Emoia (Reptilia: Scincidae) from the Banda Arc islands of eastern Indonesia: variation in morphology and description of a new species

R. A. How[1], B. Durrant[1], L. A. Smith[1] and Najamuddin Saleh[2]

[1] Museum of Natural Science, Western Australian Museum, Francis Street, Perth, Western Australia 6000, Australia
[2] BKSDA VII, PO Box 15, Kupang, Timor, Nusa Tenggara Timor, Indonesia 85228

Abstract – Skinks of the genus *Emoia* are widespread through the islands of the Pacific with 72 species recognised in a recent review, eight of these occur on the islands of eastern Indonesia. Only three of these described species were collected during a survey of this region between 1987–1993. The morphology of head shields and body scale counts of the specimens collected were subjected to univariate and canonical variate analysis. *Emoia reimschisseli* and *E. longicauda* were collected on Wokam island in the Aru group and on Selaru island in the Tanimbar group. There was a marked difference in morphology of head shields and body scale counts of the single specimen of *E. reimschisseli* from Selaru when compared to populations of this species from both Aru and Kai Besar islands. The *Emoia similis* collected on eastern Flores are morphologically similar to those collected previously from Flores and Komodo islands, but showed some differences in body patterning. The previously uncollected population of *Emoia* from Sumba island is described as a new species. It is closely allied to *E. similis* from Flores and Komodo.

INTRODUCTION

The vertebrate fauna of the islands of eastern Indonesia have long held an interest for biologists because they straddle the divisions and biota between two of the world's great biogeographic realms, the Asian and the Australasian (Wallace 1860). The islands of south-eastern Indonesia are arranged into two chains of different geological origins, the Inner and Outer Banda Arcs. Along these island chains the fauna of the two biogeographic realms come into contact, high levels of endemism are apparent (Vane-Wright 1991; Kitchener and Suyanto 1996; How and Kitchener 1997) and morphological and genetic differentiation occurs among species (Kitchener *et al.* 1993). An important factor determining this variation and endemism appears to be the alternating linkages between islands that occurred because of changes in sea-levels during Pleistocene glaciations (Schmitt, Kitchener and How 1995; How, Schmitt and Suyanto 1996).

A survey of the vertebrates on the islands of eastern Indonesia from Bali eastwards through the Inner and Outer Banda Arcs to Ambon, Kai and Aru was undertaken between 1987 and 1993 by the Western Australian Museum and the Museum Zoologicum Bogoriense, Indonesia. The survey documented the amphibians, birds, mammals and reptiles of some 28 islands during the course of 12 major surveys extending over eight years with a view to evaluating the species diversity and systematics in the zone of transition between the Asian and Australasian biogeographic realms.

Studies of the reptile fauna in the region have shown that there is significant intraspecific morphological variation in both lizard and snake species along the two island chains that form the Banda Arcs. Musters (1983) described subspecific variation in the volant dragon, *Draco*; Aplin *et al.* (1993) revised the species in the skink genus *Glaphyromorphus* and How *et al.* (1996a, 1996b) documented morphological variation in four colubrid and one viperid snake.

Brown (1991) recognised 72 species in *Emoia* across the range of the genus from south-east Asia, through the Indo-Australian Archipelago to the islands of the Pacific, where species are widespread and abundant. *Emoia* is most speciose on New Guinea and the satellite islands to the north and east along the Pacific Plate boundary but is poorly represented in the islands west of New Guinea. Brown (1991) documented seven species (*E. atrocostata* (Lesson), *E. caeruleocauda* (de Vis), *E. sp.* [*baudini* group], *E. kuekenthali* (Boettger), *E. longicauda* (Macleay), *E. reimschisseli* (Tanner), *E. sorex* (Boettger)) from the Maluku islands and three species of *Emoia* (*E. atrocostata*, *E. caeruleocauda*, *E. similis* Dunn) from the Lesser Sunda islands.
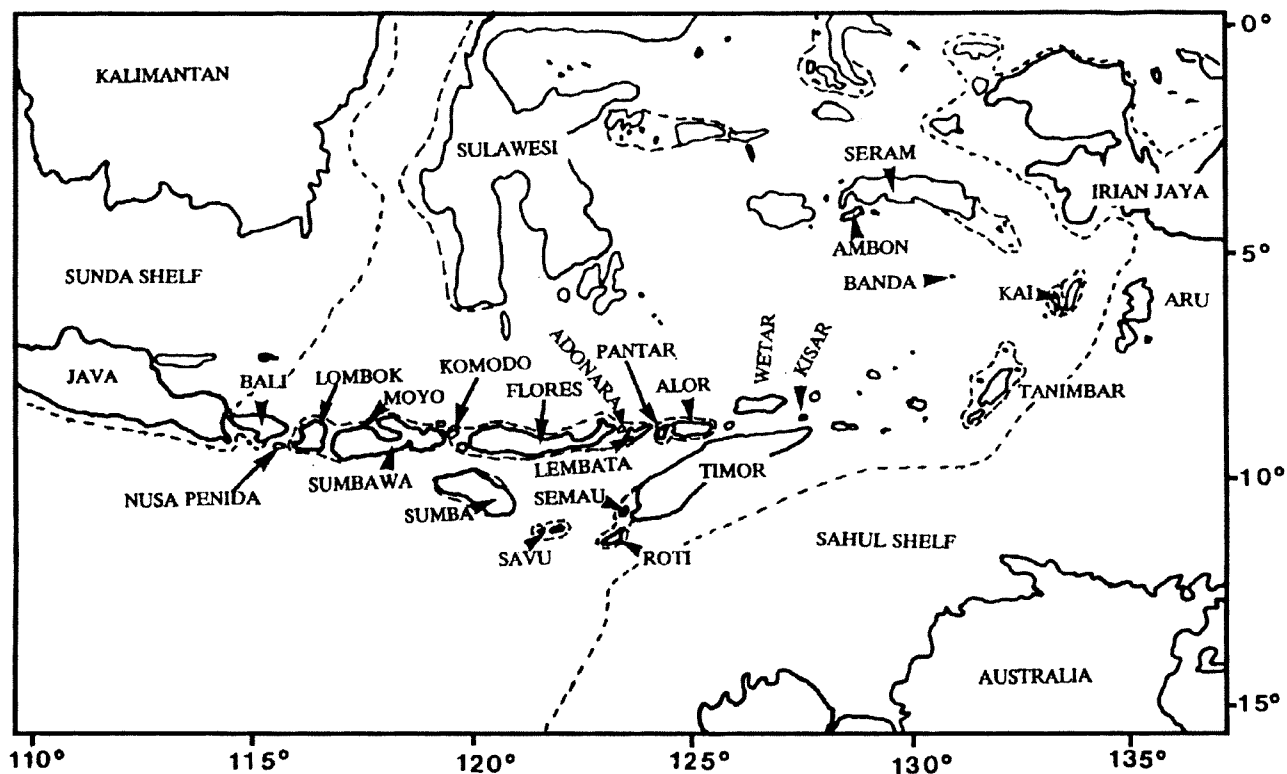
Figure 1   Islands (arrowed) in eastern Indonesia that were the subject of vertebrate surveys by the Western Australian
             Museum and the Museum Zoologicum Bogoriense between 1987 and 1993. Dotted line indicates the 100 m
             baltymetric contour.

