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A REVISION OF THE MELANESIAN–AUSTRALIAN ANGLE HEAD LIZARDS OF THE GENUS *HYPSILURUS* (SAURIA: AGAMIDAE: AMPHIBOLURINAE), WITH DESCRIPTION OF FOUR NEW SPECIES AND ONE NEW SUBSPECIES

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(with 28 text-figures)

ABSTRACT.– The genus *Hypsilurus* is reviewed on the basis of type specimens, additional museum material and earlier publications. Diagnostic features for each species are compiled and a key to the species is provided. Several species and subspecies are described as new: *Hypsilurus hikidanus* sp. n., *Hypsilurus magnus* sp. n., *Hypsilurus ornatus* sp. n., *Hypsilurus tenuicephalus* sp. n. and *Hypsilurus papuensis longicauda* ssp. n. *Hypsilurus longii* is removed from its synonymy with *H. godeffroyi*. *Hypsilurus modestus carinatus* becomes a junior synonym of *Hypsilurus modestus*. Species with common morphological characters are grouped and a possible subgeneric classification is suggested. The nomenclatural history of the genus is reviewed and *Hypsilurus* Peters, 1867 is proposed as nomen protectum, whereas the applicable name *Lophosaurus* Fitzinger, 1843 is considered a nomen oblitum. Distributional data of unambiguously identified material are given. A new lectotype is designated for *Hypsilurus godeffroyi*.

KEY WORDS.– Agamidae, *Hypsilurus*, taxonomy, redescriptions of type specimens, distribution, revalidation of *Hypsilurus longii*, *Hypsilurus modestus carinatus* new synonym of *Hypsilurus modestus, Hypsilurus hikidanus* sp. n., *Hypsilurus magnus* sp. n., *Hypsilurus ornatus* sp. n., *Hypsilurus tenuicephalus* sp. n., *Hypsilurus papuensis longicauda* ssp. n., *Lophosaurus* Fitzinger, 1843 nomen oblitum; *Hypsilurus* Peters, 1867 nomen protectum. *Hypsilurus godeffroyi* lectotype designation.

INTRODUCTION

Hypsilurus Peters, 1867 constitutes an agamid lizard genus of the Melanesian-Australian radiation. For much of the Twentieth Century, the generic nomen has been considered congeneric with the south-east Asian genus *Gonocephalus* Kaup, 1823 (e.g., Boulenger, 1885; de Rooij, 1915; Loveridge, 1948; Wermuth, 1967; Cogger, 1975; Urban, 1977; 1999).

Validity of the taxon *Hypsilurus* was confirmed through studies on skin receptors (Scortecci, 1937; 1941; Ananjeva and Matveyeva-Dujsebayeva, 1996), genital morphology (Böhme, 1988), immunological data (Baverstock and Donnellan, 1990; King, 1990), karyotype analysis (Ota et al., 1992), mitochondrial DNA-sequences of 12S- and 16S-rRNA (Honda et. al., 2000) and by DNA-sequences of three protein coding genes and eight tRNA-genes, as well as studies on the secondary structure of mitochondrial tRNAs (Macey et al., 2000; 2000a). In his thesis, Moody (1980) presented a phylogenetic analysis of the relations within the family Agamidae on the basis of morphological data. As a result of his investigations, he grouped six complexes of genera. The mainly arboreal agamid lizards of the south-east Asian radiation including the genus *Gonocephalus* were combined in group V, the genus *Hypsilurus* (subgenera *Hypsilurus* and *Arua* Doria, 1874), however, was placed in group IV as Melanesian-Australian arboreal radiation. The remaining agamid genera of the Australian radiation were subsumed in group III. A morphological differentiation of *Hypsilurus*/*Arua*–group IV against those genera of the Australian radiation (group III) is apparent in the loss of femoral–inguinal pores as well as an enlarged *Fenestra vestibularis*. Tropical Asian species (group V) were defined through three basic phenotypical characters: a change in the direction of the palatinum-maxillary suture, a displaced base of cleidodeltoid muscle fibres and the development of tactile skin organs. However, within group IV, several inconsistencies showed up. For example, the position of the *Nervus ulnaris* is different in *Hypsilurus dilophus* as compared to the other species studied [*H. godeffroyi* and *H.* (*Arua*) *modesta*], but similar to the conditions in most Australian agamid taxa. A primitive median position of the *Obturator foramen* is present in *Arua*, and missing in *Hypsilurus*.

As a consequence of his investigations, Moody (1980) removed *H. macrolepis* from its synonymy with *H. godeffroyi*. In toto, he considered 13 species as valid: *H. binotatus, boydii, bruijnii, dilophus, godeffroyi, macrolepis, nigrilabris* (error typographicus pro *nigrigularis*), *papuensis, schoedei, spinipes* as well as *H. auritus, geelvinkianus* and *modestus*, the latter assigned to the subgenus *Arua*.

Urban (1977) described *Gonocephalus schultzewestrumi* nov. spec. from Papua New Guinea: however, as the original description was within an unpublished diploma thesis, it was republished (Urban, 1999). This species shows unambiguously all characteristics of the taxon *Hypsilurus* and was consequently renamed *Hypsilurus schultzewestrumi* by Manthey and Denzer (2000).

Macey et al. (2000; 2000a) used DNA sequence analysis of mitochondrial genomes to study phylogenetic relationships among acrodont lizards (Agamidae). All taxa of the Australian-New Guinean (here, Melanesian-Australian) radiation proved to be members of a monophyletic unit and were comprised in the subfamily Amphibolurinae, according to classical taxonomy. Members of the arboreal south–east Asian agamid radiation are unambiguously distinguished and were placed in the subfamily Draconinae. With regard to the taxon *Hypsilurus* the authors proposed to separate *Hypsilurus dilophus* and *Arua modesta* on the generic level, as *Arua modesta* possesses an extra base in the sequence encoding tRNAAsn. As mitochondrial genome structure has proved to be a reliable phylogenetic character and such a change in the secondary structure of tRNAs is considered an autapomorphy, the result implies that *Hypsilurus* and *Arua* are a non-monophyletic group within the Melanesian–Australian agamid radiation (Amphibolurinae). Schulte et al. (2003) presented a comprehensive molecular phylogenetic study on the relationships among varanoid and amphibolurine agamid lizard based on mitochondrial DNA sequences. As for *Hypsilurus*, their analysis revealed monophyly for this genus and a close relationship to *Chelosania brunnea* Gray, 1845 as a sister taxon.

Currently, 14 known species are recognized with their intrageneric relationships still mostly unresolved. Owing partly to the short original descriptions and the lack of a recent revision of the genus, misidentifications and wrongly identified assigned specimens can be found in several publications. For this reason we will present detailed descriptions and extensive comparisons. For the first time since Boulenger (1885) and de Rooij (1915), this paper tries to provide a comprehensive compilation of all species with regard to type material and previous publications. We consider this revision as preliminary and hope it will serve as a basis for much-needed further morphological and biochemical studies.

MATERIALS AND METHODS

A total of 158 specimens of all hitherto known species of the genus *Hypsilurus* were studied with regard to pholidosis and morphometric characteristics and compared to available type material as well as literature data. Comparison with type material was not possible for *H. binotatus* (the type being lost during World War II [Obst, 1977]) and *H. bruijnii*. In the latter case, however, photographic records and morphological data are available. Most of the studied material is housed in the collection of the Museum für Naturkunde der Humboldt–Universität zu Berlin (ZMB). Additional specimens were borrowed from other museums. A list of taxa examined in this study is in Appendix II. Museum acronyms follow Leviton et al. (1985).

Characteristics of pholidosis– as far as they were not visible without magnification– were examined by using a microscope. Morphometric data were either taken with a sliding calliper to the precision of 0.1 mm or measured with a rule to a precision of one mm (SVL + TL). The following measurements were taken: snout–vent length (SVL); tail length (TL); head width (HW) at the angle of the mouth; head length (HL) from the tip of the snout to the posterior edge of the tympanum; hind limb length (HLL) from the base of the leg to the heel; foot length (FL) from the heel to the tip of the longest toe. Where the diameter of the eye or the tympanum is given this is represented by the symbol Ø. T/E constitutes the ratio of tympanum (T) and eye (E) diameter. Throughout the paper we will use the term "enlarged scales". If not noted otherwise this always refers to scales or groups of scales that are markedly larger than the surrounding scales. For the first time we introduce here a new quantitative character in agamid classification, i. e., the maximum number of scale rows between infralabials and enlarged submaxillaries (see Figure 1).

Data from the literature were only included after careful examinations as misidentifications are prevalent in several publications. Latitude and longitude for the localities mentioned in this paper were retrieved from the National Geospatial – Intelligence Agency website http://earth–info.nga.mil/gns/html/cntry_files.html. Older–mainly Dutch names– are used in their modern Indonesian form where applicable. Changes owing to the spelling reform in Malay and Bahasa Indonesia introduced in 1972 are described in Manthey and Grossmann (1997) and used here accordingly.

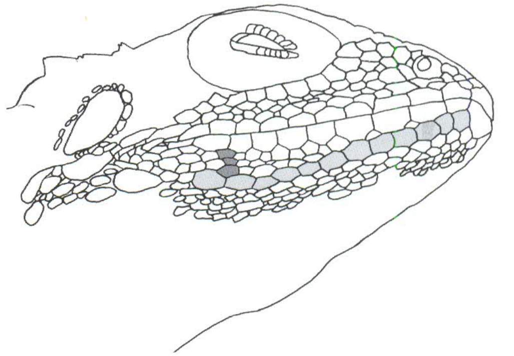

Figure 1. Position of the row of enlarged submaxillaries (light grey), present in all species of the *Hypsilurus godeffroyi*-group, and the maximum number of scale rows (here three, e. g., *H. binotatus*) between infralabials and enlarged submaxillaries (dark grey).

RESULTS AND DISCUSSION

The currently used generic name *Hypsilurus* Peters, 1867 [subgenus ad *Lophura* Gray, 1827 (non *Lophura* Fleming, 1822 = Aves, Galliformes) = *Hydrosaurus* Kaup, 1828], revalidated by Moody (1980) for Melanesian–Australian populations of angle head lizards is, strictly speaking, invalid. The first recorded species of this genus is *Lophyrus dilophus* Duméril and Bibron, 1837. On page 421 of the same volume the authors used its French name 'Tiare dilophe'. Additionally, they pointed out that *Lophyrus dilophus* represents the type specimen for a new genus and confusingly depict this species on pl. 46 under the name *Tiaris dilophus*.

However, *Tiaris* is preoccupied by Swainson, 1827 (Aves, Passeriformes). If all hitherto known species of *Hypsilurus* are considered congeneric with *Tiaris dilophus*, consequently *Lophosaurus* Fitzinger, 1843 (nomen substitutum pro *Tiaris* Duméril and Bibron, 1837) would be the appropriate genus name to use. Objectively *Hypsilurus* Peters, 1867, represents a junior synonym of *Lophosaurus* Fitzinger, 1843.

According to Article 23.9 of the International Code of Zoological Nomenclature (ICZN, 2000) we propose to consider *Lophosaurus* Fitzinger, 1843, as a nomen oblitum and consequently to conserve *Hypsilurus* Peters, 1867 as a nomen protectum. Both prerequisites of Article 23.9 – no usage of the name *Lophosaurus* after 1899 (Article 23.9.1.1) as well as a minimum of 25 publications by 10 different authors within the last 50 years using the name *Hypsilurus* (Article 23.9.1.2)– are fulfilled (e. g., Moody, 1980, Böhme, 1988, Wilson and Knowles, 1988, Welch et al., 1990, A. Manning, 1991, A. Manning and Ehmann, 1991, Manthey and Denzer, 1991, Shea et al., 1991, A. Manning, 1992, Cogger, 1992, 1994, Steiof and Grossmann, 1992, Ehmann, 1992, Welch, 1994, Hawkes and O'Brien, 1995, Rummery et al., 1995, Ananjeva and Matveyeva–Dusebayeva, 1996, Manthey and Schuster, 1996, Barts and Wilms, 1997, Denzer et al., 1997, Shea and Sadlier, 1999, Honda et al., 2000, Macey et al., 2000, Manthey and Denzer, 2000, McCoy, 2000, Melville et. al., 2001, Bauer and Watkins–Colwell, 2001; Honda et al., 2002, B. Manning, 2003, Schulte et al., 2003).

In case the species groups defined in this paper should prove to be separate genera, the name *Lophosaurus* Fitzinger, 1843 for *dilophus*–like species would still be available.

Hypsilurus Peters, 1867

Tiaris Duméril and Bibron, 1837: 419; Atlas Pl. 46 (non *Tiaris* Swainson, 1827 = Aves, Passeriformes) – Species typica (by monotypy): *Lophyrus dilophus* Duméril and Bibron.

Lophosaurus Fitzinger, 1843: 15, 45 (nomen substitutum pro *Tiaris* Duméril and Bibron, 1837).

Hypsilurus Peters, 1867: 707 [subgenus ad *Lophura* Gray, 1827 (non *Lophura* Fleming, 1822 = Aves, Galliformes)] – Species typica (by monotypy): *Lophura* (*Hypsilurus*) *godeffroyi* Peters.

Arua Doria, 1874: 345 (subgenus ad *Gonyocephalus* = *Gonocephalus* Kaup, 1825) – Species typica (by monotypy): *Gonyocephalus* (*Arua*) *inornatus* Doria = *Hypsilurus modestus* Meyer, 1874 fide Peters and Doria 1878.

Lophosteus Peters and Doria, 1878: 377 (subgenus ad *Gonyocephalus* = *Gonocephalus* Kaup, 1825) – Species typica (by monotypy): *Gonyocephalus* (*Lophosteus*) *albertisii* Peters and Doria = *Tiaris papuensis* Macleay, 1877, fide Boulenger, 1885.

Gonyocephalus (= *Gonocephalus* Kaup, 1827) Boulenger, 1885 (part.): 282.

Diptychodera Boettger, 1893: 45 – Species typica (by monotypy): *Diptychodera lobata* Boettger = *Hypsilurus modestus* Meyer, 1874, fide Mertens, 1922.

Gonocephalus Wermuth, 1967 (part.): 55.

Hypsilurus (*Hypsilurus*) Moody, 1980: 300.

Hypsilurus (*Arua*) Moody, 1980: 300.

Diagnosis.– Body laterally compressed, dorsals small, rhomboid, hardly overlapping, keeled, directed backwards and upwards; uniform ventrals significantly larger, strongly keeled. Upper head scales small, slightly heterogeneous; a more or less curved row of enlarged scales below the eye adjacent to the orbit (weakly or not developed in *H. boydii*, *dilophus* and *spinipes*); tympanum visible; males and females with almost equally developed gular pouch (frequently with one or two transverse folds in the relaxed state) and well developed vertebral crest (no dorsal crest in *H. modestus*). Sexual dimorphism usually only weakly developed. No preanal– or femoral pores.

Hypsilurus modestus Meyer, 1874

Gonyocephalus (*Hypsilurus*) *modestus* Meyer in Peters, 1874: 130; Lectotype: SMNS 2001, Locus typicus: Jobi, Indonesia (= Yapen, Papua, Province of Indonesia); Paralectotype: ZMB 8783, "Ansus, Jobi", leg. A. B. Meyer; Locus typicus: Ansus, Jobi Island (= Yapen), 1°44'S 135°49'E, Papua, Province of Indonesia.

Gonyocephalus (*Arua*) *inornatus* Doria, 1874: 345; Taf. XI, Fig. 2; Syntype: ZMB 7941, "Insel Wokan", leg. Beccari and Doria. – Locus typicus: Wokan Island (= Wokam), Aru Islands, 5°37'S 134°30'E, West Papua Province, Indonesia (Syn. fide Peters and Doria, 1878: 381).

Gonyocephalus (*Arua*) *modestus* Peters and Doria, 1878: 380.

Gonyocephalus modestus Boulenger, 1885: 294, 1897: 697; Werner, 1898: 555, 1900: 43; Lönnberg, 1900: 576; de Rooij 1909: 377; de Roux, 1910: 215; Vogt, 1911b: 421, 1912: 3; Barbour, 1912: 86; Boulenger, 1914: 255; de Rooij, 1915: 113, 1919: 1920: 137; de Jong, 1927: 310, 1930: 405; Brongersma, 1930: 13; Vogt, 1932: 282; Parker, 1936: 85.

