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The Lizards of Rarotonga and Mangaia, Cook Island Group, Oceania[1]

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ABSTRACT: Eight species of lizards are reported from the islands of Rarotonga and Mangaia with comments on their distribution, ecology, reproduction, and variation. Particular attention is given to systematic problems in the genus *Cryptoblepharus* and pattern polymorphism in *Emoia cyanura*. *Emoia trossula*, recently described from Fiji, is reported for the first time in the Cook Islands. Historic and zoogeographic evidence suggests that most species of lizards arrived on Rarotonga and Mangaia in Polynesian voyaging canoes within the past 1000 years, although *Gehyra mutilata* and *Hemidactylus garnotii* may have arrived by incidental boat or air transport in the past several decades.

UNDERSTANDING the distribution and zoogeography of organisms in the Pacific region is hampered by the virtual absence of data on the biotas of many islands. The few summaries of the herpetofauna of Oceania (Sternfeld 1920; Loveridge 1945; Brown 1956) are generalized and incomplete. Published herpetological records for the Cook Islands, for example, are very few. This scattered group of 15 small islands lies between the Society and Tubuai groups to the east and Samoa, Tonga, and Niue to the west (Figure 1). Boulenger (1887), Sternfeld (1920), Mertens (1931), Burt and Burt (1932), and McCann (1974) have provided some distributional information, mostly for the northern islands in the group, but little published information exists for the lizards of Rarotonga and Mangaia, the two largest of the Cook Islands.

One of us (DWS) recently spent 8 weeks (13 March–23 April 1984, 28 May–13 June 1985) surveying the living and fossil vertebrate faunas of Mangaia and Rarotonga. Here we summarize the lizard collections (181 specimens), which contain all but two of the species previously known from the Cooks and include two additional species previously unreported. The two taxa not found in this survey appear to be restricted to the northern Cooks. The nocturnal forest gecko *Nactus pelagicus* (formerly *Cyrtodactylus pelagicus*; see Kluge 1983 and Zug 1985 for usage of this combination) is widespread in Samoa, Fiji, and elsewhere in Oceania, but it has only been reported from Nassau Island in the Cooks (Burt and Burt 1932). The skink *Emoia adspersa* has been found on Pukapuka (Burt and Burt 1932), Samoa, and other scattered islands to the west (Schwaner and Brown 1984).

MATERIALS AND METHODS

Data on sex, size, and habitat were taken for all specimens. DWS recorded snout–vent length (SVL) in millimeters with a ruler and weight in grams with Pesola scales on freshly killed specimens in the field. Sex and reproductive condition of specimens field-prepared as skeletons also were noted. On fluid-preserved material, sex, size, and selected scale counts were taken in the lab by RIC. All catalog numbers refer to the Amphibian and Reptile collections of the U.S. National Museum of Natural History (USNM).

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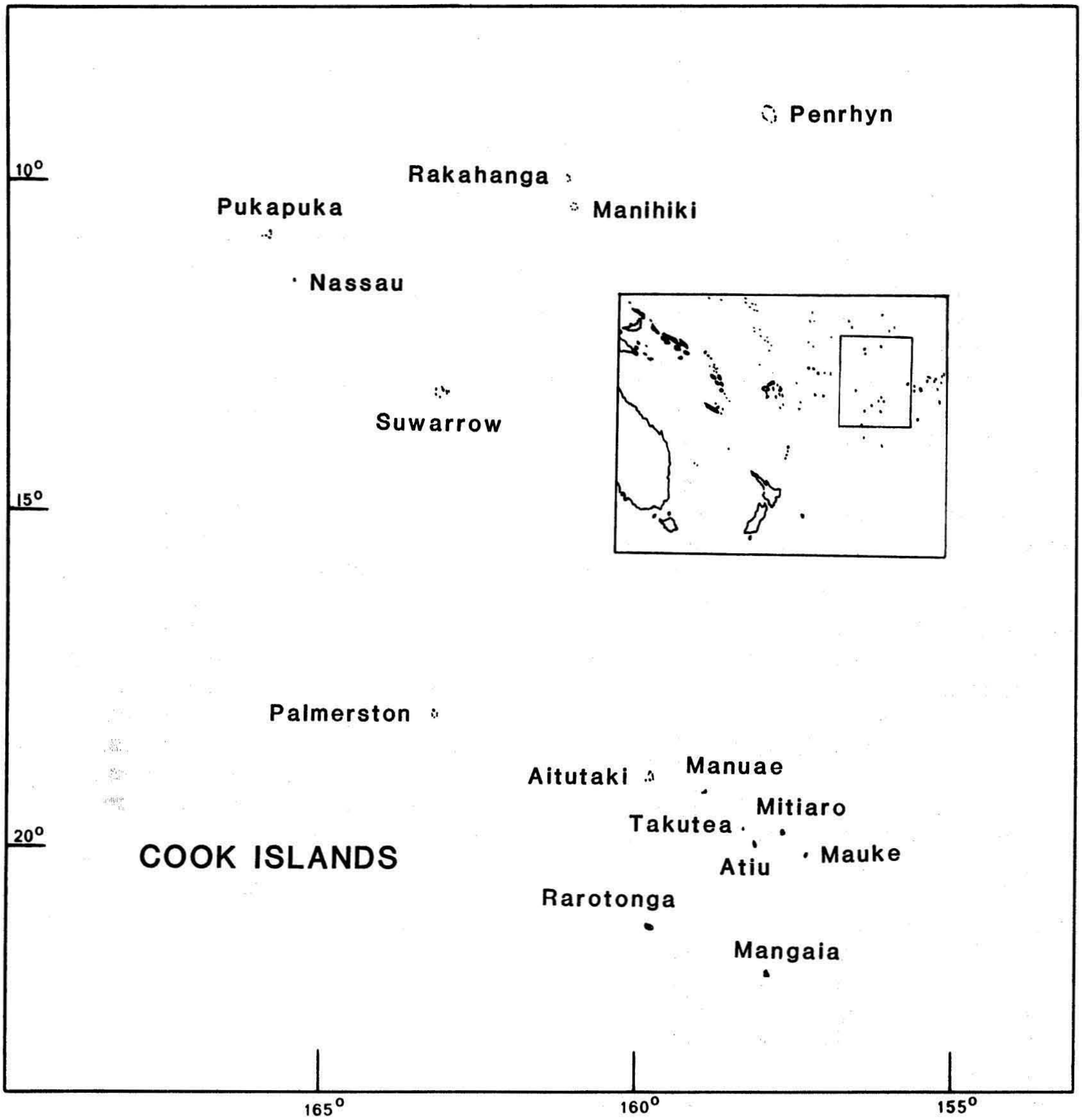

FIGURE 1. Outline map of the Cook Islands with their relative position in Oceania (inset). Redrawn from Survey Dept. Rarotonga (1983).

