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Fossil Lizards from the Late Quaternary of 'Eua, Tonga[1]

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ABSTRACT: The lizard fauna of Polynesia consists mainly of skinks and geckos that are believed to have reached many of the islands by way of human assistance beginning with the early Polynesian voyagers. Documenting the natural versus human-assisted origins of lizards in the Pacific would be greatly enhanced by a fossil record, but that record for lizards has been limited to a few archaeological and noncultural sites that postdate human arrival. This study reports fossil remains of eight, possibly nine, species of lizards screened from cave sediments on 'Eua, Tonga. One of these deposits is precultural, the deepest layers of which were excavated from below a calcite lens dated at ca. 60,000 to 80,000 yr B.P. Fossils from the precultural strata include a gecko referred to *Perochirus* sp., a genus known today no nearer than Vanuatu; a skink representing either an undescribed species of *Emoia* or *Emoia trossula* Brown & Gibbons; and remains of the widespread *Emoia cyanura* (Lesson). A single bone of an unidentified large (> 150 mm snout–vent length) skink (cf. *Emoia, Eugongylus*) was recovered from deposits of post–human arrival age, but no such large skinks are currently known from the island. Additional cave sites yielded essentially contemporaneous remains of species extant on 'Eua: *Gehyra oceanica* (Lesson), *Lepidodactylus* cf. *lugubris* (Duméril & Bibron), *Nactus pelagicus* (Girard), *Cryptoblepharus poecilopleurus* (Wiegmann), and *Lipinia noctua* (Lesson). No fossil evidence was found of the Crested Iguana, *Brachylophus fasciatus* (Brongniart), whose presence on 'Eua never has been verified by specimens.

THE FOSSIL RECORD for lizards in Polynesia is brief. In all instances the few specimens from archaeological excavations or noncultural sites are younger than the earliest human occupation. For example, seven lizard species are known from the Kuakini archaeological site near Kona, Hawaii (Pregill 1984). On Aitutaki and Atiu, Cook Island Group, excavations of cultural and noncultural sites have yielded remains of vertebrates including lizards, but only the birds have been identified (Steadman 1991). Perhaps the most unusual lizard fossils from Polynesia are the remains of extinct giant iguanas (*Brachylophus* spp.) unearthed at the Tongoleleka archaeological site on Lifuka, Ha'apai Group, Tonga (Pregill and Dye 1989).

This paper describes fossils of eight, possibly nine, species of lizards from Late Quaternary cave deposits on the island of 'Eua in southern Tonga (Figure 1). Bones of three of these species were recovered from precultural sediment. Lizard bones from eight other caves were also found, all of which are referable to species extant on 'Eua.

I visited 'Eua from 20 November to 3 December 1987 to collect and study resident lizard populations and to search for fossil deposits in caves and other erosional features in the island's limestone cliffs. I dug test pits and screened sediment in three sites that were noted briefly by Steadman (1989). Parties led by David Steadman visited the island from 24 November to 17 December 1988 and from 22 November to 16 December 1989 to continue

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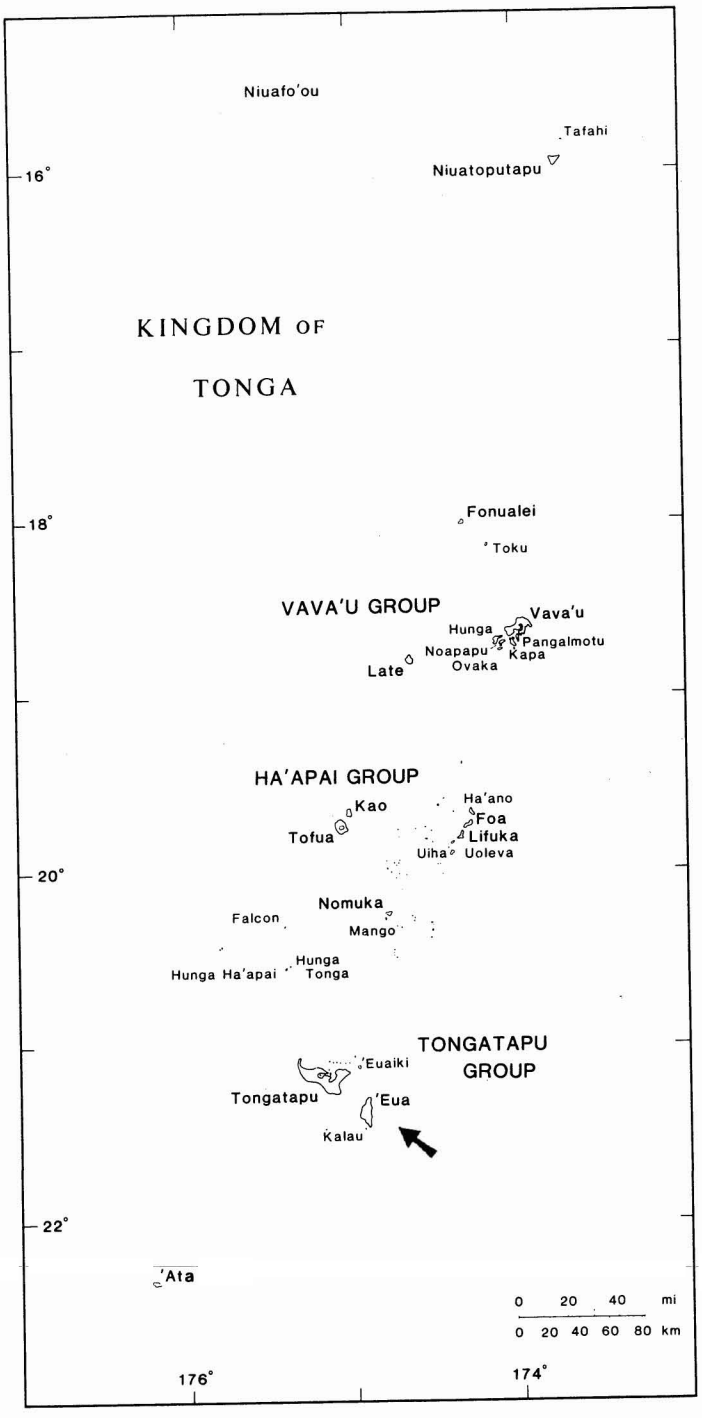

FIGURE 1. The Kingdom of Tonga, showing the location of 'Eua in the Tongatapu Group.

these excavations and search for additional fossil-bearing sites.