Goniocephalus modestus Müller, 1885b: 294;

Meyer, 1886/87: 5; Loveridge, 1948: 337.
Diptychodera lobata Boettger, 1893: 45, Holotype: SMF 4299, subadult, Neubritannien, purchased 1887 from Poehl, Hamburg, Locus typicus: New Britain (Syn. fide Mertens, 1922: 45).
Diptychodera lobata Werner, 1900: 46.
Gonyocephalus modestus carinatus Sternfeld, 1918: 393, Lectotype SMF 9770, Paralectotype 9771–9772– Locus typicus: Anir Islands, Northeast of Neu–Mecklenburg (= New Ireland). Another paralectotype SMF 9773 from Tanga Island, north-east of New Ireland.
Gonocephalus modestus Hediger, 1933b: 4; Wermuth, 1967: 60; Zweifel, 1980: 414.
Hypsilurus (*Arua*) *modestus* Moody 1980: 300; Denzer et al., 1997: 323.
Hypsilurus modestus Schlüter and Hallermann, 1997: 5.
Arua modesta Macey et al. 2000: 241.
Hypsilurus modestus Schulte et al., 2003: 600.

Diagnosis.– Small slender, long–tailed species (SVL mostly < 100 mm; TL/SVL > 2.3) with homogeneous dorsal scalation and without dorsal crest. Scales below the tympanum usually not enlarged; a row of enlarged submaxillaries sometimes present; anterior part of the gular pouch without enlarged scales. Edge of the gular pouch enlarged. Similar to *H. geelvinkianus*. *H. modestus* differs from all other species by the absence of a dorsal crest (vs. present) as well as the widely separated scales of the nuchal crest; additionally differs from *H. geelvinkianus* by a small gular pouch with rounded base approximately in the region of the clavicle (vs. acuminate base on the chest).

Description.– SVL males up to 107, females up to 94 mm (Urban, 1977). Slightly enlarged temporal scales; below the tympanum sometimes a single enlarged scale; 9–13 supralabials, 7–10 infralabials (Brongersma, 1930); from the mental to below the angle of the mouth sometimes (7 out of 28 studied specimens) a row of enlarged submaxillaries; between enlarged submaxillaries and infralabials maximum 2–5 scales. Gular pouch usually greatly reduced, with minute smooth, almost grained scales; gular pouch with one to three transverse folds. Nuchal crest with 4–6 (exceptionally one, two, 7 or none) low lanceolate, widely separated scales (height << Ø tympanum), no nuchal sail; no dorsal crest, but a row of enlarged, keeled sometimes erected vertebral scales. Tail laterally slightly compressed with small keeled scales.

Colour in life after photographs from Yapen Island and Wondiwoi mountains, Papua, Province of Indonesia.– Head and dorsum brilliant green. Labials sometimes light blue. Throat whitish, gular pouch bright yellow. Posterior part of the dorsum with or without turquoise transverse bands (3–4 bands). Dorsoventrally whitish or slightly brownish, ventrally whitish. Upper parts of the tail brownish with lighter bands most distinct in the anterior part of the tail and fading towards the end of the tail; lower part of the tail light brown.

Colouration after de Rooij (1915).– Dorsally olive–brown, ventrally yellowish with olive coloured or bluish pattern. A dark radial pattern around the eye. Limbs and tail with dark bands. Throat and gular pouch sometimes with dark red spots (not visible in alcohol-preserved specimens). Colour in alcohol blue–green or brown; limbs and tail with dark bands.

Variations and comments.– In the type series of the subspecies *Hypsilurus modestus carinatus* (Sternfeld, 1918) from Anir Islands (Bismarck Archipelago), the number of scales in the nuchal crest varies from 1–7. Overall, however, there are no distinct morphological characters that

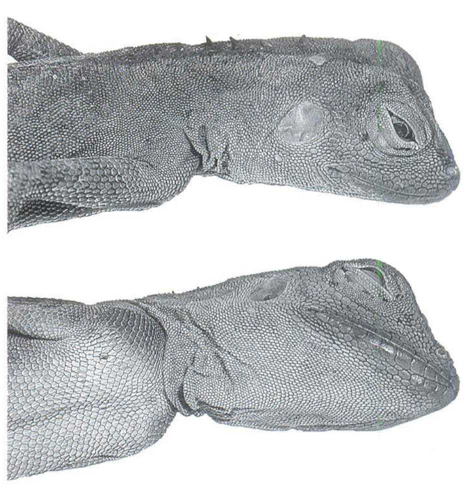

Figure 2. Paralectotype (ZMB 8783) of *Hypsilurus modestus* from Yapen Island, Papua, Province of Indonesia.

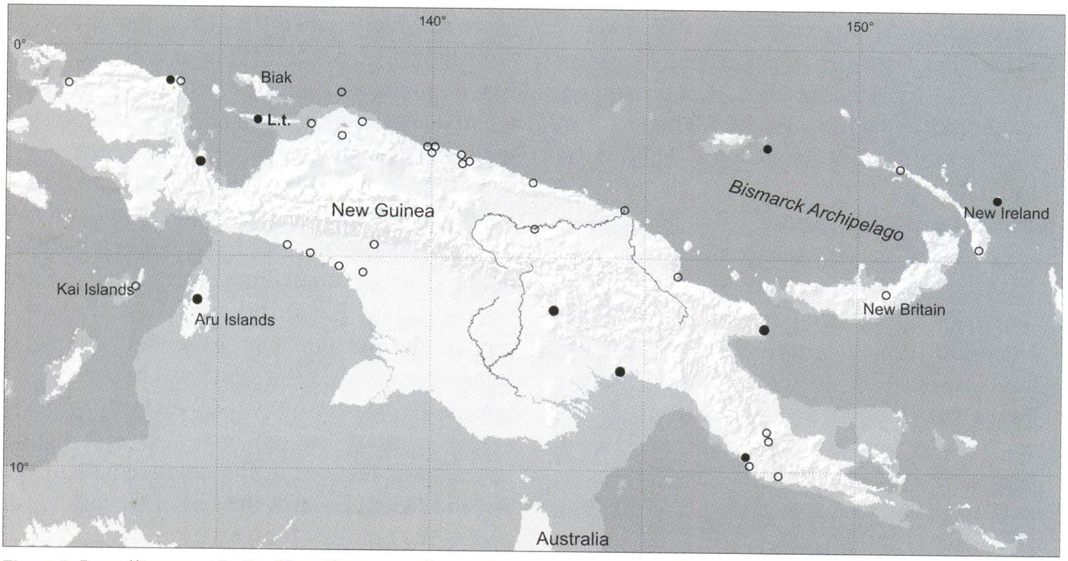

Figure 3. Locality records for *Hypsilurus modestus*. Specimens examined (solid symbols) literature records (hollow symbols). The Locus typicus is marked with L.t.

would justify a subspecific status of *carinatus*. *Hypsilurus modestus carinatus* therefore becomes a junior synonym of *Hypsilurus modestus*.

A specimen (ZSM 217/1920) from Hubertushöhe, Neu Pommern (= New Britain), shows only a hint of a nuchal crest. Two specimens (ZMB 14600) from Ralum (New Britain) possess only two scales in the nuchal crest.

In specimens from Papua New Guinea, the nuchal crest is slightly or clearly higher as compared to specimens from West Papua Province, Indonesia. One specimen from Sattelberg, Morobe Province, Papua New Guinea (ZMB 21383) has an atypically enlarged gular pouch.

Ecology.– Loveridge (1948) reported that this species is mainly found on palm tree trunks and often shows a vivid green colouration. While these lizards can be pretty fast on their escape they are quiet when handled. Zweifel (1980) found *H. modestus* in the rainforest as well as in secondary vegetation. They live mainly in trees or bushes; however, two specimens were found on the ground at night. Usually dorsal colouration is completely green, but *H. modestus* tends to change its colour. Individuals are able to change completely from green to a brownish colour with dark bands. The tail bands, usually only little distinguishable, are clearly visible in dark coloured specimens. The ventral surface is white and the iris brown according to Zweifel (1980).

Distribution.– The whole of New Guinea additionally (from West to East): Kei– and Aru Islands, Yapen, Krudu, Liki Kumamba Islands (all Papua, Province of Indonesia); Rambutyo (Admirality Islands), New Britain, New Ireland as well as Anir– and Tanga Islands, all Papua New Guinea.

Comments on the types.– Originally the MTKD was in the possession of a series of 10 types (original catalogue entry) numbered 392–395, 397–402, one of them Nr. 392 determined as lectotype and 393 as paralectotype, respectively, by L. Müller 1913, both from Jobi (= Yapen). These assignments were however never published and are therefore invalid. The specimens numbered 398 and 400–402 were subsequently cancelled and determined as types of *Gonycephalus auritus*. The whole material originally declared as types was lost during World War II.

Schlüter et al. (1997) and Denzer et al. (1997) published type catalogues of the herpetological collections in Stuttgart and Berlin, respectively, assigning types for *H. modestus*. As the paper of Schlüter et al. (1997) preceded Denzer et al. (1997) it is given priority. The lectotype is therefore housed in Stuttgart as SMNS 2001 and the specimen from Berlin formerly assigned as holotype, ZMB 8783, becomes a paralectotype.

Hypsilurus auritus Meyer, 1874

Gonyocephalus (*Hypsilurus*) *auritus* Meyer in: Peters, 1874: 130, Holotype: ZMB 8782, "Jobi", leg. A. B. Meyer; Locus typicus: Ansus, Jobi Island (= Yapen, 1°45'S 136°15'E), Papua, Province of Indonesia.
Gonyocephalus (*Arua*) *auritus* Peters and Doria 1878: 382.
Gonyocephalus auritus Boulenger, 1885: 295; de Rooij, 1909: 377; Boulenger, 1914: 255; de Rooij, 1915: 115, de Rooij, 1920: 138; Brongersma, 1933: 24, 25.
Goniocephalus auritus Meyer, 1886/87: 5.
Gonocephalus auritus Wermuth, 1967: 56.
Hypsilurus (*Arua*) *auritus* Moody, 1980: 300; Denzer et al., 1997: 322.

Diagnosis.– Medium–sized slender, long–tailed species with homogeneous dorsal scalation and continuous or discontinuous vertebral crest. Sides of the neck with a large oval dark marking bordered by enlarged scales; no additional enlarged scales below the tympanum; no row of enlarged submaxillaries; upper part of the anterior edge of the gular pouch with or without enlarged scales.

H. auritus differs from *geelvinkianus, bruijnii, modestus* and *nigrigularis* by the presence of a dark spot on either side of the neck (vs. absent); additionally from *geelvinkianus* by a well developed dorsal crest (vs. rudimentary); *modestus* and *bruijnii* by a large gular pouch with acute base on the chest (vs. small with rounded base near the clavicular region) additionally from *modestus* by narrowly spaced scales on the nuchal crest (vs. widely separated) and the presence of a dorsal crest (vs. absent), from *bruijnii* by the absence of a row of enlarged submaxillaries (vs. present) and from *nigrigularis* by small homogeneous, nearly granular anterior scales on the gular pouch (vs. larger, slightly heterogeneous elongated and broader scales); *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation and a longer tail, TL/SVL > 2.8 (vs. < 2.3); all other species by the absence of a row of enlarged submaxillaries (vs. present).

Description.– Males and females up to 130 mm SVL (Urban, 1977); TL/SVL > 2.8. Enlarged temporal scales; tympanum and sides of the neck with enlarged scales, forming an oval ring towards the shoulder; 9–10 supra–, 8–9 infralabials; no row of enlarged submaxillaries. Gular pouch large, reaching far onto the chest. Base of gular pouch acute on the chest, gular pouch without transverse folds; anterior edge in the upper region with or without enlarged scales, not forming a saw–toothed edge; complete gular pouch with minute smooth, nearly granular scales. A low, indistinct nuchal sail; nuchal crest with lanceolate scales contacting at the base (height < Ø tympanum or > Ø tympanum [de Rooij, 1915]) or separated by one or more low scales; dorsal crest similar (height < nuchal crest) continuing with an indistinct indentation or clearly separated; crest continuously decreasing towards the base of the tail, continued on the tail as a saw–toothed edge. Dorsals homogeneous. Tail laterally slightly compressed.

Colour in alcohol.– Whitish or bluish–grey with darker marbling or uniformly brownish. Gular pouch with two or three broad, dark longitudinal stripes. Tympanum surrounded by an oval dark spot; clearly distinguishable by group of enlarged scales.

Distribution.– New Guinea, West Papua Province, Indonesia: Yapen, Misol (ZSM), Salawatti and Batanta Islands as well as mainly coastal areas of the main island; Papua New Guinea:

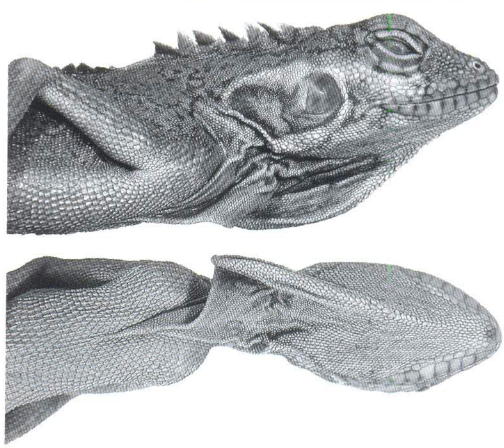

Figure 4. Holotype (ZMB 8782) of *Hypsilurus auritus* from Yapen Island, Papua, Province of Indonesia.

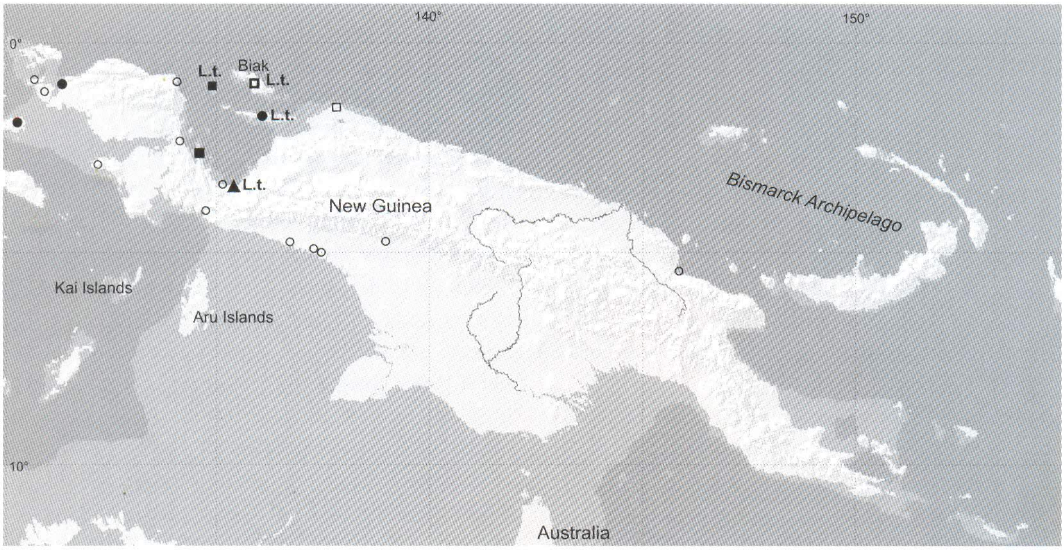

Figure 5. Locality records for *Hypsilurus auritus* (circular symbols), *H. geelvinkianus* (square symbols), and *H. nigrigularis* (triangular symbols). Specimens examined (solid symbols) literature records (hollow symbols). Loci typici are marked with L.t.

Bogadjim in Astrolabe Bay, Madang Province; Eastern and Western Highlands (MCZ) and Chimbu Province (MCZ); West Sepik Province (BPBM).