DESCRIPTION OF THE ISLANDS

Rarotonga

Rarotonga (Figure 2) is the largest, highest, and most populous of the Cook Islands. Centered at 21°14′ S and 159°47′ W, Rarotonga has a maximum elevation of 653 m, and much of the interior exceeds 300 m elevation. Rarotonga has an area of approximately 65 km^2, a population in 1981 of 9477 persons, an annual precipitation of 2040 mm, and mean maximum/minimum temperatures of 27.0 and 20.8°C (Survey Dept. Rarotonga 1983). Entirely volcanic in origin and on its own bank, Rarotonga is a lush island whose steep, knife-edged mountains are contrasted by a relatively flat, narrow coastal plain and a fringing reef surrounding the island. Four

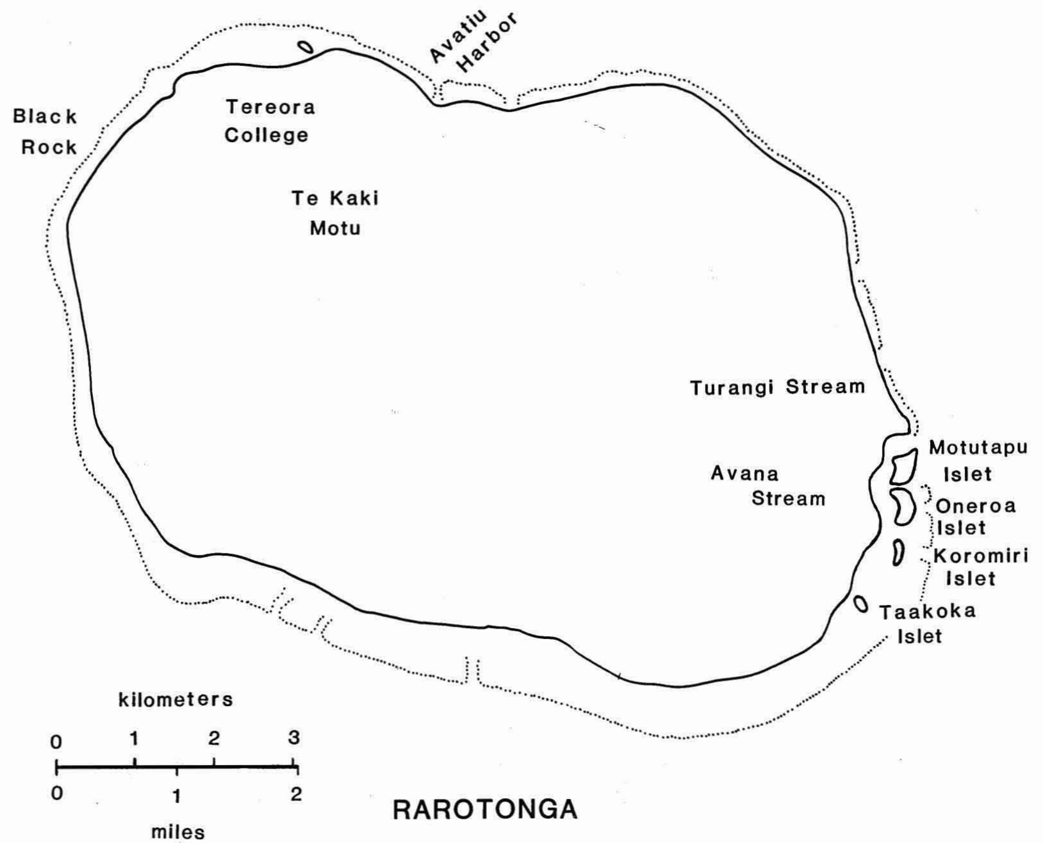

FIGURE 2. Map of Rarotonga. Redrawn from Survey Dept. Rarotonga (1983).

small islets lie off the southeastern shore, inside the reef. (See Stoddart 1972 for a detailed discussion.) The river valleys have been cultivated for centuries with food crops such as taro, bananas, and sweet potatoes. Introduced trees, shrubs, and herbaceous plants occur in even the most remote parts of the island. Many large, scattered patches of nearly pure bracken fern (*Pteridium* sp.) occur in areas damaged by periodic fires. Stoddart and Gibbs (1975) provided summaries of the history, climate, and marine environments of Rarotonga.

A total of 97 specimens (USNM numbers in parentheses) of the following species of lizards were collected on Rarotonga and three of its surrounding islets.

Rarotonga: Gehyra oceanica (249654–59, 249732–38, 252377); *Hemidactylus garnotii* (249660); *Lepidodactylus lugubris* (249661–62, 249739–41, 252378–85); *Cryptoblepharus* cf. *poecilopleurus* (252386–90); *Emoia cyanura* (249667–73, 249748–56, 252392–400); *Emoia trossula* (249663–66, 249742–47, 252391); *Lipinia noctua* (249674–75, 249757–58, 252401–03).

Motutapu Islet: *Emoia cyanura* (249676–81, 249762).

Oneroa Islet: *Emoia cyanura* (249682–86, 249759–61); *Lipinia noctua* (249687).

Taakoka Islet: *Emoia cyanura* (249688–92).