In this paper we report on new collections of *Emoia* from the islands of the Banda Arcs and Aru in eastern Indonesia. Species are identified on the basis of traditional meristic and colour pattern features and on multivariate analyses of head shield and body meristic variables. However, we are aware from recent studies of *Emoia* (Bruna *et al.* 1996) that traditional morphological analysis alone can fail to detect cryptic species that differ significantly at the molecular level and it is possible that this reappraisal may still overlook some cryptic species.

METHODS AND MATERIALS

Seventy-one specimens of *Emoia* were collected during the joint Western Australian Museum-Museum Zoologicum Bogoriense survey of the Lesser Sunda and eastern Maluku islands (Figure 1). Twenty nine *Emoia* were collected from Karranguli on the island of Wokam in the Aru group [AR], 13 from Elat and Mun on the island of Kai Besar [KB], two from Adaut on Selaru Island [SL], the southernmost island in the Tanimbar group, two from Larantuka on the eastern end of Flores Island [FL] and 27 from Ngallu on eastern Sumba Island [SB]. All numbers referring to individual specimens are Western Australian Museum reptile (R) collection numbers; the

holotype and the majority of specimens will be housed in the Museum Zoologicum Bogoriense, Indonesia.

The following 17 head shield measures were made on all *Emoia* examined: – the length [L] and breadth [W] of the Rostral [ROS], Frontonasal [FRNA], Frontal [FRO], Frontoparietals [FRPA], Interparietal [INPA] (not present in *E. similis*) and the maximum length of the nasal [NAD], four supraocular scales [SUOC] and the two loreal [LO] scales. Counts were made of the mid-body scales [MIDBODY], the dorsal scale row along the midline between the parietals to the tail base opposite the vent [DORSAL] and the subdigital lamellae [SUBDIG] under the fourth toe of the hindlimb.

The snout to vent length [SVL] was taken from every specimen and the sex determined by internal examination of the gonads and their state of development. Juveniles were excluded from further analysis.

All measurements were made by the same observer using electronic callipers and made to the nearest 0.01 mm.

The variables were then subjected to canonical variate analysis (CVA). The best variables for discrimination were selected on the basis of maximising the MANOVA F value (i.e. minimising Wilks' lambda) in a forward stepwise procedure.

The number of significant variables chosen to discriminate was limited to six initially in order to avoid overfitting. The statistical packages Statistix (1992) and SPSS (1993) were used for all analyses.

SYSTEMATICS

Specimens from the islands of eastern Indonesia were initially identified using the key and descriptions provided in Brown (1991). Specimens were assigned to one of three taxa; *E. longicauda* (Aru – a male and Selaru – a female) from the *cyanogaster* Group and *E. reimschisseli* (Aru – 18 females, 8 males; Kai Besar – 7 females, 6 males; Selaru – a female) and *E. similis* (Sumba – 17 females, 10 males; Flores – 2 females) from the *cyanura* Group. The key separation between the *cyanogaster* Group and the *cyanura* Group is in the size and shape of the anterior loreal. The interparietal is absent in *E. similis*.

Emoia reimschisseli (Tanner)

Brown (1991) considered *E. caeruleocauda reimschisseli* on Moratai and Halmahera islands in the Malukus differed sufficiently from *E. c. caeruleocauda* in the Malukus without evidence of intergradation and raised it to a full species.

Specimens from Aru, Kai and Selaru are referred to *E. reimschisseli* on the basis of their head shield pattern and the number and structure of their subdigital lamellae counts.

There was significant sexual dimorphism in 16 of the 21 variables measured from the population of *E. reimschisseli* on Aru Island (Table 1). Female values were significantly smaller than those in males for the variables SVL were, ROSH, ROSW, FRNAL, FRNAW, FROL, FROW, FRPAL, FRPAW, INPAL, INPAW, NAD, SUOC1, SUOC3, LO1 and LO2.

