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A new *Emoia samoensis* group lizard (Squamata: Scincidae) from the Cook Islands, South-central Pacific

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Abstract

The first published report of a large treeskink from Rarotonga, Cook Islands, appeared in 1988. The first museum voucher specimen was collected in 1984. Although this skink seems likely to be a recent arrival to the island of Rarotonga, it represents a unique member of the *Emoia samoensis* species group. We compare this population with other members of the *E. samoensis* group and describe the population as *Emoia tuitarere* **n. sp.**, distinguished by a suite of external characters including SVL, number of dorsal scale rows, and number of subdigital lamellae of the fourth toe. We provide preliminary definitions for the *concolor* and *samoensis* species subgroups proposed by Brown (1991), although current molecular data do not support their monophyly (Hamilton *et al*., 2010).

Key words: *Emoia samoensis* group, Pacific Ocean, Oceania, geographic variation, new species

Introduction

The Cook Islands were discovered and settled by Polynesians between 2000–2500 years ago [~500 BCE] (Kirch, 2000). By the time the first Europeans appeared in the early 1600s, the original fauna and flora had been altered significantly by hunting and agriculture. Steadman's studies of Pacific fossil avifaunas (2006) showed that ~50% of the native bird species disappeared soon after the arrival of the Polynesians. The original herpetofauna remains unknown other than we can be reasonably certain that seaturtles (likely *Chelonia mydas*, *Eretmochelys imbricata*) inhabited the local waters and used the shores for nesting. Was a terrestrial herpetofauna, specifically lizards, present or were the Cook Islands like the Hawaiian Islands denude of lizards when the first human settlers arrived? Based on the fossil records from other Pacific islands (Tonga, Guam), the potential pre-settlement lizard fauna of the Cook Islands (Table 1) was likely less diverse than the present one. Several skinks, all members of the genus *Emoia,* are components of that ancient fauna. It is possible that one might have been an *Emoia samoensis* group skink. Two large skink species occurred in the pre-settlement layer of an archeological excavation in ‘Eua, Tonga (Pregill, 1993). Their identities are uncertain, although two large skinks, *E. ‘trossula’* and until the 1800s *Tachygyia*, occur in Tonga. The large *Emoia* of Rarotonga, however, is probably a recent colonizer as suggested by a high level of genetic uniformity in island-wide sampling of the Rarotongan population (Hamilton *et al*., 2010).

Two other pieces of evidence for the absence of *E. ‘samoensis’* in the pre-Polynesian fauna are 1) its absence from other islands in the Cook group and 2) the recency of vouchers from the Cooks; however, neither separately nor together do these facts provide conclusive proof. While miscellaneous European and American biological exploring expeditions visited the Cook Islands, there are no published biodiversity inventories of all Cook Islands. The best herpetological inventories are those of D. Steadman (1984–1985; reported in Crombie and Steadman, 1986) and G. McCormack (Cooks Island Biodiversity Database, Version 2007.2; http://cookislands.bishopmuseum.org). Both of these naturalists report an *E. ‘samoensis’* skink from Rarotonga but nowhere else in the Cook

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Islands group. A possible earlier record might have been two Rarotonga skinks from the 1920's Whitney South Sea Expedition identified as *Emoia cyanogaster* (Burt and Burt, 1932). These two specimens (AMNH 29246-247), however, were re-identified subsequently as *E. impar* (fide R. Fisher).

TABLE 1. Terrestrial reptiles of Rarotonga, Cook Islands.

Taxa	Present[1]	Hypothetical[2] PREHUMAN	Fossil[3] PREHUMAN
Gehyra insulensis	+	-	0
Gehyra oceanica	+	+	-
Hemidactylus frenatus	+	-	-
Hemidactylus garnotii	+	-	0
Lepidodactylus lugubris	+	+	+
Nactus pelagicus	+	+	-
Cryptoblepharus poecilopleurus	+	+	-
Emoia cyanura	+	+	+
Emoia impar	+	+	+
Emoia 'samoensis'	+	-	+
Lipinia noctua	+	+	-

[1] Sources: Crombie & Steadman, 1988; Gill, 1994; Zug, fieldnotes 1999.

[2] Source: Zug, 1991. The list represents 'core species' and, in 1991, these species were postulated to have dispersed widely in the South Pacific prior to human settlement.

[3] No fossil reptiles are known presently from Rarotonga; occurrence in Rarotonga is predicted on basis of fossil assemblages elsewhere in Oceania. Sources: Pregill, 1993; Pregill, 1998.

Symbols: -, skeletal remains present in early settlement strata and not pre-settlement ones. +, skeletal remains in pre-settlement strata; 0, no fossils found or only in late settlement strata.

Why is the preceding discussion so focused on the 'nativeness' of *E. 'samoensis'* on Rarotonga? When Steadman first collected vouchers of the Rarotongan skink in 1984, he was surprised to discover an *E. 'samoensis'* so far east in Oceania. In reporting its occurrence, Crombie and Steadman (1986) noted the biogeographic peculiarity of its occurrence, identified it as the recently described *E. trossula*, and suggested the possibility of its recent colonization of Rarotonga. The colonization event remains a mystery, and our attempt (Hamilton *et al.*, 2010) to resolve the origin of the Rarotongan skink with molecular tools has not been totally successful, although we have demonstrated the genetic distinctiveness of the Rarotongan population from all other *E. 'samoensis'* populations (Fig. 1; see multi-locus phylogeny in Hamilton *et al.*, 2010). Herein we describe this population and offer a preliminary morphological comparison of it to Brown's other *samoensis* subgroup members, and especially to its nearest-relatives as recovered in our previous genetic analysis (Fig. 1).

