

**NEW SPECIES OF THE LIZARD GENUS *SPHENOMORPHUS*,
(LACERTILIA: SCINCIDAE), WITH NOTES ON ECOLOGICAL
AND GEOGRAPHIC DISTRIBUTION OF SPECIES IN SABAH, MALAYSIA**

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ABSTRACT. – Three new species of the scincid lizard genus *Sphenomorphus* are described from the western mountainous ridge of Sabah, Malaysia. Ten species of this genus are now known from the forests of Sabah, northern Borneo. Four species are apparently confined to submontane and montane zones (1000-1870 m ASL), five species to elevations below 800 m ASL, and just one ranging from very low elevations to 1000 m ASL. Most of the lowland species have wide, known distributions in northern Borneo and sympatry is common. All of the species are terrestrial, and data presented show that they overlap broadly in microhabitat use. Despite the geographic and ecological overlap, rarely is more than a single species found in a sample plot.

KEY WORDS. – *Sphenomorphus*, lizards, new species, ecological distribution, Sabah, Borneo.

INTRODUCTION

The scincid genus *Sphenomorphus* is probably the most speciose lizard genus in Borneo. Bacon (1967) listed 13 species, one of which, *S. alfredi* (Boulenger), is probably incorrectly included in this fauna. All the known species live deep in forest, avoiding sun flecks (Inger, 1959), and all are terrestrial, though they will climb several meters up tree trunks to avoid predators. Most of the species occur below 750 m ASL, and sympatry is common. Only three species are known from montane environments (>1000 m ASL): *S. kinabaluensis* (Bartlett), *S. tenuiculus* (Mocquard), and *S. murudensis* Smith. During the course of joint ecological studies by Field Museum and Sabah Parks on amphibians and reptiles of Sabah, samples of three undescribed species and several other poorly known species of *Sphenomorphus* were collected along the mountainous western spine of Sabah from Mt. Kinabalu in the north to Mt. Lumaku in the south. In this paper, we describe those new species, add some notes to amplify the descriptions of

poorly known species, and present information on altitudinal and local distribution.

MATERIALS AND METHODS

Lizards to be retained were euthanized, injected with 4% formalin, and held in formalin for two to four weeks before being transferred to 70% ethanol. Specimens are now in the collections of Sabah Parks (SP) and Field Museum of Natural History (FMNH). Data on vegetation type and horizontal and vertical positions were recorded for each specimen. In addition to the material examined listed under each species, we have referred to notes we had made in the past on holotypes of *Lygosoma tenuiculum* Mocquard, *Lygosoma malayanum* Doria, *Lygosoma modigliani* Boulenger, *Lygosoma butleri* Boulenger, *Lygosoma alfredi* Boulenger, and *Sphenomorphus murudensis* Smith. We also examined some material from the collection of the California Academy of Sciences (CAS).

Measurements (to 0.1 mm) were made routinely of snout-vent length (SVL), snout to ear opening (SNE), snout to forelimb insertion (SNA), and axilla to groin (AG). For some individuals it was feasible to measure length of fore and hind limb without damage. Counts were made of the number of scale rows around mid-body, number of ventral scales between the vent and the mental scale, and lamellae under the fourth finger and fourth toe. Supraocular counts ended with the scale touching both the frontoparietal and the parietal shields. In the case of *S. hallieri*, the supraocular count ended with the scale touching both the frontoparietal and the temporal scale separating the parietal from the supraocular row (see below). Adult size range was determined by the intraspecific size range of females having enlarged ova visible through the body wall. Intraspecific size ranges of females and males differed only slightly.

All the species discussed here share the following characters and fit Greer's (1979) definition of *Sphenomorphus*: Body scales smooth, no supranasal, lower eyelid movable and scaly, parietals meet behind interparietal, median preanals enlarged, and digits with three rows of dorsolateral scales.

RESULTS

Sphenomorphus aesculeticola, new species (Fig. 1)

Material examined. — Holotype — FMNH 239852 (field no. RFI 45734) an adult female, collected at Mount Lumaku (1350m) (4°52'N/115°38'E), 14.6 km from Mendolong, Sipitang District, Sabah, Malaysia, coll. Freddy Paulus & Frederick Francis, 5 Sep. 1989.

Paratypes — FMNH 239834-851, 243837-38 from Mount Lumaku, 13.9-14.6 km from Mendolong, 1000-1350 m.

Referred material. — All from Sabah, Malaysia. FMNH 243963-64 a juvenile and a hatchling from Mount Lumaku (1140 m), Sipitang District; FMNH 239833 Sunsuron (1400 m) (5°48'N/116°22'E), Crocker Range National Park, 22 km from Tambunam on Tambunam-Kota Kinabalu Road, Tambunam District; SP 06426-27, 06429, 06431-41, FMNH 152224-26 Mesilau (1650 m) (5°59'N/116°36'E), Kinabalu Park, Ranau District; SP 06343, 06348-49, 06371, 06373-74, 06376-80, 06383-87, 06389-90, 06392-97, 06399, 06401, 06403-07, 06409, 06411-12 vicinity of Mesilau Golf Course (1600-1700 m), Ranau District.

Etymology. — Specific name from “aesculetum” Latin for oak forest and “cola” Latin for dweller.

Diagnosis. — A short-legged, small (SVL<45 mm) species of *Sphenomorphus* having four supraoculars, fewer than 10 lamellae under the fourth toe; scale rows usually 28-30, and prefrontals not meeting in the midline.