Sex dimorphism was apparent in only one of the 21 variables from *E. reimschisseli* on Kai Besar Island; with females having a shorter INPAL (Table 1).

A comparison between the populations on Aru and Kai Besar showed significant differences between males in 13 of the 21 variables measured (Table 1) but no significant differences in any variable between the two females' populations.

The female from Selaru does not fit within the variation shown for this species from the populations on Aru and Kai Besar (Table 1). It is generally larger (SVL 73 mm) has fewer subdigital lamellae (26 *cf.* 31–36) and is consistently larger for all headshield measures than either the females or males from Aru and Kai Besar. It most probably

Table 1 Measures of the variables taken from populations of *E. reimschisseli* on the islands of Aru and Kai Besar. Data are expressed as means and standard deviations. Significant differences between males in the two populations are expressed as *p<0.05, **p<0.01, ***p<0.001. Females showed no significant differences between populations. The significance levels indicated for females indicate those characters that are sexually dimorphic in the Aru and Kai populations. The data from the single female from Selaru is presented along with the measurements of the *E. longicauda* specimens from Aru and Selaru.

| SPECIES	E. reimschisseli					E. longicauda	
SEX	MALES		FEMALES		F	M	F
ISLAND	ARU (8)	KAI (6)	ARU (18)	KAI (7)	SELARU	ARU	SELARU
VARIABLE							
SVL	68.38±7.43	*56.83±7.68	*58.50±12.64	58.29±3.95	73	83	82
DORSAL	71.00±1.93	68.83±2.93	70.11±2.25	68.86±2.61	71	61	61
MIDBODY	36.63±2.26	34.67±0.32	36.39±2.03	35.71±1.60	39	27	29
SUBDIG	32.50±1.20	33.83±2.14	32.56±0.92	33.00±1.73	26	73	68
ROSH	1.70±0.19	*1.40±0.20	**1.33±0.29	1.29±0.12	1.82	1.48	1.64
ROSW	3.03±0.30	**2.46±0.34	**2.43±0.50	2.34±0.19	3.15	3.10	2.94
FRNAL	2.86±0.31	**2.24±0.33	**2.29±0.46	2.07±0.25	3.16	3.50	3.39
FRNAW	3.47±0.39	*3.00±0.31	**2.82±0.51	2.77±0.19	3.79	4.05	3.98
FROL	3.93±0.50	3.45±0.60	**3.18±0.63	3.25±0.33	4.16	5.62	5.63
FROW	3.04±0.37	*2.52±0.23	*2.59±0.47	2.50±0.21	3.51	3.42	3.65
FRPAL	3.85±0.27	***3.17±0.29	**3.35±0.49	3.23±0.18	4.37	4.86	5.16
FRPAW	4.01±0.43	3.58±0.37	**3.42±0.54	3.44±0.26	4.45	4.90	4.84
INPAL	1.69±0.12	**1.41±0.18	**1.36±0.26	*1.22±0.07	1.63	1.68	1.34
INPAW	1.19±0.10	1.06±0.13	*1.05±0.15	0.98±0.10	1.28	1.12	1.23
NAD	2.36±0.17	**1.98±0.28	**1.93±0.38	1.90±0.21	2.44	2.60	2.51
SUOC1	1.78±0.20	1.56±0.35	**1.44±0.26	1.35±0.14	1.90	2.31	2.42
SUOC2	1.63±0.13	*1.44±0.19	1.59±0.36	1.41±0.15	1.93	2.44	2.06
SUOC3	1.47±0.10	**1.21±0.16	**1.22±0.20	1.18±0.13	1.92	1.84	1.92
SUOC4	1.94±0.42	*1.50±0.25	1.66±0.31	1.45±0.20	1.89	2.74	2.25
LO1	1.19±0.13	**0.97±0.12	**0.98±0.18	1.00±0.09	1.20	1.53	1.90
LO2	1.61±0.19	1.38±0.32	*1.36±0.29	1.33±0.14	2.10	2.70	2.10
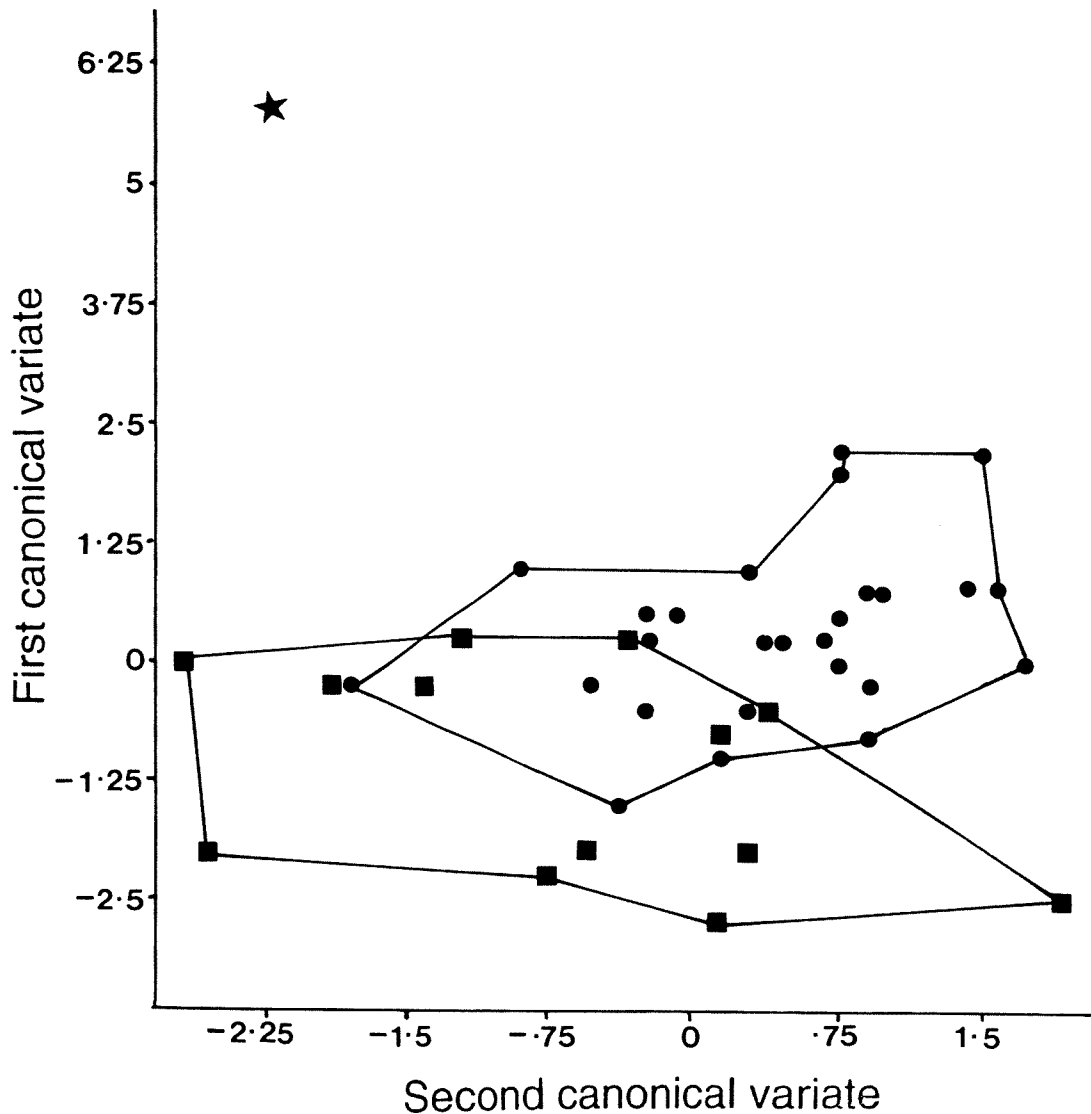
Figure 2   Canonical variate plot of the first two axes for *Emoia reimschisseli* from Selaru (star), Aru (circles) and Kai Besar (squares) islands using only the best five variables to discriminate.