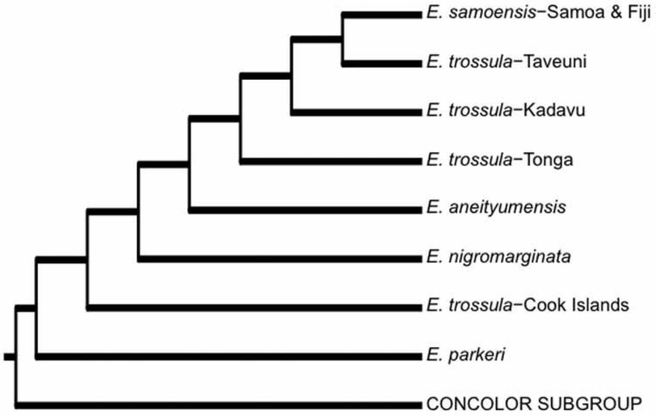

FIGURE 1. A stylized cladogram illustrating the phylogenetic relationships among South Pacific *Emoia samoensis* species group members. These species were used as comparative taxa. The relationships depicted in this cladogram are from the phylogenetic tree constructed using a combined analysis (Maximum Likelihood, Bayesian Inference, Maximum Parsimony) of mitochondrial and nuclear DNA published in Hamilton *et al.* (2010: fig. 2)

Material and methods

The morphological characters used in this study are largely the same as those used in the geographic variation of *Emoia tongana* (see Zug and Gill, 1997 for definitions). That character set was enlarged and a few character-name abbreviations modified. Definitions of new or modified character states are included in the Appendix section 1 along with abbreviations for all characters. The character set contains 13 mensural and 20 scalation (meristic) characters, although not all characters are reported herein. Sex and maturity were determined by examination of gonads. Data for the examined specimens are in the Appendix section 2. All statistical analyses were performed with SYSTAT 11. Sexual dimorphism among adults was tested by Student's t tests ($p<0.05$).

Emoia tuitarere n. sp. Zug, Hamilton and Austin

(Fig. 2)

Type material. Holotype. USNM 533712, adult male from Cook Islands, Rarotonga, ca. 7 km. [by road] WSW of Avarua [estim. 21°12'30"S 159°46'32"W], collected by George R. Zug and Patricia B. Zug, 19 March 1999.

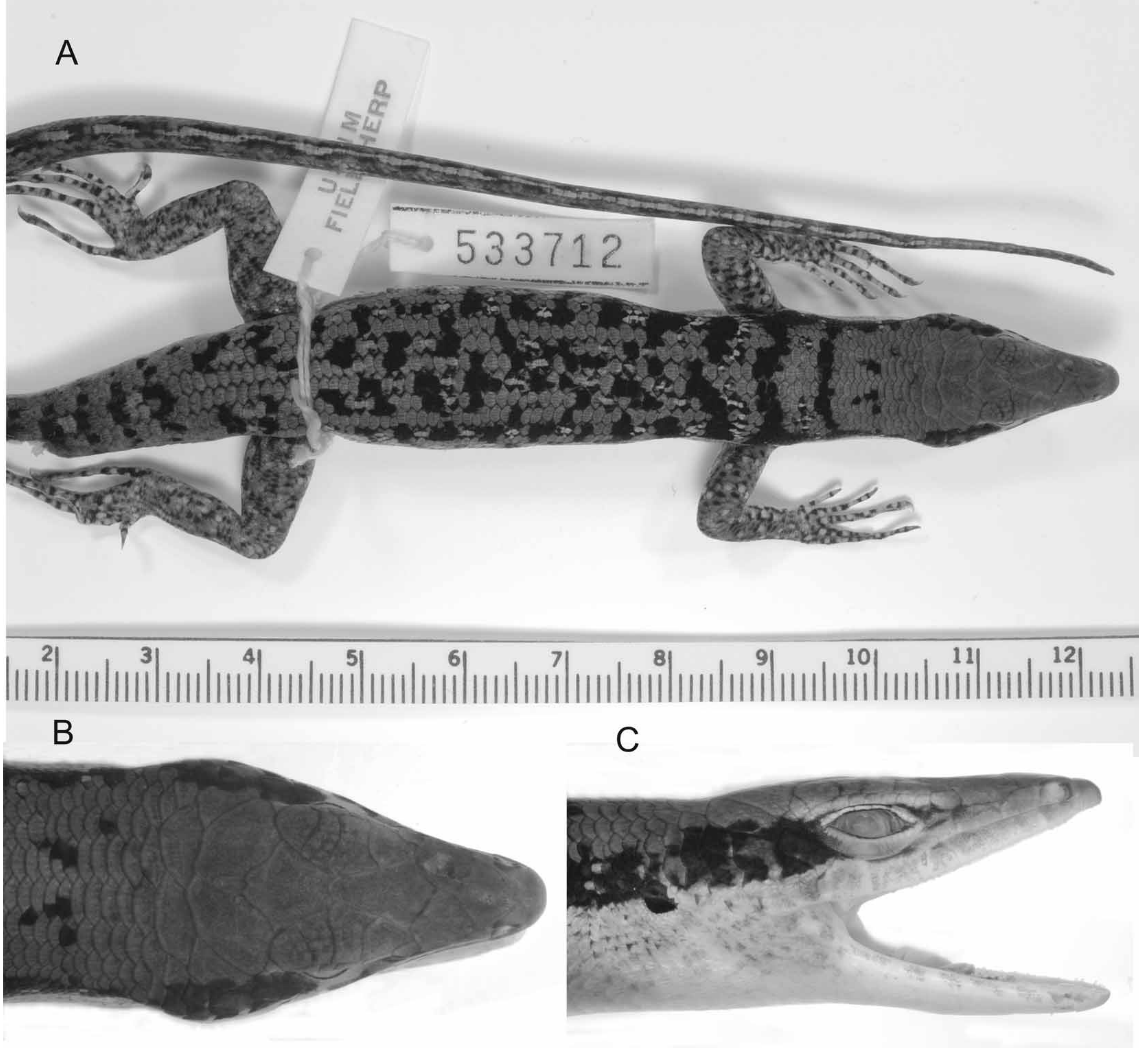

FIGURE 2. The holotype of *Emoia tuitarere* **n. sp.**, USNM 533712. A. dorsal aspect of whole body; B, dorsal aspect of head; C, lateral aspect of head.

