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HERPETOFAUNAL RECORDS FROM FRASER'S HILL, PENINSULAR MALAYSIA, WITH LARVAL DESCRIPTIONS OF *LIMNONECTES NITIDUS* AND *THELODERMA ASPERUM* (AMPHIBIA: RANIDAE AND RHACOPHORIDAE)

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***ABSTRACT.* –** A list of amphibian and reptile species is compiled for Fraser's Hill, Peninsular Malaysia, including 43 species of reptiles (two turtles, 20 lizards, 21 snakes) and 22 species of amphibians (one caecilian, 21 frogs). Reported for the first time from this locality are 19 species (three frogs, seven lizards, nine snakes), including the frogs: *Leptolalax* sp., *Limnonectes nitidus*, *Theloderma asperum*; the lizards: *Gekko monarchus*, *Hemiphyllodactylus harterti*, *Lipinia vittigera vittigera*, *Mabuya multifasciata*, *Sphenomorphus praesignis*, *Sphenomorphus stellatus*, *Varanus salvator salvator*; and the snakes: *Amphiesma inas*, *Elaphe prasina*, *Elaphe taeniura ridleyi*, *Gongylosoma baliodeira baliodeira*, *Lycodon butleri*, *Oligodon purpurascens*, *Sibynophis collaris*, *Maticora intestinalis lineata*, *Xenopeltis unicolor*. The diagnostic larvae of *Limnonectes nitidus* (Smedley) (Ranidae) and *Theloderma asperum* (Boulenger) (Rhacophoridae) are described for the first time, and comparisons made with the known larval forms of closely related species.

***KEY WORDS.* –** Herpetofauna, Peninsular Malaysia, Fraser's Hill, montane, tadpole, anuran larva, *Theloderma asperum*, *Limnonectes nitidus*.

INTRODUCTION

Fraser's Hill, or Bukit Fraser (3°43'N, 101°45'E) is located along the Main Range of Peninsular Malaysia, and is bisected by the border that separates Pahang and Selangor States. The area consists of a series of ridges with a shallow valley, at a mean altitude of approximately 1,200 metres. It begins at The Gap (formerly Semangko Pass) at 820 metres, rises to the highest point of 1,500 metres at the Telecoms Tower (bounded by the Telecoms Loop road, ca. 1,400 metres), and descends to about 945 metres at Jeriau Waterfalls. Fraser's Hill is covered in tropical rainforest, largely of the lower montane variety that is dominated by trees of the families Fagaceae and Lauraceae. This montane locale was named after British adventurer, James Louis Fraser, who apparently vanished in the early 1900's, not to be heard of again.

Examples of amphibians and reptiles from Fraser's Hill were first reported in 1922 by Smith, along with those from other montane locations in the state of Pahang. Subsequently, records of the area's herpetofauna have appeared sporadically in various publications. The present paper appears to be the first compilation of the herpetofaunal diversity of Fraser's Hill.

Fraser's Hill is the type locality for the lizards, *Gonatodes flavolineatus* (Nicholls, 1949) and *Lygosoma miodactylum* (Boulenger, 1903), both described from The Gap; and the snakes, *Keiometopon booliati* (Taylor, 1962a) and *Calamaria fraseri* (Taylor, 1962a). Both lizard species are still valid, having been transferred to the genera *Cnemaspis* and *Larutia*, respectively. The snakes, however, have been synonymised with *Calamaria schlegeli* and *Calamaria lovii gimletti* respectively (see Inger & Marx, 1965).

The present checklist is the first such compilation for Fraser's Hill, comprising 43 species of reptiles (two turtles, 20 lizards, 21 snakes) and 22 species of amphibians (one caecilian, 21 frogs). As Fraser's Hill is known to be inhabited by fauna of the mountains, as well as the foothills, many more species are to be expected if concerted efforts are made to document the reptiles and amphibians there.

In the present checklist, 19 species (three frogs, seven lizards, and eight snakes) are reported from Fraser's Hill for the first time. These include the frogs: *Leptolalax* sp., *Limnonectes nitidus*, *Theloderma asperum*; the lizards: *Gekko monarchus*, *Hemiphyllodactylus harterti*, *Lipinia vittigera vittigera*, *Mabuya multifasciata*, *Sphenomorphus praesignis*,

Sphenomorphus stellatus, *Varanus salvator salvator*; and the snakes: *Amphiesma inas*, *Elaphe prasina*, *Elaphe taeniura ridleyi*, *Gongylosoma baliodeira baliodeira*, *Lycodon butleri*, *Oligodon purpurascens*, *Sibynophis collaris*, *Maticora intestinalis lineata*, *Xenopeltis unicolor*. Many of the above records are based on specimens deposited at the Raffles Museum of Biodiversity Research of The National University of Singapore. These include a collection of snakes made by a health officer, Cho Nyit Tew, and presented to the museum in September 1952. Even earlier collections were made by R. Hanitsch in 1907; C. S. Nava Ratnam in 1928; E. O. Shebbeare in 1928 and 1947; and G. H. Sworder in 1933.

The diagnostic larvae of two anurans, *Theloderma asperum* (Boulenger, 1886) (F. Rhacophoridae) and *Limnonectes nitidus* (Smedley, 1931) (F. Ranidae) are described for the first time, and comparisons made with the known larval forms of closely related species.

MATERIALS AND METHODS

Specimens deposited in various institutions were examined. These institutions included the Zoological Reference Collection of the Raffles Museum of Biodiversity Research of the National University of Singapore (ZRC), the Department of Wildlife and National Parks, Peninsular Malaysia (DWNP), the University of Malaya (UM) and the Natural History Museum, London (BMNH). Nomenclature follows Iskandar & Colijn (2000) for amphibians, Iskandar & Colijn (2001) for snakes, Denzer & Manthey (1991) for lizards, and Manthey & Grossmann (1997) for turtles. Where obtainable from either literature or specimen labels/catalog records, the precise localities and elevation (in metres asl) are included.

Diagnostic developmental series for both *Theloderma asperum* (Boulenger) and *Limnonectes nitidus* (Smedley) were obtained during a brief field trip to Fraser's Hill in February 2002. The tadpoles were collected and preserved in a premix 1:1 solution of 10% formaldehyde with 70% alcohol. Voucher specimens of adults were also collected from the immediate vicinity of the larvae. Larval and adult specimens were deposited at ZRC; while representative adult vouchers were also deposited at the amphibian collection of the DWNP. Staging of larvae is in accordance with Gosner (1960). Snout-vent lengths (SVL) of adults, and morphometric measurements of larvae were taken using slide verniers (to 0.1 mm). Larval measurements include BL (Body Length: measured from snout tip to body-tail junction), TAL (Tail Length: from body-tail junction to tail tip), TL (Total Length: from snout tip to tail tip), MTH (Maximum Tail Height: greatest distance between dorsal and ventral fin margins), IOD (Inter-Orbital Distance: between centres of the pupils), IND (Inter-Narial Distance: between centers of narial apertures); abbreviations and definitions follow Altig & McDiarmid (1999). In addition, BW (Body Width: widest part of body) and BH (Body Height: measured at mid-body) were also taken. Description of oral apparatus also follows Altig & McDiarmid (1999), with standard denotions for specific labial tooth rows (eg. A-1 and P-1 refers to the first labial tooth row of the anterior and posterior labia respectively). Labial tooth row formula (LTRF) is in accordance with Altig (1970).