represents a new taxon that is closely related to *E. reimschisseli* but its formal description is premature given that only a single specimen exists.

The canonical variate plot of the six most significant variables determined from Wilks' Lambda (SUBDIG, SUOC4, LO2, MIDBODY, DORSAL, FROW) indicates that the Selaru specimen is separate on the first canonical variate axis (Figure 2) and that Aru and Kai specimens are slightly separated on the same axis. There is a correct assignment of 92.3% of the 13 Kai Besar specimens and 92.3% of the 26 Aru specimens.

The four variables with the highest standardised canonical discriminant function coefficients were SUBDIG (-0.72171), MIDBODY (0.63321). DORSAL (0.46328) and FROW (0.45547).

Emoia longicauda (Macleay)

Two specimens from Aru and Selaru islands

(R109540, R112327) best fit the descriptions of *E. longicauda* (see Table 2) from the islands of eastern Indonesia (Brown 1991; Auffenberg 1980) and are referred to this species. *Emoia longicauda* has been recorded previously on both Aru and Kai islands by Sternfeld (1920), but this is the first record of the species from Selaru. Both specimens have markedly different headshield measures and subdigital lamellae counts (Table 1), with bladelike subdigital lamellae in contrast to the rounded lamellae of *E. reimschisseli*, and both specimens have lower dorsal and midbody scale counts than *E. reimschisseli* and have markedly larger measures for all variables except ROSH, ROSW, INPAL and INPAW.

Both *E. longicauda* in the *cyanogaster* Group and *E. ruficauda* in the *cyanura* Group have a high number of blade-like subdigital lamellae under the fourth toe but the Groups are distinguished on the

Table 2 Comparison of the ranges and means of SVL and four scale counts reported for *Emoia* species that occur in the Lesser Sunda and Maluku islands (data from Brown, 1991 and this study).

SPECIES	SVL RANGE	MIDBODY RANGE	MEAN	DORSAL RANGE	MEAN	LAMELLAE RANGE	MEAN	LABIALS
Emoia a. atrocostata	57–98(78)	34–43(126)	38.05	61–76(122)	67.85	30–42(127)	34.67	6–8/6–7
Emoia kuekenthali notomoluccense	54–70(10)	37–42(15)	39.33	53–61(15)	57.67	41–49(16)	44.87	
Emoia longicauda	65–100(30)	23–28(37)	26.32	52–61(35)	55.66	66–94(30)	77.57	6–8/6–7
R109540 – Aru	83	27		61		73		10/10
R112237 – Selaru	82	29		61		68		8/8
Emoia sorex	51–59(10)	28–36(7)	31.29	54–60(7)	57.14	41–48(7)	43.00	7/6–7
Emoia caeruleocauda	40–65(60)	27–36(130)	30.84	50–64(125)	55.48	33–54(123)	41.89	6–7/6–7
Emoia reimschisseli	39–57(36)	29–34(23)	30.44	49–57(21)	54.10	32–39(22)	35.14	6–7/6
E. reimschisseli – (this study)	32–78(39)	34–41(39)	36.05	65–74(39)	69.87	31–36(39)	32.82	
R112400 – Selaru	73	39		71		26		
Emoia ruficauda	42–54(24)	26–29(29)	27.59	49–55(27)	51.07	54–63(30)	58.97	6–7/6–7
Emoia similis	37–42(7)	24–30(10)	26.90	53–59(10)	56.10	21–23(9)	22.22	6/6–7
E. similis – (this study)	39(2)	26(2)		58–59(2)		22–23(2)		
Emoia kitcheneri – (this study)	23–39(27)	23–34(27)	27.80	51–61(27)	55.50	24–31(27)	26.80	

basis of the former having fused nasals. However, despite the *cyanogaster* Group diagnosis presented in Brown's (1991) key, his species description for *E. longicauda* indicates that supranasals are present in the species. The specimens from Aru and Selaru have more meristic features in common with *E. longicauda* than *E. ruficauda* while supranasals are present in both species.

