

## New *Carlia fusca* complex lizards (Reptilia: Squamata: Scincidae) from New Guinea, Papua-Indonesia

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### Abstract

Recent rapid-assessment surveys in western New Guinea have provided well-documented voucher specimens that show greater speciation within the *Carlia fusca* complex in this area than indicated by the examination of older museum specimens. Variation in the morphometric and scalation traits of these new species does not differ greatly from other *fusca* complex species. This result was anticipated owing to the overall low level of variation in these morphological features in the *fusca* complex. Regionalization of distinct color patterns and abrupt shifts from one pattern to another indicate the existence of a distinct species along much of the southern coast from the Eilanden River basin to Etna Bay and another species from the northern coast of the Bomberai Peninsula. The variation and distribution of *fusca* complex species are examined for populations in the southern and western “mainland” Papua-Indonesia.

**Key words:** Squamata, Scincidae, *Carlia fusca*, Papua-Indonesia, New Guinea, geographic variation, new species

### Introduction

The island of New Guinea has a highly diverse herpetofauna with about 300 species of frogs, 200 lizards, and 86 nonmarine snakes (Allison, 1996 updated). These numbers, however, likely reflect only a portion of the actual species richness of the herpetofauna. New discoveries of strikingly different species occur with each focused field inventory of local New Guinean faunas (e.g., Allison and Kraus, 2003; Kraus and Allison, 2005). Similarly monographic studies of genera or species groups regularly double or triple the number of recognizable species. Zweifel (2000) examined diversity in the microhylid frog *Sphenophryne* sensu lato and found that this taxon actually consisted of four clades (=

genera) with 35 species, half of which had not been previously recognized. Walter Brown's decades long study (1991) of *Emoia* skinks also resulted in a doubling of the species richness of this lizard taxon.

While GZ was analyzing morphological diversity of the New Guinean rainbow skinks (*Carlia fusca* complex), he observed that a strikingly colored *Carlia* occurred in the southern Papua-Indonesian lowlands from Agats (5° 33'S 138° 08'E) to Uta (4° 33'S 136° 00'E); however, specimens in these samples were generally too faded to confirm the color pattern's widespread occurrence. Subsequently GZ discovered that AA had inventoried the herpetofauna of the Freeport Project area (4° 47'S 136° 32'E) in March 1997. This *Carlia* was the most abundant skink in AA's survey, and the voucher materials provides us with a large well-preserved sample, thereby confirming that this dark-throated *Carlia* represents a new species. AA also was involved in a rapid assessment inventory of the Tangguh area of the Bomberai Peninsula. This fieldwork provides another series of well-preserved vouchers with color notes and an opportunity to reassess the status of the *fusca* group lizards in that area. Our analysis indicates that the Bomberai populations represent an undescribed species as well. We present our results first with descriptions of the new species followed by a brief examination of the morphological variation of all *fusca*-complex samples from the Vogelkop and southern Papua-Indonesia eastward to the Eilanden River basin.

## Material and methods

This study relies on the character set and definitions used in a review of morphological variation and differentiation of the *Carlia fusca* complex of New Guinea (Zug, 2004). The set contains six mensural and 19 scalation characters. Sex and maturity determined by examination of gonads. Similarly, most other locality samples derive from Zug's 2004 study; however, in addition to BPBM Freeport and Bomberai samples, recently collected specimens from other western Papua-Indonesia localities have been included. The specimens-examined data are in the appendix, as well as the list of characters and their abbreviations. All statistical analyses were performed with SYSTAT 10.

### *Carlia caesius* n. sp.

(Fig. 1)

#### *Type material*

Holotype. MZB AA15323, adult male from Indonesia, Papua Province [Freeport Project Area], Timika [4.5417°S 136.8908°E], collected by Allen Allison, 15 March 1997.

Paratypes. BPBM 21157 (photographed), 21210, 21217–21221, 21223–21226, 21229–21231, 21233–21234, 21236–21242, 21244, 21249, 21256, 21258, 21260,

21262–63, 21267 (photographed), same locality as holotype but collected from 9–19 March 1997; BPBM 21159, 21161, 21163, 21166–67, 21169, 21176, 21179–21182, Mile 38 camp, ca. 15 km (by air) NNE Timika Airport [4.3944°S 136.9325°E]; BPBM 21206, site 3, ca. 14 mi (by air) S Timika Airport [4.6619°S 136.897°E]; BPBM 21187, site 4, east levee of Minajerwi River, ca. 18.5 km (by air) SSE Timika Airport [4.683°S 136.981°E]. IRSNB 2591–2609, Agats [5° 33'S 138° 08'E ]. RMNH 30381, 30568–569, 30571, 30579, 30581, Gariau, aan het Jamoer meer [3° 42'S 134° 56' E]. USNM 562964–966, same data as holotype except collected on 18 March 1997. ZMB 58578, Unipo [3° 29'S 135° 44'E], ca. 30 km SE Nabire.



**FIGURE 1.** A paratype of *Carlia caesius* n. sp., dorsolateral aspect, male in life, BPBM 21157.

#### *Diagnosis*

*Carlia caesius* is a member of the *C. fusca* complex and differs from all other complex members by the bright blue coloration of head and neck of adult males. Additionally, *C. caesius* averages (adult females mean 50 mm, adult males 52 mm SVL) smaller than *C. ailanpalai*, *C. beccarii*, *C. eothern*, and *C. luctuosa*, *C. pulla*, and larger than *C. aramia*, *C. babarensis*, *C. leucotaenia*, and *C. tutela*. *C. caesius* has fewer average Dorsals (46) than the similar sized *C. fusca*, *C. leucotaenia*, and *C. mysi* (48).