Description. — A small, slender skink, 35-42 mm; head not wider than neck or trunk; tail thick, round in cross section; snout obtusely pointed, shorter than eye diameter; lower eyelid scaly; tympanum in shallow, round depression, about one half area of eye, no lobules; limbs pentadactyl, short,

not or barely overlapping; axilla to tip of longest finger about half snout-axilla distance and about one-third axilla-groin distance; hind limb only slightly longer than forelimb.

No frontonasal; rostral wider than tall, dorsal margin convex; frontonasal trapezoidal, in broad contact with nasal, rostral, first loreal, and prefrontal, in narrow contact with frontal; prefrontals separated, in wide contact with frontal, both loreals, and first supraocular; four supraoculars, second largest in transverse axis and first largest in longitudinal axis, first two bordering frontal, second to fourth touching frontoparietal, last touching both frontoparietal and parietal; frontal longer than its distance from tip of snout, longer than frontoparietals; frontoparietals not fused; interparietal shorter than frontoparietals; parietals meeting behind interparietal except in one animal in which they are separated by the first vertebral; parietal bordered laterally by 4-6 scales; no nuchals; nostril in a single nasal; loreals 1+1, first taller than second; second loreal rectangular or subtriangular; two enlarged preoculars, lower one larger; six supralabials, fourth below center of eye; a row of small suboculars above supralabials; 8-10 supraciliaries; two small temporals followed by a large one lateral to the parietal. Five infralabials; mental as wide as rostral; postmental pentagonal, bordering first infralabial; three pairs of enlarged chin shields, the first pair meeting behind postmental. Scales smooth, dorsals slightly smaller than ventrals; scale rows at mid-body 26-32, usually (85%) 28-30; 60-68 scales from vent to mental; preanals only slightly larger than adjacent ventrals; subcaudals only slightly larger than dorsal caudal scales.

All digits with three dorsolateral scale rows; scales of palm and sole slightly raised, relatively large, subequal, lacking “heel” scale; lamellae smooth, relatively undifferentiated; order of size of fingers 3>4>2>5>1, toes 4=3>5>2>1; fourth finger with 5 or 6 lamellae, rarely 4; fourth toe with 7-10 lamellae, rarely 6 (Table 1).

Males: SVL 34.0-38.9 mm (n=16), axilla-groin (AG) 0.48-0.60 of SVL (median 0.521, n=13); snout to arm insertion (SNA) 0.33-0.39 of SVL (median 0.365, n=13); snout to ear opening (SNE) 0.17-0.21 of SVL (median 0.189, n=9). Females: SVL 33.3-42.0 (n=20); AG/SVL 0.47-0.59 (median 0.529, n=16); SNA/SVL 0.33-0.38 (median 0.367, n=16); SNE/SVL 0.17-0.20 (median 0.182, n=14). Seven gravid females measured 37.5-40.0 mm.

Color (in preservative) top of head and back medium to dark brown; dark spots in centers of many scales, forming an irregular series of thin dark lines or a checkered pattern or no distinct pattern; side of snout and lips dark brown, labial scales with light centers; a dark lateral band beginning as a stripe behind eye and over tympanum, continuing along trunk as a stripe on two or three scale rows, regularly interrupted by small light spots; sides below dark stripe lighter than back, many scales with small, black centers; dorsally limbs spotted black and light tan; pattern of trunk continued on tail; ventrally head, trunk, and limbs whitish; subcaudal scales with small, dark, centers.

Table 1. Geographic variation of meristic characters in *Sphenomorphus aesculeticola*.

	Lamellae under digit							
	Fourth finger			Fourth toe				
	4	5	6	6	7	8	9	10
Number of individuals								
Mount Lumaku ¹	8	8			1	8	7	1
Mount Trus Madi ²	4					2	2	
Mount Kinabalu ³	3	18	2	9	18	6		
	26		28	29	30	31	32	
Scale rows at mid-body								
Mount Lumaku			1	10	1			
Mount Kinabalu	1	8	3	7	4			2

1 At sampling site 4°52'N/115°38'E.

2 At sampling site 5°33'E/116°25'E

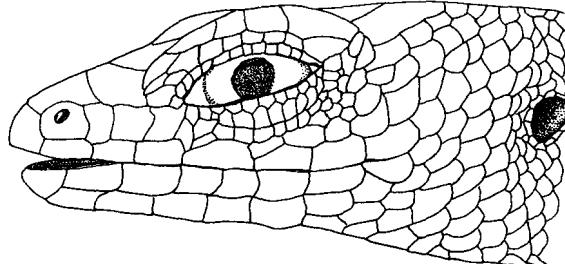
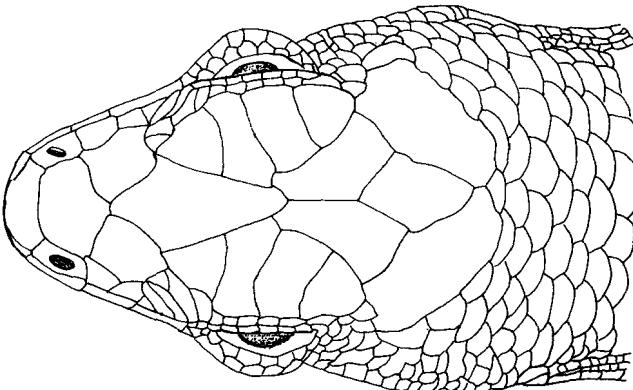
3 At Mesilau 5°59'N/116°36'E

Measurements (mm) of holotype. – SVL 37.5, axilla to groin 19.9, tip of snout to arm insertion 13.7, tip of snout to anterior edge of ear opening 7.1; tail 50.0.