Emoia similis Dunn

Auffenberg (1980) examined the holotype and 12 other specimens of *E. similis* from Komodo together with the type and other specimens of *Leilopisma kardarsani* from Komodo and Padar islands described by Darevsky (1964b), concluding that they were conspecific and, consequently, synonymised *Leilopisma kardarsani* with *Emoia similis*.

Two specimens collected at Larantuka on eastern Flores (R105079, R105080) are tentatively referred to *E. similis*. These two *E. similis* females agree in general meristics with previous descriptions of the species from both Flores and Komodo (Brown 1991, Auffenberg 1980). However, the colour pattern of the *E. similis* examined in this study differ from the descriptions of specimens from Komodo and Padar in that they lack a vertebral stripe.

Auffenberg (1980) described the pattern of the Komodo specimens as: "Color brownish-black, brown, or brownish-gray above, with 5 silvery-white longitudinal stripes (sometimes paravertebral and dorsolateral stripes are cream or yellow)". This pattern differs from the description of the eastern Flores specimens, where there is no sign of the 5 silvery white longitudinal stripes but where two pronounced lateral stripes exist flanking a broad relatively unpatterned pale dorsum. The

two *Emoia* from Larantuka have been assigned to *Emoia similis* despite these pattern differences. They may represent a discrete taxon, but more specimens are needed to confirm this.

The series of 18 specimens from Ngallu, East Sumba, are referred to a new taxon, closely related to *E. similis*.

Emoia kitcheneri sp. nov.

Holotype

R101877, in Western Australian Museum, adult male, collected by R.A. How, D.J. Kitchener, N.K. Cooper, J. Dell and A. Suyanto at Ngallu, East Sumba, Indonesia (10°06'30"S and 120°41'30"E), on 8th June 1989. The type specimen is to be lodged at the Museum Zoologicum Bogoriense, Bogor, Indonesia.

Paratypes

R101830, R101859–860, R101867, R101869–875, R101878–893, R101907 data as for the holotype.

Diagnosis

A small member of the *cyanura* Group and *caeruleocauda* Subgroup (*sensu* Brown 1991). Most like *E. similis* in lacking interparietals but differing in its smaller size (23–39 mm *cf.* 37–72 mm), more subdigital lamellae (24–31 *cf.* 21–23), lack of a vertebral stripe, blue tail and by having limbs that meet when adpressed against the body.

Description

SVL males 30–37, n = 10 and females 23–39, n = 17 females. Head medium length with rounded snout. Lower eyelid with undivided transparent disc. Ear opening nearly round and much smaller

Table 3   Measures of the variables taken from populations of *E. similis* and *E. kitcheneri* on the islands of Flores and Sumba. Data are expressed as means and standard deviations. Significant pairwise differences between *E. kitcheneri* males and females and between the females in the different species are expressed as *p<0.05, **p<0.01, ***p<0.001.

SPECIES	Emoia kitcheneri		Emoia similis
VARIABLE	MALES (N=10)	FEMALES (N=17)	FEMALES (N=2)
SVL	33.50±2.46	*30.24±3.40	***39.00±0.00
DORSAL	55.50±1.84	55.53±2.21	**58.50±2.12
MIDBODY	28.00±1.76	27.71±2.39	26.00±1.41
SUBDIG	27.20±2.20	26.59±1.62	***22.50±0.71
ROSH	0.76±0.08	**0.64±0.10	***0.84±0.03
ROSW	1.29±0.18	*1.14±0.15	***1.45±0.18
FRNAL	0.93±0.10	**0.78±0.11	*0.91±0.17
FRNAW	1.41±0.15	**1.27±0.11	***1.56±0.03
FROL	1.70±0.17	*1.54±0.13	***2.04±0.23
FROW	1.50±0.12	**1.32±0.14	*1.50±0.18
FRPAL	2.47±0.20	***2.19±0.18	*2.40±0.46
FRPAW	2.27±0.19	**2.04±0.17	***2.42±0.30
NAD	1.01±0.14	*0.91±0.86	**1.07±0.23
SUPO1	0.60±0.11	0.58±0.10	***0.78±0.06
SUPO2	1.03±0.11	0.95±0.12	1.01±0.12
SUPO3	0.71±0.08	0.62±0.13	0.60±0.13
SUPO4	1.01±0.14	***0.87±0.07	***1.04±0.24
LO1	0.42±0.09	0.37±0.07	*0.45±0.02
LO2	0.68±0.12	*0.58±0.09	**0.72±0.15

than eye, without any enlarged lobules. Supranasals present, triangular and in contact with the anterior loreal. Rostral very broad and nasals widely separated. Frontonasal wider than long, bordering rostral anteriorly and the frontal posteriorly. Frontal shorter and much narrower than the fused frontoparietals and interparietal. Four supraoculars, two in contact with the frontal. Two nuchals and 7 supralabials. Midbody scales all smooth, 23–34 (X=27.81). Dorsal scales numbering 51–61 (X=55.51) and similar size to ventral scales. Preanals slightly enlarged. Limbs meeting when adpressed against the body. Fourth digit of hindlimb longer than 3rd, with 24–31 (X=26.81) rounded subdigital lamellae.