#### *Description of holotype*

An adult male, 61.9 mm SVL, 85.5 mm tail length (21 mm tip regenerated), 26.9 mm TrunkL, 31.1 mm HindIL, 14.8 mm HeadL, 2.2 mm PalpbD, and 1.9 mm EarD. Scalation

right side for bilateral traits: interparietal separate, prefrontals not touching, 4 Supoc, 8 Supcil, 9 Eyeld, 4 Temp, 2 Lor, 7 Suplab, 5<sup>th</sup> BlwEye, 6 Inflab, round ear-opening, 1 AuricN on anterior border, 44 tricarinate Dorsal (anteriormost bilateral pair enlarged as nuchals), 32 Midbody, 22 smooth 3FingL (slight clefting of few subterminal lamellae), 25 4ToeL, and precloacal scale slightly enlarged. Coloration in life: strikingly two-toned lizard; dorsally and laterally head and neck turquoise ground color muted by black edging on all scales, irregular edged black lateral band from cheek to anterior axilla, dorsolaterally a narrow white stripe from eye to axilla, ventrally turquoise ground color shifts to light blue with persistence of black scale-edging although narrower; at axilla and forelimbs abrupt shift to bright reddish orange ground color, muted dorsally by black edging on scales, edging nearly disappears laterally, dorsally light spots greenish yellow; limbs above and below uniform reddish orange; ventrally chest onto to tail beige with orangish tint.

Coloration in preservative: Dorsally head dark brown, speckled with black and turquoise; neck similar but black restricted to scale margins; rest of dorsum golden brown with black speckling and a few scattered light brown spots; upper parts of tail similar but without light brown spots and with less black than rest of dorsum; dorsolaterally, bluish, discontinuous line from eye to shoulder, face and neck mostly black and speckled with turquoise, especially towards venter and distinct series of black lines extend posteroventrally from lower labials to directly below ear; rest of flanks and anterolateral surface of tail light brown; chin and throat light black suffused with blue, with darker black blotches on chin, and series of longitudinal black lines along throat and neck; rest of venter whitish suffused with yellowish tinge and indistinct blue-black streaks on proximal margins of scales.

Description. A moderate-sized *Carlia* ranging in adult size from 45 to 65 mm SVL (females 45.1–55.2 mm; males 45.7–64.5 mm) with HeadL 9.9–13.0 mm (females) 10.8–15.9 mm (males), PalpbD 1.0–1.8 mm (females) 1.3–2.2 mm (males), EarD 1.0–2.0 mm (females) 1.2–2.0 mm (males), TrunkL 18.8–27.0 mm (females) 18.6–31.4 mm (males), and HndIL 19.6–29.5 mm (females) 22.2–32.7 mm (males). Some populations sexually dimorphic in one or more of the following traits: SVL, HeadL, PalpbD, EarD, TrunkL, HndIL, and Dorsal. Head and nuchal scales smooth; interparietal rarely absent; 4 (rarely 5 or 6) Supoc, 7–10 Supcil, 6–12 Eyeld, 7 (rarely 6) Suplab, 5<sup>th</sup> (rarely 4<sup>th</sup>) BlwEye, and 6 (uncommonly 5, 7, or 8) Inflab on each side. Ear opening oblong vertical to oblique with 1–5 (commonly 3) AuricN, usually pointed, on anterior and dorsal margin. Trunk scales smooth to weakly tricarinate dorsally and laterally, occasionally strongly tricarinate in males, rarely in females, with 42–50 Dorsal, 31–36 Midbody. Subdigital lamellae smooth, mostly 32 4ToeL.

Coloration is summarized in the subsequent Intraspecific Variations section.

### *Distribution*

Southern New Guinea lowlands and mid-elevation mountainside from Etna Bay eastward to and including the Eilanden River basin (Fig. 5).

### *Etymology*

The specific name derives from the Latin *caesius* for bluish-gray or sea blue in reference to the color of the throat and chin. It is proposed as a noun in apposition.

### *Intraspecific variation*

Samples are available from 6 areas (Bayum to Gariau) extending from 135° E to 138° 30' E. This sampling spans more than 400 km of diverse lowland and low to mid-elevation montane habitats. Three samples (Agats, Freeport, Gariau) have 8 or more adult females and males each, and these samples show sexual dimorphism (Students' *t* tests,  $p=0.05$ ) in many mensural traits occasionally in scalation ones (Table 1). The Agats sample is dimorphic in all the mensural traits (Table 1) but in no scalation ones. The Freeport and Gariau samples show dimorphism in some mensural traits and scalation (Dorsal for both, Midbody in only Gariau). In all dimorphic mensural features, males are the larger sex. There is always a question of whether sexual dimorphism actually exists when differences between the means are small. Perhaps, the dimorphism is a statistical artifact resulting from small and/or unequal representation in the samples, or the vagaries of field collecting. The Freeport sample highlights this uncertainty. It contains a few adults (10%) that have strikingly well-developed keels on their tricarinate scales (dorsally and laterally on trunk) in contrast to the weakly tricarinate keeling or absence of keels on most of the Freeport *C. caesius* and other *Carlia fusca* complex populations. These strongly keeled individuals are predominantly males (approx. 80%) and importantly the largest individuals of the entire Freeport sample. If they are included in the Students' *t* analysis, the Freeport sample ( $n = 49$ ) is statistically sexually dimorphic in SVL, but if they are excluded ( $n = 44$ ), females and males are subequal SVL. The strongly tricarinate individuals are not more or less brightly colored than the weakly keeled ones.

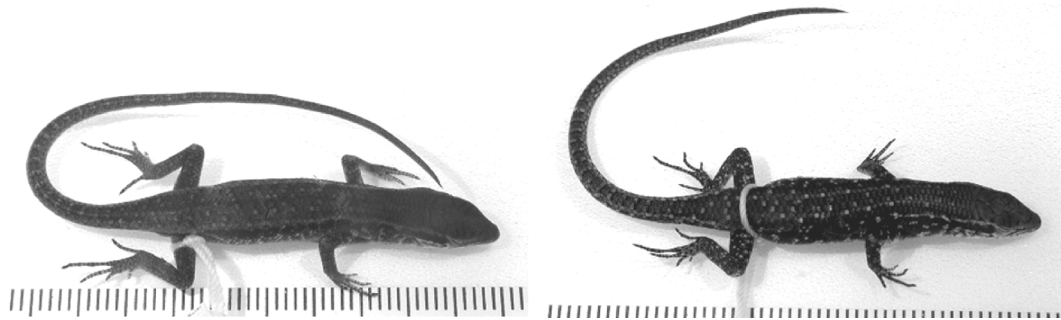
As is common in other *fusca* complex species, *Carlia caesius* displays low intra- and inter-locality variation in mensural and scalation traits. The range, minimum, and maximum values are very similar, often identical, between localities. Overall, variation within the Freeport area sample encompasses that of the other *C. caesius* samples.