Comments on the types.– Originally the MTKD was in the possession of a series of four specimens (original catalogue entry) numbered 398 (Rubi, New Guinea), 400 and 401 (Dore, New Guinea) and 402 (Jobi = Yapen). Nr. 401 had been determined as the lectotype and 398 as the paralectotype (L. Müller, 1913, unpublished). The specimen numbered 400 was exchanged to another zoological museum, the name of which is unreadable in the original catalogue. The remaining types as well as the specimen numbered 402 were lost during World War II. Therefore we consider the holotype assignment of ZMB 8782 published by Denzer et al. (1997) as still valid.

Hypsilurus nigrigularis Meyer, 1874

Gonyocephalus (*Hypsilurus*) *nigrigularis* Meyer in: Peters, 1874: 129, holotype: MTKD D 2967, "Neu–Guinea", leg. A. B. Meyer – Locus typicus restrictus (according to data from Meyer, 1886/87): Rubi, am Südufer der Geelvinkbai, ~ 3° 23'S; 135° 15'E, West Papua Province, Indonesia.

Goniocephalus nigrigularis Meyer, 1886/87: 5.

Gonyocephalus nigrigularis de Rooij, 1915 (part.): 111.

Gonocephalus nigrigularis Wermuth, 1967: 61.

Gonyocephalus nigrigularis Obst, 1977: 182.

Hypsilurus (*Hypsilurus*) *nigrilabris* (sic!) Moody, 1980: 300 (error typographicus pro *nigrigularis*).

? *Hypsilurus nigrigularis* Schulte et al., 2003: 600 (c. 2000 m., c. 10 km NW Simbai, Kaironk Village, Madang Province, Papua New Guinea).

Diagnosis.– Medium–sized, robust, long–tailed species with homogeneous dorsal scalation, a discontinuous vertebral crest and a large, dark coloured gular pouch. Scales below the tympanum minimally enlarged, no row of enlarged submaxillaries; gular pouch extremely large; anterior edge of the gular pouch without enlarged scales.

H. nigrigularis differs from *modestus, auritus* and *geelvinkianus* by larger and slightly heterogeneous, narrow, as well as broad anterior scales on the gular pouch (vs. small, homogeneous, rhomboid nearly granular scales) and by a dark gular pouch (vs. yellow gular sac, with or without stripes); additionally from *modestus* by a large gular pouch with acute base on the chest (vs. small with rounded base approximately near the clavicular region) and the presence of a dorsal crest (vs. absent), *auritus* by the absence of dark spots on either side of the neck (vs. present), *geelvinkianus* by a normally developed dorsal crest (vs. rudimentary), *bruijnii* by a large dark gular pouch with acute base on the chest (vs. small, light coloured with rounded base approximately near the clavicular region) as well as by the absence of a row of enlarged submaxillaries (vs. present), *boydii*, *spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail, TL/SVL > 2.5 (vs. < 2.3); all other species by the absence of clearly enlarged scales below the tympanum as well as the absence of a row of enlarged submaxillaries (vs. present).

Description.– SVL a single male 141 mm; TL/SVL 2.9. No clearly enlarged scales in the temporal region or below the tympanum; 11 supra–, 10 infralabials; no row of enlarged submaxillaries. Gular pouch extremely large reaching far onto the chest (largest gular pouch of the whole genus); anteriorly with distinct narrow, convex scales; median scales significantly broader (width = length), posteriorly with narrow as well as broader scales. Virtually, the whole vertebral crest on a small sail; nuchal crest with lanceolate scales, directed caudad, (height slightly < Ø tympanum), separated at the base by 1–3 low scales; dorsal crest separated from nuchal crest (distance approximately 2 crest scales); dorsal crest initially with lanceolate scales, in contact at the base (height slightly < nuchal crest), diminishing in the last third of the body to a saw–toothed edge. Homogeneous dorsals small. Tail laterally moderately compressed.

Colour in alcohol.– Dorsally completely brown–olive with a hint of a dark mottle and a faint reticulate pattern. Complete gular pouch dark coloured, indistinct stripes on the throat. Between tympanum and the angle of the mouth two dark, semi–rounded stripes.

Distribution.– Only known from Locus typicus.

Comment.– Several specimens listed in other museums as *H. nigrigularis* are most probably assignable to *H. magnus* sp. n. Specimens in question are from the following locations: Papua Indonesia: Sermowai (= Sungai Sermo), Lorentz River, Moaif (ZMA), Baliem River (BPBM); Papua New Guinea: Western Highlands Province (CAS, MCZ, BPBM); Eastern and Southern Province, Chimbu Province (MCZ, BPBM)

Figure 6. Holotype (MTKD D 2967) of *Hypsilurus nigrigularis* from Rubi, West Papua Province, Indonesia.

Hypsilurus geelvinkianus (Peters and Doria, 1878)

Gonyocephalus (*Arua*) *geelvinkianus* Peters and Doria, 1878: 381; Syntypes: ZMB 9729–30, "Insel Mafor, Neu–Guinea", leg. Beccari; additional syntypes in Genoa under C. E. 9588 (three specimens), C. E. 29144 (seven specimens), as well as in Vienna under NMW 21050.– Locus typicus: Islands Mafor (= Mafoor = Numfoor, 1°03'S 134°54'E) and Mysore (= Biak, 1°S 136°E) Geelvink Bay, West Papua Province, Indonesia.

Gonyocephalus geelvinkianus Boulenger, 1885: 294; de Rooij, 1915: 114; de Jong, 1930: 405.

Gonocephalus geelvinkianus Wermuth, 1967: 59.

Hypsilurus (*Arua*) *geelvinkianus* Moody, 1980: 300; Denzer et al., 1997: 323.

Diagnosis.– Small slender, long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. Scales below the tympanum not enlarged; no row of enlarged submaxillaries; upper part of the anterior edge of the gular pouch with enlarged scales.

Similar to *Hypsilurus modestus*. *H. geelvinkianus* differs from *modestus* and *bruijnii* by a comparatively large gular pouch with acute base on the chest (vs. small with rounded base near the clavicular region); additionally from *modestus* by the presence of low dorsal crest (vs. absent) and from *bruijnii* by the absence of a row of enlarged submaxillaries and absent enlarged scales below the tympanum (vs. present) as well as an extremely low dorsal crest (vs. normally developed); *auritus* and *nigrigularis* by an extremely low dorsal crest (vs. normally developed); additionally from *auritus* by the absence of dark spots on either side of the neck (vs. present) and a monochrome gular pouch (vs. weakly dark striped) and from *nigrigularis* by significantly smaller, granular to rhomboid anterior scales on the gular pouch (vs. larger with elongated, as well as broader scales); *boydii, dilophus* and *spinipes* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail, TL/SVL ≥ 3 (vs. < 2.3); all other species by the absence of enlarged scales below the tympanum and an absent row of enlarged submaxillaries (vs. present).

Description.– SVL up to 100 mm (de Rooij, 1915); TL/SVL = 3.0. Slightly enlarged temporal scales, no enlarged scales below the tympanum; 8–10 supra–, 8–9 infralabials; no rows of enlarged submaxillaries. Gular pouch comparatively large, ending acute on the chest, anterior edge in the upper region with enlarged scales; complete gular pouch with small smooth, nearly granular scales as well as rhomboid, keeled overlapping scales. A low, indistinct nuchal sail; nuchal crest with lanceolate scales (height < Ø tympanum), separated at the base by one or two low scales or sometimes in contact. Dorsal crest with triangular or tongue–shaped scales (height < nuchal crest) clearly separated from nuchal crest, continuously decreasing towards the tip of the tail. Dorsals homogeneous. Tail laterally slightly compressed with keeled scales.

Dorsal colour after de Rooij (1915).– reddish brown, bluish or olive green with dark spots, sometimes forming a reticulation pattern. Tail and limbs with brown bands.

Colour in alcohol.– Bluish with dark marbling or brownish monochrome. Gular pouch without pattern.

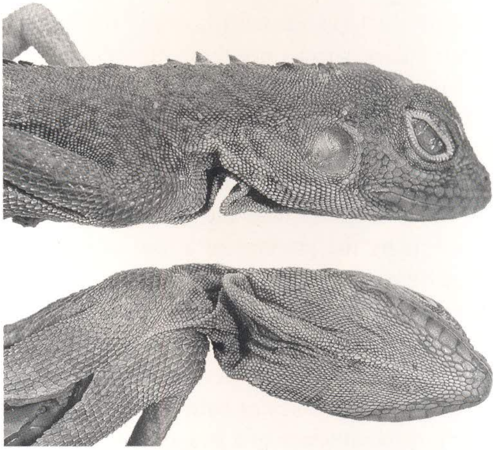

Figure 7. One of the syntypes (ZMB) of *Hypsilurus geelvinkianus* from Numfoor Islands, West Papua Province, Indonesia.

Distribution.– New Guinea, West Papua Province, Indonesia: Biak and Numfoor Islands as well as Wondiwoi mountains (ZMB) on the main island. Papua New Guinea: East Sepik Province (BPBM)

Hypsilurus bruijnii Peters and Doria, 1878

Gonyocephalus (*Hypsilurus*) *Bruijnii* Peters and Doria, 1878: 379, Holotype: MSNG 9562, "In Nova Guinea sept. ad Montes Arfak", leg. Bruijn – Locus typicus: Arfak Mountains, ~ 1°14'S 133°47'E, West Papua Province, Indonesia.

Gonyocephalus bruijnii Boulenger, 1885: 295.

Gonocephalus bruijnii Wermuth, 1967: 57.

Hypsilurus (*Hypsilurus*) *bruijnii* Moody, 1980: 300.

? *Hypsilurus bruijnii* Schulte et al., 2003: 600 (Fogamaiyu, Southern Highlands Province, Papua New Guinea).

Diagnosis.– Medium–sized, long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. Several scales below the tympanum and at the angle of the mouth enlarged; a row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales.

H. bruijnii differs from *modestus* by the presence of a dorsal crest (vs. absent), *auritus*, *geelvinkianus* and *nigrigularis* by a small gular pouch with roundish base near the clavicular region (vs. large with acute base on the chest), as well as the presence of a row of enlarged submaxillaries (vs. absent); additionally from *auritus* by the absence of dark spots on either side of the neck (vs. present), *geelvinkianus* by a normally developed dorsal crest (vs. rudimentary), *boydii, spinipes* and *dilophus* by homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.0 (vs. < 2.3), all other species the absence of large plates on either side of the head (vs. present).

Description of the holotype after Peters and Doria (1878) (from the original Italian text, adapted to the layout of descriptions presented in this paper).– SVL 130 mm. Head scales strongly keeled. 10–12 supralabials, 9–10 infralabials. From the mental to below the angle of the mouth a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials 2 – 3 rows of scales. Subauricular region (here: below the tympanum) with large scales. Gular pouch only weakly developed (probably a female), with small, nearly smooth scales. Nuchal crest with approximately 6 lanceolate scales, slightly higher than the dorsal crest. Nuchal and dorsal crest separated by small sharp scales. Dorsals small, weakly keeled, forming slightly ascending transverse rows. Ventrals enlarged, strongly keeled.

Colour (in alcohol).– dorsally brown–blue, below whitish. Dark spots on both sides along the base of the dorsal crest, approximately the same size as a dorsal scale. Enlarged scales at the angle of the mouth whitish, clearly distinct from the surrounding area. Tail with indistinct dark and light rings.

Description of MSNG 9562.– The specimen labelled as type (MSNG 9562) in the museum in Genoa differs in several characters from the original description as outlined above. Unfortunately, we did not have the holotype at hand. The following description relates to photographs and measurements that have been provided courtesy of T. Hikida: SVL male 143 mm, TL/SVL > 3.0. Enlarged scales in the temporal region and below the tympanum, largest scales at the angle of the mouth and below an enlarged submaxillaries; maximum size of the largest scale > 1/2 Ø tympanum; 10 supralabials, 9 infralabials; from the mental to below the angle of the mouth; a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials maximum three scales. Gular pouch small; anterior scales rhomboid, smooth or convex, posterior significantly smaller, rhomboid, tubercular or granular. No saw–toothed edge along the median line of the gular pouch. Nuchal crest with lanceolate scales (height ≡ Ø tympanum), separated at the base by a minute scale each. Dorsal crest clearly separated from significantly higher nuchal crest; interspace filled with small scales. Dorsal crest with lanceolate or slightly saw–toothed, posteriorly directed scales, in contact at the base; continuously decreasing towards the tail base, on the tail only developed as a saw–toothed row. Dorsals homogeneous. Tail laterally moderately compressed.

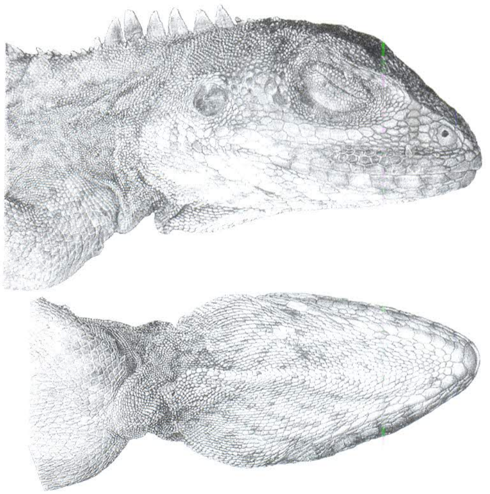

Figure 8. Holotype (MSNG 9562) of *Hypsilurus bruijnii* from the Arfak Mountains, West Papua Province, Indonesia.

Colour in alcohol.– Dorsally light reddish brown with dark spots, forming a weak marbling; ventrally slightly lighter coloured; gular pouch with indistinct dark lines.

Distribution.– Apparently only known from Locus typicus. Museums list specimens from the following locations: Papua, Province of Indonesia: Batanta Island (BPBM); Papua New Guinea: Western Province (MCZ).

Comment.– The TL/SVL ratio of the Peters and Doria type is close to 3.5; for the specimen labelled as type in the museum, the TL/SVL ratio comes only to a value of 3.1.

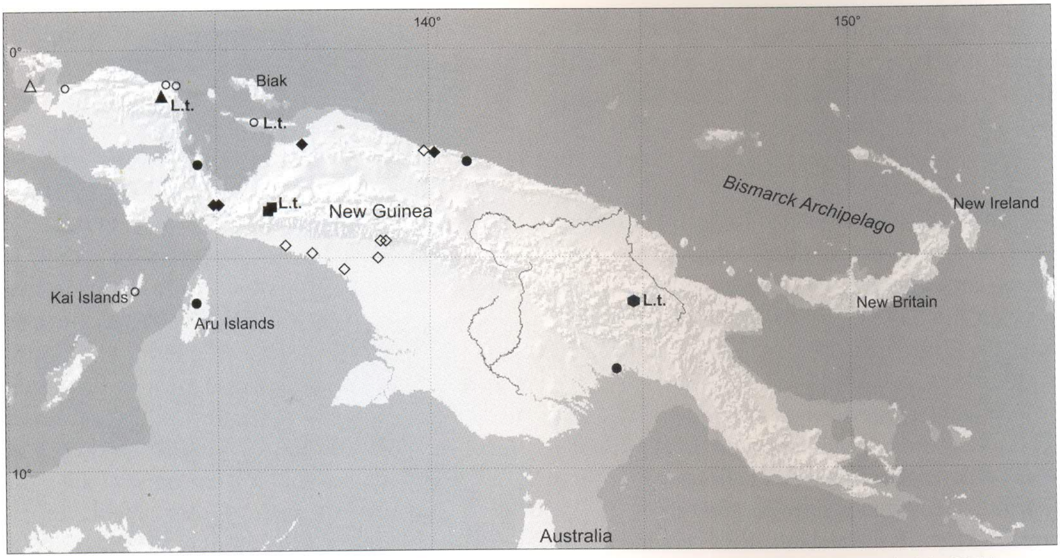

Figure 9. Locality records for *Hypsilurus bruijnii* (triangular symbols), *H. magnus* (rhombic symbols), *H. binotatus* (circular symbols), *H. hikidanus* (square symbols), and *H. schultzewestrumi* (hexagonal symbols). Specimens examined (solid symbols) literature records (hollow symbols). Loci typici are marked with L.t.