General Description of 'Eua

'Eua is a small island (87 km^2) oriented on a north-south axis. It has a maximum length of about 19 km and narrows sharply at its northern and southern ends (Figure 2). The widest part of the island, about 7 km, is across the east-west midsection. 'Eua's geology and physiography were described by Hoffmeister (1932), and there are also recent descriptions of 'Eua's limestone and caves by Cunningham and Anscombe (1985) and Lowe and Gunn (1986). Like most of southern Tonga, 'Eua is composed of bedded volcanics capped by thick deposits of Miocene and younger limestone.

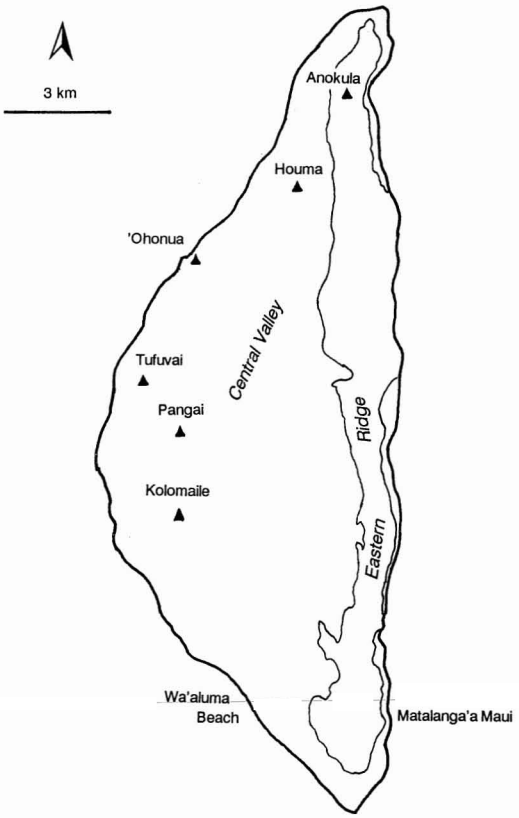

FIGURE 2. 'Eua, Tonga, showing principal localities and physiographic features discussed in text. Most of the fossiliferous caves are located on the windward (eastern) cliffs of the eastern ridge.

Hoffmeister's (1932) six physiographic provinces remain useful descriptions of the island. From east to west these are as follows: (1) eastern terraces and coast region, (2) eastern ridge (including several subprovinces), (3) western slope of the eastern ridge, (4) central valley, (5) western ridge summit, and (6) western slope terraces and coast region. The eastern ridge is 'Eua's most prominent physiographic feature, dominating the east coast of the island for nearly its entire length (Figure 2). The central portion of the ridge reaches a maximum elevation of 312 m, the highest point on the island. The windward (east) side of the ridge is defined by a series of steep cliffs, broken occasionally by terraces of forest and small gardens.

To the west of the eastern ridge the terrain slopes gently toward the large central valley, defined on the west by a gentler ridge that more or less follows the contour of the west coast. The western ridge summit meets the central valley at about the 100-m contour. A narrow fringing reef surrounds most of the island.

Rich volcanic soils have washed into the central valley, and, where not cleared for settlements or plantations, there are scattered stands of second-growth forest and fallow gardens of coconut and citrus. Much of the island is or has been under cultivation and grazing for many generations. Plantations of from one to many hectares form a patchwork over the island, even in seemingly inaccessible terrain such as the terraces seaward of the eastern ridge. This narrow stretch of the island, however, still supports the most extensive stands of undisturbed forest. The western slope of the eastern ridge maintains some fairly luxurious deciduous and evergreen woodlands, although numerous small plantations encroach up from the central valley. 'Eua's fertile soil and good climate have brought increasingly heavy agricultural demands. In fact, much of the harvest of yams, taro, bananas, manioc, sweet potatoes, and papayas is exported to Tongatapu. Undoubtedly, this transformed landscape has affected

the density and distribution of the island's lizard populations.

MATERIALS AND METHODS

Cave Sites

The limestone of the eastern ridge is deeply weathered along the windward (eastern) side, leaving numerous caves and other erosional features exposed in the forested cliffs. Remains of native vertebrate species were found in the sediment of 12 caves scattered along the length of the windward side of the eastern ridge. The bones, all recovered by screening sediment through 6-mm (1/4″) and 3-mm (1/8″) mesh, mainly represent ancient prey remains brought into the caves by Barn Owls (*Tyto* spp.). The most important of these sites are That Cave, Tupou Cave, Collapse Cave, and 'Anatu. That Cave and Tupou Cave are located near the northeastern coast, just below Anokula. The abundance of rat (*Rattus* spp.) bones in the sediments of That Cave and Tupou Cave indicate that the fossil deposits postdate the arrival of people to 'Eua and are less than 3000 yr old. Collapse Cave is located 2 km east of Kolomaile village. No excavations were conducted in Collapse Cave, but bones of birds and bats were found scattered on the surface, the age of which is unknown because of the lack of cultural or sedimentary contexts, but most probably they are also latest Holocene. Similarly, Paul's Cave practically lacks sediment altogether. The bones collected there were all concentrated on the surface of a shallow pocket. Paul's Cave is located on a cliff face near the extreme southernmost tip of 'Eua, ca. 1.5 km S of Matalanga'a Maui.