Mangaia

Mangaia (Figure 3) is the second largest, second highest, and the third most populous island in the Cook Group. Centered at 21°55′ S and 157°57′ W, it is the southernmost

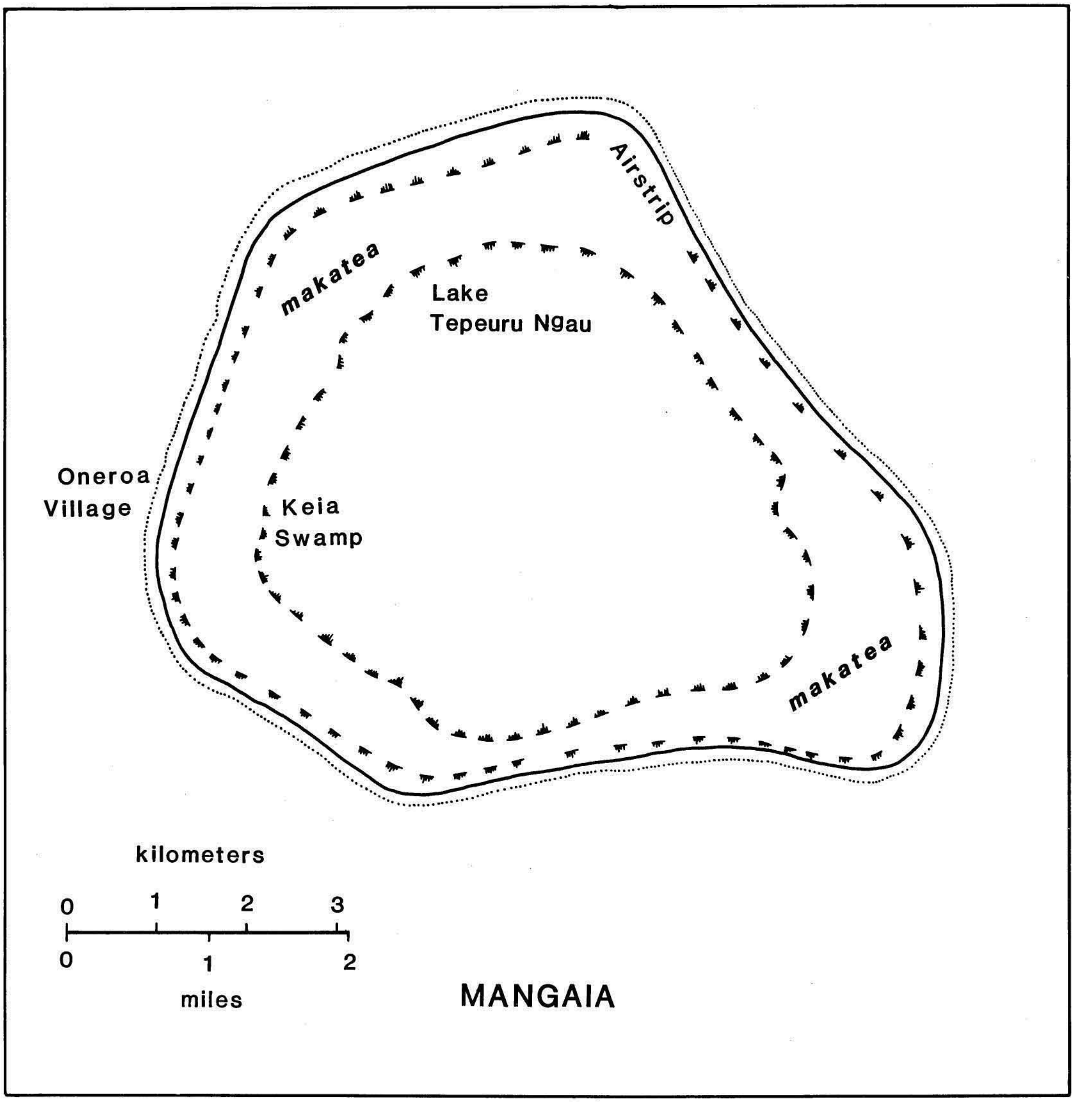

FIGURE 3. Map of Mangaia. Redrawn from Survey Dept. Rarotonga (1983).

of the Cook Islands, 200 km east-southeast of Rarotonga. Mangaia has an approximate area of 51 km^2, a maximum elevation of 169 m, an average annual precipitation of 1992 mm, and a human population of 1364 in 1981 (Survey Dept. Rarotonga 1983). Mangaia is on its own bank, encircled by a fringing reef. The highly weathered, volcanic uplands in the center of Mangaia are surrounded by a raised coralline limestone reef known as the "makatea." The makatea, often delimited by steep cliffs on both the seaward and especially the landward sides, reaches an elevation of approximately 60 m and is up to 1.2 km wide. The narrow coastal plain of Mangaia has thin pockets of soil interspersed with limestone outcroppings. Much of the volcanic soil of the central uplands has eroded away because of centuries of deforestation. Except for near the three villages, the coastal plain and makatea are mainly forested, although all is second growth with many introduced plants. The uplands are largely devoid of trees, except in stream valleys, and are covered mainly with bracken fern or pineapples. Most agriculture, especially wet taro in low-lying areas, occurs in volcanic soils just inside the inner cliff of the makatea.

A total of 84 specimens of the following lizards were collected on Mangaia: *Gehyra mutilata* (249693–94); *Gehyra oceanica* (249695–97, 249763–69, 252404); *Lepidodactylus lugubris* (249698–702, 249770–75, 252405); *Cryptoblepharus* cf. *poecilopleurus* (249703–04, 249776); *Emoia cyanura* (249705–30, 249777–96, 252406–09); *Lipinia noctua* (249731, 249797–99, 252410–11).