Peters and Doria (1878) assumed the holotype to be a female. However, the clearly broadened base of the tail of the specimen labelled as type suggests that it is a male. Therefore, the holotype of *H. bruijnii* is not unambiguously defined.

In the original description, a SVL 0.13 m and a TL 0.045 m (sic!) is given (most probably 450 mm) vs. SVL 143 mm, TL 440 mm (T. Hikida, pers. comm.).

Hypsilurus godeffroyi Peters, 1867

Lophura (*Hypsilurus*) *Godeffroyi* Peters, 1867: 707, Taf. Fig. 1), lectotype designatus Marx (1958): ZMB 5891, paralectotype: FMNH 73845, "Pelew–Inseln", bought from Godeffroy – Locus typicus: Pelew– Inseln (= Palau Islands).

Gonyocephalus godeffroyi de Rooij, 1915 (part.): 112.

Gonocephalus godeffroyi Wermuth, 1967 (part.): 59.

Hypsilurus (*Hypsilurus*) *godeffroyi* Moody, 1980 (part.): 300; Denzer et al., 1997: 325.

? *Hypsilurus godeffroyi* Honda et al., 2000: 535 (Irian Jaya, New Guinea = West Papua Province, Indonesia, New Guinea); Honda et al., 2002: 130.

Hypsilurus godeffroyi Bauer and Watkins–Colwell, 2001: 73.

Diagnosis.– Medium-sized, slender headed and long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. An area of enlarged scales below the tympanum present; a row of enlarged submaxillaries; anterior edge of the gular pouch without enlarged scales; scales of the gular pouch separated; tail at the base significantly higher.

H. godeffroyi differs from *schoedei* by heterogeneous, widely separated scalation of the anterior part of the gular pouch (vs. nearly homogeneous, only a few scales weakly separated) and in size SVL > 140 mm (vs. < 130 mm); *longii, binotatus, macrolepis, papuensis* and *schultzewestrumi* by separated anterior scales on the gular pouch (vs. narrowly spaced or overlapping) as well as a narrower head, HW/SVL $\leq$ 0.127 (vs. $\geq$ 0.137), additionally from *longii, binotatus, macrolepis* and *papuensis* by smooth anterior scales on the gular pouch (vs. keeled); additionally from *longii* and *macrolepis* by a lower number of scales between enlarged submaxillaries and infralabials 3 (vs. 4–5), from *binotatus* by a discontinuous vertebral crest (vs. continuous) and from *schultzewestrumi* by the absence of extremely large gular plates (vs. present); *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.0 (vs. < 2.3); all other species by the presence of an area of enlarged scales below the tympanum (vs. absent).

Description.– SVL male 151, female 147 mm; TL/SVL > 3. Temporal scales enlarged; below the tympanum, a large area of heterogeneous, enlarged, elongated, polygonal scales (horizontally approx. 7, vertically approx. 5 scales), maximum size of the largest scale > 1/2 Ø tympanum; 11 supra–, 12 infralabials; from the mental to below the angle of the mouth, a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials, a maximum of three scales. Gular pouch moderately large; anterior edge without enlarged scales; anterior scales on the gular pouch large, separated (skin clearly visible between scales), heterogeneous, smooth to tubercular (not keeled), sometimes intermixed with smaller scales; posterior scales on the gular pouch small, narrowly spaced, tubercular, smooth or weakly keeled. Nuchal sail present; nuchal crest with low triangular scales contacting at the base (height < Ø tympanum), slightly lower than the clearly separated dorsal crest (distance ≈ length of nuchal crest), the latter continued on the basal part of the tail without interruption. Dorsals homogeneous. Base of the tail laterally strongly compressed and raised.

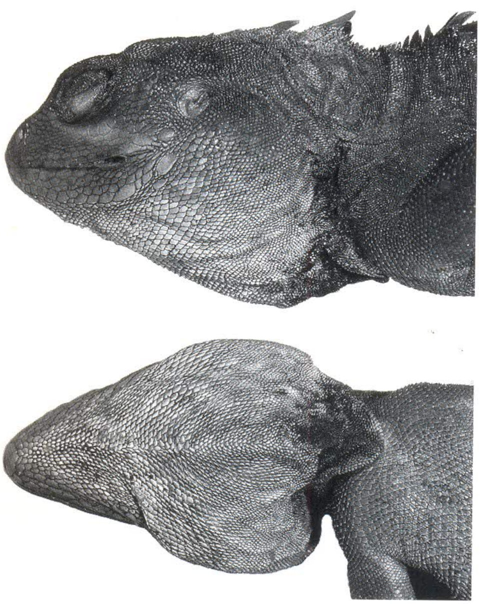

Figure 10. Holotype (RMNH 29093) of *Hypsilurus magnus* sp. n. from Gariau near Lake Jamur, Papua, Province of Indonesia.

Colour in alcohol.–Dorsum without bands, no dark/light spot on the sides of the neck, dark brown or olive with brown marble pattern (Peters, 1867).

Comment.– Tiedemann and Häupl (1980) report a syntype numbered NMW 21049 from the museum in Vienna; however, this specimen cannot have the status of a syntype as only two specimens were available to Peters for his original description; one of the specimens went to the FMNH. The status of a paralectotype of the Vienna specimen as proposed by Denzer et al. (1997) can therefore not be held up. Consequently, ZMB 5891 becomes a lectotype and FMNH 73845, a paralectotype.

In a paper concerned with the origin of the type material, Bauer and Watkins–Colwell (2001) conclude that not Palau but one of the island groups of Anchorite, Hermit or Ninigo (Manus Province, Papua New Guinea) is the Locus typicus. Basis for this hypothesis are old travel reports, original catalogue entries as well as zoogeographical arguments. It has to be noted, however, that up to now, there has never been a specimen of *Hypsilurus* reported from either of the island groups suggested as Locus typicus. The nearest locality record of a *H.* cf. *godeffroyi* (UP 8532) is situated on Wuvulu Island (135 km west (sic!) of the Ninigo group (Bauer and Watkins–Colwell, 2001).

In their paper on the herpetofauna of the Palau Islands, Crombie and Pregill (1999) report bone findings that could be clearly identified as agamid bones and are possibly assignable to *Hypsilurus godeffroyi* as no other agamid species has been found so far on Palau Islands. Overall, the bones of 11 specimens were found in a cave on Ngeaur Island. The reported snout–vent–length of these agamids varies from 70 mm to 110 mm, and is therefore significantly smaller than those of the type material (SVL 151 mm and 147 mm, respectively).

Distribution.– Altogether the locus typicus as well as the distribution of *H. godeffroyi* remain a mystery. It may well turn out that this species is a true endemic agamid lizard of the Palau Is-

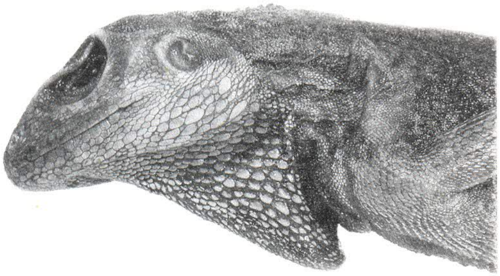

Figure 11. Lectotype (ZMB 5891) of *Hypsilurus godeffroyi* from Palau Islands, Micronesia.

lands or one of the island groups suggested by Bauer and Watkins–Colwell (2001).

Comment.– Several museums list material of *H.* (cf.) *godeffroyi* with the following locality records: West Papua Province, Indonesia: Lorentz River and Alkmaar (ZMA); miscellaneous localities (RMNH, probably all *H. hikidanus* sp. n.); Papua New Guinea: Bougainville (FMNH, BPBM, CAS, probably *H. longii*), New Britain (MCZ, BPBM, probably *H. longii*), North Salomons (MCZ), Morobe Province (MCZ), Western Highlands Province (CAS); Eastern Highlands Province (CAS, BPBM); Chimbu Province (CAS); Western Province (MCZ).

Hypsilurus longii (Macleay, 1877)

Tiaris Longii Macleay, 1877: 103, holotype: R 31935, donated by Mark H. Long, "some part of Northern Queensland" – Locus typicus: North Queensland, Australia.

Hypsilurus macrolepis (not Peters, 1872) Müller, 1885a: 163.

Gonyocephalus godeffroyi (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) Boulenger, 1885 (part.): 296, 1888 (part.): 90, 1890 (part.): 39; Boettger, 1893: 44; de Rooij, 1915 (part.): 112; 1920: 137; Burt and Burt, 1932 (part): 496.

? *Gonycephalus godeffroyi* Parker, 1939: 3.

? *Gonyocephalus Godeffroyi* Werner, 1900: 45 (Stephansort, Astrolabe Bay).

Goniocephalus godeffroyi (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) Loveridge, 1948: 336 (New Britain Archipelago).

Gonocephalus godeffroyi (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) Wermuth, 1967 (part.): 59.

Hypsilurus (*Hypsilurus*) *godeffroyi* (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) Moody, 1980 (part.): 600.

Hypsilurus godeffroyi Shea and Sadlier, 1999: 20.

Diagnosis.– large, robust, long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. Several scales below the tympanum sometimes strongly enlarged; a row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales.

H. longii differs from all other species (with the exception of the variably coloured *schoedei*) by a light V–shaped marking on the nape present in females and young males (vs. absent); additionally from *godeffroyi, papuensis, schoedei* and *schultzewestrumi* by a higher number of scales between enlarged submaxillaries and infralabials 4–5 (vs. 2–3), from *macrolepis* and *schoedei* by a larger SVL, up to 235 mm (vs. < 130 mm), additionally from *schoedei* by a lower number of light bands on the back, 4 (vs. > 4) [if present], from *godeffroyi* by a broader head HW/SVL $\geq$ 0.137 (vs. $\leq$ 0.127) as well as keeled, narrowly spaced or overlapping anterior scales on the gular pouch (vs. smooth, separated), from *schultzewestrumi* by much smaller plates on the sides of the head largest plate significantly < Ø tympanum (vs. $\geq$ Ø tympanum), from *papuensis* by smaller tympani, T/E $\leq$ 1.0 (vs. $\geq$ 1.0) and the absence of a dark spot on either side of the neck (vs. present), from *binotatus* by a clearly visible notch in the vertebral crest near the nape (vs. insignificant indentation or continuous at the same height), from *auritus, geelvinkianus, modestus, nigrigularis* and *bruijnii* by the presence of enlarged scales below the tympanum (vs. absent), from *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.0 (vs. < 2.3).

Description.– SVL males up to 235, females up to 210 mm, both usually < 200 mm; TL/SVL > 3. Head scales small, homogeneous, strongly keeled. Temporal scales slightly enlarged, below the tympanum several scattered enlarged scales often forming 1–2 rows, maxi-

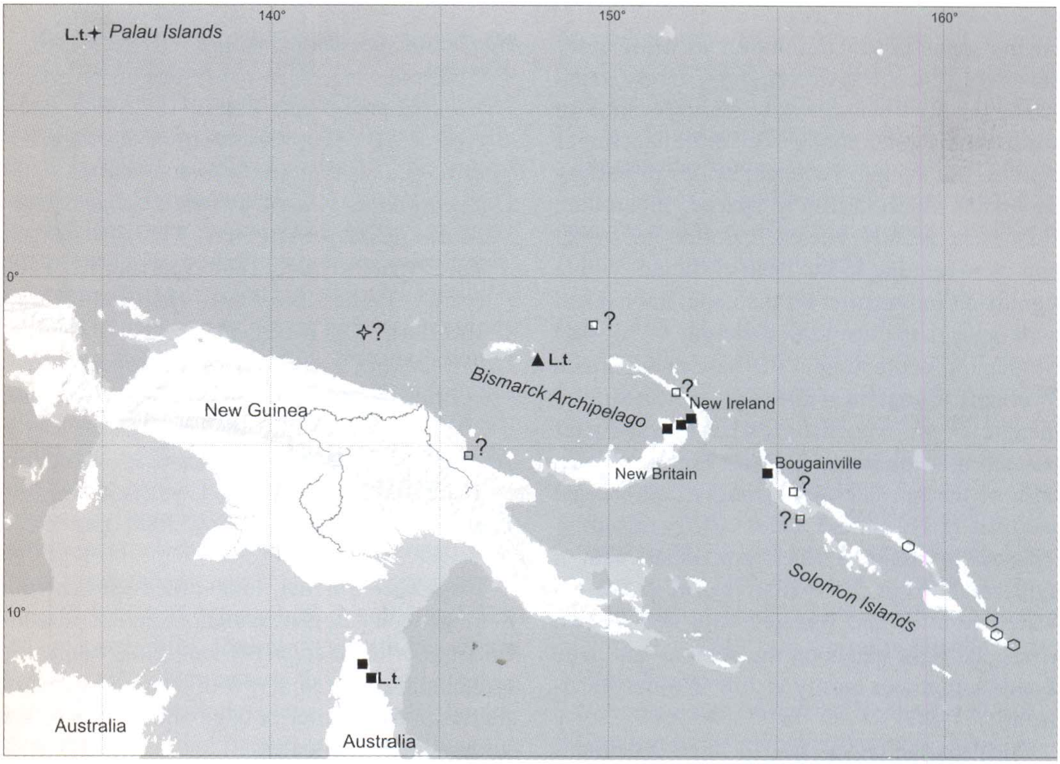

Figure 12. Locality records for *Hypsilurus godeffroyi* (star symbols), *H. schoedei* (triangular symbols), *H. longii* (square symbols), and *H. macrolepis* (hexagonal symbols). Specimens examined (solid symbols) literature records (hollow symbols). Loci typici are marked with L.t.

Figure 13. Holotype (R 31935) of *Hypsilurus longii* from Queensland, Australia.

mum size of the largest scale < Ø tympanum; 10 supralabials, 9 infralabials; from the mental to below the angle of the mouth, a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials maximum 4–5 scales. Gular pouch moderately large (similar to *H. godeffroyi*, but without visible skin between the scales); anterior edge without enlarged scales, a weakly developed saw–toothed edge sometimes visible; large anterior scales

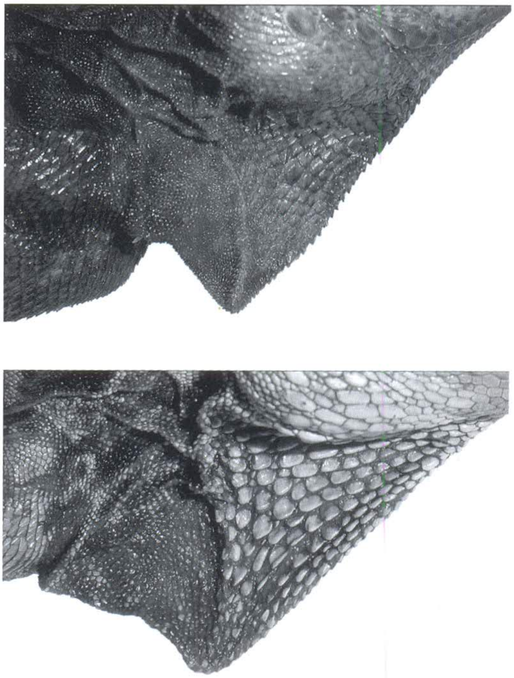

Figure 14. Comparison of gular pouch pholidosis in *H. longii* (above) and *H. godeffroyi* (below).

on the gular pouch rhomboid, in most cases narrowly spaced or overlapping, rarely separated, mainly keeled, rarely smooth; anterior scales on the gular pouch in juvenile specimens convex, not keeled. Posterior scales of the gular pouch small, narrowly spaced, tubercular, smooth or weakly keeled. Continuous vertebral crest running to the base of the tail with a significant indentation on the nape; nuchal sail with lanceolate crest scales (height < = or > Ø tympanum) contacting at the base or separated by minute triangular scales; dorsal crest similar (height < = or > nuchal crest), all crest scales contacting at the base. Dorsals homogeneous. Base of the tail laterally strongly compressed and little raised (in old males clearly raised).

Colour in alcohol.– Back and sides with 4 light bands from the axillar region to the leg base; juveniles and females with one or two V–shaped light bands on the occiput and nape (bands sometimes hardly visible in older specimens).