'Anatu (Ground Dove Cave) is located in a terrace cliff near the southern end of 'Eua. This cave is a particularly important fossil site because the deepest strata are precultural, and overall the site yielded the greatest number of fossil vertebrates, including a lizard and numerous species of birds that no longer occur on the island. The sediment in 'Anatu is stratified into three distinct, dateable layers (Steadman in press). Layer I consists of 40 cm of relatively organic, charcoal-rich sediment that represents roughly the past 3000 yr, based on the represented fauna and ^{14}C dates of 570 ± 70 yr B.P. at 20 cm and another of 2710 ± 70 yr B.P. at 36 cm. Many of the bones in layer I, other than those of rats, are from domestic animals such as chickens, pigs, and dogs that were brought to 'Eua by early people. Layers II and III comprise about 100 cm of calcareous sediment lacking cultural artifacts (charcoal) or remains of domestic animals. These layers predate human arrival and contain partially mineralized bones of native lizards (three, probably four, species described herein), birds (27 species of land birds, of which 21 no longer occur on 'Eua [Steadman in press]), and bats (at least five species, of which three no longer occur on 'Eua, under study by K. F. Koopman). Between layers II and III is a 3- to 4-cm layer of calcite flowstone having Ur/Th dates ranging from 60.0 ± 3.0 to 78.8 ± 2.7 kyr B.P. (Steadman in press). The deposits of layer III are, therefore, at least of an age that makes 'Anatu by far the oldest fossil site in all of Polynesia outside of Hawaii and New Zealand.

Systematic Paleontology

Fossils were identified with the aid of comparative skeletons, most of which were made from specimens collected in the field on 'Eua and deposited in the collections of the San Diego Natural History Museum (SDSNH). Estimates of snout–vent length (svl) for fossil individuals were determined by extrapolating from ratios of measurements taken from comparative skeletons of known size. The terrestrial reptile fauna of 'Eua consists of five species of geckos and four, possibly five, species of skinks. The first recorded specimens are those of Burt and Burt (1932), who listed three species from the island. Recent collecting activity has expanded the lizard fauna to the nine species now known (Gibbons and Zug 1987, Gill 1987, 1988, 1990, Gibbons and Brown 1988, Gill and Rinke 1990). These literature records along with my own observations are summarized in the following accounts.

RESULTS

GEKKONIDAE

Gehyra oceanica (Lesson). Oceanic Gecko

MATERIAL EXAMINED: 'Anatu: Layer I, dentary (2L, 1R); articular + surangular (1L, 2R); maxilla (2L); pterygoid (1L); frontal (two complete, two partial).

That Cave: Dentary (1L, 3R); articular + surangular (1R); maxilla (1L, 2R); frontal (2).

Cave 1 of McKern: Frontal (one partial).

Collapse Cave: Dentary (1L).

Paul's Cave: Maxilla (3L, 2R), frontal (4).

REMARKS: Fossils are easily referred to this species on the basis of size and morphological detail. The dentary of *G. oceanica* tapers toward the symphysis of the jaw, little if any of the lingual side of the bone is visible below the splenial, coronoid overlap labially just reaches the level of the most posterior tooth, and ca. one-third of each tooth is exposed above the parapet of the jaw. There are 35–42 teeth on the adult (>90 mm svl) dentary. The frontal of *Gehyra* [*oceanica*, *mutilata* (Wiegmann), *vorax* Girard] is distinguished by its broad proportions and rolled, convex supraorbital borders (Figure 3). The largest and smallest individuals represented by the fossils were 97–100 mm and 85–90 mm svl, respectively. My collection of *G. oceanica* from 'Eua included nine females ranging from 64 to 83 mm svl ($\bar{x} = 76$) and five males from 82 to 94 mm svl ($\bar{x} = 87.4$), respectively.

I encountered this large gecko island-wide on 'Eua in both disturbed and undisturbed habitats. Burt and Burt (1932) reported one specimen from the island (AMNH 40194), Gibbons and Zug (1987) collected seven eggs that they incubated in the laboratory (hatchlings $\bar{x} = 33$ mm svl), and Gill (1987) and Gill and Rinke (1990) reported specimens from several localities. *Gehyra oceanica* is predominantly nocturnal, but I made no attempt to document that activity other than to note one individual on the wall of a lighted building in 'Ohonua at 2100 hr. During the day I found them easily by searching under the loose bark of large trees and tree stumps, usually 1–2 m above the ground; several may congregate in a single tree. On 'Eua *G. oceanica* prefers shady situations, although individuals were seen and collected in dead trees in an open, feral pasture west of Matalanga'a Maui.

Lepidodactylus cf. *L. lugubris* (Duméril & Bibron). Mourning Gecko

MATERIAL EXAMINED: Paul's Cave: Frontal (20); miscellaneous unsorted cranial bones.