SPECIES ACCOUNTS

FAMILY GEKKONIDAE

Gehyra mutilata (Wiegmann, 1834)

Two juveniles (22 and 21 mm SVL, respectively; each 0.2 g) were taken on Mangaia in a suburban area. Although none was found on Rarotonga, the species does occur there (G. McCormack, pers. comm.). Its rarity in the southern Cooks suggests a recent arrival. *Gehyra mutilata* is widespread in Oceania (Crombie) and occasionally is abundant in edificarian habitats. In the Cooks it has been previously reported only from Manihiki Atoll (McCann 1974), Pukapuka (Slevin 1934), and an unspecified locality ("Danger Group," Burt and Burt 1932).

Gehyra oceanica (Lesson, 1830)

Fourteen specimens (six males, 68–85 mm; eight females, 67–81 mm SVL) of this large gecko were collected along Turangi and Avana streams on Rarotonga. All were found on or near the trunks of large "i'i" or "chestnut" trees (*Inocarpus edulis*) in both open and closed forest.

On Mangaia, 7 of the 11 specimens (three males, 72–78 mm; seven adult females, 65–79 mm; one subadult female, 55 mm SVL) were also on *Inocarpus*, in or at the edge of forest. Four others were found in or on houses, an unusual habitat for *G. oceanica*, which normally prefers large trees with abundant crevices for diurnal retreats. Both houses were close to forested areas and not in a strictly suburban habitat.

Although males from both islands had enlarged testes, none of the females was gravid; the largest ovarian follicles were 2–3 mm in diameter. The stomachs of several individuals from both islands were packed with small seeds. This was the only species of gecko active during the day, although this diurnal activity was restricted to individuals in deep furrows of the trunks of *Inocarpus*.

Hemidactylus garnotii (Dumeril and Bibron, 1836)

One juvenile female (46 mm SVL, 2.2 g) was collected on a house in Nikao, a suburban area of Rarotonga. This is the first record from the Cooks. No others were seen on Rarotonga or Mangaia.

This parthenogenetic species (Kluge and Eckardt 1969; Eckardt and Whimster 1971), native to Southeast Asia and the Indoaustralian Archipelago, has a restricted distribution in Oceania, suggesting the recency of its arrival in the area. Since only a single individual theoretically is needed to establish a population, additional dispersal may be expected. This species is well established in Hawaii and has been recorded in the Gambier, Marquesas, Samoan, Society, and Tubuai islands (Crombie; Gibbons, in litt. 1985).

Lepidodactylus lugubris (Dumeril and Bibron, 1836)

This small, gregarious gecko is widely distributed in Oceania, the Indoaustralian Archipelago, Southeast Asia, and Indian Ocean islands (Wermuth 1965:99; Crombie). The remarkable dispersal abilities of *L. lugubris* are enhanced by its seemingly all-female, parthenogenetic nature (Cuellar and Kluge 1972; Cuellar 1984). Although occasional males have been recorded in some populations, all

25 of our specimens from Rarotonga and Mangaia were females or unsexable juveniles.

Of 13 specimens of *L. lugubris* from Rarotonga, all except one were collected on buildings. Ten adults (32–42 mm SVL) had very small follicles; three others were juveniles (21–27 mm SVL). A 41-mm female with small oviducal follicles was found on a forested slope above Avana Stream, 1 km from human dwellings. This specimen was taken beneath the rotting wood of a standing dead tree, accompanied by two infertile and five already hatched eggs.

The 12 specimens from Mangaia were all adult or subadult females. All specimens between 31 and 35 mm SVL had very small follicles. A 37-mm individual had distended, convoluted oviducts. The three largest specimens (41–45 mm SVL) contained shelled and unshelled ova from 5 to 9 mm in length.

One of the Mangaian *L. lugubris* was on a papaya tree near Oneroa Village and another was on a coconut tree in disturbed coastal forest. These two specimens were darker than the ten individuals taken from man-made structures. On both islands, specimens from buildings are remarkably uniform, being pale dorsally with rows of darker paravertebral spots, vague sacral markings, and dark eye stripes. These differences may be due to individual color change, but more data are needed.

Elsewhere in the Cooks, *L. lugubris* has been recorded from Manihiki Atoll and Pukapuka (McCann 1974; Burt and Burt 1932).

FAMILY SCINCIDAE

Cryptoblepharus cf. *poecilopleurus* (Wiegmann, 1834)

Five specimens were collected, and at least five others were seen, at low elevation (about 3 m) in an open, grassy woodland of *Hernandia*, *Casuarina*, *Barringtonia*, and *Coccoloba*, 0.3–0.7 km northwest of Avatiu Harbor, Rarotonga. Each lizard was on the trunk of a tree, usually less than 1 m from the ground. *Barringtonia* was used less commonly than the other three trees. Both *Emoia cyanura* (common) and *Lipinia noctua* (uncommon) were also found at this locality. Four of these *Cryptoblepharus* were adult females (46–48 mm SVL) with distended oviducts but only small ovarian follicles. The fifth specimen was a subadult female (37 mm).

On Mangaia, three specimens were collected at about 10 m elevation. Two juveniles of 23 and 21 mm SVL, respectively, were found on a cement water cistern. One 39-mm male with small testes was from the base of a coconut tree in open forest of *Hernandia*, *Barringtonia*, *Cocos*, and *Pandanus*. Like the other species of skinks reported here, *Cryptoblepharus* was strictly diurnal and difficult to find before 0800 hr or after 1700 hr, preferring sunny exposures.

Mertens (1931, 1933, 1934, 1964) interpreted the 40 or more taxa in the genus *Cryptoblepharus* (which he erroneously called *Ablepharus*) as subspecies of *C. boutonii*. Several areas of sympatry in Indoaustralia involve two or more of these "subspecies" (Storr 1976; Covacevich and Ingram 1978; Auffenberg 1980), suggesting that they may be full species. We see no value or justification in associating Pacific taxa with *C. boutonii*, originally described from Mauritius in the Indian Ocean. The taxonomic status and nomenclature of the widespread Oceanic populations of *Cryptoblepharus* are poorly understood as well. The name most commonly applied to them is *C. poecilopleurus* Wiegmann, the type locality of which has been misinterpreted (Crombie and Dixon; Crombie in prep.).