Variations and comments.– In three specimens from the Bismarck Archipelago (ZMB 28391, three males SVL 195–235 mm) and one specimen from New Britain (ZMB 26657, female SVL 170 mm) nuchal and dorsal crest are comparatively close together and only separated from each other by a few low scales. In one specimen from New Britain a vertical row of enlarged scales below the tympanum extending onto the gular pouch is visible.

In several specimens (ZMB 14599 Ralum, New Britain, ZMB 19898, North Queensland) small supporting scales on either side of the dorsal crest are present; these scales are missing in juveniles.

Distribution.– Queensland Australia; New Britain, Bougainville, Duke of York; New Ireland? and Treasury? (Boulenger, 1885 as *godeffroyi*), Shortland Islands?, New Guinea main island? (see also comment on *H. godeffroyi*).

Comment.– Queensland as Locus typicus is doubted by several authors (e. g., Cogger, 1979). However, the ZMB possesses a second specimen (female ZMB 19898) with exactly this locality record. Queensland can, therefore, no longer be excluded as part of the distribution of this species.

Hypsilurus macrolepis Peters, 1872

Hypsilurus macrolepis Peters, 1872: 775, holotype: ZMB 7510, "Salomon–Inseln", leg. Krefft. – Locus typicus: Solomon Islands.
Gonyocephalus godeffroyi (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) Boulenger, 1885 (part.): 296, 1888 (part.): 90, 1890 (part.): 39; de Rooij, 1915 (part.): 112; Burt and Burt, 1932 (part): 496.
Gonocephalus godeffroyi (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) Wermuth, 1967 (part.): 59; McCoy, 1980 (part.): 13.
Hypsilurus (*Hypsilurus*) *macrolepis* Moody, 1980: 300; Denzer et al., 1997: 322.
Hypsilurus godeffroyi McCoy, 2000 (part.).

Diagnosis.– Smaller, long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. Several scales below the tympanum enlarged; a row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales.

H. macrolepis differs from *godeffroyi, papuensis, schoedei* and *schultzewestrumi* by a higher number of scales between enlarged submaxillaries and infralabials 4 (vs. 2–3), additionally from *godeffroyi* and *schoedei* by mainly or at least at the tip of the gular pouch keeled anterior scales (vs. smooth); additionally from *godeffroyi* by a broader head HW/SVL 0.156 (vs. ≤ 0.127) and a smaller SVL, < 130 mm (vs. > 140 mm), from *schultzewestrumi* by significantly smaller scales below the tympanum, largest scale clearly < Ø tympanum (vs. ≥ Ø tympanum) and from *papuensis* by the absence of a dark spot on either side of the neck; *longii* by a uniform green juvenile colouration (vs. dorsum with light bands, nape with one or two light V–shaped markings; ground colour probably brownish) and a smaller SVL, < 130 mm (vs. > 200 mm); *binotatus* by a discontinuous vertebral crest (vs. continuous); *auritus, geelvinkianus, modestus, nigrigularis* and *bruijnii* by the presence of enlarged scales below the tympanum (vs. absent); *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.5 (vs. < 2.3).

Description.– SVL of males and females on average 120 mm (McCoy, 2000, as *H. godeffroyi*); TL/SVL ≥ 3.5. Temporal scales enlarged, below the tympanum enlarged scales, some slightly more enlarged, maximum size of the largest scale > 1/2 Ø tympanum; 10–12 supra–, 9–11 infralabials; from the mental to below the angle of the mouth, a row of enlarged submaxillaries; between enlarged submaxillaries and infralabials, maximum 4 scales. Gular pouch moderately large; anterior edge without enlarged scales; large anterior scales on the gular pouch rhomboid, narrowly spaced or overlapping, at least at the tip of the pouch clearly keeled, posterior scales on the gular pouch small, narrowly spaced, tubercular, smooth or keeled. Nuchal sail present; nuchal crest well developed with 10–12 lanceolate crest scales contacting at the base (height ≡ Ø tympanum). Nuchal and dorsal crest separated. Dorsal crest with lanceolate scales, decreasing towards the tail. Tail crest in anterior third well developed. Dorsals homogeneous. Tail at the base clearly laterally compressed, not raised.

Colouration (after McCoy, 1980, 2000).– Males with grey green to grey brown dorsal colouration. Area of the hip and anterior part of the tail often mauve. Light transverse bands across the dorsum, becoming more distinct towards the tail where they continue. Throat cream or grey, sometimes with yellow, orange or black dots. Ventral side cream or yellowish, pattern less. Females and juveniles dorsally almost completely brilliant green; sides of the body sometimes with isolated black dots. Ventrally yellow or yellow–green.

Colour of the type in alcohol.– Nape, sides of the neck and throat yellowish; throat without markings. Dorsally blue–grey; with dark grey transverse bands in the posterior third of the body, becoming more distinct towards the tail. Distinct bands – alternating brownish grey and light grey – on the limbs and the tail. Ventrally light grey. Inside of hind limbs speckled black.

Distribution (assumed).– Southern Solomon Islands: Isabel?, Makira and adjacent smaller islands Malaupaina (Olu Malau Ids.), Ugi, Santa Ana and Uki Ni Masi (CAS).

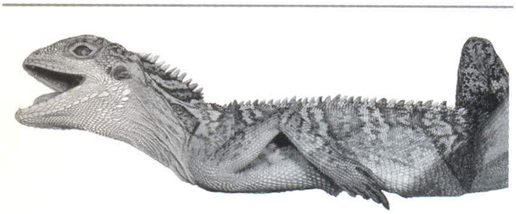

Figure 15. Typical pattern of a young specimen, SVL 125 mm (ZMB 19898) of *H. longii* from Queensland, Australia.

Hypsilurus schoedei (Vogt, 1932)

Gonyocephalus godefroyi (sic!) (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) Vogt, 1912a: 3; de Rooij, 1915 (part.): 112.

Gonyocephalus schoedei Vogt, 1932: 282, syntypes: ZMB 32205, ZMB 54474–500 (formerly ZMB 32205 part.), leg. Schoede, "Insel Lambussu, Neu–Guinea". – Locus typicus: Lambussu Island (= Lambusso = Rambutyo, 2°18'S 147°49'E, Admirality Islands, Papua New Guinea).

? *Gonocephalus godeffroyi* Hediger, 1933: 3.

? *Gonocephalus schoedei* Wermuth, 1967: 61.

Hypsilurus (*Hypsilurus*) *schoedei* Moody, 1980: 300; Denzer et al., 1997: 323.

Diagnosis.– Small, long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. Scales below the tympanum weakly enlarged; a row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales.

H. schoedei is extremely similar to *H. godeffroyi*. *H. schoedei* differs from *godeffroyi* by a nearly homogeneous scalation of the anterior part of the gular pouch; sometimes several scales slightly separated (vs. heterogeneous, almost all scales widely separated) as well as a smaller SVL < 130 mm (vs. > 140 mm); *macrolepis* and *longii* by a lower number of scales between enlarged submaxillaries and infralabials 3 (vs. 4–5) and by smooth, rounded anterior scales on the gular pouch (vs. mainly keeled, acuminate); additionally from *longii* by a smaller SVL < 130 mm (vs. > 200 mm) and a higher number of light bands on the back, 5–10 (vs. 4) [if present]; *binotatus* by a discontinuous vertebral crest (vs. continuous); *schultzewestrumi* by significantly smaller plates on the sides of the head, largest plate clearly < Ø tympanum (vs. ≥ Ø tympa-

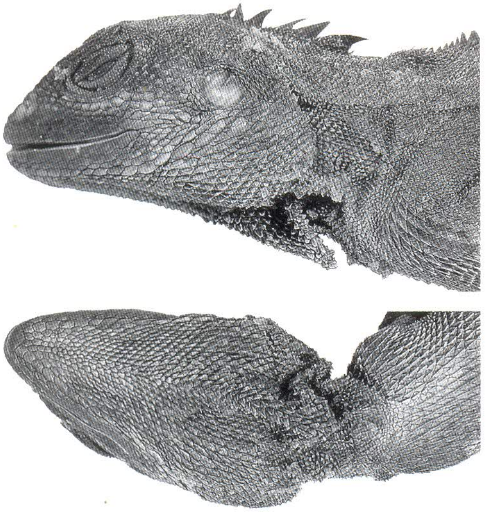

Figure 16. Holotype (ZMB 7510) of *Hypsilurus macrolepis* from the Solomon Islands, without precise locality data.

Figure 17. One of the syntypes (ZMB 54486) of *Hypsilurus schoedei* from Rambutyo, Admirality Islands, Papua New Guinea.

num); *papuensis* by the absence of a dark spot on either side of the neck (vs. present); *auritus, geelvinkianus, modestus, nigrigularis* and *bruijnii* by the presence of enlarged scales below the tympanum (vs. absent); *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.0 (vs. < 2.3).

Description.– SVL in males up to 128, females up to 122 mm, both usually < 120 mm; TL/SVL > 3. Temporal scales enlarged; below the tympanum a large, hardly limited area of weakly enlarged scales, maximum size of the largest scale < or > 1/2 Ø tympanum; 12–14 supra–, 10–12 infralabials; from the mental to below the angle of the mouth a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials maximum 3, in one exception 4 scales. Gular pouch small, anterior edge without enlarged scales; anterior scales on the gular pouch rhomboid, rounded, narrowly spaced, overlapping or weakly separated and intermixed with smooth to convex smaller ones; posterior scales on the gular pouch similar but smaller, nearly granular. Vertebral crest as far as the base of the tail with an indentation near the nape (distance nuchal to dorsal crest 1/4 to 1/1 of the nuchal crest length), with or without nuchal sail; nuchal crest with 8–10 lanceolate scales contacting at the base (height <, = or > Ø tympanum), or separated by minute triangular scales; dorsal crest similar (usually < nuchal crest), with most crest scales contacting at the base. Dorsals homogeneous. Tail with small keeled scales, base of the tail laterally strongly compressed, sometimes weakly raised in the first quarter.

Colouration (in alcohol).– Males dorsally usually uniform brown, sometimes with 5–10 light transverse bands or brown dotting; typically no light bands on the occiput and nape; but sometimes present in several specimens. Ventrally yellowish white. Tail with broad transverse bands. Females dorsally uniform brown, sometimes blue–green, blue or brown with green; ventrally with a lighter colouration.

Distribution.– Apparently known only from its Locus typicus. A further distribution on the adjacent islands such as Manus Island is highly probable.

Hypsilurus binotatus Meyer, 1874

Gonyocephalus (*Hypsilurus*) *binotatus* Meyer in: Peters, 1874: 130, lectotype and paralectotype: lost, fide Obst, 1977, "Jobi", leg. A.B. Meyer – Locus typicus: Ansus, Jobi Island (= Yapen), 1°44'S 135°49'E, West Papua Province, Indonesia.

Gonyocephalus (*Hypsilurus*) *binotatus* Peters and Doria, 1878: 379.

Gonyocephalus binotatus Boulenger, 1885: 295; de Roux, 1910: 215; Vogt, 1911a: 414; de Rooij, 1915 (part.): 110.

Gonocephalus binotatus Wermuth, 1967: 57.
Hypsilurus (*Hypsilurus*) *binotatus* Moody, 1980: 300.

Diagnosis.– Large robust, long–tailed species with homogeneous dorsal scalation and a continuous vertebral crest. Several strongly enlarged scales below the tympanum; a row of enlarged submaxillaries present; upper part of the anterior edge of the gular pouch or with or without enlarged scales.

H. binotatus is similar to *H. papuensis*. *H. binotatus* differs from all other species by a continuous vertebral crest of nearly uniform height (vs. separated near the nape or with distinct indentation), additionally from *papuensis* by smaller tympanum T/E ≤ 1.0 (vs. > 1.0) a base of the tail that is not raised in males (vs. significantly raised); *auritus, geelvinkianus, modestus, nigrigularis* and *bruijnii* by the presence of enlarged scales below the tympanum (vs. absent); *schultzewestrumi* by smaller gulars ≈ Ø tympanum (vs. several scales ≥ Ø tympanum); *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.4 (vs. < 2.3).

Description.– SVL of males up to 195 mm, females up to 157 mm; TL/SVL > 3.4. Temporal scales enlarged; below the tympanum, an area of strongly enlarged scales, maximum size of the largest scale > 1/2 up to ≡ Ø tympanum; 10–12 supra–, 9–11 infralabials; from the mental to below the angle of the mouth, a row of enlarged submaxillaries; between enlarged submaxillaries and infralabials maximum 2–3 scales. Gular pouch moderately large with keeled scales; scale size decreasing slightly towards the chest. Nuchal sail present. Nuchal and dorsal crest continuous with triangular scales. Nuchal crest slightly or clearly higher than dorsal crest. Dorsal crest decreasing towards the tail, again raised slightly at the base of the tail. Dorsals homogeneous. Tail laterally strongly compressed.

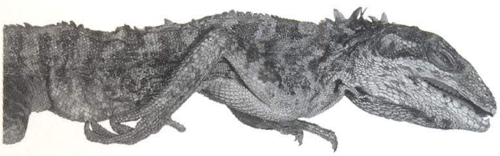

Figure 18. Typical pattern of male *Hypsilurus schoedei*.

Colour in life (after Meyer, 1874).– Dorsally with pink and blue colouring. Dorsum with black dots. Nape and neck with marble pattern. Elongated, oval black bordered spots on either side of the neck. Limbs and tail striped. Ventrally yellowish.

Distribution.– Papua, Province of Indonesia: Aru and Kei Islands, Yapen Island; Vogelkopf; Wondowoi mountains, Wandammen Peninsular (Geelvink Bay); Tami River (2°38' S 140°56'); Papua New Guinea: Veiru, Gulf Province; West and East Sepik Province (BPBM); Western Province (BPBM, CAS, MCZ).

Comment.– The description of the colouration of a specimen from Lorentz River in de Rooij (1915) most probably does not relate to *H. binotatus*. There is, however, a great similarity in the colouration with *H. ornatus*, a species described as new in this paper.

Hypsilurus papuensis papuensis (Macleay, 1877)

Tiaris papuensis Macleay, 1877: 101, holotype: R 31883, "Hall Sound" – Locus typicus: Hall Sound, Central Province, 8°49'S 146°36'E, Papua New Guinea.
Gonyocephalus (*Lophosteus*) *Albertisii* Peters and Doria, 1878: 377, syntypes: ZMB 9722, 9724–25, "Nicora, Nova Guinea austro–orientalis, Insulae Yule opposite", leg. D'Albertis. – Locus typicus: Nicora (= Nikura) opposite Yule Island, 8°48'S 146°37'E (Hall Sound), Central Province, Papua New Guinea.
Gonyocephalus papuensis de Rooij, 1915 (part.): 113 (Yule Island, Nicura).
Gonocephalus papuensis Wermuth, 1967: 61.
Hypsilurus (*Hypsilurus*) *papuensis* Moody, 1980: 300; Denzer et al., 1997: 322.

Diagnosis.– Large, robust, long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. An area of strongly enlarged scales below the tympanum, a row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales. Males with a high tail at base.

Similar to *H. binotatus* (with the exception of the basal part of the tail in males). *H. papuensis* differs from *binotatus* by a vertebral crest indented near the nape (vs. continuous), larger tympani T/E > 1.0 (vs. ≤ 1.0) as well as a strongly raised tail at the base present in males (vs. not raised); *auritus, geelvinkianus, modestus, nigrigularis* and *bruijnii* by the presence of strongly enlarged scales below the tympanum (vs. absent); all other species by the presence of a dark, above and behind brighter limited spot on either side of the neck (vs. absent); additionally from *schultzewestrumi* by smaller gulars, ≈ Ø tympanum (vs. some = ≥ Ø tympanum) and from *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 2.9 (vs. < 2.3).