REMARKS: The frontal bone of this small gecko is identified by its flat dorsal surface and wide anterior end (Figure 3). The frontal of *Nactus pelagicus* (Girard), the only other comparably sized gecko on 'Eua (see below), is not much wider anteriorly than the intraorbital width. The fossils referred to *L. lugubris* are all of similar size, typically with a midsagittal length of 4.9 mm, a width of 3.9 mm across the parietal border, and an intraorbital width of 1.4 mm. These frontals came from individuals ca. 45–47 mm svl. My series of nine specimens of *L. lugubris*, a widespread parthenogenetic species, ranged from 32 to 44 mm svl ($\bar{x} = 40$). Possibly bones of the endemic species *Lepidodactylus euaensis* Gibbons & Brown are among these fossils. However, the osteology of *L. euaensis* is unknown, and I was unable to obtain any specimens while on the island. This species was described by Gibbons and Brown (1988) from specimens collected at several scattered localities occasionally syntopic with *L. lugubris*. It was also listed by Gill (1990) from Fungafonua.

As with *G. oceanica*, I found the Mourning Gecko island-wide, often syntopic with that species. Most any rotten log, tree stump, or large trash pile of vegetation offers suitable retreat. I observed it nightly on the walls of the Fungafonua Hotel in Pangai, and it is common at night around other village dwellings according to residents.

Gibbons and Zug (1987) reported a hatchling from 'Eua that measured 25 mm. Gill (1987) collected two individuals at night on walls of the Hango Agricultural College, and Gill and Rinke (1990) noted specimens from 'Ohonua.

Nactus pelagicus (Girard). Pacific Slender-toed Gecko

MATERIAL EXAMINED: 'Anatu: Layer I, dentary (1L); frontal (3).

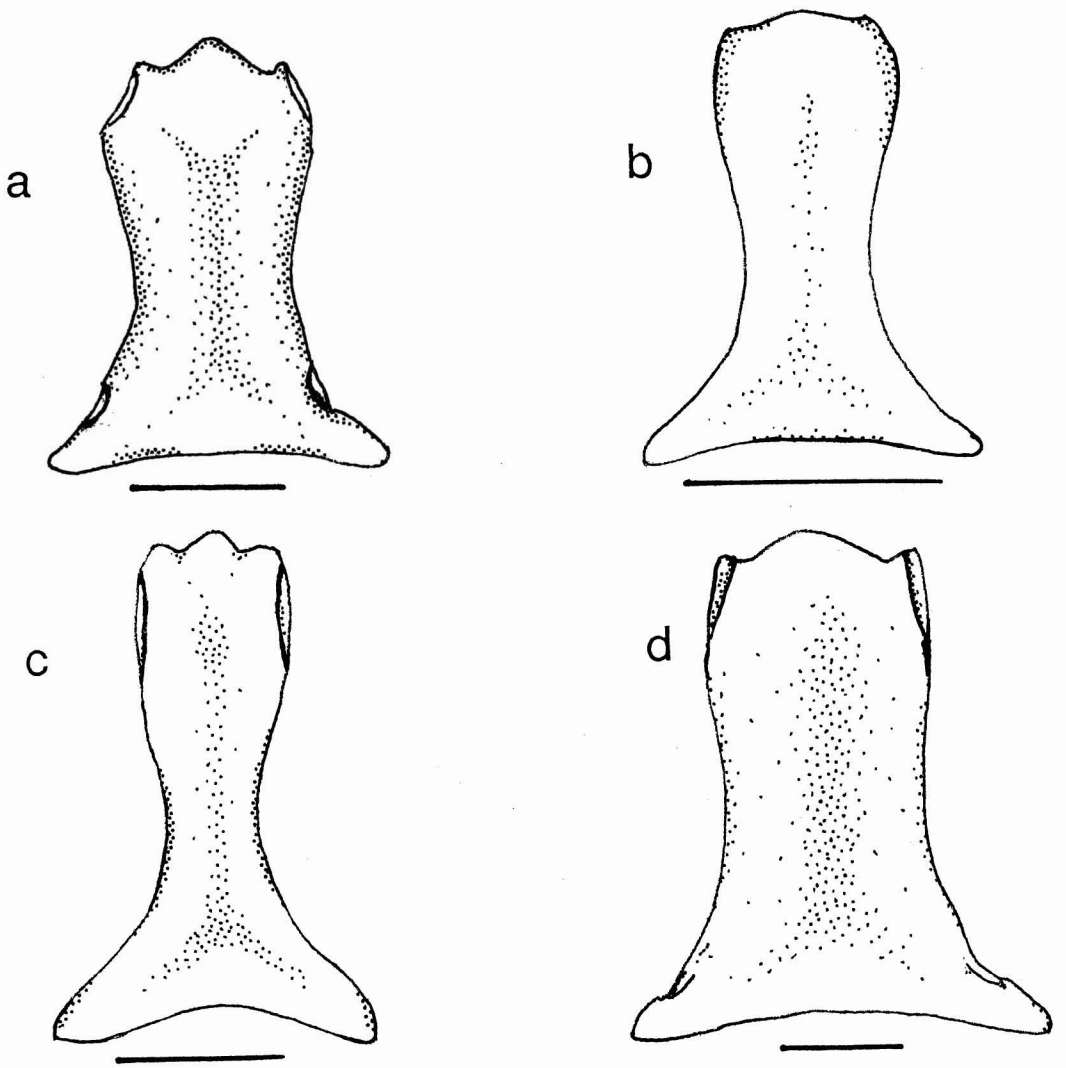

FIGURE 3. Outline of frontal bones of four geckos, in dorsal view: *a*, *Gehyra oceanica*; *b*, *Lepidodactylus* cf. *lugubris*; *c*, *Nactus pelagicus*; *d*, *Perochirus* sp. Scale = 3 mm.

That Cave: Dentary (1L, 1R).