Paratypes. All specimens from Cook Islands, Rarotonga. AIM LH1896 Avana Valley by Brian Gill, 28 September 1995; CAS 183322-325 Tupapa stream by Ted J. Case, 15 September 1991; SDNHM 66114-117, Avana stream, 1 to 2 km W of mouth, by Gregory K. Pregill, 4 November 1987; SDNHM 66145-146, Avana stream, 1 to

2 km W of mouth, by Gregory K. Pregill, 13 November 1987; USNM 249663-664 Turangi stream, 1.5 mi W of Ngatangia, collected by David W. Steadman, 15 March 1984; USNM 249665-666, data as preceding record, 16 March 1984; USNM 252391, Avana stream, 2.0 km [upstream] of Ara Tapu, by David R. Steadman, 29 May 1985; USNM 539181-182, Takitumu Conservation Area [21°15’05”S 159°46’00”W], collected by James R. Stewart and Rebecca A. Pyles, 11 January 2000; USNM 539184-186, 539188, data as preceding, 13 January 2000; USNM 539183, Marae Arai-Te Tonga parking lot [21°12’00”S 159°45’00”W, NE end of Rarotonga, by James R. Stewart and Rebecca A. Pyles, 12 January 2000; USNM 539189-190, Te Rua-Manga track [21°13’00”S 159°47’00”W], N end of Rarotonga, by James R. Stewart and Rebecca A. Pyles, 16 January 2000. Juvenile females SDNHM 66146, USNM 249665, 539186, 539190; juvenile males SDNHM 66144-145; adult females SDNHM 66115, USNM 249663, 252391, 539181-182, 539184-185, 539189; adult males SDNHM 66116-117, USNM 249664, 533712, 539183, 539188; sex not confirmed AIM LH1896, USNM 249666.

Diagnosis. *Emoia tuitarere* is a member of the *Emoia samoensis* species group and differs from other group members by a combination of traits. *E. tuitarere* averages (mean 82 mm, range 72–93 mm SVL) smaller than the *E. trossula* type-series (90 mm, 87–101 mm; Table 2), *E. ‘trossula*’ Tonga (94 mm, 82–101 mm), *E. samoensis* (98 mm, 92–109 mm), *E. sanfordi* (103 mm, 97–109 mm), *E. erronan* (85 mm, 69–101 mm), and *E. nigra* (~100 mm, 85–114 mm), and larger than *E. concolor* (~72 mm, 57–86 mm), *E. flavigularis* (67 mm, 59–73 mm), *E. loyaltiensis* (~68 mm, 66–68 mm), *E. mokosariniveikau* (~55 mm), *E. nigromarginata* (63 mm, 55–68 mm), *E. parkeri* (47 mm, 40–52 mm), and *E. tongana* (62 mm, 56–75 mm). *E. tuitarere* has fewer dorsal scales [Dorsal] (65, 62–69) than *E. aneityumensis* (78, 74–80) and *E. ‘trossula’* Rotuma (71, 65–77), and more than *E. nigromarginata* (58, 57–61), *E. parkeri* (56, 52–60), and *E. sanfordi* (58, 56–61). *E. tuitarere* has fewer 4th toe lamellae [4ToeLm] (49, 47–51) than *E. sanfordi* (66, 67–71) and more 4ToeLm than *E. aneityumensis* (35, 33–38), *E. nigromarginata* (37, 35–42), and *E. parkeri* (35, 33–40).

Description of holotype. An adult male, 84.7 mm SVL (88.6 mm in life), 170 mm tail length (~20 mm regenerated tip), 38.5 mm TrunkL, 32.8 mm SnForel, 42.2 mm HindlL, 20.0 mm HeadL, 11.6 mm JawW, 9.4 mm HeadH, 8.9 mm SnEye, 6.3 mm NarEye, 6.3 mm EyeEar, 3.1 mm SnW, and 6.4 mm Interorb. Scalation right side for bilateral traits: modest-sized semilunate rostral posteriorly contacting 1st supralabial, anterior nasal, elongate triangular supranasal and medially large pentagonal frontonasal; large rectangular prefrontals broadly in contact medially, large elongate pentagonal frontal, large hexagonal frontoparietal, moderate elongate interparietal separating paired oblong parietals except posteriorly, large paired nuchals; 4 Supoc 1st and 2nd subequal and largest, 9 Supcil, 10 Eyeld, oblong palpebral disc about third area of lower eyelid; large circular naris dividing nasal into anterior and posterior halves, AntLor and posterior loreal longer than high and subequal, 2 preoculars and 1 subocular on anterior margin of orbit, double row of postoculars with dorsalmost one largest, 2 modest-sized primary temporals, upper twice size of lower, 2 large secondary temporals, upper twice size of lower; 8 Suplab, 6th BlwEye, 7 Inflab, moderate nearly circular ear-opening with 1 blunt-triangular AuricN on lower anterior border; 62 smooth Dorsal, 32 Midbody, 37 smooth 4FingLm, 49 4ToeLm, and precloacal scale distinctly enlarged.

Coloration in life: boldly colored lizard; dorsally head unicolor coppery brown merging into brown with tarnished copper tint on neck, trunk, and tail with miscellaneously shaped blotches and stripes of dark brown to nearly black; dorsally on nape fragmented dark transverse bar, followed midneck and anterior axilla by complete transverse bars, bars remaining relatively thick but fragmented into middorsal bar and dorsolateral bar on each side, dorsum accentuated by numerous small longitudinally elongate lime-green spots arranged in irregular transverse rows; laterally loreal area with dark smudge and broad dark stripe between eye and axilla, dorsolateral dark bars well defined anteriorly becoming smaller and irregular posteriorly on trunk, lateroventrally neck and trunk lighten and merge into lime-green venter from posterior throat onto base of tail, chin golden yellow and chin to anterior chest immaculate, dark speckling begins behind axilla increasing in number posteriorly although not darkening the bright venter, dark speckling on tail coalesces into midventral stripe.