Description.– SVL males up to 190 mm females 150 mm; TL/SVL ~ 3.0. Head scales small, homogeneous and keeled. Temporal scales enlarged; below the tympanum, an area of strongly enlarged scales, maximum size of the largest scale > 1/2 up to (Ø tympanum; 10–12 supra–, 7–10 infralabials; from the mental to below the angle of the mouth a row of enlarged submaxillaries; between enlarged submaxillaries and infralabials maximum 2–3 scales. Gular pouch moderately large with rhomboid, keeled scales; scales decreasing in size towards the chest. Nuchal sail present. Nuchal and dorsal crest with lanceolate scales (height (Ø tympanum); scales in contact at the base. Nuchal and dorsal crest clearly separated; nuchal crest slightly higher than dorsal crest; the latter insignificantly decreasing caudad and continued on the tail. Keeled dorsals nearly homogeneous, overlapping. Tail in males strongly compressed laterally, with a significantly raised basal part in the anterior third. Scales on the tail strongly keeled.

Colour in life after photographs in Manthey and Schuster (1996, Engl. Ed.: 105 and 108).– Colour change apparently possible. Head grey or grey brown; gular pouch same colour with dark stripes. Colour of neck and dorsum yellow olive or light brown orange or with black interspersions forming a wavy pattern on either side of the dorsal crest. A dark grey brighter bordered spot on either side of the neck, as well as an oblique light grey band running posteriorly from the dorsal crest to the ventral parts of the anterior third of the body. A much less distinct oblique band approximately in the median part of the body. Body laterally uniform dirty yellow or light brown ventrally fading to grey. Limbs brown with a hint of a grey band pattern. Tail with alternating light and dark bands; the width of the dark rings increasing towards the tip of the tail.

Colour in alcohol.– Dorsally dark with brighter spots or light brownish with darker spots; a band pattern across the dorsum is indicated. On both sides of the neck a large dark brown spot bordered by a semicircular broad bright ring. Ventrally dirty white. Gular pouch whitish, with an indistinct striped pattern.

Colouration after Boulenger (1885).– Above whitish, with reddish interspersions and a brown

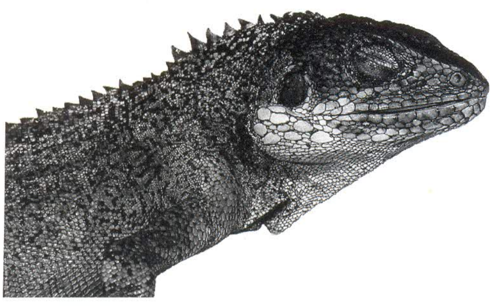

Figure 19. *Hypsilurus binotatus* (RMNH 28957) from Wasior (nearest locality to the Locus typicus of this species present in museum collections, type being lost) on the Geelvink Bay, West Papua Province, Indonesia.

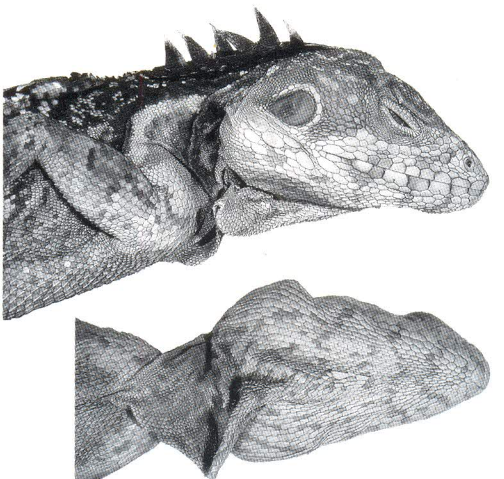

Figure 20. One of the syntypes of *Gonyocephalus* (*Lophosteus*) *Albertisii* Peters and Doria (ZMB 9722, synonymous with *H. p. papuensis*) from Nicora, Hall Sound, Central Province, Papua New Guinea.

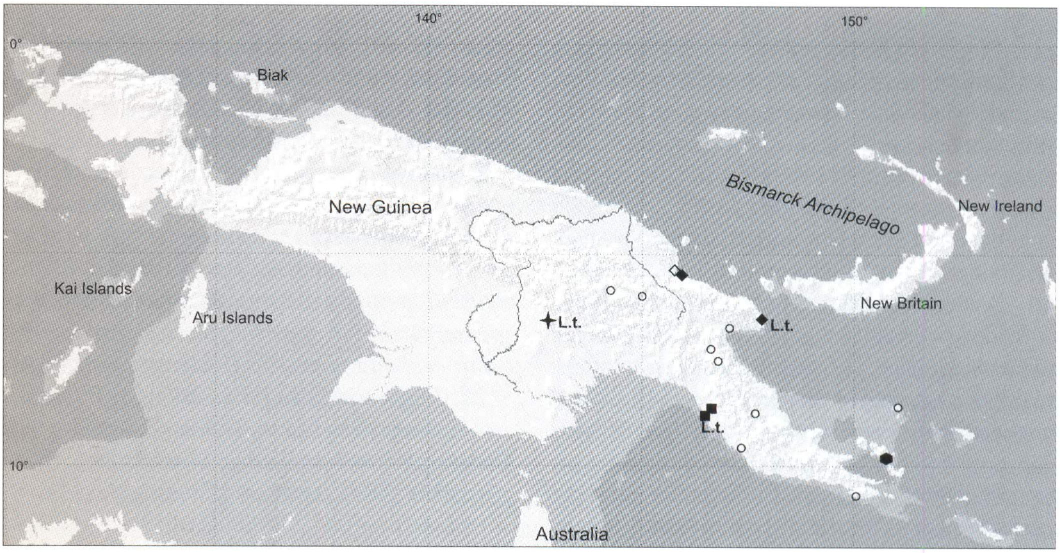

Figure 21. Locality records for *Hypsilurus p. papuensis* (square symbols), *H. p. longicauda* (rhombic symbols), *H. p.* ssp. *A* (hexagonal symbols), *H. papuensis* (circular symbols), and *Hypsilurus ornatus* (star symbols). Specimens examined (solid symbols) literature records (hollow symbols). Loci typici are marked with L.t.

wave pattern. Dorsal part of the nape and spots on either side of the neck brown. Throat with a brown, wide-mesh reticulation.

Distribution.– In the vicinity of the Locus typicus.

A collection consisting of one male and two females from the Sattelberg, Papua New Guinea, agrees in all pholidosis characters with the type material of *H. papuensis* and *H. albertisii* (= *H. papuensis*), but differs significantly with regard to morphometric characters. These specimens will be described in the following as a new subspecies.

Hypsilurus papuensis longicauda ssp. n.

? *Gonyocephalus papuensis* Müller, 1892: 210 (Kaiser–Wilhelmsland); Boettger, 1892: 148 (male, Kaiser–Wilhelmsland).

Gonyocephalus papuensis van Lidth de Jeude, 1896: 249 (Astrolabe Bay); Méhely, 1895: 130 (Astrolabe Bay); Vogt, 1911b: 421 (Sattelberg); de Rooij, 1915 (part.): 113 (Bongu on Astrolabe Bay), Bogadjim on Astrolabe Bay, Sattelberg).

? *Gonocephalus papuensis* Zweifel, 1980: 415 (Huon Peninsula: Lae).

Material examined.– Holotype adult male ZMB 21387, paratypes adult females ZMB 16371 and 16372, all leg. Prof. Dr. Neuhauss; Sattelberg, Kaiser–Wilhelmsland – Locus typicus: Sattelberg (6°29'S 147°47'E), Huon Peninsula, Morobe Province, Papua New Guinea. No paratype adult male RMNH 4356, Astrolabe Bay (5°27'S 145°45'E), Madang Province, Papua New Guinea.

Diagnosis.– Large, robust, long-tailed and long-legged species (SVL of males up to 205, females up to 190 mm; TL/SVL usually > 3.6) with homogeneous dorsal scalation and a discontinuous vertebral crest. Strongly enlarged scales below the tympanum; a row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales.

The subspecies *longicauda* differs from the nominate form by an only moderately raised tail at its base in adult males (height of tail/width of tail < 1.7), decreasing in height slowly behind the first third of the tail [vs. strongly raised (height of tail/width of tail ≥ 1.97), decreasing abruptly], a longer tail TL/SVL > 3.6 (vs. ≤ 3.4) as well as longer legs HBL + FL > 0.831 (vs. < 0.81) and feet FL/SVL > 0.37 (vs. < 0.36).

Description of holotype.– SVL 196 mm; TL/SVL 3.701; HBL + FL/SVL 0.831; FL/SVL 0.37; HW/SVL 0.147; T/E 1.35. Temporal scales enlarged; below the tympanum 7–8 large plates of varying shape and size; largest extension slightly < Ø tympanum. From the mental to below the angle of the mouth, a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials, maximum two scales. Gulars intermixed with few enlarged scales. Gular pouch with two transverse folds; scales on gular pouch anteriorly rhomboid, keeled, overlapping; posterior scales on the gular pouch similar but smaller. Gular pouch without stripes. Nuchal sail present; nuchal crest nearly double as high as the dorsal crest (height (Ø tympanum), clearly separated. Scales of nuchal crest lanceolate to weakly sickle shaped, separated at the base by minute scales; dorsal crest in contact at the base with rather saw–toothed scales; contiguous on the first quarter of the tail. Tail laterally strongly compressed at its base and slightly raised, height decreasing strongly but in a continuous way.

Colour in alcohol.– Upper side of the head and nape brownish, a large dark brown spot on either side of the neck, bordered by a lighter coloured semicircular ring; gular pouch anteriorly uniform cream, posteriorly slightly darker; body beige with darker spots arranged in faint transverse bands; tail in the first quarter clearly banded; ventrally lighter coloured.

Differences between paratype ZMB 16371 and holotype.– SVL 190 mm; TL/SVL 3.631; (HLL + FL)/SVL 0.89; FL/SVL 0.381; HW/SVL 0.137; T/E 1.0. Below the tympanum 4–6 large plates; overall darker coloured; gular pouch anteriorly clearly striped; first quarter of the tail significantly lower; whole tail with bands. The female contained one egg sized 16.2×36.8 mm.

Differences between paratype ZMB 16372 and holotype.– SVL 165 mm; TL/SVL 3.606; (HLL + FL)/SVL 0.861; FL/SVL 0.38; HW/SVL 0.144; T/E 1.2. Below the tympanum 6–7 large scales; gular pouch anteriorly weakly striped; first quarter of the tail significantly lower; approx. the first half of the tail with distinct bands. The female contained a small roundish egg in an early stage.

Comment.– A male specimen (RMNH 4356) from Astrolabe Bay agrees in most characteristics with the holotype but has a shorter tail (TL/SVL 3.25); two additional specimens from the same locality, however, have a significantly longer tail TL/SVL 3.7 (Méhely, 1895) and TL/SVL 3.4 (van Lidth de Jeude, 1896). Therefore we consider the population from Astrolabe Bay as belonging to the new subspecies. Likewise specimens from Lae, Huon Peninsula (Zweifel, 1980) and Bulolo (CAS, 7°12'S 146°39') are most probably assignable to the new subspecies.

Etymology.– Owing to the extraordinary length of the tail we name this subspecies *longicauda* (lat. longus – long; lat. cauda – tail).

Hypsilurus papuensis ssp. A

Gonyocephalus papuensis Boulenger, 1895 (part): 28 (Fergusson Island); de Rooij, 1915 (part.): 113 (Fergusson Island, Trobiand Island).

Goniocephalus papuensis Loveridge, 1948 (part.): 336 (Fergusson Island).

Material examined.– Adult female containing one egg of dimensions ca. 10.5 × 27.5 mm, MCZ R–28660, Fergusson Island, Milne Bay Province, Papua New Guinea.

Diagnosis.– With a SVL of 122 mm *Hypsilurus papuensis* ssp. A is significantly smaller compared to females from the main island (SVL ≥ 150 mm), but similarly long legged (HLL + FL)/SVL 0.892 (vs. ≤ 0.89), FL/SVL 0.401 (vs. ≤ 0.383) and long tailed TL/SVL 3.606 (vs. ≤ 3.701) as *H. papuensis longicauda*. It differs from the nominate form as well as from *longicauda* by a higher number of scales between infralabials and enlarged submaxillaries 4 (vs. 2–3), by a smaller tympanum T/E < 1.0 (vs. = 1.0) and a lower number of plates below the tympanum one (vs. > 3).

Comment.– We prefer not to describe *H. papuensis* ssp. A as a new subspecies because *H. p.*

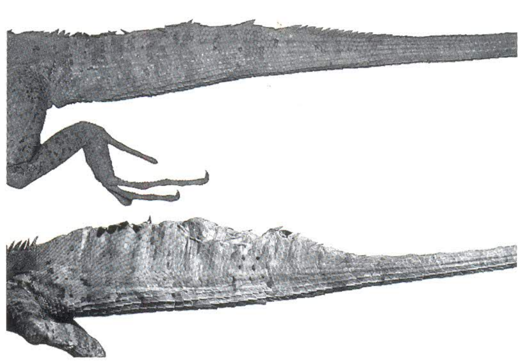

Figure 22. Comparison of tail appearance in males of *Hypsilurus papuensis papuensis* (below) and *H. p. longicauda* ssp. n. (above).

longicauda may turn out to be sufficiently variable to accommodate specimens from Fergusson and Trobiand Islands. The distribution limits of the subspecies described here as *H. p. longicauda* and *H. p.* ssp. A remain uncertain; likewise, where transition forms may occur. Therefore, the large number of specimens in BPBM and in CAS collections from different localities cannot be assigned unambiguously to either of the three possible subspecies as is true for the following publications:

Gonyocephalus papuensis Boulenger, 1885: 297 (Aleya, S. E. New Guinea); Boulenger, 1897: 697 (Gerekanumu, southern slopes of Astrolabe Range; Haveri, in Moroka); de Rooij, 1915 (part.): 113 (Dinawa 1,200 m, Gerekanumu, Haveri, Aleya, Fife Bay); Parker, 1936: 85 (Kokoda 15 miles e. Mt. Victoria).

Goniocephalus papuensis Loveridge, 1948 (part.): 336 (Bulowat, Wau); Forcart, 1953: 65 (Chimbu–Subdistrict 6°S 145°E, Waghi–Tal, approx. 1,700 m asl. 5°45'S 144°20'E to 6°10'S 144°50'E).

Hypsilurus papuensis Schulte et al., 2003: 600 (Wau, Morobe Province).

Hypsilurus schultzewestrumi (Urban, 1999)

Gonocephalus schultzewestrumi Urban, 1999: 185, holotype: ZSM 1965/82, paratype: ZSM 1965/89 both "in der Nähe von Nondugl, Papua–Neu Guinea", leg. T. Schultze-Westrum. – Locus typicus: Near Nondugl (5°52'S, 144°46'E), Western Highlands Province, Papua New Guinea.

Hypsilurus schultzewestrumi Manthey and Denzer, 2000: 15.

Diagnosis.– Medium–sized, slender, long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. Extremely large plates below the tympanum and several extremely large gulars; a row of enlarged submaxillaries present; upper part of the anterior edge of the gular pouch with enlarged scales.

H. schultzewestrumi differs from all other species by the presence of large plates on the sides of the head, maximum size of the largest scale > Ø tympanum (vs. ≤ Ø tympanum), several large gulars ≥ Ø tympanum (vs. ≈ Ø tympanum), as well as a saw–toothed anterior edge of the gular pouch consisting of enlarged scales (vs. anterior edge of the gular pouch smooth); additionally from *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.0 (vs. < 2.3)

Description.– SVL in males up to 166 mm, females up to 121 mm; TL/SVL > 3.0. Head scales small, homogeneous, strongly keeled. Temporal scales enlarged; below the tympanum several large plates, maximum size of the largest scale > Ø tympanum (male ≈ 1.5 ×, female ≡ Ø tympanum); 10–11 supra–, 10 infralabials; from the mental to below the angle of the mouth a row of enlarged submaxillaries; between enlarged submaxillaries and infralabials maximum 3 scales; gular pouch small; upper edge with enlarged scales forming a saw–tooth pattern, anterior scales large, rhomboid, overlapping, smooth; posterior scales on the gular pouch small, tubercular. Gular region with heterogeneous scalation and covered with several large, rounded, smooth plates; maximum size of the largest scale > Ø tympanum (male) slightly < Ø tympanum (female). Nuchal sail present; scales of the nuchal crest lanceolate in contact at the base, continuing without interruption but clear indentation as dorsal crest of approx. half the height. Dorsal crest with lanceolate to saw–toothed scales, decreasing slightly towards the tail and continued on the basal part of the tail (approx. first third). Homogeneous dorsals comparatively large, strongly keeled. Tail laterally compressed, with keeled scales.