Remarks. – We refer the specimens from Mesilau, Mount Kinabalu to this species provisionally. There are slight differences between the samples from Mount Lumaku, the type locality, and Mesilau, on Mount Kinabalu (Table 1). Although males from both series have small dark spots scattered over the throat, those from Mesilau are more heavily spotted. The two samples do not differ in body proportions.

The entire Lumaku sample was taken in forest floor quadrats in oak forest, three individuals just under the surface of soil, 11 under dead leaves, three under rocks, four under logs, and one on bare soil. Seven females 37.5-40.0 mm SVL, collected during the months of January, April, July, August, and September, contained two enlarged ova visible through the body wall. Two ova were found just below the surface of soil; the hatchling that emerged from one ovum measured 15 mm SVL. Of the series from Mesilau, Mt. Kinabalu, 26 were found under dead leaves, nine under logs, and 13 on bare soil.

Comparisons. – Fifteen species of *Sphenomorphus* from the Malay Peninsula, the Greater Sunda Islands, and the Philippine Islands have four supraoculars (de Rooij, 1915; Smith, 1930; Taylor, 1922). *Sphenomorphus aesculeticola* differs from 12 of these in having fewer than 10 lamellae under the fourth toe. The exceptional three species, all from the Philippines, are *S. atrigularis* Stejneger (8-11 lamellae), *S. biparietalis* Taylor (9-11), and *S. luzonense* (Boulenger) (9-12). The last species is sharply distinguished from *aesculeticola* in having the tympanum almost completely covered by scales and in having two posterior loreals and enlarged preanals (Brown and Alcala, 1980). According to Brown and Alcala (1980), in *S. biparietalis* and *S. atrigularis* the prefrontals are in contact and "rarely separated," whereas these two shields are separated in all *S. aesculeticola*. All nine *S. atrigularis* seen in this study have the prefrontals meeting; in two of the six *S. biparietalis* seen, the prefrontals are separated. *Sphenomorphus biparietalis* also differs from *S. aesculeticola* in having each parietal



5mm

Fig. 1. Dorsal and lateral views of head of *Sphenomorphus aesculeticola*, new species. FMNH 239834, paratype.

divided into two shields and in having fused loreals.

Six Bornean species of *Sphenomorphus* agree with *S. aesculeticola* in having four supraoculars. Three of these have fewer scale rows than *S. aesculeticola*: *S. tenuiculus* (Mocquard) (26), *S. buettikoferi* (van Lidth de Jeude) (24), and *S. stellatus* (Boulenger) (22-24). Three have more scale rows: *S. hallieri* (van Lidth de Jeude) (33-41), *S. shelfordi* (Bartlett) (34), and a new species, described below, (32). All six have more lamellae under the fourth toe, although one, *S. hallieri* (11-14), approaches *aesculeticola* (7-10). Only *S. buettikoferi* [SVL 35 mm (de Rooij, 1915)] is as small as *S. aesculeticola* (maximum SVL 42). Three species from the Malay Peninsula and the Mentawai Islands having

four supraoculars differ from *S. aesculeticola* in having the prefrontals in contact and more lamellae under the fourth toe: *S. modigliani* (Boulenger) (15), *S. malayanus* (Doria) (13-15), *S. butleri* (Boulenger) (12-13).

Other material examined. – *Sphenomorphus atrigularis* Stejneger CAS 60242, 60245, 60248, 138282-86, 138289 from Zamboanga Peninsula, Mindanao, Philippine Islands. *Sphenomorphus biparietalis* Taylor CAS 60703-4, 60706, 60708-9, 60712 from Jolo Island, Sulu Archipelago, Philippine Islands.

***Sphenomorphus crassa*, new species**

(Fig. 2)

Material examined. – Holotype – FMNH 243839 (field number RFI 46020), an adult female from Mendolong ($4^{\circ}54'N/115^{\circ}42'E$), Sipitang District, Sabah (Borneo), Malaysia, collected at 670 m ASL under dead leaves in selectively logged forest, coll. Robert F. Inger, Tan Fui Lian & Paul Yambun, 8 Aug. 1990.

Etymology. – Specific name from *crassa* Latin, meaning fat or stout, referring to the body shape.

Diagnosis. – A large species of *Sphenomorphus* (holotype SVL 82 mm) having relatively short limbs, four supraoculars, prefrontals widely separated, loreals 1+1, 32 scale rows, 18 lamellae under the fourth toe, and no lateral dark band.

Description. – Body robust; limbs pentadactyl, relatively short, just meeting when adpressed; tail roundish in cross

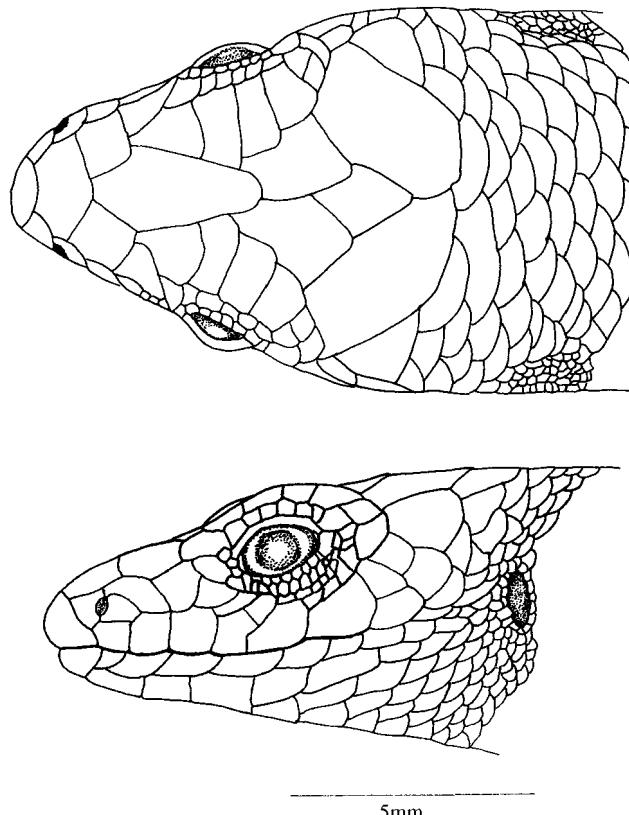


Fig. 2. Dorsal and lateral views of head of *Sphenomorphus crassa*, new species. FMNH 243839, holotype.