In life, adult males presumed to be in breeding coloration closely resemble the holotype. Different individuals vary primarily in the amount of black on the dorsum. In some, black is restricted principally to the head and neck region. In others, it extends nearly to the rump. There is also some variation in the intensity and extent of turquoise in the head and neck area.

Some of the adult males in our sample lack the two-tone color pattern. In these individuals, the dorsum is light-brown, the head and neck are mostly immaculate, and the rest of the dorsum, including the tail, is speckled with black. There is generally a faint

yellowish-white dorsolateral stripe from the loreal region to rump; this stripe is brightest above forelimbs where stripe is discontinuous and thinly edged in black. The flanks are light-brown with a slight rust tinge, immaculate, and become lighter towards venter. The chin and throat are whitish with diffuse patches of blue-black and remainder of venter immaculate yellowish-white. Adult females have very similar coloration.

In juveniles, the head and neck are bronze-brown and immaculate. Trunk dorsum gradually darkens from bronze brown on the neck to dark brown on the rump and is speckled with white. A thin whitish dorsolateral stripe extends from the eye onto neck then breaks into a series of small whitish blotches, which coalesce at the rump into a continuous row of blotches extending along the tail. A thin indistinct tan stripe lies one scale row medial to the dorsolateral stripe and extends from the parietal area to the rump. The flanks are dark brown to black with numerous scattered yellowish-white spots. The venter, including the chin and throat, are immaculate white to cream.



**FIGURE 2.** Juveniles of *Carlia caesioides* (BPBM 21195 [left], BPBM 21203 [right]), dorsolateral aspect, preserved.

In preservative, the color of all life stages are muted and the overall appearance is the typical adult “fuscum” of various shades of brown dorsally and laterally, but with various degrees of darkening of the venter from chin to the chest in adults. The juvenile pattern is a brown dorsum with dark scale edges, and these edges occasionally align, forming very narrow dark brown stripes (Fig. 2). A broad dark brown (black) band extends from the temporal area to inguen; it is bordered above by a dorsolateral white stripe from above eye to anterior trunk, thereafter fading and/or breaking into a series of spots or lines. The lateral band is also bordered below by a white midlateral stripe that fades or breaks into spots at midbody. Ventrally, juveniles are immaculate white or cream from chin to base of tail. Adults retain the brown dorsum of juveniles and variously alter the lateral and ventral patterns, mainly with females (except the larger ones) retaining a subdued juvenile pattern and males losing any pattern on the trunk and appearing monochrome although dorsum darker and grading into the lighter venter.

In an attempt to quantify coloration to examine the shift from juvenile to adult pattern (preserved specimens), we recognized five color traits: 1) difference in contrast between

trunk dorsally and ventrally; 2) level of lateral “white” spotting on side of neck and trunk; 3) length of mid-lateral “white” stripe; 4) chin and throat color; and 5) side of neck color. We also categorized individuals in this color sample as either strongly tricarinate or weakly keeled/smooth. This color sample consisted of 20 juveniles (<40 mm), 43 adult females, and 23 adult males. There was no significant difference in the proportion of strongly tricarinate adult females and males ( $\chi^2 = 0.01$ , df 1,  $p = 0.91$ ), approximately 22–24% of the adults in each sex were strongly keeled. In contrast, strongly tricarinate individuals represent about 60% of the juveniles. Stronger keeling in juveniles versus adults occurs regularly in other *C. fusca* complex species.

The color coding demonstrates the fading of coloration (pattern) from juvenile to adult. Only the lightly colored chest is persistent in the three groups ( $\chi^2 = 4.2$ , df 2,  $p = 0.38$ ). With the exception of a greater proportion (95%) of adult males having darker chins and throats than juveniles (40%) or adult females (72%), juveniles are more brightly or contrastingly colored in preserved specimens. Adult males and females share the same proportion (color pattern) of the other color traits.

#### *Natural history*

*Carlia caesius* is heliothermic. In the Timika area, it is often observed basking in patches of sunlight on the floor of primary and secondary lowland alluvial rain forest. These forests have a semi-closed canopy that is 30–35 m high and are dominated by large buttressed trees and lianas. The forest floor is relatively open with a thin layer of leaf litter or bare ground and a sparse growth of herbs and shrubs. Some of the dominant tree genera include *Pometia* (Sapindaceae), *Celtis* (Ulmaceae), *Octomeles* (Datisceae), and *Syzygium* (Myrtaceae).

There are at least three other similarly sized, ground-dwelling, heliothermic species of skinks inhabiting these forests, including *Emoia aenea*, *E. jamur* and *E. tropidolepis*. These species, together with *Carlia caesius* prefer relatively open parts of the forest that receive moderate to abundant sunlight. Another skink, *Lygisaurus* [*Carlia*] *novaeguineae*, a smaller species, also inhabits the forest floor but tends to prefer denser forest than the other species. *Emoia caeruleocauda* also occurs in these forests but tends to be semi-arboreal and forage in low vegetation such as shrubs and fallen trees.

*Carlia caesius* also occurs in disturbed habitats such as village margins and garden clearings where in the Timika area it co-occurs with at least five species of heliothermic skinks, including *Emoia aenea*, *E. jamur*, and *E. tropidolepis* which occur in small numbers on the ground, and *E. caeruleocauda* and *E. longicauda* which are semi-arboreal and arboreal, respectively, and common. *Carlia caesius* is by far the most abundant lizard in disturbed areas.

