atolls that experience sea level inundation, successful colonization by terrestrial reptiles and mammals can occur only after a high sea level event has passed. Recent studies of paleoshorelines (Dickinson 1999, 2003) coupled with archaeological excavations (e.g. Weisler 2001) demonstrate that people first colonized the Marshall Islands after on-set of mid-

Holocene high sea level regression. Across the Pacific, mid-Holocene high (MHH) sea levels at 4000–3000 BC peaked at around 2000 BC in the central Pacific (Dickinson 2003). In the Marshalls sea levels at low tide rose to slightly over 2 m above present levels. Atolls with elevations of 2–4 m would have been submerged in the mid Holocene. Minimally, any emergent land would have been subject to tidal and storm surges. Human habitation was not possible, and neither perhaps was it for any terrestrial vertebrate. Generally, habitability was not obtained until the cross over date when high tide levels fell below MHH low tide levels. Cross over dates vary across the Pacific from around AD 500 -1400 depending on the island group, for example AD 1000-1200 in the Marshalls (Dickinson 1999, 2003). Humans, however, colonized the Marshalls almost a millennium before the cross over date. These and other atolls in the central Pacific were habitable earlier than islands in the South Pacific probably because tidal ranges in the central Pacific are nearly twice as great as those in the south. Consequently, mid-Holocene reef flats projected higher at low tides, and allowed for faster and earlier accumulations of unconsolidated sediment (Dickinson 2003).

Ebon Atoll's highest elevation currently is no more than 3 m. If any dry land was exposed during MHH it must have been a fraction of what it is today. Conceivably, *Eugongylus albofasciolatus* colonized prior to the MHH and survived in small demes amongst scant terrestrial vegetation. More likely it colonized sometime after the on-set of sea level regression. We know it was present by no more than 400-500 years after first human settlement. It may have reached the Marshalls by waif dispersal from sources in the Carolines, or it was unintentionally brought in by people. Burial artifacts from Majuro indicate inter-island contact among not only other Marshall Islanders, but also with people farther west in the Carolines to Chuuk and Pohnpei (Weisler 2000), where *E. albofasciolatus* occurs.

The smaller lizards are stronger candidates for human-mediated dispersal. For example, the skinks *Emoia arnoensis* and *E. boettgeri* are active diurnal species that scavenge around dwellings and coconut debris near beach strand. They could easily climb into a canoe, and Marshall (1951) observed as much on Arno Atoll (Brown & Marshall 1953).

Dated bone records, even small ones like this, are indispensable for constructing a history of Pacific island reptiles, a history that would otherwise rest on speculation. Future paleontological studies in the Marshall Islands would benefit from fine-mesh (1.6 mm) screening. Fine-mesh sieves will increase the sample size of bones from smaller species, and help clarify the chronology of lizard colonization.

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