section, not laterally compressed; head deep; snout slightly longer than eye; lower eyelid scaly; tympanum deeply sunk, opening vertically oval, no lobules.

No supranasal; rostral convex, with straight posterior border; frontonasal large, laterally occupying dorsal border of anterior loreal, narrow suture with frontal; prefrontals not meeting, narrow contact with first supraocular, broad contact with second loreal and upper half of rear border of first loreal; four supraoculars, first largest in longitudinal axis, second largest in transverse axis, first two in contact with frontal, second to fourth touching frontoparietal, last touching both frontoparietal and parietal; supraciliaries 8, first enlarged; frontal longer than its distance from tip of snout, longer than frontoparietal; frontoparietals not fused; interparietal small, much shorter than frontoparietals; parietals in contact with fourth supraocular, meeting behind interparietal, larger than frontoparietal, left parietal bordered posterolaterally by large temporal and three dorsal scales, right parietal bordered by large temporal and two dorsals; two enlarged nuchals on one side, none on the other; nostril in single nasal; loreals 1+1, first taller than second; two preoculars, lower one larger; supralabials 7, 5-6 below eye; two rows of small suboculars; temporals large, 3 + 3/2, largest immediately lateral to parietal; infralabials 7; postmental larger than mental, bordering first two infralabials; two pairs of enlarged chin shields, only the first pair in contact medially; .

Scales smooth, in 32 rows around mid-body; scales between vent and mental 72; dorsals slightly larger than ventrals; lamellae smooth, fourth finger with 11, fourth toe with 18/19; digits with three rows of dorsolaterals in distal two phalanges; scales of palm and sole slightly raised; no heel scale; fourth toe distinctly longer than third; fourth finger slightly longer than third. Median preanals distinctly enlarged, overlapping lateral preanals. Median subcaudals larger than adjacent scales.

SVL 81.9, tail 139.6, axilla-groin 46.0, snout to arm insertion 25.9, tip of snout to ear opening 13.1, elbow to tip of longest finger 12.7.

Color in preservative dorsally and laterally medium brown with faint dark lines formed by dark centers of most dorsal scales; small yellowish spots on trunk, especially dense on sides, each light spot on back less than one scale wide; same coloration continued on tail; no dark bars or band on the sides; ventrally cream, immaculate.

Comparisons. – This species differs from other Bornean *Sphenomorphus* that have four supraoculars in several morphological features as shown in Table 2. In addition, the robust body, the light-spotted trunk, and the absence of a dark lateral stripe or band distinguishes this species from the others listed in Table 2. Three other Southeast Asian species of *Sphenomorphus* agree with *S. crassa* in having four supraoculars and separated prefrontals, *S. cameronicus* Smith, *S. mindanensis* Taylor, and *S. victoria* Brown and Alcala. All three of these species have dark lateral bands (Smith, 1924; Brown and Alcala, 1980), a pattern element

Table 2. Comparison of Bornean species of *Sphenomorphus* having four enlarged supraoculars.

	Scale rows	Lamellae fourth toe	Prefrontal contact ¹	SVL ²
<i>crassa</i> n. sp.	32	18	0	82
<i>hallieri</i> (van Lidth de Jeude)	36-38	10-14	+	40-55
<i>aesculeticola</i> n. sp.	28-32	6-10	0	<45
<i>stellatum</i> (Boulenger)	22-24	18-25	+ (0)	55-75
<i>büttikoferi</i> (van Lidth de Jeude)	24	22	+	<45
<i>tenuiculus</i> (Mocquard)	26	21-24	0	45-60
<i>shelfordi</i> (Boulenger)	30-34	27-29	+	65-70

1 + prefrontals in contact; 0 prefrontals separated; +(0) rarely separated.

2 Range of snout-vent length of adults.

absent in *S. crassa*. *Sphenomorphus crassa* is much larger than these species: *S. cameronicus* 65 mm (Smith, 1924), *S. mindanensis* "large male" 55 mm (Brown and Alcala, 1980), and *S. victoria* "mature female" 45 mm (Brown and Alcala, 1980). *Sphenomorphus cameronicus* has more scales rows (38) than *S. crassa*.

***Sphenomorphus tanahtinggi*, new species**
(Fig. 3)

Material examined. – Holotype – FMNH 239855 (field number RFI 45321) an adult female from Mt Lumaku (4°52'N/115°38'E), Sipitang District, Sabah (Borneo), Malaysia, collected in leaf litter of a selectively logged forest at 1180 m ASL, coll. Robert F. Inger & Tan Fui Lian, 2 Aug. 1989.

Paratypes – SP 06580 an unsexed adult from Upper Sungai Pangas, Mt. Trus Madi (5°33'N/116°31'E), Keningau District, Sabah, collected in submontane forest at 950 m ASL coll. Tan Fui Lian; 15 May. 1991; FMNH 258867 (field number RBS 4007) an unsexed subadult from same area as preceding paratype, collected at 850 m ASL, coll. Robert B. Stuebing 17 May. 1991.