Common trees in these areas include *Macaranga* sp. (Euphorbiaceae), *Casaurina equisetifolia* (Casuarinaceae), *Camposperma montana* (Anacardiaceae), *Pisonia* sp. (Nyctaginaceae), *Linociera* sp. (Oleaceae), *Artocarpus* sp. (Moraceae), and *Pandanus* sp.

(Pandanaeae).

The Timika area has a mean temperature of 25.9 °C with little seasonality (monthly means range from 24.2 to 26.6 °C). Rainfall is somewhat more seasonal, with a peak in July but no distinct dry season. Generally, monthly rainfall is at least 200 mm with an average of about 20 rain days each month.

***Carlia bomberai* n. sp.**

(Fig. 3)

*Type material*

Holotype. MZB AA16285, adult male from Indonesia, Papua Province, Tanah Merah village [2.4382°S 133.1350°E], collected by Allen Allison, 14 March 2002.

Paratypes. BPBM 21315–328, 21330–333, 21335, USNM 562962–963, same collecting locality as holotype; BPBM 21329, Indonesia, Papua Province, Tanah Merah savannah [2.4426°S 133.1402°E]; BPBM 21293–302, 21308, 21312–314, Indonesia, Papua Province, Saengga River, east bank (hill forest behind Saengga Base Camp) [2.4575°S 133.1108°E]; BPBM 21303–307, 21309–311, Indonesia, Papua Province, Saengga village [2.4727°S 133.1104°E].



**FIGURE 3.** The holotype of *Carlia bomberai* n. sp., dorsolateral aspect, male in life, MZB AA16285.



### Diagnosis

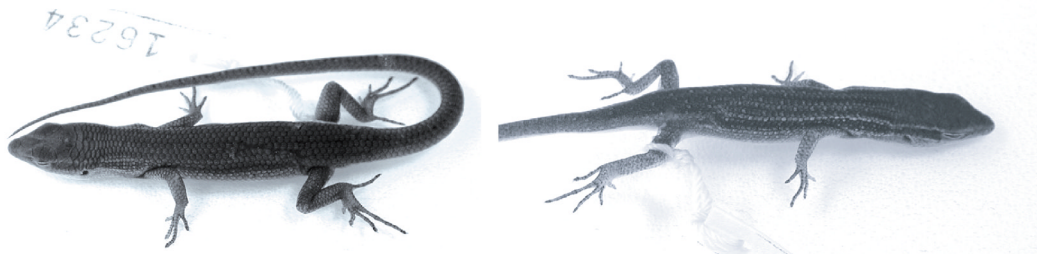
*Carlia bomberai* is a member of the *C. fusca* complex; adults are unicolored brown, occasionally with persistence of the juvenile dark brown lateral band on neck and anterior trunk thereby differing from adults of the variously striped complex members (*C. aenigma*, *C. aramia*, *C. babarensis*, *C. beccarii*, *C. caesius*, *C. digulensis*, *C. eothen*, *C. fusca*, *C. leucotaenia*, *C. luctuosa*, *C. mysi*, and *C. pulla*). Additionally, *C. bomberai* averages (adult females mean 47 mm, adult males 51 mm SVL) smaller than *C. ailanpalai*, *C. beccarii*, *C. eothen*, *C. luctuosa*, and *C. pulla* and larger than *C. aramia*, *C. babarensis*, *C. leucotaenia*, and *C. tutela*. *C. bomberai* has fewer average Dorsals (47) than *C. fusca*, *C. leucotaenia*, and *C. mysi* (48).

### Description of holotype

An adult male, 45.2 mm SVL, ca. 74 mm tail length (incomplete), 23.7 mm TrunkL, 22.6 mm HindIL, 10.2 mm HeadL, 1.1 mm PalpbD, and 1.2 mm EarD. Scalation right side for bilateral traits: interparietal separate, prefrontals not touching, 4 Supoc, 8 Supcil, 9 E yeld, 2 Temp, 4 loreals, 7 Suplab, 5<sup>th</sup> BlwEye, 6 Inflab, oblong ear opening, 3 AuricN on anterior border, 47 very weakly tricarinate Dorsal (1 enlarged as nuchals), 32 Midbody, 19 smooth 3FingL (no lamellae clefted), 26 4ToeL (some penultimate lamellae clefted), and precloacal scale slightly enlarged. Coloration in life: monochrome lizard; dorsally uniform medium brown with a coppery sheen from head onto tail, brown grades laterally into a dark lateral band (diffuse edges) extending from loreals to inguen, no dorsolateral or mid-lateral light stripes evident, and ventrolaterally lighter brown grades into creamy white, immaculate venter; limbs same color as dorsum. Coloration in preservative: a darker brown, monochrome lizard; dorsum dark brown grading to a medium brown on sides with no evidence of lateral band; ventrolaterally brown grades through a bluish tint into a white venter with areas (chin, throat, belly) with bluish tint; laterally cheek to axilla, scales dark-edged on their sides (not posterior free edge) creating a pattern of thin, longitudinal stripes on bluish white background.

Description. A moderate-sized *Carlia* ranging in adult size from 42 to 51 mm SVL (females 42.3–50.2 mm; males 47.8–53.9 mm) with HeadL 9.2–10.8 mm (females) 10.2–12.39 mm (males), PalpbD 0.8–1.4 mm (females) 0.9–1.6 mm (males), EarD 0.9–1.5 mm (females) 1.0–1.6 mm (males), TrunkL 19.1–26.1 mm (females) 20.2–26.0 mm (males), and HindIL 19.7–24.6 mm (females) 21.7–25.5 mm (males). Only the Saenn sample is large enough to test for dimorphism, and tests indicate sexual dimorphism in SVL, HeadL, PalpbD, and HindIL. Head and nuchal scales smooth; interparietal uncommonly absent; 4 Supoc, 8 Supcil, 7–11 Eyeld, 7 (rarely 6) Suplab, 5<sup>th</sup> (rarely 4<sup>th</sup>) BlwEye, and 6 (rarely 5 or 7) Inflab on each side. Ear opening oblong vertical to oblique with 1–5 AuricN, usually pointed, on anterior margin. Trunk scales smooth to weakly tricarinate dorsally and laterally, with 42–50 Dorsal, 29–34 Midbody. Subdigital lamellae undivided, smooth: 16–26 3FingL (occasionally penultimate few cleft), 24–30 4ToeL.