Coloration in preservative: Still boldly colored although muted by preservation. Pattern of dark and light markings unchanged. Dorsal ground color muted olive brown, ventrally tannish white and elongate dorsal and lateral spots also tannish white. Fore- and hindlimbs lighter brown ground color than trunk and with numerous small irregularly shaped dark blotches and smaller light flecks, ventrally limbs as venter and both with dark spotting.

Description. A moderately large *Emoia* ranging in adult size from 67 to 93 mm SVL, females 72.0–92.6 mm (adult ♀, *n* = 13); males 67.5–93.0 mm (ad. ♂, *n* = 9) with HeadL 16.3–19.3 mm (♀) 16.1–21.3 mm (♂), JawW 8.3–12.3 mm (♀) 11.2–14.9 mm (♂), HeadH 6.5–8.0 mm (♀) 6.3–10.1 mm (♂), SnEye 7.0–8.7 mm (♀) 6.3–9.2

mm (♂), NarEye 5.0–6.7 mm (♀) 5.1–6.7 mm (♂), EyeEar 4.9–6.8 mm (♀) 5.4–7.0 mm (♂), SnW 2.4–2.9 mm (♀) 2.5–3.2 mm (♂), Interorb 5.6–7.2 mm (♀) 6.3–8.1 mm (♂), SnForel 26.3–31.7 mm (♀) 27.3–33.6 mm (♂), TrunkL 35.0–47.3 mm (♀) 30.6–43.7 mm (♂), and HindlL 34.6–46.0 mm (♀) 35.9–45.5 mm (♂).

TABLE 2. Summary of variation in select mensural characters in adult samples of the *Emoia samoensis* species group. Mean ± 1 standard deviation, range, and statistically significant dimorphism * (Student's t $p \leq 0.05$); sample size in brackets; SVL & HeadL in mm.

Taxon	SVL	HeadL	TrunkL/SVL	HindlL/TrunkL	SnForel/SVL	HeadL/SVL
SAMOENSIS SUBGROUP						
Emoia tuitarere						
females [13]	80.8±5.49	17.5±0.80*	0.49±0.019*	0.96±0.077*	0.36±0.017*	0.22±0.010*
	72.0–92.6	16.3–19.3	0.46–0.52	0.83–1.10	0.33–0.38	0.20–0.24
males [9]	83.7±7.06	19.6±1.50*	0.47±0.015*	1.06±0.077*	0.38±0.015*	0.23±0.004*
	67.5–93.0	16.1–21.3	0.45–0.49	0.97–1.19	0.36–0.40	0.23–0.24
Emoia trossula (type-series)						
females [11]	90.2±7.48	20.2±2.19	0.48±0.031	1.01±0.098	0.38±0.019	0.22±0.010*
	87.0–101.2	17.4–24.9	0.45–0.55	0.88–1.23	0.36–0.41	0.21–0.25
males [18]	90.9±8.53	21.2±2.16	0.46±0.02	1.07±0.10	0.38±0.020	0.23±0.008*
	75.9–102.4	17.0–24.2	0.42–0.50	0.82–1.25	0.35–0.43	0.22–0.25
Emoia trossula (northern Fiji)						
females [7]	94.4±6.55	20.9±2.96	0.48±0.012	0.95±0.056	0.38±0.011	0.22±0.014
	81.5–101.2	17.9–24.9	0.47–0.50	0.88–1.04	0.37–0.39	0.20–0.25
Emoia ?trossula (Rotuma)						
females [17]	81.6±2.87	17.9±0.67*	0.48±0.019	0.94±0.053*	0.36±0.015	0.22±0.004*
	75.4–85.3	16.9–19.2	0.45–0.52	0.86–1.02	0.34–0.39	0.21–0.23
Emoia ?trossula (Tonga)						
females [11]	95.5±6.70	20.7±1.64*	0.49±0.033	0.99±0.110	0.37±0.035	0.22±0.014*
	84.3–105.2	18.8–24.7	0.44–0.55	0.0.84–1.25	0.32–0.43	0.20–0.25
Emoia samoensis (Samoa)						
females [10]	98.2±4.54	21.0±0.78	0.50±0.018*	0.92±0.041*	0.36±0.013	0.21±0.003*
	92.4–108.8	19.9–22.7	0.46–0.53	0.87–1.02	0.34–0.38	0.21–0.22
Emoia sanfordi						
females [11]	102.8±4.49	22.4±0.82*	0.49±0.017	0.89±0.062*	0.35±0.015*	0.22±0.005*
	96.9–110.5	21.3–23.9	0.46–0.52	0.80–1.01	0.33–0.38	0.21–0.23
CONCOLOR SUBGROUP						
Emoia aneityumensis (Anatom, Vanuatu)						
adults [4]	84.8±8.47	17.4±1.13	0.50±0.027	0.91±0.084	.	0.22±0.004
	76.0–92.9	16.6–18.2	0.48–0.53	0.82–1.03	.	0.21–0.22
Emoia nigromarginata (Efate & Malakula, Vanuatu)						
females [8]	63.0±3.99	14.6±0.819*	0.49±0.025*	0.93±0.062*	0.38±0.018	0.23±0.010*
	55.4–66.7	13.3–15.5	0.46–0.53	0.87–1.02	0.35–0.41	0.22–0.25
Emoia parkeri (Fiji)						
females [10]	46.8±4.28	10.5±0.629	0.47±0.018*	0.95±0.079	0.39±0.030	0.22±0.015
	40.0–52.0	9.8–11.6	0.45–0.50	0.88–1.10	0.36–0.45	0.20–0.25

E. tuitarere is sexually dimorphic in most mensural features and nearly half the proportions. Males average larger (83.7 mm SVL) than females (80.7 mm), although the means are not significantly different. In contrast, all measurements, except TrunkL (39.8, 39.3 mm; means females [*n* = 13], males [9], respectively), and SnW (2.7, 2.8 mm), are dimorphic (statistically significant) in adults: HindlL (38.2, 41.6 mm), SnForel (30.0, 31.3 mm), HeadL (17.5, 19.6 mm), JawW (10.6, 12.5 mm), HeadH (7.2, 8.5 mm), SnEye (7.7, 8.4 mm), NarEye (5.7, 6.3 mm), and EyeEar (5.6, 6.4 mm). Body proportions showing significant dimorphism in adults are: HeadL/SVL (22, 23%), TrunkL/SVL (49, 47%), HindlL/TrunkL (96, 106%) and SnForel/SVL (36, 38%); the statistically non-dimorphic ones are: JawW/HeadL (60, 62%), SnEye/SVL (9.5, 10.1%), NarEye/SnEye (74, 75%), EyeEar/SnEye (74, 78%) and SnW/HeadL (15, 15%).