SYSTEMATIC LIST

CLASS AMPHIBIA

ORDER GYMNOPHIONA

FAMILY ICHTHYOPHIIDAE

Ichthyophis sp.

Ichthyophis glutinosus – Berry, 1975: 31 (Genting Semangkok Gap).

Material examined. – ZRC.1.1-2 (2), Jeriau, 10 Jul.1935; ZRC.1.3-4 (2), The Gap: Bukit Telaga at 1,060m, not dated.

ORDER ANURA

FAMILY BUFONIDAE

Ansonia penangensis (Stoliczka)

Bufo penangensis – Smith, 1922: 282.

Material examined. – None.

Bufo asper Gravenhorst

Bufo asper – Butler, 1904: 397 (Semangko Pass); Boulenger, 1912: 272 (Semangkok Pass); Lim & Subharaj, 1991: 7 (High Pines).

Material examined. – ZRC.1.9319 (1), Telecoms Loop, 23 Feb.2002.

FAMILY MEGOPHRYIDAE

Leptolalax sp.

Material examined. – ZRC.1.1828-1831 (4 larvae), stream at The Gap, 1 Jun.1990.

Remarks. – As the larval stages of *Leptolalax* species in the Malay Peninsula have not been studied and described in detail, we are unable to determine the exact identity of the present specimens.

Megophrys longipes Boulenger

Megalophrys longipes – Smith, 1922: 282.
Megophrys longipes – Smith, 1930: 132; Berry, 1975: 39; Leong & Chou, 1998: 472, figs. 1-3; Chan-ard et al., 1999: 62 (at 1,100m).
Megophrys monticola monticola – Berry, 1975: 40.

***Material examined.* –** ZRC.1.3458 (15 larvae), ZRC.1.3459 (1 larvae), ZRC.1.3460 (2), stream along Bishop's Trail, 11 Dec.1996; ZRC.1.9354 (1 larva), stream about 1 km from The Gap, 24 Feb.2002; ZRC.1.9260 (1 larva), stream at The Gap, 22 Feb.2002.

***Remarks.* –** Berry's (1975: 40) record of *Megophrys monticola monticola* from Fraser's Hill may refer to *Megophrys longipes*.

Megophrys nasuta (Schlegel)

Megophrys monticola nasuta – Yong, 1974: 56 (Water Falls – probably Jeriau Falls); Berry, 1975: 41; Yong, 1976: 37 (water falls).

***Material examined.* –** None.

FAMILY MICROHYLIDAE

Metaphrynella pollicaris (Boulenger)

Metaphrynella pollicaris – Berry, 1975: 117 (at 1,210m); Manthey & Grossmann, 1997: 58, Abb. 24.

***Material examined.* –** ZRC.1.1779 (1), on leaves of ornamental plant, 30 Dec.1989; ZRC.1.3453 (1), from tree hole 1.5 m above ground, beside stream along Bishop's trail, 11 Dec.1996; ZRC.1.8040-8041 (2), May.2001.

Microhyla butleri Boulenger

Microhyla butleri – Smith, 1922: 281; Parker, 1934: 132.

***Material examined.* –** None.

FAMILY RANIDAE

Amolops larutensis (Boulenger)

Rana larutensis – Smith, 1922: 277.

***Material examined.* –** None.

Limnonectes blythii (Boulenger)

Rana macrodon var. *blythii* – Smith, 1922: 272.
Rana macrodon (non- Duméril & Bibron) – Berry, 1975: 79.
Limnonectes blythii – Chan-ard et al., 1999: 65.

***Material examined.* –** ZRC.1.3452 (1 larva), roadside drain, 12 Dec.1996; ZRC.1.9261-9280 (20 larvae), stream at The Gap, 22 Feb.2002; ZRC.1.9310-9311 (2 larvae), seepage area about 1 km uphill from Jeriau, 23-24 Feb.2002; ZRC.1.9355 (1 juvenile), seepage area about 1 km uphill from Jeriau, 24 Feb.2002.

Limnonectes doriae (Boulenger)

Rana doriae – Berry, 1975: 66.

***Material examined.* –** None.

Limnonectes laticeps (Boulenger)

Rana laticeps – Smith, 1922: 271; Smith, 1930: 98; Berry, 1975: 73.

***Material examined.* –** ZRC.1.3454 (5), Bishop's Trail, 11 Dec.1996.

Limnonectes nitidus (Smedley)
(Figs. 1-3)

***Material examined.* –** ZRC.1.9281-9309 (29 larvae), seepage area about 1 km uphill from Jeriau, 23-24 Feb 2002; DWNP.A.1186 (1), ZRC.1.9356-9361 (6), seepage area about 1 km uphill from Jeriau, 24 Feb.2002.

***Remarks.* –** See larval description below.

Limnonectes plicatellus (Stoliczka)

Rana plicatella – Smith, 1922: 272; Smith, 1930: 100.

***Material examined.* –** None.

Rana hosii Boulenger

Rana cataracta Smith, 1922: 275.
Rana hosii – Smith, 1930: 110; Berry, 1975: 70; Manthey & Grossmann, 1997: 111; Chan-ard et al., 1999: 76.

***Material examined.* –** None.

Rana luctuosa (Peters)

Rana luctuosa – Smith, 1922: 273; Smith, 1930: 103.

***Material examined.* –** ZRC.1.9312-9315 (4 larvae), seepage area about 1 km uphill from Jeriau, 23-24 Feb.2002.

Rana sp.

Rana glandulosa (non- Boulenger) – Smith, 1922: 272; Smith, 1930: 102; Berry, 1975: 68.
Rana signata (non- Günther) – Berry, 1975: 87.

***Material examined.* –** ZRC.1.3455 (2), Bishop's Trail, 11 Dec.1996; ZRC.1.1108-1110 (3 larvae), Jeriau Falls, 10 July.1935; ZRC.1.1834-1835 (2 larvae), The Gap, 1 Jun.1990.

***Remarks.* –** Upon further investigation, this *Rana* was found to be a new species. A formal description of both adults and its diagnostic tadpole has been prepared (Leong & Lim, 2003). It is also known from other montane localities within the Malay Peninsula, including Cameron Highlands (proposed type locality), Maxwell's Hill (Perak), Gunong Bunga Buah (Selangor) and Hala-Bala Wildlife Sanctuary (southernmost Thailand, bordering Peninsular Malaysia).

FAMILY RHACOPHORIDAE

***Philautus vermiculatus* (Boulenger)**

Philautus vermiculatus – Berry, 1975: 96.