In life, most adult males are fairly similar in coloration to the holotype. BPBM 21296 had slightly darker flanks and a dull iridescent rust-reddish sheen on the lower flanks and belly and a bright rust-reddish sheen on the underside of the tail. BPBM 21333 had a slightly darker brown dorsum and darker flanks than the holotype and unlike that specimen had a parasagittal line of sparse white specks between the midline and flanks, a pale whitish dorsolateral line extending from the eye to inguen, and ventral coloration similar to that of BPBM 21296. An adult female (BPBM 21297) had a brown to dark olive-brown dorsum and flanks and a whitish to pearl venter lacking the rust-reddish tinge on the lower flanks and venter. Another adult female (BPBM 21293) was similar in all respects to 21297, but the dorsum had a reddish iridescent sheen and the venter was pale pearl with a slight reddish tinge.



**FIGURE 4.** Juveniles of *Carlia bomberai* (BPBM 21315 [left], BPBM 21325 [right]), dorsolateral aspect, preserved.

In preservative, the color of all life stages are muted. The dorsal and lateral surfaces darken; nonetheless, the dark lateral band remains evident on the neck and trunk of most adults, and the venter becomes cream to glossy white, remaining immaculate. The juvenile pattern (Fig. 4) is either a uniform or nearly uniform brown from head through base of tail or olive-brown with a middorsal narrow black stripe on trunk accompanied by a light peppering of single scaled white and black spots; brown, of variable darkness, lateral band runs from cheek to inguen, and bordered by distinct dorsolateral white stripe from eye to inguen or lighter area of brown rather than a distinct stripe; a midlateral white stripe is absent although that area beneath is lighter in some individuals; predominantly a grading of brown to white from beneath the lateral band to venter. In adults, the juvenile pattern disappears in most adult females and males, yielding unicolor brown or with the persistence of the darker lateral band without the lighter areas above and below it. The venter is immaculate and cream to white.

#### *Distribution*

*Carlia bomberai* is known with certainty only from the lowlands of Tangguh area along the northern part of the Bomberai Peninsula along the margins of Bintuni Bay (Fig. 5). There are, however, no barriers to faunal dispersion throughout most of the Bomberai Peninsula, and it is probable that this species occurs through much of the peninsula.

### Etymology

The specific name derives from the origin (occurrence) of these populations on the Bomberai Peninsula. It is proposed as a noun in apposition.

### Intraspecific variation

Most mensural traits and two scalation ones are summarized in Table 1 for the two populations/samples recognized as *C. bomberai*. There is a slight suggestion that the Saennga population may have a slightly smaller adult size, but the sample sizes are inadequate to confirm this difference. Scalation shows the limited variation observed in most other *Carlia fusca* complex species and offers no striking differences between these two samples. The species as described is limited to two samples, Saennga and Tanah Merah. There is a strong likelihood that the populations in Fak-Fak and Mandiwa are also *C. bomberai*; that topic is examined below in the Morphological variation section.

### Natural history

*Carlia bomberai* inhabits leaf litter on the floor of primary and secondary hill forest, mostly in areas receiving abundant direct sunlight. It also occurs in open areas, such as garden clearings and village margins and patches of natural savanna woodland (probably the result of poor drainage and low soil fertility) that are scattered throughout the hill forests of the Tangguh area and cover extensive areas south of Tangguh.

Locally dominant tree species comprising the hill forest habitat include *Agathis labillardieri* (Araucariaceae), *Pometia pinnata* (Sapindaceae) and *Acronychia dimorphocalyx* (Rutaceae). The savanna areas are dominated by grasses, with patches of ferns such as *Dicranopteris linearis* (Gleicheniaceae), *Nephrolepis hirsutula* (Nephrolepidaceae), and *Pteridium aquilinum* (Dennstaedtiaceae); scattered small, myrtaceous, shrubs such as *Tristaniopsis macrosperma*, *Lophostemon suaveolens*, *Decaspermum bracteatum*, and *Octamyrtus insignis*; and trees, particularly *Melaleuca leucadendron* (Myrtaceae) and *Acacia mangium* (Fabaciae).

The herpetofauna of Tangguh is depauperate compared to most other areas of lowland New Guinea and is dominated by a relatively small number of lizard species. *Carlia bomberai* is the most abundant lizard in the area. The only other common ground-dwelling lizards encountered in ten days of field surveys were all skinks and included *Emoia* cf. *physicae*, *E.* cf. *pallidiceps*, and *Sphenomorphus simus*, all of which are similar in size to *C. bomberai*. The two species of *Emoia* tend to co-occur with *C. bomberai* in relatively open, sunny areas of the forest, whereas *S. simus* generally prefers relatively closed, dark forest. Another ground-dwelling species of skink, *Lygisaurus* [*Carlia*] *novaeguineae*, which has similar ecological preferences to *Sphenomorphus simus* and is somewhat smaller than *C. bomberai*, was also present but uncommon in the Tangguh area. A third species of *Emoia*, *E. caeruleocauda*, is similar in size to *C. bomberai* and is often found in the same habitat, but is semi-arboreal, inhabiting shrubs, fallen trees and other areas within a meter or so of the ground.

**TABLE 1.** Summary of variation in select characters in the larger samples of the *Carlia* “*fusca*” group from southern and western Papua-Indonesia. Median  $\pm$  1 standard deviation, range, and \* sexually dimorphic; sample size in brackets; species assignment in parentheses.