Of the scalation traits, only Eyelid (10, 11) shows sexually dimorphism. The interparietal is rarely absent, frontoparietal almost always single, and prefrontal usually in contact; 4 Supoc, 8 (uncommonly 7 or 9) Supcil, 9–12

Eyeld, 8 (rarely 9) Suplab, 6th (rarely 7th) BlwEye, and 7 (uncommonly 8) Inflab on each side. Palpebral disc small, about one-quarter area of lower eyelid area; moderate-sized, oblong vertical (occas. oblique) ear opening with 2–5 (commonly 3) AuricN, usually blunt, on anterior margin. Trunk scales usually smooth, uncommonly weakly tricarinate dorsally and laterally, with 60–69 Dorsal (median 64), single (uncommonly 2 or 3) pair of Nuchal, 32–35 Midbody (33). Subdigital lamellae smooth, 34–42 4FingLm (37), 46–53 4ToeL (49).

TABLE 3. Summary of variation in select meristic characters in adult samples of the *Emoia samoensis* species group. Median ± 1 standard deviation, range, and statistically significant dimorphism * (Student's t $p \leq 0.05$); sample size in brackets.

taxon	Dorsal	Midbody	4FingLm	4ToeLm	DorsKN
SAMOENSIS SUBGROUP					
Emoia tuitarere					
females [10]	65±2.3	32±1.0	37±1.4	49±1.0	0±0
	62–68	32–34	36–39	47–51	0–0
males [8]	64±1.1	33±0.9	36±2.6	50±2.3	0±0
	62–65	32–34	34–42	46–53	0–0
Emoia trossula (type-series)					
females [11]	65±2.7	34±1.4	33±2.2	47±3.7	0±1.1
	62–71	31–36	30–37	42–55	0–3
males [18]	65±3..0	33±1.5	33.5±2.5	46.5±3.4	0±0
	59–70	31–36	30–38	41–55	0–0
Emoia trossula (northern Fiji)					
females [7]	63±1.4	34±1.9	36±2.9	51±5.2	0±1.2
	62–66	31–36	30–39	42–47	0–3
Emoia ?trossula (Rotuma)					
females [17]	71±3.1*	35±1.6	39±1.7	56±2.4	0±0
	65–77	33–38	34–40	50–59	0–0
Emoia ?trossula (Tonga)					
females [11]	65±1.9	33±1.2	34±1.1	47±2.2	0±0
	62–69	30–34	32–36	44–51	0–0
Emoia samoensis (Samoa)					
females [10]	63.5±1.6	31±1.0	33±1.0	46±2.4	0±0
	62–66	30–33	31–34	44–51	0–0
Emoia sanfordi					
females [11]	58±1.8	31±0.9	47±2.7	66±4.0	3±1.6*
	56–61	30–32	43–51	57–71	0–4
CONCOLOR SUBGROUP					
Emoia aneityumensis (Anatom, Vanuatu)					
adults [4]	78±3.1	40.5±1.0	26±2.2	35.5±2.9	0±0
	74–80	39–41	23–28	33–38	0–0
Emoia nigromarginata (Efate & Malakula, Vanuatu)					
females [8]	58.5±1.2	30±0.7	28±1.5	37±2.4	0±1.4
	57–61	30–32	26–31	35–42	0–3
Emoia parkeri (Fiji)					
females [10]	56±2.2	30±2.2	25.5±2.4	35±2.7	0±0.9
	52–60	26–33	22–30	33–40	0–3

Variation is relatively low in most mensural and meristic traits. Using a repeated data-gathering protocol, GZ examined one specimen multiple times ($n = 11$) on different days to estimate intra-observational variation (see discussion in Hayek and Heyer (2010) and Schmaltz and Zug (2002)). This repeats protocol establishes a measure of an observer's variation in data-gathering and serves as a guide, either using standard deviations (s) or coefficients of variation (V), to the minimum level of variation within a data set that derived from data collection and that is not a component of trait variation within a population of a species. The level of variation seen in the *E. tuitarere* sample, or for that matter any other sample, is a composite of actual (natural) populational variation and data-gathering variation. Overall, morphological variation in *E. tuitarere* is low, and that may be a reflection of their high genetic homogeneity (Hamilton *et al*., 2010).

For the mensural traits, the repeats protocol gives a range of *V* from 0.7% (SVL) to 5.8% (HeadL) with a median of 3.45% and mode of 3.5% for the twelve traits. Comparison of *V*s for adult females and males shows female measurements range from 4.7 to 8.6% (median 8.3%) and for males 7.0 to 15.0% (9.5%). These ranges are typically *V*s for animal populations (Simpson *et al*., 1960). The difference (Table 2) between males and females is the broader range of body size in adult males, suggesting that males mature at a smaller size and then grow longer (time) than females. JawW variation has the highest *V* value (10.9%) in female measurements and is nearly the same in males (10.7%). HeadH has the highest *V* in males (15%) and much lower in females (5.9%), further emphasizing the dimorphism in head size and shape between females and males (HeadL/SVL 22% vs. 24%, see Table 2).

Observer variation (repeats protocol) is less among the scalation traits. Within the repeats, twelve scalation traits had no variation among successive counts. Variable counts occurred for Eyeld (*V* = 5%), Dorsal (1%), and 4FingLm (1.6%). More traits showed variation within the adult samples. Females and males share subequal variation in Supcil, Eyeld, Inflab, Dorsal, Midbody, 4FingLm, and 4ToeLm, ranging 1.7–6.5% and 1.8–9.2%, respectively. Five other traits (Interpa, Frontpa, Suprcil, AuricL, Nuchal) had *V*s ranging 22.3–40.4%) because one or two individuals in the sample had a different state, such as Interpa absent when this scale is present in the majority.