Cave 1 of McKern: Megapode pocket, dentary (1L, 6R); maxilla (1L, 2R); frontal (5); basicranium (1). Disturbed pocket, dentary (2L, 1R), articular + surangular (1R); maxilla (1R), quadrate (1); pelvis (1).

Bat Cave: Frontal (1).

'Ana Paka Cave: Dentary (1L, 1R), articular + surangular (1L, 1R); maxilla (1 partial L); pterygoid (1).

Paul's Cave: Frontal (125); numerous unsorted cranial bones.

REMARKS: The dentary of *N. pelagicus* is distinguished by a long surangular process that in a fully articulated mandible extends posteriorly past the level of the posterior border of the coronoid. The teeth are small and peglike, and <25% of the crowns are exposed above the parapet of the jaw. There are ca. 45 dentary teeth in adults (ca. >55 mm

svl). Tooth row lengths of the fossil dentaries range from 7.9 to 8.7 mm. The frontal is long and narrow, being nearly five times longer than the intraorbital width (Figure 3). The parietal border curves slightly inward toward the snout. The bone is moderately concave dorsally and the supraorbital margins are flat. In the isolated frontal, the facets for the prefrontal are visible dorsally, whereas those for the postfrontal are not. The referred frontals range in midsagittal length from 7.7 to 9.3 mm. Snout–vent length estimates of the fossil individuals are 61–67 mm based on dentary tooth row lengths and 55–65 mm based on midsagittal length of the frontals. The largest of each of two males and four females of this species that I collected are 59 mm and 55 mm svl, respectively.

I found this species only along the west and southwest coasts, always under dry rotting logs in shaded areas, occasionally syntopic with *Cryptoblepharus poecilopleurus* (Wiegmann) or *Lipinia noctua* (Lesson). Two specimens were collected in woods adjacent to Wa'aluma Beach, and three others in forest margins beside the large pasture at Matalanga'a Maui. A single female was collected 1 km N of Tufuvai in coastal second-growth forest.

Burt and Burt (1932) included AMNH 40193 (as *Gymnodactylus pelagicus* Girard) as their only 'Eua record of this species, and Gill (1988) and Gill and Rinke (1990) listed one specimen each (as *Cyrtodactylus pelagicus* Girard).

Perochirus sp.

MATERIAL EXAMINED: 'Anatu: Layer III below breccia, dentary (1L, 2R, 1 frag.); articular + surangular (2R); prefrontal (1); frontal 1. Breccia between layers II and III, dentary (1L). Layer II, dentary (2L, 7R); articular + surangular (2L, 1R); maxilla (1L, 1R); pterygoid (1); frontal (7). Layer II wet, dentary (1L, 1R), frontal (1); pelvis (2). Layer I, dentary (1R); articular + surangular (1R); frontal (1).

Paul's Cave: Frontal (1).

REMARKS: The most nearly complete dentary, from 'Anatu layer III, has a tooth row length of 12.8 mm. There are spaces for 38–40 teeth, the majority of which are present. Teeth are unremarkable, being like those of most all geckos in having simple, unicuspid crowns. The anterior end of the dentary is broad, and the subdental shelf is uniformly wide to the back of the tooth row. Meckel's groove is exposed anteriorly as a small pore below the first tooth. Posterolingually a splenial facet is visible that extends anteriorly below the level of the nine most posterior teeth. A reduced facet marking the overlap of the coronoid in life is visible, but does not reach the level of the tooth row. Both the angular and the surangular processes at the posterior end of the dentary are incomplete, but neither appears to have extended past the level of the coronoid. The fossil came from an individual estimated at 95 mm svl. None of the frontals is complete, but most are sufficiently whole to determine details of the intact bone. The frontal is nearly as wide across the parietal border as it is in midsagittal length. The most nearly complete frontal from 'Anatu measures 10.4 mm midsagitally, 9.6 mm along the parietal border, and it has an intraorbital width of 4.5 mm. It came from an individual estimated at 95–100 mm svl. Dorsally, the frontal is concave, with the orbital margins sweeping gently dorsolaterally; articular facets for the prefrontal, but not those for the postfrontal, are visible dorsally (Figure 3).

The fossil dentaries differ from those of the only other 'Euan gecko of comparable size, *G. oceanica*, in several ways. That of *G. oceanica* tapers anteriorly rather than remaining uniformly wide, the splenial extends to below the level of the most posterior 13 teeth, less of the dentary is visible below the splenial in lingual view, coronoid overlap posterodorally reaches the tooth row, and the teeth are more pointed and slightly recurved. Likewise, the frontal of *Gehyra* (*oceanica*, *vorax*, *mutilata*) is characterized by rolled, convex orbital margins; is proportionately broader anteriorly; and articular facets for the postfrontal bone are visible in dorsal view. I also compared these fossils with *Gekko*, but in *Gekko* the nasals approach or contact the prefrontals, thereby excluding the maxillae from participating in the nasal-frontal articulation; consequently, the frontal is truncated anteriorly.