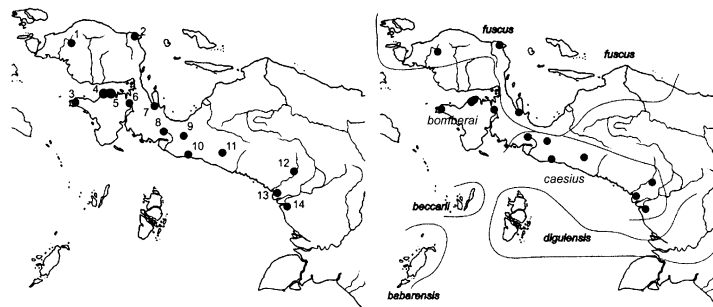
Locality		SVL	TrunkL	HindL	HeadL	Dorsal	Midbody
Agats ( <i>caesius</i> )	Female [8 ]	47.8 $\pm$ 1.8*	22.5 $\pm$ 1.4*	23.8 $\pm$ 0.7*	10.5 $\pm$ 0.4*	45.5 $\pm$ 1.7	34 $\pm$ 0.7
		45.1–50.0	20.5–24.9	22.7–24.4	10.2–11.3	44–49	33–35
	Male [8 ]	55.3 $\pm$ 2.0*	26.7 $\pm$ 3.1*	26.7 $\pm$ 0.7*	12.6 $\pm$ 0.5*	45 $\pm$ 1.1	34 $\pm$ 0.9
		52.0–58.0	22.3–31.4	25.5–27.9	12.1–13.5	45–48	32–34
Freeport ( <i>caesius</i> )	Female [27]	49.6 $\pm$ 2.7*	22.7 $\pm$ 1.4*	25.4 $\pm$ 1.8	11.2 $\pm$ 0.7*	46 $\pm$ 1.1*	33 $\pm$ 1.0
		45.2–55.2	18.8–24.8	21.4–29.5	10.0–13.0	43–48	31–34
	Male [22]	51.5 $\pm$ 5.1*	22.5 $\pm$ 3.0*	26.6 $\pm$ 2.3	12.4 $\pm$ 1.3*	45 $\pm$ 1.6*	33 $\pm$ 1.0
		45.7–64.5	18.6–28.8	25.0–32.7	10.8–15.9	42–48	32–35
Gariau ( <i>caesius</i> )	Female [10]	50.2 $\pm$ 2.0	23.2 $\pm$ 1.7	23.4 $\pm$ 1.1*	11.5 $\pm$ 0.2*	47 $\pm$ 0.9*	34 $\pm$ 1.1*
		45.1–51.8	20.4–26.3	22.4–25.8	11.2–11.9	45–48	32–36
	Male [10]	50.2 $\pm$ 1.7	21.3 $\pm$ 1.7	26.1 $\pm$ 0.4*	12.2 $\pm$ 0.3*	46 $\pm$ 0.8*	33 $\pm$ 0.9*
		47.9–52.5	19.8–25.9	25.7–26.8	11.8–13.0	45–48	32–35
Mandiwa (unassigned)	Female [9]	50.3 $\pm$ 2.4*	22.6 $\pm$ 1.6*	22.1 $\pm$ 0.8*	10.7 $\pm$ 0.4*	48 $\pm$ 1.5	32 $\pm$ 1.0*
		46.4–53.0	21.2–25.7	20.7–23.4	10.2–11.2	45–50	32–34
	Male [9]	52.8 $\pm$ 2.1*	25.3 $\pm$ 1.7*	24.1 $\pm$ 0.8*	12.5 $\pm$ 0.7*	48 $\pm$ 1.2	34 $\pm$ 0.8*
		51.0–56.5	23.5–28.1	22.2–24.6	11.3–13.5	46–50	32–35

continued.

Locality		SVL	TrunkL	HindL	HeadL	Dorsal	Midbody
Saengga ( <i>bomberai</i> )	Female [10]	45.8 $\pm$ 2.3	21.2 $\pm$ 2.1	21.8 $\pm$ 1.2	9.6 $\pm$ 0.6	47 $\pm$ 1.2	32 $\pm$ 0.8
		42.3–50.2	19.1–26.1	20.0–24.0	9.2–10.6	44–47	30–33
	Male [1]	52.3	24.3	23.7	11.9	46	32
Tanah Merah ( <i>bomberai</i> )	Female [5]	47.2 $\pm$ 2.*	22.0 $\pm$ 0.8	20.9 $\pm$ 1.1*	10.3 $\pm$ 0.2*	46 $\pm$ 1.3	32 $\pm$ 0.4
		44.9–49.9	20.8–22.9	20.3–23.2	10.1–10.5	45–48	31–32
	Male [7]	49.9 $\pm$ 1.1*	22.3 $\pm$ 1.3	24.6 $\pm$ 0.9*	11.9 $\pm$ 0.7*	46 $\pm$ 1.3	32 $\pm$ 1.0
		48.1–51.6	20.2–23.7	22.6–25.5	10.2–12.3	44–48	31–34
Ajamura (unassigned)	Female [13]	48.5 $\pm$ 3.2	22.2 $\pm$ 2.1	22.5 $\pm$ 1.6	10.5 $\pm$ 0.6	48 $\pm$ 0.8	33 $\pm$ 1.1
		43.9–53.2	19.6–26.8	20.2–25.0	9.7–11.5	47–50	31–34
	Male [17]	51.5 $\pm$ 2.6	23.9 $\pm$ 1.1	24.0 $\pm$ 1.8	12.1 $\pm$ 0.5	47 $\pm$ 1.4	33 $\pm$ 1.0
		43.1–54.7	21.9–25.4	22.5–28.2	11.1–12.7	45–49	31–34
Manokwari ( <i>fusca</i> )	Female [10]	49.2 $\pm$ 3.9	23.0 $\pm$ 2.1	22.5 $\pm$ 1.2*	11.0 $\pm$ 0.6*	49 $\pm$ 1.5	33.5 $\pm$ 1.5
		44.0–57.4	21.1–28.1	21.4–25.7	10.0–11.9	46–51	31–36
	Male [6]	51.0 $\pm$ 2.2	25.4 $\pm$ 2.4	26.2 $\pm$ 1.1*	12.4 $\pm$ 0.5*	48 $\pm$ 0.6	34 $\pm$ 1.4
		49.4–55.0	21.1–27.9	24.8–27.8	12.0–13.2	47–49	31–35

### Morphological variation

We confine our examination to “mainland” Papua-Indonesia exclusive of the north coast from Cape Valsch eastward. The latter area is excluded owing to the existence of only a single large sample (Toem); its specimens were collected nearly a century ago, hence questionable coloration data, and Toem is geographically distant from the other samples. Toem *Carlia* have been assigned to *C. fusca* (Zug, 2004).