Colour in alcohol (after Urban, 1999).– Dorsally uniform grey blue, ventrally whitish. Plates clearly distinct.

Variations.– Two specimens imported for husbandry (adult male ZSM 39/1990/1, adult female ZMB 53291), presumably from Papua, Province of Indonesia, agree in their pholidosis with the above description and are, therefore, tentatively identified as *schultzewestrumi.* Their gulars as well as their plates below the tympanum are slightly smaller, additionally their heads are broader and their tail slightly shorter. We consider two specimens as conspecific with *schultzewestrumi* depicted on photographs from

Figure 23. *Hypsilurus papuensis* ssp. A (MCZ R-28660) from Fergusson Island, Milne Bay Province, Papua New Guinea.

Dogobak, Baliem, West Papua, Province of Indonesia.

Colour in life after photographs of a pair from Dogobak (1,700 m), Baliem (ca. 4° 25'S; 138° 59'E), Papua, Province of Indonesia: Colour of head, upper part of the body and tail yellow brown (female) to dark grey (male). Dorsum with 4 more or less distinct mauve (male) or yellowish transverse bands. Enlarged temporal scales and scales below the tympanum, as well as labials, dirty white, light grey and yellowish (male) or whitish and yellow (female) and clearly distinct from the remaining parts of the head. Sides of the neck with a large dark spot. Gular pouch anteriorly near the enlarged scales whitish, posteriorly dark grey with dirty orange inclusions (male) or brownish with yellowish inclusions (female). Limbs and tail correspond to dorsal colouration; but limbs with faint indistinct bands.

Distribution.– Papua New Guinea and probably West Papua Province, Indonesia.

Hypsilurus boydii (Macleay, 1884)

Tiaris boydii Macleay, 1884: 432, syntypes: R 31884–85 – Locus typicus: Herbert River, Qld.
Gonyocephalus boydii Boulenger, 1885: 297.
Gonocephalus boydii Wermuth, 1967: 57.
Hypsilurus (*Hypsilurus*) *boydii* Moody, 1980: 300.
Hypsilurus boydii Ananjeva and Matveyeva–Dujsebayeva, 1996: 86; Schulte et al., 2003: 600.

Diagnosis.– Medium–sized, short tailed species with heterogeneous dorsal scalation and a discontinuous vertebral crest. Several enlarged plates and large conical scales next to the tympanum; no row of enlarged submaxillaries; anterior edge of the gular pouch with enlarged, triangular scales.

H. boydii differs from *dilophus* and *spinipes* by the presence of plates and conical scales below the tympanum; all other species by a heterogeneous dorsal scalation.

Short description.– SVL up to 150 mm; TL/SVL < 2.0. Large plates below the tympanum; large conical scales near the chin joint. Gular pouch medium large with small scales. Scales at the edge of the gular pouch larger anteriorly, triangular, arranged as saw–tooth. Nuchal crest on a distinct nuchal sail, with triangular crest scales; nuchal and dorsal crest separated. Dorsal crest with triangular scales, slightly bend to the back running up to the tail. Dorsals small, intermixed with enlarged scales particularly on the sides. Ventrals larger than dorsals, strongly keeled.

Colouration variable. Usually olive to chocolate brown with a black spot on the nape. Plates and conical scales white; gular pouch orange brown; tail with brown–whitish bands.

Distribu;tion.– Rainforest areas of Northeast Queensland, Australia

Hypsilurus spinipes (A. Duméril, 1851)

Lophyrus spinipes A. Duméril in: C. Duméril and A. Duméril, 1851: 90 – Locus typicus: "Nouvelle–Hollande" (= Australia).
Gonyocephalus spinipes Boulenger, 1885: 292.
Gonocephalus spinipes Wermuth, 1967: 62.
Hypsilurus (*Hypsilurus*) *spinipes* Moody, 1980: 300.
Hypsilurus spinipes Ananjeva and Matveyeva–Dujsebayeva, 1996: 86.

Diagnosis.– Small, short tailed species with heterogeneous dorsal scalation and a discontinuous vertebral crest. No enlarged scales below the tympanum; no row of enlarged submaxillaries; anterior edge of the gular pouch with weakly enlarged scales.

H. spinipes differs from *boydii* by the absence of plates and conical scales below the tympanum (vs. present); *dilophus* by the form of nuchal and dorsal crest (triangular spiny scales vs. lanceolate); all other species by a heterogeneous dorsal scalation.

Short description.– SVL up to 115 mm; TL/SVL < 2.3. Head scales small with several enlarged tubercular scales behind the tympanum. Gular pouch with small keeled scales, intermixed with some enlarged tubercular scales and a saw–toothed edge. Nuchal sail with nearly triangular spiny scales. Nuchal and dorsal crest clearly separated. Scales of the dorsal crest increasing in size towards the middle of the back, then decreasing and continuing as tail crest. Dorsals heterogeneous and small intermixed with several strongly keeled and enlarged scales, sometimes forming transverse rows on the flanks. Limbs with keeled scales; several limb scales strongly enlarged and spiny.

Colouration variable. Basic colour rusty red to light brown, sometimes with darker spots or reticulation. Throat and venter dirty white.

Distribution.– Rainforest areas of Southeast Queensland and north-eastern parts of New South Wales, Australia.

Hypsilurus dilophus (Duméril and Bibron, 1837).

Lophyrus dilophus (*Tiaris dilophus*) Duméril and Bibron, 1837: 419 – Locus typicus: "Nouvelle–Guinée" (= New Guinea).
Tiare dilophe Duméril and Bibron, 1837: 421.
Tiaris dilophus Duméril and Bibron, 1837: Atlas Pl. 46.
Tiaris megapogon Gray, 1845: 239 – Locus typicus: New Guinea (Syn. fide Boulenger, 1885).
Gonyocephalus (*Tiaris*) *dilophus* Peters and Doria, 1878: 376.
Gonyocephalus dilophus Boulenger, 1885: 290, 1895: 28, 1897: 697; Lönnberg, 1900: 576; de Rooij, 1909: 37; de Roux, 1910: 215; Vogt, 1911a: 414; Barbour, 1912: 86; Boulenger, 1914: 256; de Rooij, 1915: 108, 1919; de Jong, 1927: 310; Brongersma, 1930: 13; Vogt, 1932: 282; Brongersma, 1933: 25; Parker, 1936: 85.
Goniocephalus dilophus Meyer, 1886/87: 5; Loveridge, 1948: 336.
Gonocephalus dilophus Wermuth, 1967: 58.
Hypsilurus (*Hypsilurus*) *dilophus* Moody, 1980: 300.
Hypsilurus dilophus Macey et al., 2000: 241.

Diagnosis.– Large, short tailed species with heterogeneous dorsal scalation and a discontinuous vertebral crest. Several weakly enlarged scales below the tympanum; a row of enlarged submaxillaries present; anterior edge of the gular pouch with large lanceolate scales.

H. dilophus differs from *boydii* by the absence of large conical scales below the tympanum (vs. present); *spinipes* by lanceolate scales of the nuchal and dorsal crests (vs. triangular); all other species by a heterogeneous (vs. homogeneous) dorsal scalation.

Short description.– SVL up to 220 mm (de Rooij, 1915); TL/SVL < 2.0. Upper head scales small, homogeneous, keeled; several enlarged scales on the occiput. Temporal scales and scales below the eye significantly larger; below the tympanum several enlarged scales, but no plates. 11 supra– and 11 infralabials. Isolated enlarged submaxillaries. Gular pouch large reaching onto the chest. Scalation of the gular pouch heterogeneous; scale size decreasing from the edge towards the throat; scales at the upper edge triangular to lanceolate. Nuchal sail with elongated enlarged scales. Nuchal crest with long lanceolate scales. Nuchal and dorsal crest separated; with long lanceolate scales, decreasing towards the tail. Tail crest present. Dorsals small, keeled, intermixed with enlarged scales, sometimes forming longitudinal lines. Ventral scales larger dorsals; strongly keeled. Tail laterally compressed, with strongly keeled scales.

Colour in life.– Highly variable, from olive green or yellowish brown colourations to completely black coloured specimens. Colour of head sometimes in orange nuances with conspicuous red rings around the eye. Throat whitish with dark marble pattern.

Distribution.– New Guinea, from the Western most to the most Eastern parts of the island, additionally on the islands (from West to East). Batanta, Salawati, Kei Islands, Aru Islands, Numfoor, Yapen, all from West Papua Province, Indonesia; Fergusson, Papua New Guinea.

Comment.– Nicolai Orlov provided a photograph depicting a *Hypsilurus* species from Su-

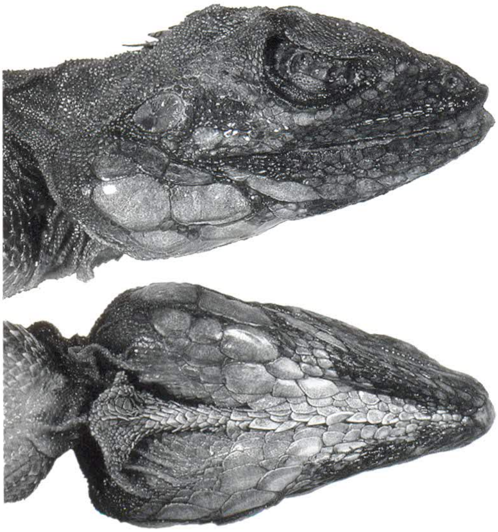

Figure 24. Holotype of *Hypsilurus schultzewestrumi* (ZSM 1965/82) from the vicinity of Nondugl, Western Highlands Province, Papua New Guinea.

lawesi extremely similar to *H. dilophus*, and possibly even conspecific.

Description of new species.– Comparison of the examined material with the type material available revealed that several specimens were not conspecific with any of the known species of *Hypsilurus* and is, therefore, described as new.

Hypsilurus magnus sp. nov.

Gonyocephalus godeffroyi (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) de Rooij, 1909: 377.

Gonyocephalus nigrigularis (not *Gonyocephalus* (*Hypsilurus*) *nigrigularis* Meyer, 1874) Boulenger. 1914: 255, Pl. XXVIII, Fig. 4; de Rooij, 1915 (part.): 111, 1919; 1920: 137; de Jong, 1927: 310.

Gonocephalus nigrigularis (not *Gonyocephalus* (*Hypsilurus*) *nigrigularis* Meyer, 1874) Urban, 1977: 75, 110 Fig. 18 and 19.

? *Hypsilurus nigrigularis* Schulte et al., 2003: 600 (c. 2000 m., c. 10 km NW Simbai, Kaironk Village, Madang Province, Papua New Guinea).

Material examined.– Holotype: adult male RMNH 29093, Gariau aan het Jamoer meer (Gariau near Lake Jamur, 3°42'S 134°56'E); Paratypes: adult female RMNH 28983, Kampong Goreda aan het Jamoer meer (Village Goreda, Lake Jamur, 3° 39'S; 134° 58'E); adult male RMNH 4621, Moais, Ned. N. Guinea (= Moaif?, 2° 21'S; 140° 03'E); no type RMNH 28984, between Siromi and Sidate (2° 18'S; 137°E), all from West Papua Province, Indonesia.

Diagnosis.– Large, long–tailed species (SVL males up to 232, females up to 184 mm [Urban, 1977 as *nigrigularis*]; TL/SL > 2.8) with homogeneous dorsal scalation and a discontinuous vertebral crest. Scales below the tympanum weakly enlarged, at the angle of the mouth sometimes several more enlarged scales; a row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales.

Hypsilurus magnus differs from *H. bruijnii* by a higher number of scales between enlarged submaxillaries and infralabials 4 (vs. 3) as well as a SVL up to 232 mm (vs. 143 mm) and differing colouration in alcohol (greenish grey without or with darker dorsal bands, each enclosing a light band vs. reddish brown without clear bands); *H. modestus* by the presence of a dorsal crest (vs. absent); *H. auritus, geelvinkianus* und *nigrigularis* by the presence of a row of enlarged submaxillaries, a small gular pouch with rounded base near the clavicular region (vs. large with acute base on the chest) as well as a differing gular pouch scalation, anterior half with large scale, posterior with small scales (vs. complete gular pouch with equally sized scales); *godeffroyi* and *schoedei* by a higher number of scales between enlarged submaxillaries and infralabials 4 (vs. 3) and a smaller tympanum T/E < 0.76 (vs. > 0.80), additionally from *godeffroyi* by narrowly spaced and overlapping anterior scales on the gular pouch (vs. widely spaced), a shorter tail TL/SVL < 3.1 (vs. > 3.3), as well as a broader head HW/SVL > 0.145 (vs. < 0.128) and from *schoedei* by a significantly larger SVL up to 232 mm (vs. < 130); *longii* by smooth anterior scales on the gular pouch (vs. keeled) and in females as well as younger males an absent V–shaped marking on the nape (vs. present); *macrolepis* by a shorter tail, TL/SVL < 3.1 (vs. > 3.5), a smaller tympanum T/E < 0.76 (vs. > 0.80) and a significantly larger SVL, up to 232 mm (vs. < 130); *binotatus* by a discontinuous vertebral crest on the nape (vs. continuous); *papuensis* by the absence of dark spots on either side of the neck surrounded by a lighter colour above and behind (vs. present); *schultzewestrumi* by the absence of extremely large plates on the sides of the head (vs. present) and by smaller gular scales ≈ Ø tympanum (vs. several ≥ Ø tympanum) and *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.2 (vs. < 2.3).

Description of holotype.– SVL 210 mm, TL 645 mm; TL/SVL 3.091; (HLL + FL)/SVL 0.834; FL/SVL 0.368; HW/SVL 0.170; T/E > 0.72. Temporal scales enlarged; below the tympanum a large an indistinctly limited area of weakly enlarged scales, sometimes also several more enlarged scales, maximum size of the largest scale < maximum size tympanum. 10 supra–, 8 infralabials; from the mental to below the angle of the mouth, a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials 4 scales. Gular pouch small, anterior edge without enlarged scales; anterior scales on the gular pouch rhomboid, smooth and overlapping; posterior scales on the gular pouch smaller, granular to tubercular. Vertebral crest continuous with a clear indentation on the nape (distance between nuchal and dorsal crest approx. 1/3 of the nuchal crest length) continued to the base of the tail (rarely vertebral crest discontinuous on the nape); nuchal sail with erect lanceolate scales, separated at the base by minute triangular crest scales (height ≡ Ø tympanum); dorsal crest scales in contact at the base directed backwards (caudad) developing into saw–toothed shaped scales in posterior half of the body. Dorsals homogeneous. Base of tail laterally strongly compressed.

Colour (in alcohol).– Dorsum uniformly dark grey–green; with hardly visible light bands on the back. Posterior part of the gular pouch and ventrolateral parts of the neck black. Ventrally brownish.

Differences between the paratype RMNH 28983 and the holotype.– SVL 180 mm, TL 515 mm; TL/SVL 2.86; (HLL+FL)/SVL 0.719; FL/SVL 0.295; HW/SVL 0.148; T/E > 0.69. 10 supra–, 9 infralabials. Distance between nuchal and dorsal crest approx. 1/1 of the nuchal crest length; no nuchal sail.