Elsewhere in the Cooks, *Cryptoblepharus poecilopleurus* has been reported from Manihiki, Mui (Manuae), Mittiero (Mitiaro), Nassau, Pukapuka, and Suwarrow (Mertens 1931:131; Sternfeld 1920:420; Burt and Burt 1932:514; McCann 1974).

Emoia trossula (Brown & Gibbons, 1986)

This large, arboreal skink of the *samoensis* group was recently described from Fiji and Rotuma. Eleven specimens (four males, 73–84 mm; six females, 62–82 mm; one juvenile, 33 mm SVL) were collected along Turangi and Avana streams on Rarotonga; none was seen on Mangaia. Except for a single individual seen in the fronds of a young coconut tree (*Cocos nucifera*) near Avana Stream on 29 May 1985, all adults seen or collected were on *Inocarpus* or *Hibiscus* trees along forest edges near the streams. The single juvenile was active among rocks along the banks of Turangi Stream. These lizards often are found up to 2.5 m above the ground and are very wary, ascending to 5 m or more into the trees when disturbed. The males had enlarged testes; the females contained only small follicles.

No member of the *E. samoensis* group (as defined by Brown and Gibbons 1986) has been reported previously from the Cooks, and the presence of *E. trossula* as far east as Rarotonga is surprising (see Zoogeographic Comments).

Emoia cyanura (Lesson, 1830)

This small skink is widely distributed in Oceania and the Papuan region. The considerable inter- and intrapopulational variation in morphology, color, and pattern in lizards of the *cyanura* group has led to much systematic confusion. We conservatively refer our material to *E. cyanura*, providing data on color and pattern to aid future investigators.

As elsewhere in Oceania, *E. cyanura* was the most common and ubiquitous lizard on Mangaia, Rarotonga, and even the smaller islets. Most of the 25 specimens from Rarotonga were found among rocks and leaf litter (particularly coconut palm fronds) along streams in forest. Others were found on a large root on a vertical road cut, on a horizontal limb of a *Hibiscus* tree, in coastal strand vegetation (mostly *Convulvulus*) with coral cobbles near Black Rock, and in a grassy, rocky exposure at 200 m, near Te Kaki Motu, the highest elevation recorded for the species on Rarotonga. Like the other lizards on Rarotonga, *E. cyanura* seems to prefer lower elevations and may be absent from much of the montane forest. Nevertheless, *E. cyanura* usually is rarer in the coastal lowlands of Rarotonga than in similar areas on Mangaia. This distribution may be related to the extreme abundance on Rarotonga of the introduced Asian mynah (*Acridotheres tristis*), an aggressive, inquisitive, omnivorous bird that may prey on these and other diurnal lizards. *Acridotheres* occurs on Mangaia as well, although in lower numbers and for fewer years. If predation by *Acridotheres* has a significant impact on lizard populations, then we can expect to witness a decline in lizards on Mangaia over the next decade or two as the number of *Acridotheres* increases.

Although the 14 adult male *E. cyanura* (43–55 mm SVL) from Rarotonga all had moderate to very enlarged testes, none of the six females (43–52 mm SVL) had mature follicles or shelled ova. One female (52 mm SVL), collected on 31 May 1985, had enlarged, convoluted oviducts and probably had laid her eggs recently. Four males and one female (35–41 mm SVL) with small gonads were regarded as immature.

The Rarotongan populations are more variable in color and pattern than those on Mangaia. The "typical" *E. cyanura* is boldly striped with a bright blue tail, although many populations contain unicolored individuals called "melanistic" by Oliver and Shaw (1953:90) and the "bronze" morph herein. Although the bronze individuals are often distinctive and have been recognized taxonomically (*Lygosoma cyanurum* var. *schauinslandi* Werner 1901), all intermediates between the striped and bronze morphs may occur in a single population. Certain specimens with no body striping have variable remnants of head stripes. The tail on most striped, intermediate, and even full bronze lizards was blue, but some bronze and striped individuals had bronze tails. All eight specimens from near Black Rock were striped with bronze tails. The bronze pattern does not seem to be correlated with sex. We do not know if it is seasonal or permanent. Four males and two females from Rarotonga were completely bronze; one male and one female had intermediate patterns. Tail color apparently is not correlated with sex or maturity and may be constant within a small, localized population.

Of seven specimens collected in forest of *Cocos*, *Casuarina*, and *Hibiscus* on Motutapu Islet, five were juveniles or subadults (28–36 mm SVL) and two were adult females (45 and 47 mm SVL). One of the females had enlarged, convoluted, and flaccid oviducts, indicating recent egg deposition, and another had only small follicles. Six of the seven had strongly striped dorsal patterns with blue tails; one juvenile was striped with a bronze tail.

The eight specimens collected on Oneroa Islet were from habitat similar to that on Motutapu. Six juveniles or subadults (26–41 mm SVL) were striped with blue tails. One gravid female was striped with a gray tail (50 mm SVL) and another (50 mm SVL) was bronze without a tail. Both contained two large (13 × 6 mm) shelled eggs ready for deposition, confirming Greer's (1968) suggested clutch size for the species.

The sample from Taakoka Islet contained four juveniles or subadults (27–36 mm SVL) and one adult male (46 mm SVL) with slightly enlarged testes. Three of the smaller specimens were striped; their tails were either blue, green, or missing. A subadult male was recorded as bronze with a blue tail in the field, but in preservative the pattern is more intermediate and faded striping is evident on the head and body. The adult was greenish bronze with a blue tail.

The sample from Mangaia ($N = 50$) was much more uniform than that from Rarotonga. All specimens were striped and, with the exception of a small series from a slightly higher elevation, all had blue tails. The four specimens from Lake Tepeuru Ngau (30 m) had bronze or greenish bronze tails. Reproductive activity occurred on Mangaia in April 1984, since all the adult males (40–54 mm SVL; $N = 14$) collected had enlarged testes and most stages in the female reproductive cycle were represented. Follicles in adult females (42–52 mm; $N = 19$) ranged from tiny (1–2 mm) to large and yolky; two specimens (46 and 47 mm SVL) contained shelled eggs ready for deposition and several others had the distended, convoluted oviducts of females that had recently laid eggs. Thirteen juveniles and subadults ranged from 26 to 38 mm SVL. The reproductive status in May–June 1985 was unknown because the sample was small (two adult males of 46 and 44 mm SVL and two juveniles of 28 and 31 mm SVL).