***Material examined.* –** None.

***Polypedates leucomystax* (Boie)**

Rhacophorus leucomystax – Smith, 1922: 278.

***Material examined.* –** ZRC.1.8042 (1), May.2001; DWNP.A.1184 (1), ZRC.1.9368-9371 (4 larvae), Telecoms Loop, 23 Feb.2002.

***Rhacophorus bipunctatus* Ahl**

Rhacophorus bimaculatus (non- Boulenger) – Smith, 192 ': 278; Smith, 1930: 114; Berry, 1975: 99.
Rhacophorus reinwardtii bipunctatus – Wolf, 1936: 214.
Rhacophorus bipunctatus – Manthey & Grossmann, 1997: 133; Chan-ard et al., 1999: 84 (at 1,000m).

***Material examined.* –** ZRC.1.3272 (1), at 1,200 m, roadkill along Valley Road, Nov.1995.

***Rhacophorus prominanus* Smith**

Rhacophorus promianus – Berry, 1975: 107 (Sri Bakat).
Rhacophorus prominanus – Manthey & Grossmann, 1997: 135, Abb. 90; Chan-ard et al., 1999: 85 (at 1,100m).

***Material examined.* –** ZRC.1.3273 (1), at 1,200 m, roadkill along Lady Maxwell Road Nov.1995; ZRC.1.3456 (33 emergents), from roadside puddle, 11 Dec.1996; ZRC.1.3461 (6 larvae), from roadside drain, 11 Dec.1996; ZRC.1.3462 (20 larvae), from roadside puddle, 11 Dec.1996; ZRC.1.3463 (10 larvae), from roadside puddle, 11 Dec.1996; ZRC.1.3661-3664 (4), from roadside puddle near Singapore House, 6 Nov.1999; ZRC.1.9316-9318 (3 larvae), seepage area at about 1 km uphill from Jeriau, 23-24 Feb.2002.

***Remarks.* –** The species name is originally spelt '*prominanus*' (see Smith, 1924: 185).

***Theloderma asperum* (Boulenger)**
(Figs. 4-7)

***Material examined.* –** ZRC.1.8043 (1), May.2001; DWNP.A.1185 (1), ZRC.1.9320-9321 (2 females), ZRC.1.9372-9373 (2 embryos), ZRC.1.9374-9375 (2 embryos), ZRC.1.9376-9389 (14 larvae), ZRC.1.9390 (1 emergent), Telecoms Loop, 23 Feb.2002.

***Remarks.* –** See larval description below.

LARVAL DESCRIPTIONS

***Limnonectes nitidus* (Smedley)**
(Figs. 2, 3)

***Distribution.* –** Endemic to the highlands of Peninsular Malaysia. Fraser's Hill is the second montane locality where the species has been recorded. Type locality: Peninsular Malaysia; Pahang, Cameron Highlands, Tanah Rata, elevation ca. 1,300m asl.

***Microhabitat.* –** The larvae were found in a flat, water-logged seepage area behind a concrete embankment at edge of montane forest just adjacent to a bend in the road leading towards the Jeriau waterfalls. The elevation at this site was ca. 1,000m asl. The entire seepage area (ca. 5 x 1m) consisted of shallow (ca. 5cm depth) pools with dense leaf litter/humus substrate. Voucher specimens of adult and sub-adult *L. nitidus* were collected from this same locality (DWNP.A.1186, ZRC.1.9356-9361, Fig. 1). Apart from *L. nitidus*, other anuran larvae encountered at this microhabitat included *L. blythii* (ZRC.1.9310-9311), *Rana luctuosa* (ZRC.1.9312-9315) and *Rhacophorus prominanus* (ZRC.1.9316-9318). The calls of *Polypedates leucomystax* and a *Microhyla* (possibly *M. annectens*) were also heard in the area.

***Diagnosis.* –** A benthic larva which inhabits the lentic microhabitat of clear, shallow forest pools or puddles. A dorso-lateral pair of symmetrical, black patches at the anterior-most portion of tail muscle (body-tail junction) clearly visible from dorsal perspective. Body lightly speckled with fine pigments, whereas tail randomly interspersed with light dustings and concentrated patches. LTRF 2(2)/3(1); P-1 divided, each half with lateral extremities arched on both ends, P-2 undivided but arranged in a symmetrical sinusoidal curve, P-3 shortest and assuming a crescent-shaped arch.

***Morphology.* –** (Fig. 2) Body ovoid, snout tip rounded, BW 0.49-0.61 of BL; slightly depressed, BH 0.62-0.74 of BW; maximum width around mid-body; eyes dorsal, directed laterally, not visible from below, IOD 0.40-0.49 of BW, 1.53-1.93 of oral disc width; nostrils dorsal, open, midway between eye and snout tip; IND 0.35-0.52 of IOD; spiracle sinistral, located on lateral surface, continuous with body wall, spiracular opening directed posterio-dorsally, snout-spiracle 0.40-0.45 of BL; anal tube dextral, continuous with ventral fin. Tail lanceolate; dorsal margin slightly convex, gradually tapering towards a narrow, rounded tip; ventral fin with straight margin, curving only at posterior _ of tail towards tail tip. TAL 1.50-1.99 of BL, MTH 0.21-0.22 of TAL; caudal muscle deeper than both fins for proximal 2/3 of tail. Dorsal fin originating a little after body-tail junction, forming a gentle gradient towards mid-tail convex, dorsal fin deeper than ventral at mid-tail only. Lateral line pores observable only in the earlier (Stages 25-27) larvae. No observable sub-dermal glands.

***Colour and markings.* –** (In life) Dorsum and sides light olive, rather translucent. Tail muscle olive, fins translucent.

Body lightly speckled with melanophores, without concentrated blotches. Tail with heterogeneous arrangement of fine specklings and larger blotches. Venters, including anal tube and ventral margin of tail, unpigmented. Ventral fin without pigment for proximal 2/3 to 3/4 of tail length. Two dark patches located dorsally at body-tail junction. Pigmentation on snout tip extending onto anterior labium.

Oral disc morphology. **–** (Fig. 3) Mouth ventral, subterminal, width 0.25-0.31 of BW, single row of marginal papillae on anterior labium confined to lateral portions only; lower labium with continuous row of short, conical papillae along margin, with an extra infra-marginal row towards the centre. Jaw sheaths finely serrated, upper jaw sheath with gentle median convexity, both upper and lower jaw sheaths heavily pigmented black. LTRF: 2(2)/3(1); A-1 continuous, A-2 broadly divided by upper jaw sheath, each half confined to lateral portions, 1/5th width of first row. P-1 narrowly divided, with the lateral extremities arched upwards; P-2 undivided, but arranged in the form of a symmetrical, sinusoidal curve; P-3 undivided as well, shortest (less than 1/2 width of second row), and arched to resemble a partial crescent. Individual labial teeth of anterior and posterior labia uniform in shape and length.