Referred material. – FMNH 239854 (field number RFI 45203) a juvenile from same locality as holotype, but at 1000 m ASL.

Etymology. – Specific name from *tanah*, Malay, meaning land, and *tinggi*, Malay, meaning high, referring to the montane home of this species.

Diagnosis. – A medium-sized *Sphenomorphus* having five supraoculars, three small superimposed anterior loreal scales, prefrontals narrowly in contact or separated; 40-42 scale rows at mid-body, limbs overlapping widely.

Description. – Body moderately robust; limbs pentadactyl, long, overlapping; tail round in cross section; head deep, snout longer than eye; lower eyelid scaly; tympanum deeply sunk, opening vertically oval, maximum dimension less than half eye opening, no lobules.

No supranasal; rostral convex, posterior margin straight; frontonasal large, lateral border touching upper anterior loreal; prefrontals meeting at a point or narrowly separated, bordering anterior and posterior loreals and narrowly in contact with first supraocular; frontal longer than its distance

to tip of snout and as long as or longer than frontoparietal and interparietal combined; supraciliaries 8-10, first very large; five supraoculars, first largest in longitudinal axis, second largest in transverse axis, first two in contact with frontal, last three usually in contact with frontoparietal, fifth in contact with frontoparietal and parietal, fifth followed by two or three small scales; frontoparietals not fused, larger than interparietal; parietals meeting behind interparietal, parietals bordered posterolaterally by five or six scales; no enlarged nuchals; nostril in single nasal; loreals 3+2; supralabials 8-9, 5-7 below eye; two rows of small suboculars; four enlarged temporals in two rows between last supralabial and much enlarged upper temporal; infralabials 7; postmental smaller than mental, in contact with first infralabial; two pairs of chinshields behind postmental, first pair meeting in midline.

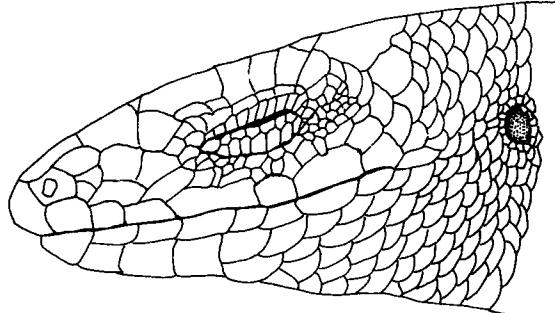
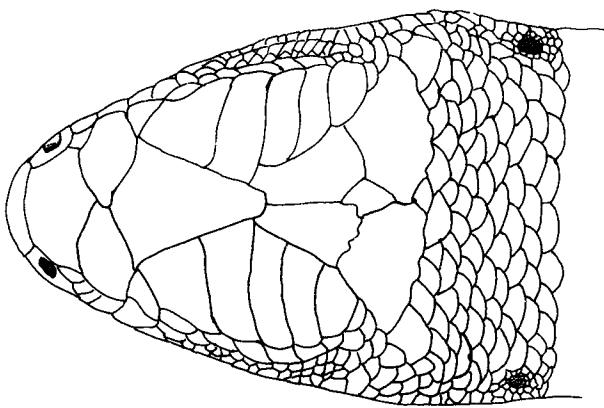


Fig. 3. Dorsal and lateral views of head of *Sphenomorphus tanahtinggi*, new species. FMNH 239855, holotype.

Scales smooth, 40-42 rows around mid-body; dorsals slightly larger than ventrals; scales between vent and mental 76-79; median preanals enlarged, overlapping lateral scales. Third finger slightly longer than fourth; fourth toe longer than third; fourth finger with 11 smooth lamellae; fourth toe with 16, 17 keeled lamellae; digits with three rows of dorsolaterals; scales of palm and sole elevated.

Color in preservative of dorsum olive-brown, becoming darker over tail, without markings or with widely scattered small dark spots on centers of a few scales; side of head and trunk dark brown, sharply contrasting with back; light line along dorsal margin of dark lateral band; 10 full scale rows between dark bands; ventral margin of band gradually fades into ventral coloration; a few small light spots in lower portion of band; venter pale olive gray, no markings.

Measurements (mm) and body proportions. – (Holotype followed by two adult paratypes) SVL 63.5, 47.6, 58.4; snout-ear opening (SNE) 13.1, 10.8, 12.2; snout-arm insertion (SNA) 23.6, 18.6, 20.4; axilla-groin (AG) 30.8, 22.6, 28.0; hindlimb 27.5, 20.6, 26.9; forelimb 20.4, –, 17.8. Measurements of the limbs have large errors because of limbs fixed in flexed positions. SNE/SVL 0.21-0.23, SNA/SVL 0.36-0.39, AG/SVL 0.48-0.49; hindlimb/AG 0.89-0.95.

Comparisons. – *Sphenomorphus tanahtinggi* resembles seven Bornean species in having the anterior loreal divided into several superimposed small scales, although *S. tanahtinggi* differs from all seven in having three rather than two anterior loreals. The number of scale rows in *tanahtinggi* (40-42) distinguishes it from *S. kinabaluensis* (33-37), *S. murudensis* (30), and *S. maculicollus* (35-36). All four specimens of *S. tanahtinggi* (including the juvenile) have five supraoculars, whereas all *S. sabanus*, *S. cyanolaemus*, *S. multisquamatus*, and *S. haasi* have six and *S. maculicollus* has six or seven. The numbers of supraoculars and scale rows separate *S. tanahtinggi* from all the species of *Sphenomorphus* listed in Table 2.