Ecological associations on Mangaia from which *E. cyanura* was taken include: rocky leaf litter beneath breadfruit trees (*Artocarpus*) in suburban areas; brush piles at edge of sweet potato field (Lake Tepeuru Ngau); coastal forest (mostly *Pandanus*); disturbed coastal forest (*Cocos*, *Barringtonia*, and *Hernandia*); and *Hibiscus*, *Cocos*, and *Manglifera* litter (Keia Swamp). Fallen fronds of coconut palms are frequently used for basking as well as shelter. Although *E. cyanura* is primarily terrestrial, several specimens confirm the arboreality observed on Rarotonga. One juvenile male (38 mm SVL) and three females (42–46 mm SVL) were collected up to 1 m high on *Inocarpus* trunks in forest bordering a taro patch.

The taxonomic confusion in the *E. cyanura* complex precludes a complete summary of its distribution. In the Cooks, *E. cyanura* has been recorded from Manuae, Mauke, Mitiaro, Nassau, Pukapuka, and Suwarrow (Crombie). Boulenger (1887:291) previously reported *E. cyanura* from Rarotonga. The record of *E. cyanogaster* from Rarotonga (Burt and Burt 1932:320) was based on misidentified *E. cyanura* (Brown 1956).

Lipinia noctua (Lesson, 1830)

On Rarotonga, one specimen of *L. noctua* was collected in a suburban area near Tereora College, another in coastal strand vegetation mixed with coral cobbles near Black Rock, and a third in open, grassy woodland of *Hernandia*, *Casuarina*, *Barringtonia*, and *Coccoloba*, 0.5–0.7 km northwest of Avatiu Harbor. Four females (31–46 mm SVL) were in open forest near Turangi or Avana streams. Along Turangi Stream, one was active among rocks and leaf litter, whereas another was sunning on a large steel pipe. Near Avana Stream, one was under moist, rounded boulders and the other was on an *Inocarpus* tree. Only one (43 mm SVL) of these, taken in March 1984, was reproductively active, with a 6 × 5 mm ovum in the left oviduct. In contrast, a female (41 mm SVL) collected in May 1985 contained a fully formed, ready to be born fetus (about 14 mm SVL) in the left oviduct and several small ova in the right oviduct. Another female collected in May (46 mm SVL) contained two large (8–10 mm) yolky ova.

One specimen (40 mm male with enlarged testes) was collected on Oneroa Island in forest of *Cocos*, *Casuarina*, and *Hibiscus*.

Of the six Mangaian specimens, one was in rocky leaf litter beneath a breadfruit (*Artocarpus*) tree in suburban Oneroa village, three others were in leaf litter of second-growth forest near the base of the inner cliff of the makatea, and two others were in disturbed coastal forest (mostly *Cocos* and *Barringtonia*) about 0.8 km southwest of the end of the airstrip. The males (40–42 mm SVL; $N = 3$) from the March–April 1984 collection had enlarged testes, and the single female (45 mm SVL) had one enlarged (6 × 5 mm) follicle. The adult females (46–47 mm SVL) collected in June 1985 were reproductively active, the smaller one with two large, yolky follicles and the other with one full-term fetus in the right oviduct.

Sternfeld (1920:402) reported *L. noctua* from Rarotonga. It is also known from Mauke, Mitiaro, Nassau, Pukapuka, and Suwarrow in the Cooks (Crombie).

ZOOGEOGRAPHIC COMMENTS

Possible explanations for the distribution of lizards in Oceania include natural dispersal and human transport. If endemic genera or species of lizards were present in the Cooks, as in western Oceania, this would suggest a longer period of isolation than would be possible if human transport had been the dispersal agent. With the possible exception of *Emoia trossula*, we believe that most or all species arrived on Rarotonga and Mangaia with people. Thus a brief review of the human history of the islands is appropriate.

The southern Cook Islands, including Mangaia and Rarotonga, were first colonized by Polynesians, perhaps from the Society Islands, about 1000 years ago (Bellwood 1979:348), although Kirch (1986:33) has suggested that the initial colonization may have been more than 1000 years ago and may have originated from any one of several groups of Polynesian islands. The culture (including language) of the southern Cook Islands is similar to that of the "eastern" Polynesian island groups of the Society, Tuamotu, Tubuai, Marquesas, Hawaii, and New Zealand. Contact among the southern Cook Islands has occurred since their initial settlement.

The first recorded European landing on Rarotonga was in 1814 (Crocombe 1964). The first significant European influence came with British and Tahitian missionaries in 1823 (Carter 1984). Since that time, Europeans have had a greater impact on Rarotonga than on any of the other Cook Islands, culminating in the construction of an international airport in the 1970s.

Significant European influence on Mangaia began with the arrival of British and Tahitian missionaries in 1823 (Gill 1894: 243–250, 323–325). Since that time, irregular boat traffic has traveled to and from Mangaia, an island with less European influence than Rarotonga. A small airstrip was completed on Mangaia in the late 1970s, and there are flights to Rarotonga and sometimes elsewhere in the southern Cooks.

Natural dispersal (rafting) of lizards on driftwood or palm trash is a likely means of colonization for islands near the Australasian landmass. With lowered sea levels during the Pleistocene, the area of many island groups in the western Pacific was much greater than now (Gibbons 1985), thus facilitating oversea dispersal. Geckos in particular are well adapted for oversea dispersal. Kluge (1969:46) has listed 18 traits of gekkonids that render them successful "rafters." To this list we may add parthenogenesis (as in *Hemidactylus garnotii* and *Lepidodactylus lugubris*), whereby a single individual can establish a population.