Color variation in alcohol. Dorsal ground color is dark to light brown with a coppery sheen, particularly on head and anterior neck. The darker brown occurs in the older preserved specimens, although a set of specimens preserved in mid-2000 range from dark to light, two of which (USNM 539185, 539190) are nearly olive. Ventrolaterally, ground color lightens as it grades into dull yellow venters, greenish overtones in some and dusky beige in longer preserved specimens. Dorsally head and neck are immaculate and similarly unicolor in loreal area. All individuals have moderately broad, black postorbital stripe on each side extending from posterior edge of orbit rearward above ear-opening to axilla. This stripe is continuous only in two individuals; in most, stripe is a series of irregular, black blotches narrowly separated by brown interspaces. In the lightest two individuals, a black postorbital spot is widely separate from dark stripe above ear to axilla. All individuals have yellow eyelid scale borders, highlighted with a dark border on upper eyelid. Dark marking occurs dorsally and dorsolaterally on trunk from mid neck onto base of tail; size and density of dark marks vary from a few black spots (occupying one to two scales) to broad transverse crossbars. These crossbars are best developed on posterior neck and over shoulders, becoming smaller and fragmented on trunk. In a few individuals, the postorbital stripe continues posteriorly on trunk as fragmented stripe. Narrow, longitudinal greenish flecks occur on dorsum from posterior neck to posterior trunk in slightly less than half the sample and flecks are numerous in about half of these individuals. Venters of most individuals (~80%) are immaculate from chin to vent; scattered, tiny black flecks occur from chest posteriorly in a few other individuals. Ventrally, tails have larger (although still small) black flecks, and in some, fleck forms a midventral series.

Distribution. Presently known only from Rarotonga, Cook Islands. The other Cook Islands are visited regularly by naturalists, but no one has reported seeing this skink on any of them (G. McCormack, *in litt*. 11 Nov. 2009).

Etymology. The specific name derives from the Cook Island Maori *tuitarere* for wanderer, pilgrim, stranger, alien, and is proposed in reference to the putative recent arrival of this species on Rarotonga. It is proposed as a noun in apposition.

Comparison to other taxa. In a review (Brown and Gibbons, 1986) of central Pacific arboreal *Emoia* populations, Brown proposed the *samoensis* species group [= complex]. Neither in this review nor in his subsequent monograph (Brown, 1991) did he provide a definition of the *samoensis* group or its subgroups, the *concolor* and the *samoensis* subgroups, proposed therein. The group can be defined by extracting couplets from his key to *Emoia* species groups (1991: 4): 11 premaxillary teeth; nasal bone paired (not fused); parietal eye present; anterior loreal elongate, its length equal or nearly so that of posterior loreal; less than 88 Dorsal; less than 44 Midbody; subdigital lamellae smooth rectangular to moderately narrowed (not blade-like). His *samoensis* subgroup is less easily characterized, and at the present, there is no unique character or character set differentiating *concolor* and *samoensis* subgroup members. Three *samoensis* subgroup members (*E. samoensis*, *E. sanfordi*, *E. trossula*) are large *Emoia* (>66 mm minimum adult SVL), but several *concolor* subgroup members also do not mature (females) at SVLs less than 65 mm (e.g., *Emoia nigra*). In spite of this difficulty, we tentatively accept Brown's two subgroups, although recognizing that our molecular data do not advocate his species assignments [our molecular data set lacks representation from many islands, hence it is too soon to re-partition membership in Brown's two subgroups]. Because of its gross similarity to other member of the *samoensis* subgroup, we treat *E. tuitarere* as a member of that subgroup.

The following comparison focuses on the members of that subgroup and select members (*E. aneityumensis*, *E. nigromarginata, E. parkeri*) of the *concolor* subgroup identified as sister-group taxa in our molecular analysis (Hamilton *et al*., 2010: Fig. 1).

Conceptually for Brown (1991), *Emoia samoensis* was the large, 'green' skink of Samoa; we similarly accept the Samoan populations as *E. samoensis*. For Brown, *E. trossula* was the large, greenish brown and usually dark cross-barred skinks of Fiji, Rotuma, Tonga, and Rarotonga. Although we initially accepted the skinks from Fiji, Rotuma, and Rarotonga as *E. trossula*, our molecular analysis (Hamilton *et al*., 2010) revealed the uniqueness of populations of '*trossula*', hence requiring a conceptual adjustment; thus, we compare *E. tuitarere* with '*trossula*' from separate island groups. A sample from Brown's and Gibbon's type series (Table 2, 3) immediately reveals differences; however, use of these data is inappropriate because the type series encompasses a broad geographic area including Rotuma and all Fijian island groups and probably represents multiple genetic entities (see Fig. 1). The northern Fijian *E. trossula* sample includes individuals from the type-locality, Ovalau, and other islands (e.g., Viti Levu, Vanua Levu) that were parts of single landmasses or separated by narrow marine straits during the last glacial period (Zug, 1991:fig. 17B).

The *E. trossula* population of Kadavu has insufficient specimens for valid morphological comparison even though it is genetically distinct from other *trossula* populations. The Rotuman *trossula* sample is large, but we lacked genetic samples for inclusion in our molecular analysis. With these caveats, we compare *E. tuitarere* to five *samoensis* subgroup populations/samples: *E. samoensis* (Samoa); *E. trossula* (northern Fiji, including the type-locality); *E. trossula* (Rotuma); *E. trossula* (Tonga); *E. sanfordi* (Vanuatu); and to its three sister-group taxa (*E. aneityumensis*, *E. nigromarginata*, *E. parkeri*).

TABLE 4. Summary of distinguishing characters between *Emoia tuitarare* and other *Emoia* species and populations examined in this study (for adult females). Differences distinguishing species are denoted (√); those with differences that are statistically significant for mean ± 2 standard errors (√√). Percent divergence among lineages for 1726 bp of mitochondrial DNA is from analysis in Hamilton *et al*. 2010.