Developmental changes. **–** Although recent metamorphs were not encountered at the microhabitat site, the most advanced larva (Stage 40) already developed well formed hind limbs, which demonstrated diagnostic characters of adult *L. nitidus*. These include slightly expanded, bulbous toe tips and incompletely webbed hind feet (fourth toe with two phalanges free of webbing). The developmental series was measured and reported in Table 1.

Interspecific comparisons. **–** In Peninsular Malaysia, there is one species of *Limnonectes* [*L. tweediei* (Smith, 1935)], which had been previously considered a junior synonym of *L. nitidus*, according to Kiew (1974). Both species have subsequently been regarded as valid names each, with the diagnostic larval form of *L. tweediei* having been recently described (Leong & Yaakob, 2002). The finding of larval *L. nitidus*, along with determination of its diagnostic characters, reinforces the fact that both are indeed distinct species. The larvae of both species, while sharing basic characters, may be distinguished from each other by consistent differences in their (a) pigmentation patterns, and (b) LTRF. In larval *L. tweediei*, a distinct single dark patch is present at the body tail junction, whereas in *L. nitidus*, this marking at the same region consists of two separate patches not meeting in the middle. In *L. tweediei*, there is a uniform pattern of evenly distributed dark patches along the dorsal margin of its tail muscle, whereas in *L. nitidus*, such dark patches are randomly arranged throughout the tail. In *L. tweediei*, the LTRF is 2(2)/2(1); whereas in *L. nitidus*, it is 2(2)/3(1), exhibiting an additional row of labial teeth in the posterior labium.

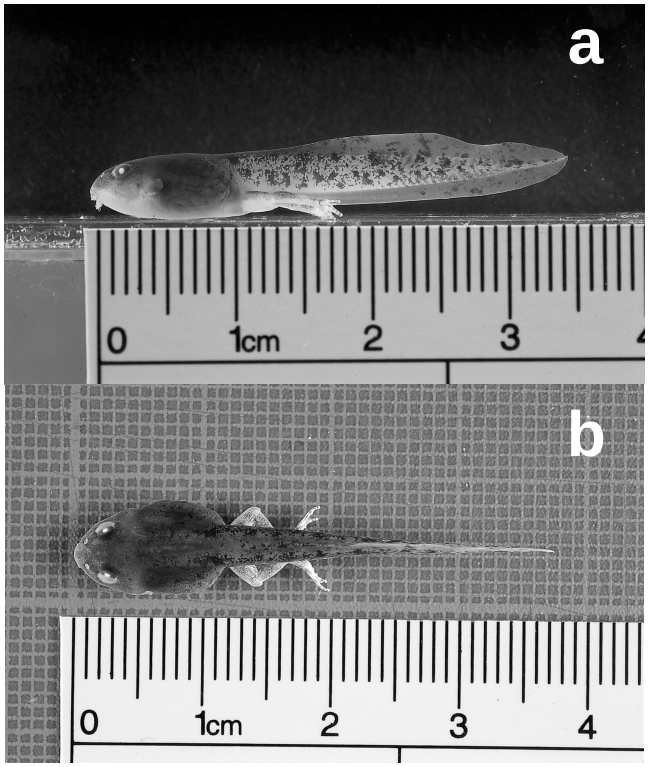

Fig. 2. Lateral (a) and dorsal (b) aspects of Stage 40 larval *Limnonectes nitidus*.

Fig. 1. Adult male *Limnonectes nitidus* (ZRC.1.9356, SVL 40.7mm).

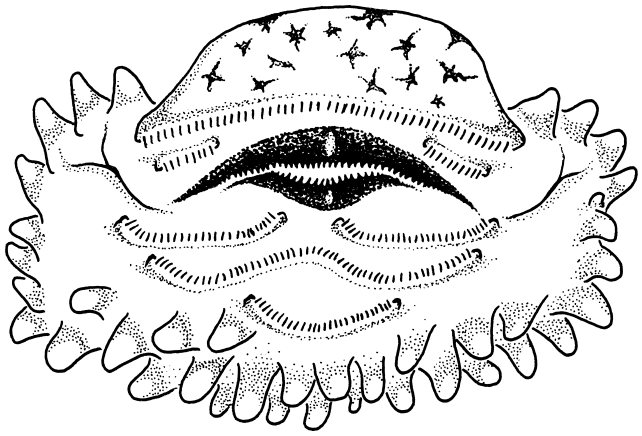

Fig. 3. Oral disc of larval *Limnonectes nitidus* (Stage 27).

Table 1. Developmental changes in BL (body length) and TL (total length) of larval *Limnonectes nitidus* (ZRC.1.9281-9309; n = 29, Stages 25-40).

Gosner Stage	No.	BL (mm)	TL (mm)
25	2	4.8-5.0	18.2-18.3
26	6	6.3-7.8	18.2-24.5
27	7	7.8-9.0	20.6-24.7
28	3	9.2-9.8	24.5-27.0
29	3	9.7-10.0	26.6-29.0
30	4	9.4-9.8	24.1-27.5
31	1	9.9	25.5
37	1	10.5	28.1
39	1	10.8	31.5
40	1	12.7	36.5

***Theloderma asperum* (Boulenger)**
(Figs. 5-7)

***Distribution.* –** NE. India (Arunachal Pradesh), S. China, Myanmar, Vietnam, W. and N. Thailand, Peninsular Malaysia, Sumatra (Dutta, 1997; Iskandar & Colijn, 2000; Taylor, 1962b). In Peninsular Malaysia, previously recorded from Bukit Itam and Bukit Belachan, Selangor (Berry, 1975). Type locality: Peninsular Malaysia; Perak, Maxwell's Hill (Bukit Larut), elevation ca. 1, 000 m asl.

***Microhabitat.* –** Although it may be safely presumed that members within this genus are generally phytothelm breeders (Taylor, 1962b), tadpoles of *T. asperum* were found in an artificial water container. Adults (DWNP.A.1185, ZRC.1.9321, Fig. 4), embryos (ZRC.1.9372-9375), and larvae (ZRC.1.9376-9390) were found within a large (1m x 1m x 1m), black, plastic drum used for collection of rainwater runoff. This covered drum was within private residence along the Telecom's Loop (ca. 1, 400 m asl), adjacent to montane forest. The commensal rhacophorid, *Polypedates leucomystax*, was also sharing this artificial breeding site. Adults (DWNP.A.1184, ZRC.1.8042) and larvae (ZRC.1.9368-9371) of *P. leucomystax* were collected as vouchers. The embryos of *T. asperum* were found attached in pairs ca. 2-3cm above the water surface, via a clear, viscous gelatin. The earliest embryos (ZRC.1.9372-9373, Stage 20) were still bound within their transparent egg membranes (diameter 8.0mm), while a more advanced pair (ZRC.1.9374-9375, Stage 21) was wriggling inside a slightly larger egg membrane (diameter 9.3mm). The gelatinous remains of previously hatched ova were observed along the inner rim of this container as well. There were no signs of any foam nest formations. Larval *T. asperum* were predominantly swimming around the bottom of the container, occasionally surfacing cautiously for gulps of air, then rapidly diving down again.