**FIGURE 5.** Distribution of sample localities [left] and *Carlia fusca* complex species [right] in Papua-Indonesia. Sample localities: 1, Ayamaru; 2, Manokwari; 3, Fak-Fak; 4, Tanah Merak; 5, Saengga; 6, Mandiwa; 7, Yeretina; 8, Gariau; 9, Unipo; 10, Uta; 11, Freeport; 12, Lorentz River; 13, Agats; 14, Bayum.

Within the whole expanse of Papua-Indonesia and its great topographic and habitat diversity, morphometry and scalation show little variation. These similarities are evident in the comparison of selected characters depicted in Table 1. Discriminant function analyses (DFA) of adult females of the combined Papua-Indonesia sample also demonstrated the relatively low variation within and between these populations and species. DFA of morphometric traits (SVL, HeadL, PalpbD, TrunkL, HindIL) yielded a 40% classification accuracy for assignment using the 15 major locality samples. Using six “species” groups (*bomberai*, *caesius*, *fusca*, Ajamura, Fak-Fak, Mandiwa), classification accuracy increases to 59%, with 80% assignment-accuracy for *bomberai* and the remaining groups at 44–60%. The situation is similar for classification using scalation (Supcil, Eyeld, Suplab, Inflab, AuricN, Dorsal, Midbody, 3FingL, 4ToeL, Precl) with average of 64% assignment accuracy for localities (although only 35% accuracy in a jackknifed classification). “Species” group assignments using scalation has an even lower accuracy, 56% average (42–85%), with classification of *bomberai* (80%) and *fusca* (85%). These DFA results re-enforce our observation on the uniformity of *Carlia fusca* complex morphometrics and scalation and support our proposition that specimens cannot be reliably identified solely on the basis of one or a set of morphometric or scalation traits.

Coloration is the only means of recognizing species; however, the striking differences in coloration are only available in living lizards and must be inferred in most preserved

specimens. In life, the blue-black head of adult *Carlia caesius* is unique among Australopapuan *Carlia*, but in preservation, that coloration must be inferred from a dark head and dusky chin and throat. It is on the basis of the latter that *C. caesius* is proposed to extend along most of the south coast of Papua-Indonesia. *C. digulensis* populations occur to the east of *C. caesius*, and these lizards lack the dark head and throat, although preserved specimens suggest that reproductively active males share a reddish orange trunk. Red to orange neck and/or trunk coloration (although differently patterned) is widespread in *Carlia* species, e.g., *C. longipes* and, *C. schmeltzi* of Australia. The red/orange coloration, however, appears in Papua-Indonesia *C. fusca* only in the two south coast species.

In the area between Etna Bay and Cenderwasih Bay, *Carlia caesius* occurs in the areas of south coast drainage and *C. fusca* in the northward drainage systems. Populations of dark-headed and -throated *Carlia* occur at Unipo in the Siriwo R. basin and at Gariau on Yamur Lake. *C. fusca* occurs on the north coast at the base of the Wandammen Peninsula and Umar Bay. The Unipo population has the typical *fusca* unicolor brown adult males. Most adult females retain the distinct dorsolateral light stripe from ear to midtrunk and a dark brown band from behind eye to inguen; there is no midlateral light stripe although the area beneath the dark band is a light grayish brown and grades into an immaculate white venter. The juvenile pattern is a brighter version of females; however, a light midlateral stripe is evident from eye to midneck and thereafter as a series of spots and lines. This general *fusca* pattern applies to the populations at Manokwari and Sorong.

Adult females and males of *Carlia bomberai* (Saennga and Tanah Merah) share the unicolor male coloration of *C. fusca*, although with the faded persistence of the lateral dark band on neck and trunk. The juvenile pattern is distinctly non-*fusca*-like with most individuals approaching the unicolor of the adults; a few juveniles show a variably contrasting light dorsolateral stripe from eye to anterior trunk.

Presumably, the Fak-Fak population is *Carlia bomberai*. We are, however, reluctant to make such an assignment unequivocally. The dorsal and lateral coloration of adult males and females matches that of *C. bomberai* from Saennga and Tanah Merah; however, males and females to a lesser extent have dusky chins and anterior throats, remainder of venter immaculate white. This duskiness suggest that reproductively active males have a bright and contrasting head coloration. A similarly uncertainty applies to the specific assignment of the Mandiwa population. Overall, the general coloration is unicolor for males and remnant light dorsolateral and midlateral stripes enclosing a dark lateral band from head to anterior trunk. With the exception of the dusky throat, the Mandiwa pattern suggest a *C. fusca* assignment. As Zug (2004) noted, the Ajamaru sample appears to contain two morphotypes. We have no new specimens or observations on this population. The southern two-thirds of the Vogelkop, i.e., southern drainage basin, is inadequately sampled. The few specimens that derived from pre-1960s Dutch biological surveys are insufficient to identify the *Carlia fusca* complex species occurring there.

Rainer Günther (in litt., Aug. 2004) called our attention to the presence/absence of a visible parietal eye, that appears to differentiate individuals from Unipo and the Wandammen Peninsula. Our examination of these specimens reveals that an interparietal scale is present in all individuals and all individuals possess a parietal eye; however, this eye or organ does not perforate the scale in two individual (ZMB 58578, -580) and create an external modification on the scales surface. A parietal eye is present in both individuals, although lying below the interparietal scale. This median eye would not be visible in life because of darker scale pigmentation, but likely would still function physiologically as a light receptor. Where visible in these samples, the parietal eye appears to be the same size as in individuals from other *Carlia fusca*, *C. bomberai* and *C. caesius* populations.