Despite this considerable potential for oversea dispersal, the immense distances between islands in eastern and central Oceania make the possibility of a successful landfall by a rafting lizard very unlikely. Consequently, natural dispersal has been largely discounted to explain the presence of lizards on the more distant and isolated islands. The virtual absence of endemic reptiles east of Samoa is further, albeit indirect, evidence that colonization of these islands has been relatively recent. The homogeneity of the lizard faunas on islands east of Samoa (usually five or six out of eight possible species on any island) suggests a common and multidirectional mode of transport, such as the wide-ranging Polynesian voyaging canoes. These vessels would have offered numerous hiding places for eggs or adult lizards in the thatching, coconuts, and wooden objects carried on board; fruit, dried fish, and associated insects would have provided adequate food. Zweifel (1979: 18–19) has suggested this method of dispersal for both *Lipinia noctua* and *Cryptoblepharus*. He provides convincing evidence that the relative morphological homogeneity of *L. noctua* in Oceania, compared to the presumed source area (New Guinea), argues for a single introduction and subsequent wide dispersal within Oceania. Although comparable morphological and genetic data are lacking for most widespread Oceanic species, Cuellar (1984) has demonstrated high histocompatibility within and even between distant Oceanic populations (Hawaii and the Society Islands) of *Lepidodactylus lugubris*. Indeed, he has gone so far as to suggest that "the entire species, now distributed throughout the Indian and Pacific Oceans, originated from a single ancestral female" (Cuellar 1984: 183).

Incidental transport of lizards between islands undoubtedly continued (and may have increased) with the wooden sailing ships of early European explorers and the resulting expansion of boat traffic between islands. Although modern, steel-hulled vessels offer fewer refuges for stowed-away lizards, sufficient shipments of wood, fruit, and thatch pass between islands to ensure that this mode of transport continues today.

Six of the eight species of lizards collected on Rarotonga and Mangaia are common and widespread on distant islands in Oceania. Five of these (*G. oceanica*, *L. lugubris*, *C. poecilopleurus*, *E. cyanura*, *L. noctua*) were found on both Rarotonga and Mangaia and probably arrived with the Polynesians. The offshore islets of Rarotonga, inside the reef, are inhabited by a small subset of the Rarotongan fauna, with only *E. cyanura* on two islets and *E. cyanura* and *L. noctua* on one. Additional species (particularly geckos) may be present on the islets since no nocturnal collecting was done and comparatively little time was spent surveying the fauna.

The other two geckos (*G. mutilata* and *H. garnotii*) were found in low densities in edificarian habitats, suggesting a recent arrival in the southern Cooks. *Gehyra mutilata*, collected only on Mangaia but reported to occur on Rarotonga, is widespread in Oceania, including the northern Cooks, so its presence in the southern islands is expected. The case of *Hemidactylus garnotii* is more problematical. This lizard has a spotty distribution in Polynesia, so its discovery on Rarotonga was surprising. Details on the dispersal of this species in Oceania are unknown, but we assume that it was a recent event. Since *H. garnotii* is parthenogenetic and ecologically versatile, its potential for establishing new colonies is theoretically far greater than bisexual species, and we would expect a wider distribution in Oceania if it had been present for a long time. *Lepidodactylus lugubris*, for example, is also parthenogenetic and has been recorded from 22 island groups in Oceania, compared to 7 for *H. garnotii*. The range of *H. garnotii* may still be expanding, for although the species was described in 1836 from Tahiti and was recorded from Hawaii by the mid-1800s, documentation of its presence on other island groups has been much more recent. For example, earlier reports (Burt and Burt 1932; Higgins 1943) on the herpetofauna of Savai'i, western Samoa, did not include *H. garnotii*. John Gibbons (pers. comm. April 1985) informed us that the species occurs on the island today. Since *H. garnotii* is frequently found in edificarian habitats, where collectors might easily find it, the species probably arrived on Savai'i within the past 40 years or, as Gibbons believes, within the past decade. Biochemical or histocompatibility studies on Oceanic *H. garnotii* populations may be informative, particularly since Darevsky et al. (1984) have demonstrated that some Southeast Asian populations previously referred to *garnotii* are a distinct species. We assume that both *G. mutilata* and *H. garnotii* arrived in the southern Cooks in post-Polynesian times, perhaps within the past few decades.

The final species, *Emoia trossula* from Rarotonga, is a large, conspicuous, forest-dwelling skink that does not fit the pattern of most Polynesian-transported species. Its presence on Rarotonga (and not Mangaia), in the absence of Fijian/Tongan species more likely to have been transported (such as *Cryptoble-*

pharus eximius and *Nactus pelagicus*), is difficult to explain and may indicate natural dispersal. This unexpected faunal relationship between the southern Cooks and Fiji/Tonga suggests that the Tonga Trench does not represent a completely effective barrier to the dispersal of nonvolant terrestrial organisms. Niue, nearly midway between Rarotonga and Tonga, would be a logical place to find a species common to Tonga and the southern Cooks, yet no *Emoia* of the *samoensis* group has been reported from Niue. The fauna of the island consists of four species of skinks, three geckos, and a sea snake (Gunther 1874; Crombie). One skink (*Emoia lawesii*) has Samoan affinities, but the other lizard species (*C. poecilopleurus*, *E. cyanura*, *G. oceanica*, *L. lugubris*, *L. noctua*, *N. pelagicus*) are all widespread in Oceania. Gunther's record of the Papuan *Mabuya* (= *Emoia*) *baudinii* was based on misidentified *Emoia cyanura* (BMNH 71.4.16.43). Many other characteristic Fijian/Tongan herpetofaunal elements (ranid frogs, iguanid lizards, boid and elapid snakes) have also not crossed the Tonga Trench to Niue or the southern Cooks. We cannot rule out the possibility that *E. trossula* recently colonized Rarotonga with human assistance, but more detailed comparative studies should clarify this problem.

Although most or all of the lizards discussed in this paper owe their modern Oceanic distribution in large part to human activities, the dates of their arrival in the southern Cooks are speculative. The only lizard whose bones have been found in the caves of Mangaia is *Gehyra oceanica*, although these limited remains were not from a clear chronological context (Steadman 1985). Further paleontological and zooarchaeological work in Oceania would provide information on the chronology and mechanisms of dispersal for lizards and other terrestrial organisms.