***Diagnosis.* –** A benthic larval form, with distinctly depressed body; eyes and nostrils set dorsally; oral disc subterminal; LTRF 3(2-3)/3(1); upper jaw sheath without median convexity; spiracle sinistral, ventrolateral, not projecting as a free tube; anal tube median; tail musculature strong; body and tail dark ashy grey.

***Morphology.* –** (Figs. 5, 6) Body ovoid, snout broadly rounded, BW 0.70-0.84 of BL; clearly depressed, BH 0.64-0.80 of BW, maximum width at mid-body; eyes dorsal, directed dorso-laterally, not visible from below, IOD 0.32-0.37 of BW, 0.91-1.22 of oral disc width; nostrils dorsal, nearer to snout tip than eye; IND 0.47-0.66 of IOD; spiracle sinistral, ventro-lateral position, not extended as a tube, spiracular opening a vertical, oval slit, snout-spiracle 0.62-0.83 of BL; anal tube median, tapering towards the tip, continuous with ventral fin, projecting slightly beyond ventral fin margin. Tail elongate, dorsal and ventral fin margins sub-parallel, tapering only towards the end to a broadly rounded tip; TAL 1.32-1.79 of BL, MTH 0.26-0.43 of TAL; caudal muscle deeper than both fins for proximal _ of tail; dorsal fin originating at body-tail junction, depth comparable with ventral fin. Fine rows of lateral line pores visible dorsally under microscope.

***Colour and markings.* –** (In life) Dorsum and sides of body dark ashy grey, tail muscle and fins uniformly pigmented ashy grey, venters unpigmented around abdominal region. Anal tube unpigmented. In preservative, the intensity of the grey colouration is slightly reduced.

***Oral disc morphology.* –** (Fig. 7) Mouth antero-ventral, subterminal, width 0.30-0.37 of BW, marginal papillae of anterior labium confined to lateral corners, consisting of 1-2 rows of short, rounded papillae; lower labium with continuous margin of 1-2 rows of similarly shaped papillae. Jaw sheaths finely serrated in early stages, but margins increasingly worn smooth in more advanced (Stage 35 onwards) larvae; upper jaw sheath without median convexity; both jaw sheaths partially pigmented black. LTRF: 3(2-3)/3(1); A-1 continuous and gently arched, A-2 and A-3 broadly divided by upper jaw sheath, A-3 shorter than A-2. P-1 narrowly divided in the middle, P-1 to P-3 almost parallel and of similar lengths (0.75 width of oral disc).

***Developmental changes.* –** A recently hatched larva (ZRC.1.9376, Stage 23) still possessed a pair of cement glands immediately posterior to the oral disc, yet operculum development was already complete. An advanced two-limbed larva (Stage 41) collected from the container had already exhibited dark barrings on its well developed hind

Table 2. Developmental changes in BL (body length) and TL (total length) of larval *Theloderma asperum* (ZRC.1.9376-9390; n = 15, Stages 23-43).

Gosner Stage	No.	BL (mm)	TL (mm)
23	1	4.1	12.7
25	7	5.8-7.8	15.5-20.1
27	1	10.5	25.6
28	1	13.2	33.0
29	1	15.3	37.4
31	1	15.6	40.0
33	1	15.5	36.0
35	1	16.8	45.0
43	1	19.3	25.5

limbs. The dark inter-orbital bar and mid-scapular patch was already noticeable. The tuberculated texture of the back and hind-limbs were also visible at this stage. Both dorsal and ventral fins had begun resorption, accompanied by a lightening of the tail muscle to a buff, cream colour. After four days, the fore-limbs eventually erupted, exhibiting characteristic dark bands on the fore-arms and fingers. Fingers with very rudimentary webbing, as in the adults. Tuberculation on fore-limbs distinct, as in the hind limbs. After live photographs were taken, it was preserved at Stage 43 (Fig. 6). Upon complete tail resorption, the individual (ZRC.1.9390) would have an SVL of 19.3mm. Measurements of BL and TL of the developmental series are reflected in Table 2.

***Interspecific comparisons.* –** Within the genus *Theloderma* Tschudi, nine species are currently recognised (Iskandar & Colijn, 2000), of which three already have detailed tadpole descriptions. The larval identity of *T. horridum* (Boulenger, 1903) was revealed together with the first description of the adults, and clearly illustrated with excellent lithographs (Boulenger, 1903: Pl. VI, Fig. 2a, b). The second species whose larvae have been well described is *T. stellatum* Taylor, 1962b. Its tadpole was first described from Thailand by Wassersug et al. (1981) and even included detailed characteristics of the buccal area. Larval specimens of the same species from Vietnam were also briefly described subsequently (Inger et al., 1999). The third species, *T. molloch* (Annandale, 1912) was also described and illustrated with remarkable detail (Annandale, 1912: Pl. IV, Fig. 6). One other species, *T. corticale* (Boulenger, 1903), has been successfully bred and raised in captivity (Orlov & Rybaltovsky, 1999), but unfortunately, no detailed larval descriptions were provided.

Larvae of *T. asperum* may be distinguished from those of *T. horridum*, *T. molloch* and *T. stellatum* by examining their LTRF, which is 3(2-3)/3(1), instead of 4(2-4)/3 (Boulenger, 1903; Annandale, 1912) for *T. horridum* and *T. molloch*, or 4(2-4)/3(1) (Wassersug et al., 1981), 4(2-4)/3 (Inger et al., 1999) for *T. stellatum*. In addition, the upper jaw sheath of *T. asperum* lacks a median convexity, which is present in *T. horridum*, *T. molloch* and *T. stellatum*. In terms of colouration, *T. horridum* is a uniform dark brown or blackish (Boulenger, 1903); *T. molloch* is uniformly black or dark grey; *T. stellatum* can be dark brown (Wassersug et al., 1981) or black (Inger et al., 1999), whereas *T. asperum* tends

Fig. 4. Adult female *Theloderma asperum* (ZRC.1.9321, SVL 33.1mm).