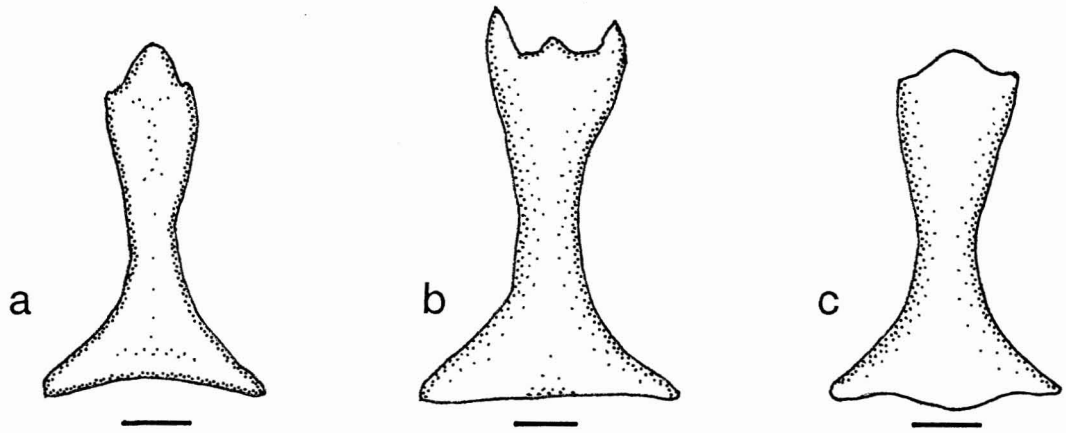

FIGURE 4. Outline of frontal bones of three skinks, in dorsal view: *a*, *Cryptoblepharus poecilopleurus*; *b*, *Emoia cyanura*; *c*, *Lipinia noctua*. Scale = 1 mm.

Another readily observable difference is that the teeth of *Gekko* are proportionately narrower and taller than those on the fossils.

Size of the fossils is not an apparent bias in their identification, although body size of some insular lizards has been shown to have decreased during the Holocene such that an unambiguous referral to species may not be possible (Pregill 1986). In the case at hand the bones do not exhibit any shifts in size from the oldest through the youngest sediments. The only Pacific gecko that agrees morphologically with the fossils, particularly the frontal bone, is *Perochirus*. As defined by Brown (1976), *Perochirus* consists of three species: *guentheri* Boulenger in Vanuatu, *scutellatus* (Fischer) in the Kapingamarangi group of the Caroline Islands, and *ateles* (Duméril) [with which Brown synonymized *depressus* (Fischer) and *articulatus* (Fischer)] from the Marianas and from Truk Island and Kapingamarangi in the Carolines. Other populations occur on Yap, Pohnpei, Kosrae, the Marshall Islands, and the southern Bonin Islands. Doubtless, further investigation of all of these populations would refine the taxonomy of *Perochirus*. My comparative specimens (CAS 123735, 159770) were collected from Kapingamarangi and Ponape and identifed as *P. ateles*. I am reluctant to assign the fossils unequivocally to *Perochirus* in the absence of comparative osteology within that genus.

SCINCIDAE

Cryptoblepharus poecilopleurus (Wiegmann). Snake-eyed Skink

MATERIAL EXAMINED: Paul's Cave: Frontal (1).

REMARKS: The frontal bone of this small skink lacks distinct prefrontal processes and is half as long midsagittally as it is across the parietal border (Figure 4). The single fossil came from an individual ca. 42 mm svl. My collection of *C. poecilopleurus* consisted of two males (37 mm and 43 mm svl) and three females (42 mm, 42 mm, and 44 mm svl).

This lizard was difficult to find on 'Eua. I never encountered it more than a straight-line distance of about 0.5 km from the coast, although it did occur in situations rather distinct from the rocky, littoral woodlands (*Hernandia*, *Hibiscus*, *Coccoloba*) typical of its habitat elsewhere in Polynesia (McKeown 1978, Crombie and Steadman 1988; pers. obs.). One individual was collected 2.5 km NE of Houma under a *Casuarina* log in nearly open pasture atop the windswept cliff of the eastern ridge, ca. 250 m elev. Two others were found under logs in woods adjacent to Matalanga'a Maui at ca. 175 m elev. These two specimens occurred syntopically with *N. pelagicus*. The other individuals were taken as they basked on fallen *Hibiscus* stumps in coastal scrub 1 km N of Tufuvai. The Snake-

eyed Skink is diurnal, being most active between 1000 and 1600 hr when it is usually sunning on large logs and fallen trees. Gill and Rinke (1990) reported specimens (as *Cryptoblepharus eximius* Girard) from 'Ohonua.

Crombie and Steadman (1988) traced the erratic nomenclatural history of these Pacific skinks and their relatives. I follow their usage of *C. poecilopleurus* for the populations in Polynesia.

Emoia cyanura (Lesson) complex. Azure-tailed Skinks

MATERIAL EXAMINED: 'Anatu: Layer II 67–85 cm, articular + surangular (1). Layer II below 85 cm, pelvis (2). Layer II wet, basicranium (1 partial).

Paul's Cave: Frontal (18); other unsorted cranial elements.

REMARKS: These elements are referred to a species of the *E. cyanura* complex on the basis of size, proportions, and conformation in detail to comparative skeletons. The frontal bone has a straight parietal border (Figure 4). Fossils came from individuals between 50 and 55 mm svl.

Ineich (1987) identified two syntopic species of Azure-tailed Skinks, based primarily on specimens from French Polynesia. He recognized nominate *cyanura* and a cryptic sibling species he called *pheonura*, a name recently placed in the synonymy of *E. impar* (Werner), which itself was resurrected from the synonymy of *E. cyanura* (Ineich and Zug 1991). Supposedly *E. impar* differs from *E. cyanura* by the absence of fused scales on the middorsal row, white to ivory thighs ventrally, a brown to brown-green tail, and occasionally the presence of an occipital spot. Of eight specimens that I collected on 'Eua, one is referable to *E. impar* on the basis of the first two of these characters, a female 52 mm svl. Of the remainder, males ranged from 36 to 49 mm svl ($\bar{x} = 42$), and females from 41 to 50 mm svl ($\bar{x} = 45$).