### Biogeographic comments

Although *Carlia bomberai* is currently known with certainty only from the type locality, it likely ranges over much of the Bomberai Peninsula as most of the area is flat and there are no major barriers to faunal dispersal throughout the peninsula. All flat areas are part of the Salawati sedimentary basin that began to form probably in the early Miocene after the amalgamation of the Kemum-Misool terranes (Pigram and Davies, 1987). In the early Pleistocene (ca. 3–5 MYA), the Pacific plate fractured near the north coast of New Guinea and began thrusting under the depositional basins. Parts of the Bintuni Basin first became subaerial at this time, suggesting that the biota of the Bomberai Peninsula may be relatively young.

The western part of the Bomberai Peninsula adjoins a mountainous area known as the Lengguru terrane that occupies much of the western expanse of the Bird's Neck region from the southern part of the Vogelkop eastward to the Wandamen terrane (Pigram and Davies, 1987). The Lengguru terrane, which is likely of late Miocene age and is separated from the Australian craton to the south by the Tarera-Aiduna Fault, essentially includes the center of the known distribution of *Carlia fusca* (Pigram and Davies, 1987; Zug, 2004). Because the region occupied by *C. fusca* is geologically older than the areas on the Bomberai Peninsula inhabited by *C. bomberai*, it is quite possible that this latter species was derived from *C. fusca* subsequent to the emergence of the Bomberai Peninsula in the Pleistocene.

The area on the south coast of New Guinea occupied by *Carlia caesius* is part of the Australian craton and is geologically quite old. This region is composed largely of alluvium deposited from the mountains to the north, at the junction of the Pacific and Australian plates. These alluvial deposits form a continuous band of coastal lowlands, which receive relatively high rainfall, from Etna Bay (which coincides with the Tarera-Aiduna Fault) east to the Digul and Fly rivers. The Digul drainage is occupied by *C. diguliensis*, which also occurs on the Aru Islands (also part of the Australian craton; this archipelago was connected to mainland New Guinea during the last glacial maxima). The

remainder of the New Guinea portion of the Australian craton is occupied solely by *C. caesius*. Its range tends to be significantly wetter and less seasonal than the Digul drainage and areas to the east in Papua New Guinea. These climatic factors may be important to the presumed evolutionary and ecological separation of *C. caesius* and *C. diguliensis*.

Several other species of reptiles have a distribution similar to *Carlia caesius* or are found within the range of that species. These include at least two skinks, *Emoia jamur*, which is widespread in the foothills of the Jayawijaya Range (Brown, 1991), and *Lipinia nototaenia* which is known from two widely separated localities in the Otakwa and Lorentz drainages (Shea and Greer, 2002). In addition there are at least four localized endemics occurring within the range of *C. caesius*: three skinks, *Prasinohaema parkeri*, *Sphenomorphus mimikanus*, *S. wollastoni*, and an elapid snake, *Toxicocalamus grandis* (Boulenger, 1914). The recent Freeport surveys have resulted in the discovery of additional localized endemics, e.g. a frog, *Xenorhina adisca* (Kraus and Allison, 2003). However, most fieldwork has concentrated in areas between the Mimika and Otakwa Rivers or in the Lorentz River drainage (ca. 200 km to the east), and likely some localized endemics are actually more widely distributed along the Papua-Indonesian south coast than the past biodiversity surveys indicate. In any case, it does appear that the south coast of New Guinea comprising the Australian craton is an important area of herpetofaunal endemism.

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## Appendix

### *Character definitions*

The character set is the same one as used in the monograph of New Guinean *Carlia fusca* group lizards (Zug, 2004) and the characters are fully defined there. The following is a list of characters and their abbreviations.

MEASUREMENTS: Ear diameter (EarD); Head length (HeadL); Hindlimb length (HndLL); Palpebral diameter (PalpbD); Snout-vent length (SVL); Trunk length (TrunkL).

SCALATION: Auricular lobes, number (AuricN); Dorsal body scales, number (Dorsal); Eyelid scales, number (Eyeld); Infralabial scales, number (Inflab); Interparietal scale (Interp); Keeling of body scales (DorsKN); Loreal scales, number (Lor); Midbody scale rows, number (Midbody); Preclacal scales size (Precl); Subdigital lamellae, number on third finger (3FingL) and on fourth toe (4ToeL); Supraciliary scales, number (Supcil); Supralabial scales, number (Suplab); Supralabial scale below orbit (BlwEye); Supraocular scales, number (Supoc); Temporal scales, number (Temp).

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.

*Specimens examined*

*Carlia bomberai*: Saengga area BPBM 21293–314; Tanah Merah area BPBM 21316–333, 21335, MZB AA16285, USNM 562962–963; examined for coloration & SVL only: BPBM 21315.

*Carlia caesius*: Bayum IRSNB 13582 (5); Agats IRSNB 24.868A-T (19); Lorentz River ZMA 15315 (2), not cataloged (3); Uta RMNH 30392–398; Freeport area BPBM 21154, 21156–157, 21159–161, 21163, 21166–167, 21169, 21176, 21179–182, 21187, 21206, 21209–210, 21217–221, 21223–226, 21229–231, 21233–234, 21236–242, 21244, 21249, 21256, 21258, 21260 21262–263, 21267, MZB AA15323, USNM 562964–966; examined for coloration & SVL only: BPBM 21153, 21155, 21162, 21164, 21168, 21172, 21175, 21177–178, 21183, 21200–21205, 21214–216, 21222, 21227–228, 21232, 21235, 21243, 21245–248, 21250–255, 21257, 21259, 21261, 21264–266, 21280–282; Gariau RMNH 30381, 30568–569, 30571, 30579, 30581; Unipo ZMB 58578–580.

*Carlia fusca*: Manokwari MCZ 7679 (9), RMNH 30307–310, not cataloged [1]. Umar Bay Yeretna ZMB 63985–991.

Unassigned: Mandiwa RMNH 30340–357. Fak-Fak MCZ R7309, RMNH 6745, 7295, 303378–379, ZMB 64096–100. Ayamaru RMNH 30358–377 (Ayamaru), not cataloged (Semu [2], Djitmau [5], Takum [2])