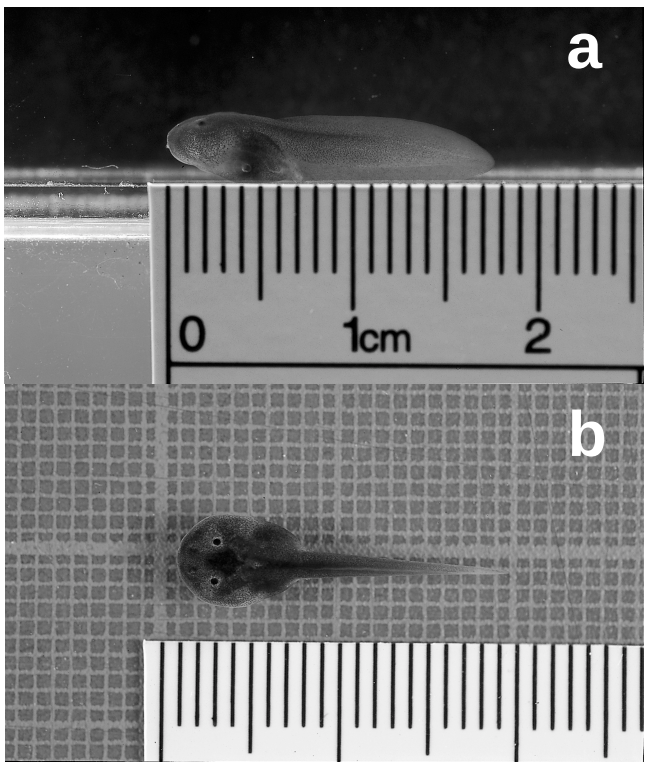

Fig. 5. Lateral (a) and dorsal (b) aspects of early (Stage 25) larval *Theloderma asperum*.

towards an ashy grey. All known larval forms, however, share the common characters of a distinctly flattened body, with dorsally positioned eyes and nostrils. It is interesting to note that although the anal tube of *T. asperum*, *T. molloch* and *T. stellatum* are consistently median in position, that of *T. horridum* was reported to be dextral ('anus towards the right', Boulenger, 1903). This seems to be a departure from the apparently predominant median position and may either have been an (a) artefact of the preservation process, or (b) observational error.

There is also another inconsistency in the reproduction mode of *T. horridum*, which was reported to deposit ova in foam nests (Boulenger, 1903), while in *T. corticale*, the ova were merely attached onto plants with the help of their viscous, sticky membranes (Orlov & Rybaltovsky, 1999). Taylor (1962b) found the eggs of *T. stellatum* in 'two masses attached to the trunk of a forest tree, about two feet from the ground, some five inches directly above a small hole in the trunk containing a quantity of black-brown water, coloured by rotting wood and leaves'. However, there were no indications as to whether the egg 'masses' were in the form of a foam nest or clear gelatin. Egg deposition in *T. asperum* appears to be similar to that in *T. corticale*, without any construction of a foam nest.

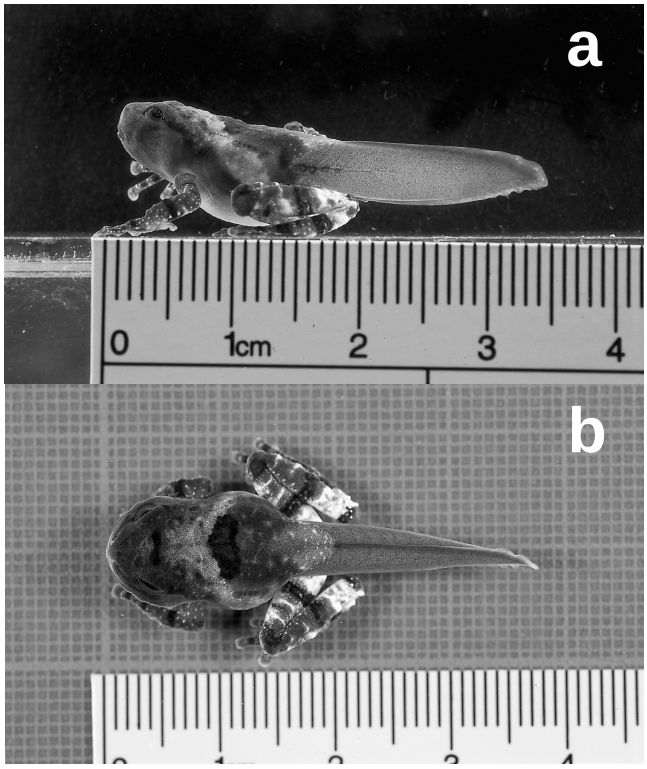

Fig. 6. Lateral (a) and dorsal (b) aspects of late (Stage 43) larval *Theloderma asperum*.

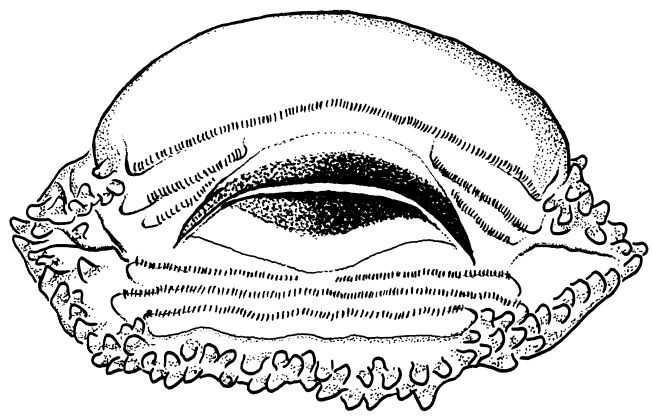

Fig. 7. Oral disc of larval *Theloderma asperum* (Stage 35).

CLASS REPTILIA

ORDER CHELONII

FAMILY TESTUDINIDAE

Manouria emys emys (Schlegel & Müller)

Testudo emys – Hanitsch, 1908: 38 (below "Gap" Resthouse)

***Material examined.* –** ZRC.2.44 (1), The Gap, coll: R. Hanitsch, 1907.

Manouria impressa (Günther)
(Fig. 8)

Testudo impressa – Smith, 1922: 264.
Manouria impressa – Lim & Das, 1999: 112; Sharma & Tisen, 2000: 128.

***Material examined.* –** None.

***Observation.* –** One photographed (Fig. 8) along Bishop's Trail at about 900 m between April and May 1994 (D. Wee & A. T. C. Wong). *Manouria impressa* may be clearly distinguished from *M. emys* by comparisons of carapace scute characters. In *M. impressa*, the dark/black pigmentation is confined only to the anterior margins of each scute, whereas in *M. emys*, this dark pigmentation lines the entire margin of each scute. Furthermore, in *M. impressa*, the first to third (most anterior) vertebral scutes exhibit a fairly uniform 'rectangular' shape, whereas in *M. emys*, the first vertebral scute adopts a pentagonal shape, followed by the second and third which adopt a hexagonal shape (Lim & Das, 1999).

ORDER SQUAMATA

FAMILY GEKKONIDAE

Cnemaspis affinis (Stoliczka)

Gonatodes kendalli (non- Gray) – Smith, 1922: 268.
Gonatodes affinis – Smith, 1930: 16.

***Material examined.* –** None.

Cnemaspis flavolineatus (Nicholls)

Gonatodes flavolineatus Nicholls, 1949: 47 (The Gap at about 820m).
Cnemaspis flavolineatus – Manthey & Grossmann, 1997: 211 (The Gap).

***Material examined.* –** None.

Cyrtodactylus quadrivirgatus Taylor

Cyrtodactylus quadrivirgatus – Chan-ard et al., 1999: 115 (at 1,100m).