The Azure-tailed Skink is the most conspicuous member of 'Eua's lizard fauna, as is usually the case elsewhere in Polynesia where it occurs. As diurnal, terrestrial lizards they range over most of 'Eua, but generally prefer some shade. They readily climb tree trunks and fallen logs, and may retreat behind exfoliating bark. More often they are seen scurrying over leaf litter, palm trash, and plantation rubble. Burt and Burt (1932) recorded two specimens of *E. cyanura* from 'Eua. Gill (1987) and Gill and Rinke (1990) also listed this species.

Emoia sp. (*trossula*?)

MATERIAL EXAMINED: 'Anatu: Layer III, dentary (1R); maxilla (1R); articular + surangular (1); pelvis (3L, 1R). Layer II, dentary (6L, 3R); articular + surangular (1L, 1R); frontal (2); parietal (1); pelvis (2); sacrum (1).

That Cave: Frontal (1).

This Cave: Parietal (1)

Paul's Cave: Dentary (3R); maxilla (2L, 1R); pterygoid (1L).

REMARKS: These fossils are referred to a species of *Emoia* ca. 75 mm to 110 mm svl. The only species of these dimensions that has been reported from 'Eua is *Emoia trossula* Brown & Gibbons. As discussed below, either the 'Eua population has been misidentified or there is a second species of comparably sized skink on the island.

The type series of *E. trossula* comes from Fiji. Shortly after its description (Brown and Gibbons 1986), Crombie and Steadman (1988) identified specimens from Rarotonga, Cook Islands, as this taxon. Gibbons and Brown (1988) included 'Eua within the range of *E. trossula* in southern Tonga, and in his monograph Brown (1991) noted several specimens with 'Eua localities (AMS R96577–79, R96584; CAS 158244–45). In the first of three papers on the vertebrates of Tonga, Gill (1987:220) made reference to "a large brown skink more than 80 mm from snout to vent... and had a striped pattern across its lips." Subsequently, he (Gill 1990) concluded that the specimen he saw, and several others collected previously from 'Eua, were *E. trossula* based on Brown and Gibbons's (1986) characterization that agreed in the number of midbody scale rows (32–35), fourth-toe lamellae (45–52), and what he regarded as overall similarity of color and pattern. I have not seen Gill's material, but two specimens of a large *Emoia* I collected on 'Eua (SDSNH 66147,

66186), as well as two of those noted by Brown (1991; CAS 158244–45) along with four others (CAS 158926, 159407–09), do not closely resemble the *trossula* from Rarotonga except for agreement in scale counts. However, those numbers for midbody scale rows and fourth-toe lamellae are not diagnostic of *E. trossula*; rather they characterize (or overlap) several species of *Emoia* (Brown 1991). Apparently, the Rarotonga population matches Fijian *trossula* in the bold, tiger-striped dorsal pattern and vivid lime-green venter. In life, the 'Eua skinks have flatter heads, less-pointed snouts, and are olive dorsally with a few whitish green flecks between the axillary region and midbody. Dark, dorsal tiger strips are absent in the 'Eua lizards, which instead have three (four in a single young male) elongate dark brown to black blotches located dorsolaterally on either side of the arms; a few smaller dark flecks continue onto the dorsum. There is also a small dark blotch immediately posterior of the eye. The chin and throat are white, tinged with pale blue-green and peppered with dark flecks, especially on the chin. The venter and proximal half of the tail are pale yellow-green with scattered dark spots.

Pending detailed examination of all available specimens, the present possibilities are that: (1) these skinks are aberrant *trossula*, which seems unlikely; (2) they are a distinct species, although true *trossula* is in fact present on 'Eua as reported and I simply never encountered it; (3) this is the species thought to be *trossula* but which has been misidentified, and it is the only large species of *Emoia* on the island.

The first of the two 'Eua specimens I collected was a large male (115 mm svl) found in a plantation on the upper terrace below the cliff summit of the eastern ridge, 2 km SE of Houma. It was noon on an overcast day and the lizard was exposed behind the bark of a large, dead *Ficus* tree. A repeated search of the area failed to turn up additional specimens. The second specimen, a juvenile male (61 mm svl), was collected on the trunk of a small tree amidst a large stand of *Albizzia* trees 1 km W of Pangai, also about midday. Two other individuals were seen in this area but escaped capture.

Lipinia noctua (Lesson). Moth Skink

MATERIAL EXAMINED: Paul's Cave: Frontal (17).

REMARKS: The frontal bone of this small skink displays a wide, convex parietal border (Figure 4). The fossil frontals came from individuals estimated at 44–48 mm svl.

Three males and three females of this species that I collected measured 42 mm, 45 mm, and 45 mm svl, and 33 mm, 40 mm, and 45 mm svl, respectively. These six specimens were collected from the west side of the island: four beneath palm trash 1 km N of Tufuvai along the coast road, and two beneath fallen logs in a grove of *Albizzia* 1 km W of Pangai. Gill and Rinke (1990) reported specimens from 'Ohonua. The Moth Skink is a comparatively abundant terrestrial species on many islands of Oceania, although it is not conspicuously active above ground. More often it remains beneath the protective cover of surface debris or behind the loose bark of fallen logs.

Genus and species unknown, large skink

MATERIAL EXAMINED: Anokula Cave: Articular + surangular (1 R).

REMARKS: This bone is recognizably scincid by the narrow, spoon-shaped retroarticular process bearing a semilunate medial cusp; in general aspect the bone resembles that of *Emoia* or *Eugongylus*. The fossil came from an individual having an estimated svl of 150–175 mm. Conceivably it represents an exceptionally large individual of the enigmatic *Emoia* discussed above, which so far as known is the largest skink on 'Eua. More likely the bone is from a different species that apparently is extinct on the island. Unfortunately, nothing about the fossil is remarkable other than its large size. All of the remains of vertebrates from Anokula Cave were collected primarily from the surface and therefore are assumed to be latest Holocene. The largest skink known from Tonga is *Eugongylus microlepis* (Duméril & Bibron), which is ca. 175 mm svl. That species is known only from two specimens collected on Tongatapu in the eighteenth century and presumably is extinct (Rinke 1986). All other Tongan skinks are less than 115 mm svl.