Sphenomorphus hallieri (van Lidth de Jeude) (Fig. 4)

Lygosoma hallieri van Lidth de Jeude, 1905:197–Putus Sibau, Kalimantan Barat (Borneo), Indonesia; de Rooij, 1915:210. *Lygosoma (Sphenomorphus) hallieri* – Brongersma, 1942:129. *Sphenomorphus hallieri* – Bacon, 1967:72.

Material examined. – Sabah: Lahad Datu District, Danum Valley Field Centre (5°12'N/117°50'E) FMNH 230181, 240614; Tenom District, Sungai Malutut (5°17'N/115°58'E), 15 km N of Tenom FMNH 239743; Tenom District, Kampong Maganiton (5°13'N/115°57'E), 12 km N of Tenom FMNH 239744-45, 239747-50, 243814-18; Sipitang District, Mendolong 235162-67, 235169, 239751-55, 243813, 243959-60; Tawau District, Tawau Hills Park (4°37'N/117°55'E) FMNH 248996-97, 249779; Sandakan District, Sandakan FMNH 76225. Sarawak: Seventh Division, Belaga District, Sungai Linau (2°37'N/114°3'E) FMNH 251724.

Remarks. – This species has been recorded only from the type locality in the lowlands of western Kalimantan and from Sungai Pesu in north-central Sarawak (Bacon, 1967). We

report here on specimens from southwestern and eastern Sabah, at elevations of 170-710 m ASL, indicating that the species is distributed across much of the lowland forests of Borneo.

The large upper temporal that is characteristic of many species of *Sphenomorphus* has in *S. hallieri* become wedged between the last supraocular and the parietal so that the last two shields do not meet. This character distinguishes *S. hallieri* from all of its congeners in Southeast Asia, except for *S. biparietalis* Taylor (southeastern Philippines). These two species differ in size (mature females: *S. hallieri* 37-48 mm, *S. biparietalis* 33-35; mature males *S. hallieri* 45-52, *S. biparietalis* 31-35), in the number of scale rows at mid-body (*S. hallieri* usually 36-38, *S. biparietalis* 30-34), and in the number of loreals [*S. biparietalis* 1+0 (Taylor 1922, fig. 22; Brown and Alcala, 1980), *S. hallieri* 1+1]. We amplify Bacon's (1967) description of *S. hallieri*.

Fourth toe lamellae 10-14, usually (35 of 38) 11-13; fourth finger lamellae 7-8; digits with three rows of dorsolaterals; scales smooth, in 33-41 rows at mid-body, usually (14 of 22) 36-38; mid-ventral scales from cloaca to mental 63-73 (mean \pm SE 66.7 \pm 0.91, n=11); axilla to groin 0.47-0.60 of SVL (median 0.519, n=21); insertion of arm to tip of snout 0.33-0.39 of SVL (median 0.350, n=14); mature males

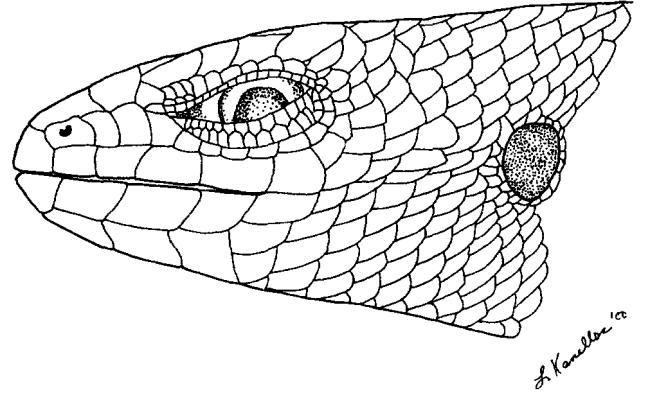
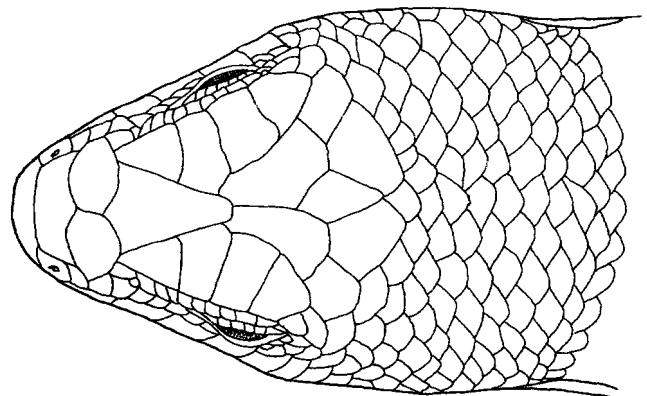


Fig. 4. Dorsal and lateral views of head of *Sphenomorphus hallieri* (Lidth de Jeude). FMNH 243816, Tenom District, Sabah, Malaysia.

mean \pm SE 48.6 \pm 0.71 mm (n=13); mature females mean \pm SE 43.9 \pm 1.09 mm (n=13). Each of six females (37.0-49.3) contained two enlarged ova visible through the body wall.

Color in life (of animals from Sabah) is variable; dorsal surfaces generally brown, often with a red or rust-colored dorsolateral streak from eye to behind shoulder, streak broken into spots or bars on the trunk; some individuals with three or four rows of scales below dorsolateral line blackish; sides light brown or olive with many small, yellow or greenish spots; chest and belly dark yellow or pale green; underside of tail may be red or blackish; males with throat light blue heavily spotted with black and side of head black. Bacon (1967) reported that females from Sarawak had pinkish throats; in those from Sabah, the entire ventral surface is yellowish and there is no black on the side of the neck.