Material examined. – None.

Gehyra mutilata (Wiegmann)

Gehyra mutilata – Manthey & Grossmann, 1997: 230. Abb. 166; Chan-ard et al., 1999: 119.

***Material examined.* –** None.

***Observation.* –** One in a building at Buona Vista along the Telecoms Loop on 22 Feb.2002 (K. K. P. Lim).

Gekko monarchus (Duméril & Bibron)

***Material examined.* –** None.

***Observation.* –** One in a building at Buona Vista along the Telecoms Loop on 22 Feb.2002 (T. M. Leong & K. K. P. Lim).

Hemiphyllodactylus harterti F. Werner

***Material examined.* –** ZRC.2.4573 (1), at about 1,210m, from a lamp-post, 2 Jun.1990.

Ptychozoon kuhli Stejneger

Ptychozoon kuhli – Tweedie, 1954: 108 (The Gap at about 730m).

***Material examined.* –** None.

FAMILY AGAMIDAE

Draco blanfordii blanfordii Boulenger
(Fig. 9)

Draco cyanolaemus – Boulenger, 1912: 61 (hills above Semangko Pass at 1,060m).
Draco blanfordii – Hennig, 1936: 216 (Semangko Pass).

***Material examined.* –** None.

***Observation.* –** One of 205 mm total length and 108 mm snout-vent length (Fig. 9) found at night about three metres up a tree trunk at the town centre on 2 June 1990 (K. K. P. Lim & B. C. Ng).

Gonocephalus bellii (Duméril & Bibron)

Gonyocephalus borneensis (non- Schlegel) – Boulenger, 1903: 153 (Semangko Pass).
Gonocephalus borneensis (non- Schlegel) – Boulenger, 1912: 66 (Semangko Pass).
Gonocephalus bellii – Manthey & Denzer, 1992: 8.

***Material examined.* –** None.

FAMILY SCINCIDAE

Larutia miodactyla (Boulenger)

Lygosoma miodactylum Boulenger, 1903: 159, pl. x, fig. 3 (Semangko Pass at 820m); Boulenger, 1912: 98 (Semangko Pass at 820m); Tweedie, 1940: 84 (Semangko Pass); Berry, 1974: 31 (Semangko Pass).

***Material examined.* –** ZRC.2.1584 (1), at 1,210m, Aug.1933; BMNH.1946.8.5.56 (1), Semangko Pass at 820m, 1946.

Larutia trifasciata (Tweedie)

Lygosoma trifasciatum Tweedie, 1940: 83.
Larutia trifasciata – Manthey & Grossmann, 1997: 265.

***Material examined.* –** None.

Lipinia vittigera vittigera (Boulenger)

***Material examined.* –** ZRC.2.4622 (1), The Gap rest house, 23 Jul.1999.

Fig. 8. *Manouria impressa*, photographed by Desmond Wee along Bishop's Trail in April-May 1994.

***Mabuya multifasciata* (Kuhl)**

***Material examined.* –** ZRC.2.1680 (1), Jul.1921.

***Sphenomorphus butleri* (Boulenger)**

Lygosoma butleri – Smith, 1922: 270; Sly, 1976: 156.

***Material examined.* –** None.

***Remarks.* –** Sly (1976: 156) found a partially digested example from the stomach of a mock viper, *Psammodynastes pulverulentus*, at 1,210m on 23 May 1975.

***Sphenomorphus indicus* (Gray)**

Lygosoma indicum – Smith, 1922: 270; Smith, 1930: 34.
Sphenomorphus indicus – Manthey & Grossmann, 1997: 279.

***Material examined.* –** BMNH.1935.11.5.11-12 (2), Jun.1921.

***Sphenomorphus praesignis* (Boulenger)**

***Material examined.* –** BMNH.1946.8.15.53 (1), Semangko Pass at 820m, 1946; BMNH.1974.3857 (1), at 1,210m, Aug.1933.

***Sphenomorphus stellatus* (Boulenger)**

***Material examined.* –** UM (uncataloged) (1 sub-adult), at about 1,290m, 10 Oct.1972.

FAMILY VARANIDAE

***Varanus dumerilii* (Schlegel)**

Varanus dumerilii – Bennett & Lim, 1995: 113.

***Material examined.* –** None.

***Varanus rudicollis* (Gray)**

Varanus rudicollis – Bennett & Lim, 1995: 114

***Material examined.* –** None.

***Varanus salvator salvator* (Laurenti)**

***Material examined.* –** None.

***Observation.* –** An adult of about one metre total length below the rest house at The Gap on 25 Feb.2002 (T. M. Leong & K. K. P. Lim).

FAMILY COLUBRIDAE

***Amphiesma inas* (Laidlaw)**

***Material examined.* –** ZRC.2.4059 (1 juvenile), 1952.

***Calamaria lovii gimletti* Boulenger**

Calamaria fraseri Taylor, 1962a: 254, fig. 15 (at 1,150m); Lim, 1967: 124 (at 1,270m).
Calamaria lowi gimletti – Inger & Marx, 1965: 229 (*C. fraseri* made synonym).

***Material examined.* –** None.

***Remarks.* ––** According to Inger & Marx (1965: 227), the two snakes they had examined from Fraser's Hill differ from all other Malayan examples of *Calamaria gimletti* only in having lower ventral counts (161 and 164 versus 184-202).

***Calamaria lumbricoidea* Boie**

Calamaria vermiformis (non- Duméril, Bibron & Duméril) – Tweedie, 1950: 192; Tweedie, 1954: 110.
Calamaria lumbricoidea – Inger & Marx, 1965: 85.

***Material examined.* –** None.

***Observation.* –** Two photographs of a dried roadkill (showing diagnostic dorsal and ventral aspect) in June 1994 by Subaraj Rajathurai.

***Remarks.* –** According to Tweedie (1950: 192), there appears to be two distinct colour forms of *Calamaria lumbricoidea* in the Malay Peninsula. One form has its entire dorsal surface dark brown, each scale bordered above and below with white, such that narrow white lines run along the body between the

Fig. 9. *Draco blandfordii* from the town centre, photographed by B. C. Ng in June 1990.

scale rows. The belly is sharply and regularly barred black and yellow (white in preserved examples). The other form differs in having a brown dorsum without narrow white lines, and an irregularly barred underside with many of the ventral scales being half black and half yellow. The snake from Fraser's Hill in the photographs examined by us exhibits the colour pattern of the first form. Tweedie (1950: 192) had the impression that the white-striped variety was confined to highlands above 1,200m, the other from the foothills and lowland. Later, Inger & Marx (1965: 82) reported a geographical rather than an altitudinal demarcation in their distribution. They postulated that the non-striped form was from the western coast of the peninsula while the striped form was found further inland. However, this 'pattern' of distribution was demonstrated inconsistent when a specimen of the non-striped form was found at Gunung Benom, an inland locality (see Tweedie, 1983: 56).