DISCUSSION

Remote and oceanic, the islands of central and eastern Polynesia are inhabited by few species of terrestrial reptiles. In practically all instances the lizard fauna of these islands presumably derives from chance, often multiple introductions that began with the early Polynesian voyagers. Introductions have continued during the past two centuries by way of cargo vessels. Only the more vagile species with fairly broad ecological tolerances and often edificarian tendencies have successfully established themselves over this enormous expanse of the Pacific Ocean. All of these lizard species, numbering no more than about 10, belong to either the Scincidae or Gekkonidae.

Despite a general pattern of anthropogenic distribution for terrestrial reptiles in central and eastern Polynesia, there are endemic and indigenous species, the number of which increases in a westerly direction from Rarotonga, the easternmost island with an apparently indigenous form. On 'Eua, the only extant endemic lizard known for certain is *Lepidodactylus euaensis* Gibbons & Brown. However, bones from layers II and III of 'Anatu demonstrate that at least three additional species colonized 'Eua unassisted by humans. Two of these are skinks: the enigmatic *Emoia* (possibly *E. trossula* of Brown [1991] and others), and *E. cyanura* (complex), which is widespread in Oceania. The third species is a gecko unknown on the island today. If correctly identified as a species of *Perochirus*, its presence on 'Eua creates a large distributional hiatus, as the nearest congeners are in Vanuatu and it is unknown on Fiji, which intervenes geographically. Last, the very large skink (*Emoia*? *Eugongylus*?) represented by a single bone from Anokula Cave was (is?) probably indigenous also, despite the fact that the fossil was not found in a precultural context; such large skinks are not readily dispersing weed species, but forest dwellers. In short, the significance of these precultural fossils is that they speak to a remarkable capability for dispersal among some of the Pacific island lizards. 'Eua is oceanic in origin, the oldest rocks being Eocene volcanics, and the island has never had any continental connection (Duncan et al. 1985). It may also be significant that the fossils of the *Perochirus* sp. and the very large skink (*Emoia*? *Eugongylus*?) represent taxa that are unknown on 'Eua. Conceivably they still exist there. If not, they survived at least up to the time people colonized the island. Human-engendered extirpation and extinction have been amply demonstrated for Polynesian land birds (Steadman in press), and it seems likely that lizards have been affected similarly (Pregill and Dye 1989).

Two species of lizards known or thought to occur on 'Eua were not represented in any of the fossil deposits (Table 1). The Fox Gecko, *Hemidactylus garnotii* Duméril & Bibron, was reported by Gibbons and Zug (1987) based on eggs and hatchlings collected on the island, although no specific locality information was given in their note. Often a forest species, *H. garnotii* may take to human dwellings in the absence of the House Gecko, *H. frenatus* Duméril & Bibron. I found no evidence of either species on 'Eua. Most likely *H. garnotii* is a recent arrival to the island.

The other species unrepresented by fossils, if in fact it is or was on 'Eua, is the Crested Iguana, *Brachylophus fasciatus* (Brongniart). Its presence on 'Eua never has been verified by specimens, and only anecdotal (but supposedly reliable) sources on Tongatapu provide any justification that it is there at all (Gibbons 1981). Moreover, the absence of iguana bones from any of the deposits is odd given that these lizards should be a choice prey item of Barn Owls. Elsewhere in Tonga *B. fasciatus* is known from the Ha'apai and Va'vau groups as well as from Tongatapu (Avery and Tanner 1970, Gibbons 1981, Rinke 1986).

I searched for *Brachylophus* while on 'Eua, but the only indication of its presence came from a conversation with a 20-yr resident of the island. He told me that about 3 or 4 yr previously he saw a "large green moko" descend a coconut tree near his plantation in the east-central highlands, and that he had killed it with a stick. The dimensions he gave suggested a lizard the size of *Brachylophus*. If they are resident, the inaccessible forested

TABLE 1

DISTRIBUTION AND MINIMUM NUMBER OF INDIVIDUALS OF FOSSIL LIZARDS FROM PLEISTOCENE AND HOLOCENE DEPOSITS ON 'EUA, TONGA

LOCALITY	*Gehyra oceanica*	*Lepidodactylus* cf. *lugubris*	*Nactus pelagicus*	*Perochirus* sp.	*Cryptoblepharus poecilopleurus*	*Emoia cyanura*	*Emoia* sp. (*trossula*?)	*Lipinia noctua*	Scincidae sp. (large)
'Anatu Cave									
Layer III				4			3		
Breccia				1					
Layer II				7		3	6		
Layer I	4		3	1					
Surface			1						
That Cave									
TP1	1		2						
TP1-disturbed	2								
TP2	2								
TP3	1						1		
This Cave							1		
Cave 1 of McKern									
Megapode pocket	1		6						
Disturbed pocket			4						
Bat Cave			1						
Collapse Cave	1								
'Ana Paka Cave			1						
Anokula Cave									1
Paul's Cave	4	20	125	1	1	18	3	17	

cliffs and terraces below the eastern ridge seem to be the most likely place to harbor a population.

Despite a few comprehensive treatises such as Zug's (1991) on the lizards of Fiji, the herpetofauna of Oceania is still poorly documented. Within Tonga itself new distributions and taxa undoubtedly remain undiscovered.

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