There is significant sexual dimorphism in 12 of the 19 variables measured in *E. kitcheneri* (Table 3). *Emoia kitcheneri* females are significantly smaller than males for the variables snout-vent length (SVL), the length and width of the rostral (ROS), fronto-nasals (FRNA), frontals (FRO) and the frontoparietals (FRRPA) as well as the diagonal length of the nasal (NAD) and the length of both supraocular 4 (SUOC4) and loreal 2 (LO2).

Colour

Dorsal colour pattern brown, four scales wide finishing in a darker band edging narrow two cream dorsolateral stripes. Dark band occurs on the outer margin of the second scale and the dorsolateral line occupies the third scale from the vertebral line. Dorsolateral stripes continuing

across supraciliaries forward to the prefrontals and finishing posteriorly on basal third of the tail. Lateral colour dark brown-black with occasional grey flecks. Ventral scales grey. Distal two thirds of the tail iridescent blue in life.

Comparisons

Female *E. kitcheneri* on Sumba were significantly smaller than the two female *E. similis* we collected on Flores for all variables except MIDBODY, SUOC2 and SUOC3 (Table 3). The subdigital lamellae count of 24 – 31 lies outside the range of that recorded from the literature for *E. similis* (Table 4). The canonical variate plot for *Emoia similis* and *E. kitcheneri*, using the five (FROL, SUBDIG, LO1, SUOC2, FRNAL) most significant variables determined from Wilks' Lambda, is shown in Figure 3. The Flores and Sumba taxa are clearly separated on the single discriminant axis. Considerable sexual dimorphism occurs in *E. similis* but SVL is not a significant variable in the canonical variate analysis with the highest standardised canonical discriminant function coefficients occurring for FROL (-2.01929), SUOC2 (1.42468), LO1 (-1.14351) and SUBDIG (1.00743).

The colour pattern of *E. kitcheneri* differs from *E. similis* by not having the three dorsal and two lateral pale stripes (Brown 1991) or the five silvery-white longitudinal stripes (Auffenberg 1980). In the eastern Flores specimens of *E. similis* the dorsolateral stripe is pale and broad (almost a scale wide) and the adjacent laterodorsal stripe is broken
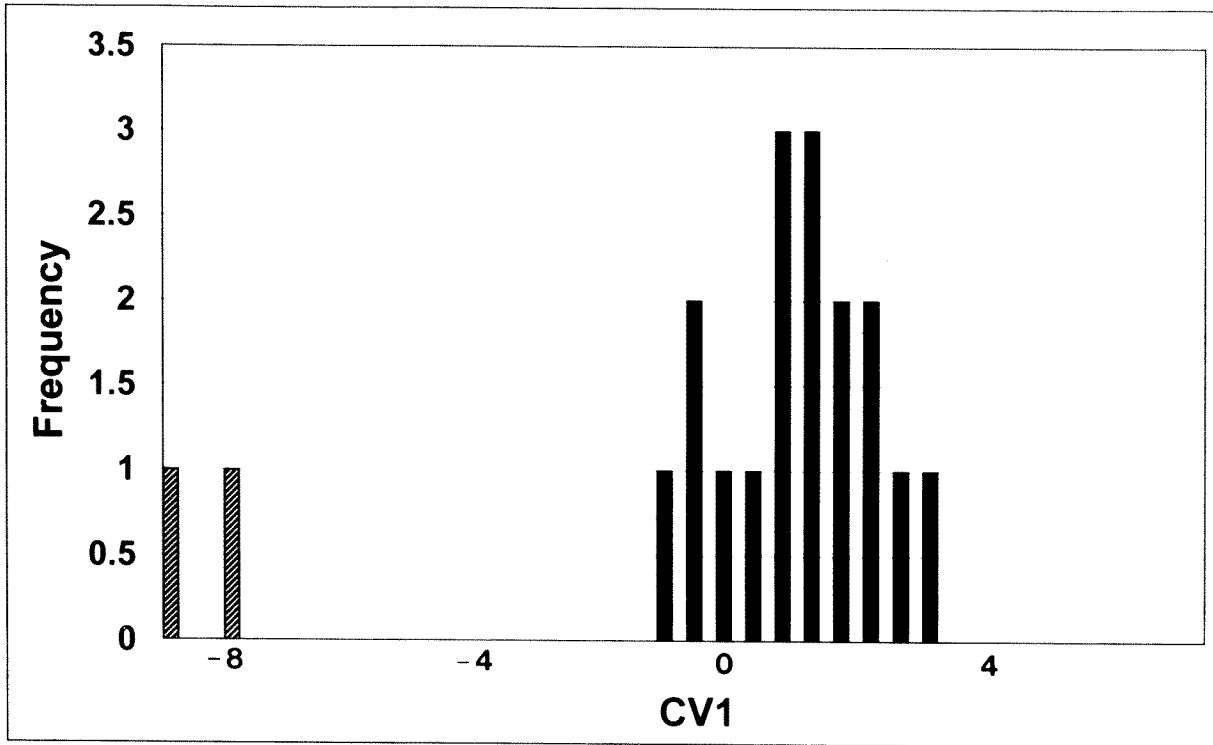
Figure 3   Histogram of the first canonical variate axis (CVI) for *Emoia kitcheneri* from Sumba (blocked) and *E. similis* Flores (striped) islands using only the best four variables to discriminate.

and barely discernible. In *E. kitcheneri* the dorsolateral stripe is narrow (much less than a scale wide) and sharply defined with the laterodorsal stripe blackish and well defined.