Calamaria schlegeli schlegeli Duméril, Bibron & Duméril

Calamaria leucocephala (non- Duméril, Bibron & Duméril) – Tweedie, 1954: 110 (The Gap at 850m).
Keiometopon booliati Taylor, 1962a: 258, figs. 16-17 (Fraser's Hill).
Calamaria schlegeli schlegeli – Inger & Marx, 1965: 163 (*K. booliati* made synonym).

***Material examined.* –** ZRC.2.3406 (1), along road to Richmond House, 4 Sep.1995.

***Remarks.* –** According to Inger & Marx (1965: 154), the type and only known specimen of *Keiometopon booliati* appears to be a *Calamaria schlegeli* with aberrant dorsal head shields where the frontal was fused with the prefrontals. The specimen we examined is a typical *C. schlegeli* with its frontal clearly demarcated from the prefrontals.

Collorhabdium williamsoni Smedley

Collorhabdium williamsoni – Manthey & Grossmann, 1997: 335.

***Material examined.* –** None.

Elaphe prasina (Blyth)

***Material examined.* –** ZRC.2.5400 (1), road-kill about 1 km from The Gap, 22 Feb.2002.

Elaphe taeniura ridleyi (Butler)

***Material examined.* –** ZRC.2.4566 (1 juvenile), 1952.

Gongylosoma baliodeira baliodeira Boie

***Material examined.* –** ZRC.2.2825 (1), The Gap at 820m, 13 Oct.1947.

Lycodon butleri Boulenger

***Material examined.* –** ZRC.2.3537 (1), Telecoms Loop, 26 Nov.1996; ZRC.2.4279 (2 juveniles), 1952; ZRC.2.4281 (1), 3 Jun.1990.

Macrocalamus lateralis Günther

Macrocalamus lateralis – Manthey & Grossmann, 1997: 366; Vogel & David, 1999: 316.

***Material examined.* –** ZRC.2.2762 (1), at about 1,210m, Aug.1933; ZRC.2.2763 (1), at about 1,210m, Nov.1928; ZRC.2.2764 (1), at about 1,210m, 1952; ZRC.2.2765 (1), at about 1,210m, 1952; ZRC.2.3405 (1), along road to Richmond House, 5 Sep.1995.

Oligodon purpurascens (Schlegel)

***Material examined.* –** ZRC.2.3886 (1), May.1932; ZRC.2.3888 (1), 1928.

Pareas vertebralis (Boulenger)

Pareas vertebralis – Sly, 1976: 156; Tweedie, 1983: 38; Manthey & Grossmann, 1997: 378.

***Material examined.* –** ZRC.2.2531 (1), at about 1,300 m in front of Telecoms tower, 30 Dec.1989; ZRC.2.2758 (1), 1952.

Psammodynastes pulverulentus (Boie)

Psammodynastes pulverulentus – Sly, 1976: 156 (at 1,210m); Lim & Subharaj, 1991: 6 (High Pines road).

***Material examined.* –** ZRC.2.2532 (1), at 1300 m: road in front of UEP bungalow, 3 Jan.1990; ZRC.2.4306 (1), 1952; ZRC.2.4310 (1), path at 1,090m, 13 Mar.1947; ZRC.2.4317 (1), 1952; ZRC.2.4321 (1), 1952; ZRC.2.4322 (1), 1952; ZRC.2.4324 (1), 1952; ZRC.2.4326 (1), Nov.1928.

Pseudorabdion longiceps (Cantor)

Pseudorhabdium longiceps – Smith, 1922: 267.

***Material examined.* –** None.

Rhabdophis chrysargos (Schlegel)

Natrix chrysargus – Smith, 1922: 265.
Natrix chrysarga – Smith, 1930: 44.
Natrix chrysarga chrysarga – de Haas, 1949: 88 (Semangko Pass).

***Material examined.* –** ZRC.2.3458 (1), at 1,200 m, Nov.1995; ZRC.2.3538 (1), Telecoms Loop, 26 Nov.1996; ZRC.2.3949 (1), The Gap, Mar.1912; ZRC.2.4230 (1), 1952; ZRC.2.4236 (1 juvenile), 1952; ZRC.2.5401 (1), Telecoms Loop, 22 Feb.2002.

***Sibynophis collaris* (Gray)**

***Material examined.* –** ZRC.2.2728 (1), 1952.

FAMILY ELAPIDAE

***Calliophis gracilis* Gray**

Calliophis gracilis – Tweedie, 1950: 199 (The Gap).

***Material examined.* –** ZRC.2.3934 (1), The Gap at 850m, 18 Oct.1947.

***Maticora intestinalis lineata* Gray**

***Material examined.* –** ZRC.2.3974 (1), at 1,365m, 1952; ZRC.2.3975 (1), at 1,210m, 1952.

FAMILY VIPERIDAE

***Ovophis monticola convictus* (Stoliczka)**

Trimeresurus monticola – Tweedie, 1941: 29.

***Material examined.* –** ZRC.2.2875 (1), 1952.

***Trimeresurus popeiorum popeiorum* Smith**

Trimeresurus gramineus – Smith, 1922: 267; Smith, 1930: 90.
Trimeresurus popeiorum popeiorum – Chan-ard et al., 1999: 201.

***Material examined.* –** ZRC.2.2888 (1), The Gap at 850m, 17 Apr.1947; ZRC.2.2889-2891 (3), 1952; ZRC.2.2892 (1), The Gap, Mar.1912.

FAMILY XENOPELTIDAE

***Xenopeltis unicolor* Reinwardt**

Xenopeltis unicolor – Lim & Subharaj, 1991: 6 (Fraser's Hill).

***Material examined.* –** None.

DISCUSSION

Among the species in the present checklist, a vast majority may be regarded as forest specific, with the few remaining species commonly referred to as human commensals, namely *Microhyla butleri*, *Polypedates leucomystax*, *Gehyra mutilata*, *Gekko monarchus*, *Mabuya multifasciata* and *Varanus salvator*. Interestingly, some of these commensals had already been recorded as far back as the early 1920's, which was about the time when the first developments had begun. However, in spite of these disturbances (construction of roads, golf courses, hotels) a good variety of herpetofauna still thrives within the existing forests. On its own, Fraser's Hill does not exhibit any particular biogeographic significance, but its relative accessibility has facilitated past and present herpetofaunal collections. This well known highland locality certainly does not stand in isolation from the Main Range, and therefore would provide a good representation of typical montane herp species throughout the mountains.

It is hoped that this paper will serve as a stepping-stone for subsequent research efforts/comparative studies focusing on this and other highland areas within the peninsula, such as Cameron Highlands (K. K. P. Lim et al., in press), which has suffered more severe natural habitat loss as a result of large scale agricultural practice. It is without a doubt that such encroachment already has and may continue to cause noticeable changes of the microclimate (eg. increase of average air/water temperatures, decrease in relative humidity). The effects of such shifts in environmental parameters on the resident montane herpetofauna remain to be seen.

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