The human influence on other vertebrates (birds) on Rarotonga and Mangaia has been one of predation and extinction rather than dispersal (Steadman 1985). The human impact on intraisland distribution and abundance of Pacific lizards may be considerable as well. Clearing of forest would increase available habitat for some species (*L. lugubris*, *H. garnotii*) while reducing space for others (*Emoia trossula*, *G. oceanica*). Modern Rarotongans and Mangaians are rather oblivious to lizards, except to recognize that geckos eat insects around their houses. There is only one word ("moko") on Rarotonga in general use for all lizards, and the Rarotongans interviewed by DWS recognize only two or three of the seven species. The Mangaians recognize only two types of lizards: the skinks ("motukutuku") and geckos ("moko karara"). Lizards do not seem to be hunted or otherwise intentionally molested on either island. Both the interisland distribution and the intraisland abundance of Cook Island lizards seem to be unintentional results of human activities.

SUMMARY

Eight species of lizards (181 specimens) from the islands of Rarotonga and Mangaia provide the most complete herpetological survey of this poorly known area. Seven species (three geckos, four skinks) were found on Rarotonga and six species (three geckos, three skinks) on Mangaia. Five species (*Gehyra oceanica*, *Lepidodactylus lugubris*, *Crytoblepharus* cf. *poecilopleurus*, *Emoia cyanura*, *Lipinia noctua*) were present on both islands; *Gehyra mutilata* may also be on Rarotonga, although we have specimens only from Mangaia. *Hemidactylus garnotii* and *Emoia trossula* were found only on Rarotonga. Three of the reef islands off Rarotonga were briefly surveyed, and one or two species (*E. cyanura* and *L. noctua*) were found on each island.

All the skinks on Rarotonga and Mangaia are diurnal and moderately to exceedingly abundant. Although *E. cyanura* may be the most common and widespread lizard on Rarotonga, it appears to be absent from much of the montane forest. Its reduced abundance in the disturbed coastal lowlands of Rarotonga may be due to predation by the introduced mynah bird (*Acridotheres tristis*). *Lipinia noctua* is ecologically similar to *E. cyanura*, and the two species are often found sympatrically. *Cryptoblepharus* cf. *poecilopleurus* prefers open, disturbed woodlands very near the coast on both islands, where both *E.*

cyanura and *L. noctua* are found as well. *Emoia trossula*, the most ecologically restricted skink, is found primarily on trees (*Cocos*, *Hibiscus*, *Inocarpus*) along streams in lowland forest on Rarotonga only. Of the geckos, *Hemidactylus garnotii* and *Gehyra mutilata* were found only on buildings. *Lepidodactylus lugubris* was most abundant (or at least most obvious) on man-made structures and rarely was found on trees. In contrast, *G. oceanica* was most common on large trees (*Inocarpus edulis*) in lowland forest, although a few specimens were collected on or in buildings on Mangaia. Several individuals of *G. oceanica* from both islands had consumed small, unidentified seeds, as well as insects.

Most species were reproductively active during the survey periods (March–April 1984 and May–June 1985). Both specimens of *G. mutilata* were recently hatched juveniles, and the single *H. garnotii* was an immature female. No gravid females of *G. oceanica* were found, although the males all had enlarged testes. All 25 specimens of *L. lugubris* were females or unsexable juveniles, indicating an all-female, parthenogenetic population. No gravid females of *L. lugubris* were found on Rarotonga, although several recently hatched juveniles were collected and one adult was associated with a communal nest of seven infertile or hatched eggs. On Mangaia, certain females were either gravid, had enlarged follicles, or had distended oviducts. In the skinks, males of *E. trossula* had enlarged testes whereas the females showed no signs of reproductive activity. The one juvenile was recently hatched. Juveniles of *C.* cf. *poecilopleurus* were present on Mangaia, and females from Rarotonga had distended oviducts with small follicles. Certain females of the viviparous *L. noctua* had enlarged follicles, while others contained a single full-time fetus, and the males were producing sperm. Gravid females and/or sperm-producing males of *E. cyanura* were found on both islands. Clutch size was invariably two.

Our application of the name *C.* cf. *poecilopleurus* to widespread Oceanic populations is problematical because of the confused nomenclature of this species. Its type locality (in Andean Peru) may be in error, or the name may apply to a distinct South American species, although the latter possibility seems unlikely. In light of morphological differences, we prefer to recognize the Oceanic *Cryptoblepharus* as specifically distinct from *C. boutonii*. The analysis of variation within Oceania is hampered by limited samples from critical areas.

The systematics of the "azure-tailed" skinks of the *Emoia cyanura* complex is complicated by pattern polymorphism and variation in tail color. Boldly striped, partially striped, and unicolor ("bronze" or "melanistic") individuals can be found within a single, localized population. On Rarotonga and Mangaia, this variation is not correlated clearly with sex or maturity.

The presence of lizards on Rarotonga and Mangaia is attributed primarily to inadvertent human transport. Five species (*G. oceanica*, *L. lugubris*, *C.* cf. *poecilopleurus*, *E. cyanura*, *L. noctua*) probably arrived with the Polynesians during the past 1000 years. Two others (*G. mutilata* and *H. garnotii*) may have arrived more recently on post-European boat or air traffic. The presence on Rarotonga of *E. trossula*, a Fijian/Tongan element, may be due to natural dispersal. The lizard faunas of Rarotonga and Mangaia are very similar except that the presence of two additional species and the greater intraisland variation (especially in *E. cyanura*) on Rarotonga suggest multiple invasions of lizard stocks on that island. This idea is supported by the human history of the islands, which indicates that Mangaia has been more isolated (especially in post-European times) than Rarotonga.

Much remains unknown about patterns of distribution and dispersal of Oceanic lizards. We suggest that surveys of extant and extinct faunas would contribute greatly to our understanding of whence, when, and how lizards came to occupy these isolated islands.

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