Habitat and Range

Only known from the area around Ngallu on the eastern end of Sumba Island. All specimens of *E. kitcheneri* were obtained from local collectors such that precise habitat details were not available. However, local collectors were seen catching specimens of *Glaphyromorphus butlerorum* Aplin, How and Boeadi, *G. emigrans* (Lidthe de Jude) *Lamprolepis smaragdina* (Lesson), *Sphenomorphus florense* (Weber) and *Emoia kitcheneri* from kebuns and forest adjacent to the village.

Etymology

After Dr Darrell Kitchener, Curator of Mammals at the Western Australian Museum, without whose drive, enthusiasm and tolerance of bureaucracy the extensive survey of islands in eastern Indonesia would never have been attempted or completed.

DISCUSSION

This study examines at least four species of the genus *Emoia* that occur on the islands of the Banda Arcs. *Emoia reimschisseli* occurs on Kai Besar and Selaru islands as well as on the Sahul Shelf island of Aru; *Emoia longicauda* occurs on Selaru and Aru islands, *Emoia similis* on Flores and Komodo (Auffenberg 1980) and *Emoia kitcheneri* on Sumba.

Table 4   Body lengths and scale counts from the present study and the literature for *E. similis* and *E. kitcheneri* from the populations on Flores-Komodo-Rinca and Sumba.

STUDY	SVL-M Range	SVL-F Mean (N)	DORSAL Range	DORSAL Mean (N)	MIDBODY Range	MIDBODY Mean (N)	SUBDIG	SUBDIG
Emoia similis								
Brown	37–42(4)	38–39(3)	53–59	56.1(10)	24–30	26.9(10)	21–23	22.2(9)
Auffenberg					26–28	27.3(12)	18–23	
This-Flores		39–39(2)	58–59	58.5(2)	26–26	26.0(2)	22–23	22.5(2)
Emoia kitcheneri								
This-Sumba	30–37(10) X=33.5	23–39(17) X=30.2	51–60	55.5(27)	23–34	27.8(27)	24–31	26.8(27)

Of the four species examined, three (*E. reimschisseli, E. similis* and *E. kitcheneri*) are placed in the *cyanura* Group and one (*E. longicauda*) is placed in the *cyanogaster* Group – *sensu* Brown (1991). The key differences between the *cyanogaster* Group and the *cyanura* Group are in the size of the two loreals - with the length being approximately equal in the former and the first loreal being much smaller than the second in the latter – and the nasal bones, which are fused in the former but separated in the latter.

Races of *E. longicauda* have been documented previously by Sternfeld (1920) from the islands of Aru and Kai while Welch *et al.* (1990) report on *E. atrocostata* from Indonesia (east from Borneo and Java), *E. cyanogaster* (Lesson) as occurring on Ambon and the Aru and Kai islands, *E. cyanura* (Lesson) on Timor, Ambon, Ceram and the Aru, Kai and Tanimbar islands, *E. kuekenthali* on Ambon, *E. sembalunica* (Mertens) on Lombok and *E. similis* on Komodo, Padar and Rinca. *Emoia sembalunica* is considered a synonym of *E. similis* (Auffenberg 1980, Brown 1991).

Brown (1991) stated that *E. reimschisseli* differed sufficiently from *E. caeruleocauda* (both species being in the *cyanura* Group) in the Moluccas to be considered a distinct species and that there was no evidence of intergradation. The principal differences between the two species were in colour pattern and both midbody scale row counts (30.44±1.20 *cf.* 30.84±1.78) and subdigital lamellae under the fourth toe (35.14±1.70 *cf.* 41.89±4.53). It is apparent from the data presented in Brown (1991), however, that there is no significant differences in the midbody scale counts of the two species. The majority of specimens of *E. reimschisseli* examined by Brown (1991) were from the island of Moratai with just a single specimen from Halmahera, whereas *E. caeruleocauda* specimens were from throughout the southwestern Pacific and from Papua-New Guinea, Ceram, Ambon, Sulawesi, Borneo and the Philippines.

The present study indicates that there is marked separation on the first canonical variate axis of the specimen of *E. reimschisseli* from Selaru from those populations of the species from Aru and Kai Besar islands. The variables weighting most heavily on this axis were subdigital lamellae counts and midbody scale counts. This suggests that the population of *E. reimschisseli* from Selaru island in the Tanimbar group may be a discrete taxon, however, no assessment of the variation in population is possible as only a single specimen was obtained.

Detailed examinations of the headshields of two wide ranging skink taxa in eastern Indonesia, *Mabuya multifasciata* (Kuhl) and *Lamprolepis smaragdina* (Lesson), using multivariate methods has indicated that there is little morphological

separation of populations from throughout the Banda Arc islands. In *Lamprolepis smaragdina*, however, the slight separation in multidimensional space of the populations from Banda, Kai and Aru islands from the remaining islands to the west is strongly supported by a genetic evaluation using electrophoresis of 24 allozymes (Schmitt *et al.* 1999). This pattern of genetic differentiation of taxa from within species that are morphologically conservative has been clearly documented by Bruna *et al.* (1996) in their study of *Emoia impar* and *E. cyanura* in the Pacific islands. Of particular note in the Bruna *et al.* study of these two recently recognised cryptic species of *Emoia*, has been the determination that both these species are more closely related genetically to other currently recognised taxa than they are to each other. In an examination of the molecular and morphological variation of species of skink in the genus *Lipinia*, Austin (1995) also detected morphological conservatism in species that were genetically quite distinct. These findings indicate the value of a combined genetic and morphological approach to the delineation of species boundaries within this complex regional skink fauna.