In preservative, blue and red areas fade to light olive; lateral dark line fades to dark brown; males with many small blackish spots on the underside of the head and a dark gray wash over the throat and side of the neck; usually a zigzag row of dark spots forming an irregular dorsolateral streak from the eye to the rear of the trunk.

***Sphenomorphus kinabaluensis* (Bartlett)**
(Fig. 5)

Lygosoma kinabaluensis Bartlett, 1895:94—Mt. Kinabalu, Sabah (Borneo), Malaysia.
Sphenomorphus kinabaluensis — Ota et al., 1989:38.

Material examined. — All from Sabah, Malaysia. Ranau District, Kinabalu Park, Headquarters Area FMNH 251833, SP 6001, 6007, 6093; Ranau District, Kinabalu Park, Mesilau FMNH 152168-72; Ranau District, Mesilau, outside of park boundary SP 6301, 6341-2, 6344-7, 6369-70, 6372, 6375, 6382, 6398, 6402, 6410, 6428, 6435, 6730; Keningau District, Ulu Kimanis (5°30'N/115°56'E), Crocker Range National Park SP 6526; Sipitang District, Mount Lumaku FMNH 239778-239789, 239870-239873; Tambunam District, Sunsuron, Crocker Range National Park, 22 km from Tambunam on Tambunam-Kota Kinabalu Road FMNH 239765-239777, 251504, 251506.

Remarks. — These samples, which extend the known range of the species south along the Crocker Range to the southwestern corner of Sabah, indicate that the species may be found farther south in the mountains of Sarawak and Kalimantan.

Supraoculars 5 (25 individuals) or 6 (14); scales smooth, 33-37 rows at mid-body; modal value 34; lamellae of fourth finger 10-14, modal value 12; lamellae of fourth toe 15-20, modal value 17; digits with three rows of dorsolaterals; ventral scales between vent and mental 73-91.

Color in life olive to dark brown above, often with indistinct black squares in rows; a black stripe from rear of eye over axilla and along dorsolateral area, or side mostly black; stripe with yellow or greenish yellow spots; labial scales with narrow brown or black sutures; chin and throat cream with small black spots; chest and abdomen white or greenish yellow; underside of tail red or rose fading to blue.

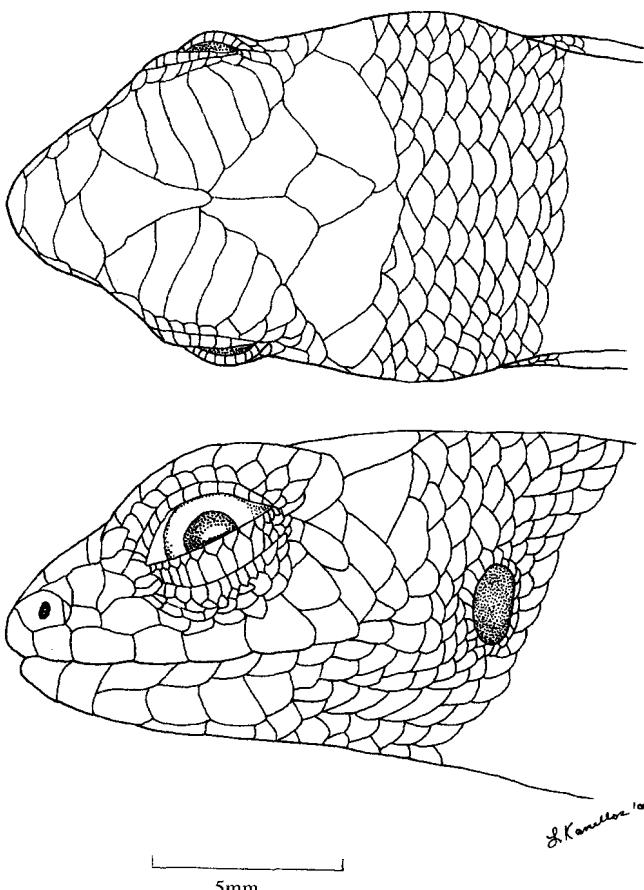


Fig. 5. Dorsal and lateral views of head of *Sphenomorphus kinabaluensis* (Bartlett). FMNH 239770, Tambunam District, Sabah, Malaysia.

In general form, this species resembles the lowland species *S. cyanolaemus*, which also has a black lateral band. But the trunk is more elongate in *S. kinabaluensis* (axilla-groin/SVL 0.45-0.54, median 0.509, n=12) than *S. cyanolaemus* (0.41-0.51, median 0.453, n=11); the difference between the two arrays is statistically significant (P<0.02; Mann-Whitney test). Also *S. kinabaluensis* has fewer scale rows and lower average number of lamellae under the digits (Table 3). *Sphenomorphus cyanolaemus* lacks black spotting under the throat and chin.

DISTRIBUTION OF SPHENOMORPHUS IN SABAH

Most of the species of *Sphenomorphus* that are known from Sabah have wide distributions within the forests of this state. Table 4 shows the extent of sympatry based on extensive sampling by staff of Sabah Parks and Field Museum, either jointly or separately, at 12 localities roughly distributed from the southwestern (4°52'N/115°38'E) and southeastern (4°37'N/117°54'E) to the northern (6°18'N/116°42'E) parts of Sabah. The same samples show almost complete segregation of the lowland and montane species (Table 5). Only *S. multisquamatus* among the lowland species was found above 850 m ASL. One northern Bornean species we did not see in the field was *S. tenuiculus* (Mocquard), which is probably a montane species. It was described by Mocquard (1890) from "Kinabalu" without specific locality or elevation, but we have examined one specimen (FMNH

Table 3. Comparison of meristic characters in *Sphenomorphus kinabaluensis* and *S. cyanolaemus*.