	Size		Scale Characters			Genetic Data
Taxa	SVL	Dorsal	Midbody	4FingLm	4ToeLm	Divergence
SAMOENSIS SUBGROUP						
Emoia trossula (northern Fiji)	√					15%
Emoia ?trossula (Rotuma)		√	√		√√	.
Emoia ?trossula (Tonga)	√			√		13%
Emoia samoensis (Samoa)	√√			√√		18%
Emoia sanfordi	√√	√√		√√	√√	.
CONCOLOR SUBGROUP						
Emoia aneityumensis		√√	√√	√√	√√	11%
Emoia nigromarginata	√√	√√		√√	√√	11%
Emoia parkeri	√√	√√		√√	√√	21%

Among the *samoensis* subgroup, *E. tuitarere* and *E. trossula*-Rotuma are the smallest members (Table 2, 4). Although males tend to average slightly larger in all members of the *samoensis* subgroup, mean SVLs of females and males are not statistically different in any subgroup taxon. Indeed, sexual dimorphism does not occur in most mensural traits, although dimorphism is strongly present in the head and body proportional differences for some samples. *Emoia tuitarere* share smaller headed females (than males, mensurally) with *trossula*-Rotuma, *trossula*-Tonga, and *E. sanfordi*; the preceding samples and *E. samoensis* and *trossula*-type-series share dimorphism of HeadL/SVL. The *trossula*-type-series displays no dimorphism of mensural traits. The proportional differences in size and shape are not greatly different between females and males in any subgroup member, yet statistically significant in all members, for example, *E. samoensis* HeadL/SVL 21% female vs. 23% male. The most striking dimorphism is the relative differences in TrunkL and HindlL; *samoensis* subgroup females have longer trunks and shorter hindlimbs than their conspecifics males. These differences are significantly only in *E. samoensis*, *E. sanfordi*, *E. trossula*-Rotuma, and *E. tuitarere*. Among the sister taxa, *E. nigromarginata* displays a relatively smaller head in females, but *E. parkeri* is not dimorphic; *E. aneityumensis* sample is too small for statistical testing. *E. nigromarginata* also has proportionately larger trunk and shorter hindlimbs in females.

In most scalation features, *E. tuitarere* is similar to other *samoensis* subgroup members. It matches *E. trossula*-type-series, *E. trossula*-Tonga, and *E. samoensis* in Dorsal, and those three taxa as well as *E. samoensis* and *E. sanfordi* in Midbody. In digit lamellae, *E. trossula* type-series, *E. trossula*-Tonga, and *E. samoensis* average slightly fewer lamellae than *E. tuitarere* (Table 3). In contrast, *E. trossula*-Rotuma and *E. sanfordi* have distinctly more lamellae, especially so for *E. sanfordi*. The sister taxa have distinctly fewer digital lamellae than *E. tuitarere*. *E. nigromarginata* and *E. parkeri* also have fewer Dorsal and Midbody than *E. tuitarere*; in contrast, *E. aneityumensis* has the highest number of Dorsal and Midbody of all the samples compared (Table 3,4).

Coloration in the *samoensis* subgroup has two general patterns: a dorsal black barred (transverse) pattern on a brown to olive background, or a bright green background with black smudges dorsally. The latter pattern occurs only in *E. sanfordi*. The top of the head of *E. sanfordi* almost always has a black blotch, usually covering the posterior third of the head, occasionally the posterior two-thirds of the head. The black smudging on the dorsum of the neck and trunk is variable, ranging from absent to extensive, i.e., covering ½ to 2/3 of dorsal surface. The barred pattern occurs in *E. samoensis*, *E. trossula*, and *E. tuitarere*, with the amount of barring variable within and among these taxa. In *E. samoensis* (from Samoa), the bars are numerous, narrow, and fragmented, commonly of four parts, two dorsolateral and a lateral one on each side. This latter pattern also occurs in *E. trossula*-northern Fiji; although generally with fewer bars and those bars concentrated on the neck and anterior half of the trunk. *E. trossula*-Rotuma has narrower dorsal bars that are continuous across the midline on most individuals, but separated in some and absent in a few individuals. The lateral barring forms a nearly continuous, broad black lateral stripe from posterior edge of eye to axilla in most individuals. Almost all Rotuman *E. trossula* have numerous bright, ‘yellow’ longitudinal flecks on dorsal, dorsolateral, and lateral surface of the trunk. *E. trossula*-Tonga has a few small black dorsal and dorsolateral bars, mainly on the posterior half of neck and anterior half of trunk. Of the *samoensis* subgroup members, the Rotuma and Rarotongan populations are the most similar in appearance.

None of the *concolor* subgroup taxa have the transverse barred and bright flecking pattern of *E. tuitarere*. *E. concolor*, as name implies, is nearly unicolor, ranging from green to greenish brown., *E. aneityumensis*, *E. nigromarginata,* and *E. parkeri* are most closely related to *E. tuitarere* yet they have dissimilar patterns to one another and to *E. tuitarere*. *E. aneityumensis* has a brownish olive background, either unicolor or with vague dark brown blotches dorsally and dorsolaterally on the trunk. *E. nigromarginata* has a silvery to coppery gray ground color with a series of small, black spots on trunk and a scattering of small black blotch dorsally. *E. parkeri* is a brightly striped lizard, with a coppery brown middorsal stripe bordered parasagittally by black, irregularly edged stripe, dorsolateral light stripe, and laterally another black, irregularly edged stripe. The lateral stripe extends from snout onto tail.

Natural history. *Emoia tuitarere* is an arboreal lizard, but not strictly so. Individuals are most frequently seen on the sides of trees, often in head-down position, perhaps to scan the forest floor or lower shrubby vegetation for prey. They also forage amidst the tangle of branch in secondary forest and ecotonal zone between gardens and forest.

The abundance or at least visibility of this species appears to be affected by weather. Few individuals were observed during a rainy period following a tropical cyclone in March 1999. The single male (holotype) captured at this time was also reproductive quiescent. During March of other years, *E. tuitarere* was abundant.