It is highly probable that there remains numerous undescribed taxa of lizards in the islands of eastern Indonesia as indicated by the description of new taxa associated with every major survey or revision of taxa from the archipelago (Dunn 1927, Mertens 1930, Darevsky 1964a, 1964b, Auffenberg 1980, Musters 1983, Aplin *et al.* 1993). This raises the prospect of finding even higher levels of endemism amongst the lizards of the region than that already documented for snakes of around 20% in Nusa Tenggara, 30% in the southern Maluku and 33% in the northern Maluku (How and Kitchener 1997).

ACKNOWLEDGEMENTS

REFERENCES

Aplin, K.P., How, R.A. and Boeadi. (1993). A new species of the *Glaphyromorphus isolepis* Species Group (Lacertilia; Scincidae) from Sumba Island, Indonesia. *Records of the Western Australian Museum* **16**: 235–242.

Auffenberg, W. (1980). The herpetofauna of Komodo, with notes on adjacent areas. *Bulletin Florida State Museum* **25**(2): 1–156.

Austin, C.C. (1995). Molecular and morphological evolution in South Pacific scincid lizards: morphological conservatism and phylogenetic relationships of Papuan *Lipinia* (Scincidae). *Herpetologica* **51**: 291–300.

Brown, W.C. (1991). Lizards of the genus *Emoia* (Scincidae) with observations on their evolution and biogeography. *Memoirs California Academy Sciences* No **15**.

Bruna, E.M., Fisher, R.T. and Case, T.J. (1996). Morphological and genetic evolution appear decoupled in Pacific skinks (Squamata: Scincidae: *Emoia*). *Proceedings of the Royal Society, London* Series B **263**: 681–688.

Darevsky, I.S. (1964a). Two new species of gekkonid lizards from Komodo island in the Lesser Sundas Archipelago. *Zoologischer Anzeiger* 173: 169–174.

Darevsky, I.S. (1964b). Die Reptiliaen der Inseln Komodo, Padar und Rintja in Kleinen Sunda-Archipelago, Indonesia. *Senckenbergiana Bioliogie* **45**: 563–575.

Dunn, E.R. (1927). Results of the Douglas Burden expedition to the island off Komodo. III Lizards from the East Indies. *American Museum Novitate* **288**: 1–13.

How, R.A. and Kitchener, D.J. (1997). Biogeography of Indonesian snakes. *Journal of Biogeography* **24**: 725–735.

How R.A., Schmitt L.H., Maharadatunkamsi (1996a). Geographical variation in the genus *Dendrelaphis* (Serpentes: Colubridae) within the Banda Arc islands of Indonesia. *Journal of Zoology, London* **238**: 351–363.

How, R.A., Schmitt, L.H. and Suyanto, A. (1996b). Geographical variation in the morphology of four snake species from the Lesser Sunda Islands, Eastern Indonesia. *Biological Journal of the Linnean Society* **59**: 439–456.

Kitchener D.J., Schmitt, L.H., Hisheh, S., How. R.A., Cooper, N.K. and Maharadatunkamsi. (1993). Morphological and genetic variation in the Bearded Tomb Bats (*Taphozous*: Emballonuridae) of Nusa Tenggara, Indonesia. *Mammalia* **57**: 63–83.

Kitchener D.J and Suyanto A. (1996). Intraspecific morphological variation among island populations of small mammals in southern Indonesia. Pp 7–14. In. Suyanto A, Kitchener DJ, eds. *Proceedings of the First International Conference on Eastern Indonesia – Australian Vertebrate Fauna*. Jakarta: Lembaga Ilmu Pertehanian Indonesia.

Mertens R. (1930). Die amphibien und reptilien der insel Bali, Lombok, Sumbawa und Flores. *Abhandlungen Senckenbergischen Naturforschenden Gesellschaft* **42**: 117–344.

Musters C.J.M. (1983). Taxonomy of the genus *Draco* L. (Agamidae, Lacertilia, Reptilia). *Zoologische Verhandelingen* (Leiden) **199**: 1–120.

Schmitt, L.H., How, R.A., Hisheh, S., Goldberg, J., and Maryanto, I. (1999). Morphological and genetic variation in two skink species (Reptilia: Scincidae) along the Banda Arc islands. *Journal of Herpetology* (submitted).

Schmitt L.H., Kitchener D.J. and How RA. (1995). A genetical perspective of mammalian variation and evolution in the Indonesian Archipelago: biogeographical correlates in the fruit bat genus, *Cynopterus*. *Evolution* **49**: 399–412.

Sternfeld, R. (1920). Zur Tiergeographie Papuasiens und der pazifischen Inselwelt. *Abhandlungen Senkenbergischen Naturforschenden Gesellschaft* **36**: 375–436.

Vane-Wright, R.I. (1991). Transcending the Wallace Line: do the western edges of the Australian Region and the Australian Plate coincide? In *Austral Biogeography*. Eds P. Y. Ladiges, C. J. Humphries, L. W. Martinelli. *Australian Systematic Botany* **4**: 183–197.

Wallace, A.R. (1860). On the zoological geography of the Malay Archipelago. *Journal of the Linnean Society, Zoology* **4**: 172–184.

Welch, K.R.G., Cook, P.S. and Wright, A.S. (1990). *Lizards of the Orient: a checklist*. R. E. Krieger Publ. Co., Florida.