	Scale rows									
	33	34	35	36	37	38	39	40	>40	
Number of individuals										
<i>kinabaluensis</i>	6	15	5	5	1					
Number of individuals										
<i>cyanolaemus</i>			1	2	1	3	1	5	4	
Lamellae of fourth finger										
	10	11	12	13	14		15	16	17	Lamellae of fourth toe
<i>kinabaluensis</i>	5	5	6	3	1		6	7	8	19
<i>cyanolaemus</i>	1	2	10	2			4	4	4	20
										>20

Table 4. Geographic distribution of species of *Sphenomorphus* at selected localities (see text) in Sabah, Malaysia. Coordinates given at end of table.

	Danum	Lumaku ¹	Maliau	Malutut ²	Marak	Parak	Mendolong ¹	Mesilau	Poring	Purulon ²	Sunsuron	Tawau Hills	Trus Madi
<i>aesculeticola</i>		+						+			+		+
<i>crassa</i>								+					
<i>cyanolaemus</i>			+	+			+		+	+			+
<i>hallieri</i>	+			+			+			+			+
<i>kinabaluensis</i>		+						+			+		
<i>maculicollus</i>								+					
<i>multisquamatus</i>	+	+				+		+		+			+
<i>sabanus</i>	+		+	+	+		+		+	+			+
<i>tanahtinggi</i>		+											+

Danum Valley Field Centre 5°12'N/117°50'E. Mt. Lumaku 4°52'N/115°38'E. Maliau Basin 4°50'N/116°33'E. Malutut 5°17'N/115°58'E. MarakParak 6°18'N/116°42'E. Mendolong 4°54'N/115°42'E. Mesilau 5°59'N/116°36'E. Poring 6°03'N/116°42'E. Purulon 5°13'N/115°57'E. Sunsuron 5°48'N/116°22'E. Tawau Hills 4°37'N/117°54'E. Trus Madi 5°33'N/116°31'E.

1 Localities separated by 13 km.

2 Localities separated by 8-10 km.

Table 5. Altitudinal distribution of species of *Sphenomorphus* in Sabah, Malaysia.

	Meters above sea level							
	50-250	251-450	451-650	651-850	851-1050	1051-1250	1251-1450	>1450
	Number of individuals							
<i>aesculeticola</i>						1	19	4
<i>crassa</i>					1			
<i>cyanolaemus</i>	7	15	10	5				
<i>hallieri</i>	2	18	16	10				
<i>kinabaluensis</i>						2	29	3
<i>maculicollus</i>			1	1				
<i>multisquamatus</i>	3	3	10	10	1			
<i>sabanus</i>	120	38	13	2				
<i>tanahtinggi</i>					1	2	1	

71857) from 1225 m on the slope of Mt. Kinabalu.

All the lizards we observed were in primary or secondary forests. They occupy a variety of microhabitats with weak indications of ecological segregation (Table 6). *Sphenomorphus multisquamatus* was the only species occurring frequently along banks of small hill streams, which accounts for the high proportion of individuals seen on rocks (Table 6). Only *S. multisquamatus* and *S. sabanus* were observed frequently on the surface. The majority of the *S.*

sabanus caught on tree trunks were <1 m above ground and only five were >2 m above ground. It is likely that many of these tree-trunk lizards were fleeing from our approach.

Many of the lizards were captured in forest floor quadrats or in buttress-enclosed areas at the base of trees, but the proportions varied among species. For example, whereas 78% of the *S. hallieri* sample was caught in quadrats and 9% in buttress areas, the corresponding proportions for *S. cyanolaemus* were 36% and 47% and for *S. sabanus* 24%

Table 6. Microhabitat distribution of species of *Sphenomorphus* in Sabah, Malaysia. Includes only specimens for which complete horizontal and vertical positions were recorded.

	Horizontal position			Vertical position							
	Riparian	Non-riparian	soil	Below surface of			soil	dead leaves	rocks	logs	On tree trunks
				dead leaves	rocks	logs					
<i>aesculeticola</i>		24	5	11	3	3	1			1	
<i>kinabaluensis</i>		32	3	11	2	13	1	1			1
<i>crassa</i>		1		1							
<i>cyanolaemus</i>	1	33	4	20	1	1		2		1	5
<i>hallieri</i>	1	44	14	17	2	7	2	1	1	1	
<i>maculicollus</i>	1	1		1							1
<i>multisquamatus</i>	17	9		5		1			16	2	2
<i>sabanus</i>	1	154	3	46	2	23	6	18	3	4	50
<i>tanahtinggi</i>		4	1				1				

and 46%, respectively. A total of 77 forest floor quadrats at six of the lowland sampling sites contained lizards of four species of this genus (*cyanolaemus*, *hallieri*, *multisquamatus*, *sabanus*). Yet despite the wide interspecific overlap in use of microhabitat types (Table 6), none of these quadrats had more than one species of *Sphenomorphus*. Similarly, at these lowland sites, none of the 78 buttress areas that contained *Sphenomorphus* held more than one species. The two montane species, *S. aesculeticola* and *S. kinabaluensis*, were found in 18 quadrats at Mt. Lumaku. Both species occurred in three of those quadrats.

The general conclusion derived from these observations is that species of *Sphenomorphus* are widely sympatric in Sabah, but show partial segregation on the basis of elevation. Although they show broad overlap in the use of forest floor microhabitats, they avoid true co-occurrence (i.e., syntopy) through means not yet understood.

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