Biogeographic comments. The *E. samoensis* group is a south-central and south-west Pacific clade of largely arboreal lizards. The two subgroups (*concolor* and *samoensis*) overlap broadly throughout this area of Oceania, and in most areas, a *concolor* and a *samoensis* subgroup member are sympatric. Also in most areas, *Emoia nigra*, one of the two primarily terrestrial species in this clade, has a broad distribution and co-occurs with arboreal congeners through much of the Southwest Pacific. Our present knowledge of phylogenetic relationships supports the monophyly of the *samoensis* group and suggests paraphyly of the two subgroups (Hamilton *et al*., 2010). Furthermore, our morphological and molecular data indicate that diversity is considerably greater than our present taxonomy displays. Until this diversity is described, biogeographic hypotheses are premature.

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APPENDIX

1. Character definitions

The character set is an expansion of the set defined in our study of morphological variation of *Emoia tongana* (Zug and Gill, 1997). Many of the characters are defined there; only the recently added ones are defined below. The following list provides character names and their abbreviations.

MEASUREMENTS*:* Eye-ear length (**EyeEar**) distance from posterior corner of orbit to anteromedial edge of ear-opening; Head height (**HeadH**), distance from top to bottom of head measured perpendicular at posterior corners of jaw; Head length (**HeadL**); Hindlimb length (**HindlL**); Interorbital width (**Interorb**), transverse distance between anterior corner of eyes measured at edge of supraciliaries; Jaw width (**JawW**), width of head measured across posterior corners of jaw; Naris-eye length (**NarEye**) distance from center of nares to anterior corner of orbit; Snout-eye length (**SnEye**), distance from tip of snout to anterior corner of orbit; Snout width (**SnW**), transverse distance from center of left and right nares. Snout-forelimb length (**SnForel**), distance from anterior edge of forelimb to tip of snout; Snout-vent length (**SVL**); Tail length (**TailL**), distance from vent to tail tip; Trunk length (**TrunkL**).

SCALATION: Anterior loreal shape (**AntLor**), three states of length <, = or > height; Auricular lobes, number on anterior and anterodorsal border (**AuricL**); Dorsal body scales, number (**Dorsal**); Eyelid scales, number (**Eyeld**); Frontoparietal, single or paired (**Frontpa**); Infralabial scales, number (**Inflab**); Interparietal scale, present or absent (**Interpa**); Keeling of body scales, number of keels (**DorsKN**, **LatKN**, **VntlKN**); Loreal scales, number (**Lor**); Midbody scale rows, number (**Midbody**); Nuchal scales, number of pairs (**Nuchal**); Precloacal scales size (**Precl**); Prefrontal scales, in contact or not (**Prefr**); Subdigital lamellae, number on fourth finger (**4FingLm**) and on fourth toe (**4ToeLm**); Supralabial scales, number (**Suplab**); Supralabial scale below orbit (**BlwEye**); Supraocular scales, number (**Suproc**); Supraciliary scales, number (**Suprcil**).

All mensural characters are straight-line measurements of body segments to the nearest 0.1 mm with dial calipers. Scalation features of head, body and limbs were recorded from right side on paired features. Sex and reproductive state (maturity) were determined by dissection and examination of the gonads. Mature females possess vitellogenic follicles >1.5 mm, oviducal eggs/embryos, or stretched but empty oviducts; mature males have enlarged testes and epididymides. Determination of maturity for female is more reliable for the lizards in transition owing to the discreteness of virginal versus nonvirginal oviducts in females compared to the recognition of "enlarged" testes in males.

2. Specimens examined

Emoia samoensis subgroup populations.

Cook Islands [*Emoia tuitarere*]: AIM LH1896; CAS 183322-325; QM J42397, J45620, 45622-623; SDNHM 66114-117, 66145-146; USNM 249663-666, 252391, 533712, 539181-190.

Fiji [sample from type series – *E. trossula*]: AMNH 20927, 29010-011, 29017-022, 40196, 40442-443, 40445, 40491, 40503, 40506, 40539; BMNH 62.10.23.4, 75.12.31.6, 81.10.12.19, 82.9.18.5, 1938.8.2.9; BPBM 1504; CAS 155958, 155960-962,156128-130; DW F524-25, F541-42; FMNH 13644-645; MCZ R16941-942, R16945, R16965; USNM 230201.

Fiji [northern islands: Viti Levu & Taveuni – *E. trossula*]: AMNH 20927, 40442-443, 40445, 40491, 40506; AMS 106753,-766, 111425-428, 111431, 116161; BMNH 1938.8.2.9; CAS 156128-129, 155958, 155960-962, 172545; DW F612; FMNH 13644-645; USNM 230201, 267939, 499933-934.

Rotuma [*E. ?trossula*]: BMNH 97.7.29.9-10; USNM 268256-289, 268291, 268294, 268299-302, 268305-309.

Samoa [*E. samoensis*]: AMNH 27695, 27702, 27706, 29244-245, 41738, 41741; USNM 215295-301, 215304, 268376-380, 215244, 215247-549, 215251.

Tonga [*E. ?trossula*]: AMS 96577-579, 96584; CAS 158241-242, 158245, 159407-408, 159999; FMNH 58144, 191762; SDNHM 66147, 66186; USNM 259331-333, 267849, 322228-230, 333577, 333684, 333763-764.

Vanuatu [*Emoia sanfordi*]: FMNH 13664, 13666, 13668-670, 13672-673; USNM 122176, 334035-046, 334261-265.

Emoia concolor subgroup populations.

Emoia aneityumensis [Anatom, Vanuatu]: BMNH 1956.1363-1365, 1973.1534-1536; FMNH 69151.

Emoia nigromarginata [Efate & Malakula, Vanuatu]: AMNH 81668; USNM 333999-4018, 334022-029.

Emoia parkeri [Fiji]: BMNH 55.8.16.10, 63.5.11.16, 1938.8.2.11; BPBM 1648; CAS 14960-966, 47570-572, 156005, 174249-250, 174256, #81, #170.