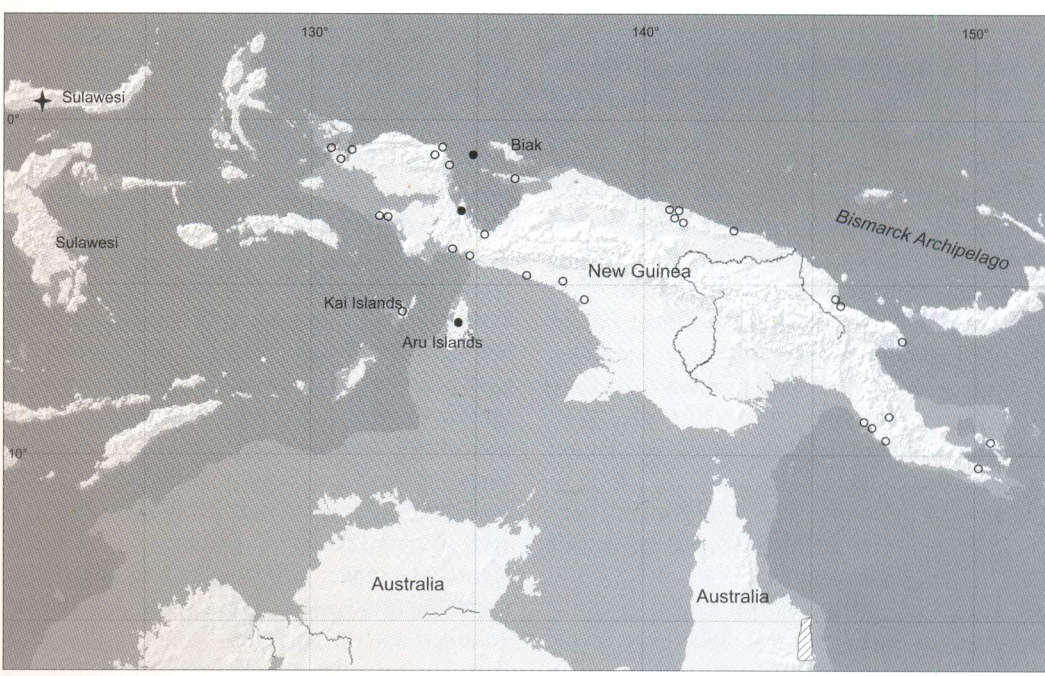

Figure 25. Localities of record for *Hypsilurus boydii* (striped area) and *H. dilophus* (circular symbols). The star symbol represents a photographic record of cf. *H. dilophus*. Specimens examined (solid symbols), literature records (hollow symbols).

Differences between the paratype RMNH 4621 and the holotype: SVL 223 mm, TL (tail broken); (HLL+FL)/SVL 0.813; FL/SVL 0.355; HW/SVL 0.174; T/E > 0.75. 11 supra–, 8 infralabials. Distance between nuchal and dorsal crest approx. 1/4 of the nuchal crest length. The maximum number of scales between enlarged submaxillaries and infralabials differs depending on which side of the gular region is considered and is 3 and 4, respectively.

Etymology.– Owing to its large size, we name this species *Hypsilurus magnus* (lat. *magnus* – large).

Distribution.– Papua, Province of Indonesia and probably also Papua New Guinea (see also comment on *H. nigrigularis*).

Comment.– Boulenger (1914) erroneously described several specimens from Mimika River and Setekwa River, Papua, Province of Indonesia, as *H. nigrigularis* and depicted a detailed drawing of one of the specimens. Presumably all later determination of *H. nigrigularis* relate to this paper, and not to the original description by Meyer (1874). We consider Boulenger's material conspecific with *H. magnus*.

Hypsilurus hikidanus sp. n.

Gonocephalus godeffroyi (not *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867) Urban, 1977: 76, 116 Fig. 20, 21.

Material examined.– holotype: adult male RMNH 28905, Enarotali, Wisselmeren (3°55'S, 136°21'E); paratype: adult female RMNH 29080 Tigi meer (4°03'S, 136°12'E), all West Papua Province, Indonesia; adult female ZSM 39/1990/2 (imported for commerce, without locality); additional material: female RMNH 29081 Tigi meer; young male RMNH 28934 Araboe, Ara–river, Wisselmeren; all West Papua Province, Indonesia.

Diagnosis.– Medium sized, long–tailed species (SVL males up to 158, females up to 120 mm [Urban, 1977 as *godeffroyi*]); TL/SVL > 2.9) with homogeneous dorsal scalation and a discontinuous vertebral crest. With or without weakly enlarged scales below the tympanum; a row of enlarged submaxillaries present; anterior edge of the gular pouch with enlarged scales.

H. hikidanus differs from *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 2.9 (vs. < 2.3); all other species with the exception of *schultzewestrumi* by significantly enlarged scales along the anterior edge of the gular pouch and from *schultzewestrumi* by smaller plates at the sides of the head (if present usually only near the angle of the mouth), largest extension < Ø tympanum (vs. present, largest extension > Ø tympanum); additionally from *godeffroyi* by a broader head HW/SVL > 0.131 (vs. < 0.128), a higher nuchal crest > Ø tympanum (vs. < 1/2 Ø tympanum), as well as not having the base of the tail raised (vs. raised); *auritus, geelvinkianus* and *nigrigularis* by the presence of a row of enlarged submaxillaries (vs. absent) as well as a rounded base of gular pouch approximately near the clavicular region (vs. acuminate on chest); *modestus* the presence of a dorsal crest (vs. absent); *macrolepis* and *longii* by a lower number of scales between enlarged submaxillaries and infralabials, 3 (vs. 4–5) as well as smooth scales on the anterior part of the gular pouch (vs. keeled); *schoedei* by shorter legs HBL/SVL < 0.45 (vs. > 0.46); *binotatus* by a discontinuous vertebral crest on the nape (vs. continuous); *bruijnii* and *papuensis* by a larger tympanum, T/E > 0.73 (vs. < 0.73).

Description of holotype.– SVL 147 mm; TL/SVL 3.333; (HLL + FL)/SVL 0.833; FL/SVL 0.391; HW/SVL 0.175; T/E 1.093. Temporal scales enlarged; below the tympanum, a large area of weakly enlarged scales, additionally near the angle of the mouth and below, three large plate-like scales of different size and shape; largest extension < Ø tympanum. From the mental to below the angle of the mouth a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials, maximum three scales. Gulars differing in size and shape, smooth overlapping, rounded or slightly acuminate. Anterior part of the gular pouch with smooth, overlapping rounded and slightly acuminate scales differing in size and shape; upper anterior edge of the gular pouch with enlarged scales, posterior scales on the gular pouch nearly homogeneous and significantly smaller. Low nuchal sail present; nuchal crest significantly higher than dorsal crest (height

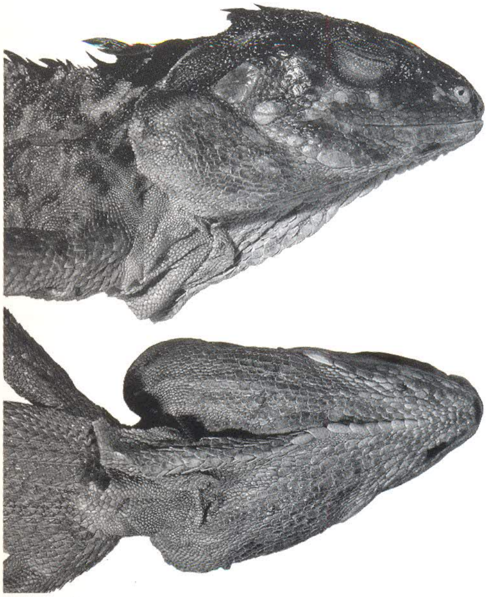

Figure 26. Holotype of *Hypsilurus hikidanus* sp. n. (RMNH 28905) from Enarotali, Papua, Province of Indonesia.

slightly < Ø tympanum); nuchal and dorsal crest separated by an indentation, nuchal crest scales in contact at the base, lanceolate to weakly sickle shaped and slightly pointing backwards; scales of the dorsal crest in contact at the base, lanceolate slightly pointing backwards, height nearly constant until the base of the tail, continuing on the first quarter of the tail as a saw–toothed crest. Tail laterally compressed at the base.

Colour (in alcohol).– Upper side of the head brown mottled irregularly with light brown spots; gular pouch and lower parts of the head beige to grey blue; tail with indistinct bands; ventrally uniform light brown.

Differences between the paratype RMNH 29080 and holotype.– SVL 118 mm; TL/SVL 3.169; (HLL + FL)/SVL 0.788; FL/SVL 0.391; HW/SVL 0.135; T/E 0.9. Below the tympanum only two large plates; height of the dorsal crest slightly decreasing towards the tail, continuing weakly raised on the first fifth of the tail. Brown colouration often with a reddish touch.

Differences between the paratype ZSM 39/1990/2 and holotype.– SVL 139 mm; TL/SVL 3.143; (HLL + FL)/SVL 0.807; FL/SVL 0.387; HW/SVL 0.171; T/E 0.87. Below the tympanum 2–3 large plates, largest extension = Ø tympanum; dorsal crest developed clearly only in the first third of the body, followed by an obvious saw–toothed ridge, continuing on the first fifth of the tail as a saw–toothed edge. Upper parts of the body brown with a few grey inclusions near the nape; ventrally light brownish to grey blue.

Distribution.– Papua, Province of Indonesia.

Etymology.– This species is dedicated to Tsutomu Hikida, of the Department of Zoology, Faculty of Science, Kyoto University, for his important contributions on the *Gonocephalus*/*Hypsilurus*–complex and who kindly made necessary morphological data and photographs of the type specimen of *H. bruijnii* available to us.

Hypsilurus tenuicephalus sp. n.

Material examined.– Holotype: adult male MTKD D 30608, Locus typicus: Reportedly from the highlands of Western Papua, Province of Indonesia; imported for commerce.

Diagnosis.– Medium–sized, slender, narrow headed and long–tailed species with homogeneous dorsal scalation and a discontinuous vertebral crest. Weakly enlarged scales below the tympanum; a short row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales.

Hypsilurus tenuicephalus differs from all other species by a slender head, HW/SVL < 0.115 (vs. > 0.124); additionally from *H. auritus, geelvinkianus* and *nigrigularis* by a rounded base of gular pouch approximately near the clavicular region (vs. acuminate base on the chest) and a lower number of enlarged scales below the tympanum (vs. absent or numerous and forming an oval ring), additionally from *H. auritus* and *nigrigularis* by keeled scales on the gular pouch (vs. smooth to convex); *H. modestus* by the presence of a dorsal crest (vs. absent); *H. binotatus* by an indented vertebral crest (vs. continuous), less clearly enlarged scales below the tympanum, largest extension < 1/2 Ø tympanum (vs. > 1/2 Ø tympanum), a longer tail, TL/SVL > 3.7 (vs. < 3.6) and a larger tympanum, T/E > 1.15 (vs. ≤ 1.0); *H. bruijnii, godeffroyi, schoedei, schultzewestrumi* and *hikidanus* by keeled scales on the gular pouch (vs. smooth); *H. papuensis*, *macrolepis* and *longii* by a shortened row of enlarged submaxillaries running form the mental region, approximately to middle of the snout (vs. at least to the angle of the mouth); *H. boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 3.7 (vs. < 2.3)

Description of holotype.– SVL 151 mm; TL/SVL 3.741; (HLL + FL)/SVL 0.894; FL/SVL 0.417; HW/SVL 0.112; T/E 1.16. Temporal scales enlarged; below the tympanum a large area of weakly enlarged scales; two elongated, weakly enlarged scales directly below the tympanum; largest extension < 1/2 Ø tympanum. From the mental approximately to the middle of the snout a row of enlarged submaxillaries, between enlarged submaxillaries and infralabials maximum 2–3 scales. Anterior part of the gular pouch with keeled, rhomboid scales arranged side by side; posterior scales on the gular pouch similar, but slightly smaller than anterior scales. A low nuchal crest, approx. same height as the dorsal crest (height < 1/2 Ø tympanum); nuchal and dorsal crest separated by an indentation of 9 low scales; triangular, slightly backwards directed nuchal crest scales weakly separated; dorsal crest consisting of saw–toothed scales in contact at the base and continuing with approx. the same height on the first quarter of the tail. Tail laterally compressed at its base.

Colouration (in alcohol).– Anterior part of the body including the head dorsally uniform dirty greenish dark brown, posterior part of the body light brownish with several dark brown coloured scales, forming indistinct transverse bands; upper side of the limbs similarly coloured; upper side of the tail in the same colouration but with distinct bands; sides of the head, throat and not striped gular pouch light brownish sometimes with a reddish touch; sides of the neck with a large but not clearly limited dark spot; remaining parts of the body light brown with irregularly distributed dark scales.

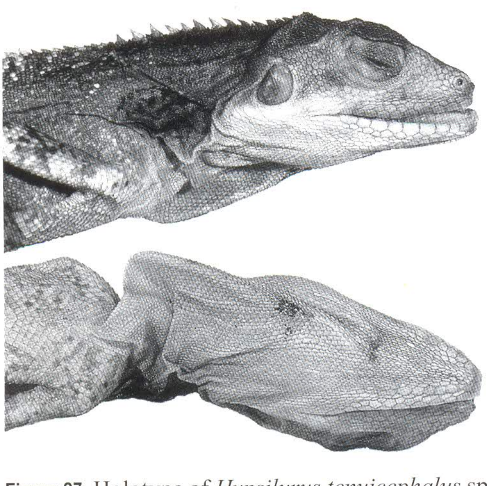

Figure 27. Holotype of *Hypsilurus tenuicephalus* sp. n. (MTKD D30608).

Etymology.– Owing to its elongated, slender head we name this species *tenuicephalus* (lat. tenuis – slim, slender; gr. cephal – head).

Hypsilurus ornatus sp. n.

Material examined.– Holotype: adult female ZSM 122/1979; Locus typicus: Village Didessa, Mt. Bosavi (6°35'S 142°50'E), Southern Highlands Province; Papua New Guinea; leg. Schultze–Westrum.

Diagnosis.– Medium sized, robust, long–tailed species with homogeneous dorsal scalation and a nearly continuous vertebral crest. A strongly enlarged plate below the tympanum, as well as a less strongly enlarged scales near the angle of the mouth; a row of enlarged submaxillaries present; anterior edge of the gular pouch without enlarged scales.

Hypsilurus ornatus similar to *H. binotatus* and *H. tenuicephalus,* as well as *H. papuensis. Hypsilurus ornatus* differs from *binotatus* and *tenuicephalus* in showing a broader head HW/SVL 0.155 (vs. < 0.143), HW/HL 0.611 (vs. < 0.592), as well as the presence of dorsal bands (vs. absent); additionally from *binotatus* by a larger tympanum, T/E 1.15 (vs. ≤ 1.0) and from *tenuicephalus* by a nearly continuous vertebral crest (vs. with clear indentation near the nape); papuensis by a nearly continuous vertebral crest (vs. clearly discontinuous near the nape), additionally from *p. papuensis* and *p. longicauda* by a larger number of scales between infralabials and the row of enlarged submaxillaries 4 (vs. 2–3), as well as by the presence of only one plate below the tympanum (vs. > 3) and from *papuensis* ssp. A by a broader head HW/SVL 0.155 (vs. < 0.14), HW/HL 0.611 (vs. < 0.57) and by a larger tympanum T/E > 1.1 (vs. < 1.0); *auritus, geelvinkianus, modestus, nigrigularis, magnus* and *bruijnii* by the presence of a plate below the tympanum (vs. absent) and additionally from *auritus, geelvinkianus*, and *nigrigularis* by the presence of enlarged submaxillaries (vs. absent); *schultzewestrumi* and *hikidanus* by a smooth anterior edge of the gular pouch without enlarged scales (vs. saw–toothed edge with enlarged scales), as well as from *schultzewestrumi* by the absence of strongly enlarged gulars (vs. present) and significantly smaller plates below the tympanum; *godeffroyi, macrolepis, longii* and *schoedei* by a single isolated enlarged scale below the tympanum (vs. an indistinctly limited area of several or numerous enlarged scales); *boydii, spinipes* and *dilophus* by a homogeneous dorsal scalation (vs. heterogeneous) and a longer tail TL/SVL > 2.9 (vs. < 2.3).

Description of holotype.– SVL 155 mm; TL/SVL 3.612; (HLL + FL)/SVL 0.88; FL/SVL 0.394; HW/SVL 0.155; T/E 1.15. Enlarged temporal scales; a plate (maximum extension slightly < Ø tympanum) below the tympanum; 11 supra–, 9 infralabials. From the mental to below the angle of the mouth, a row of enlarged submaxillaries; between enlarged submaxillaries and infralabials, maximum four scales. Gular pouch moderately large; anterior scales rhomboid, keeled; posterior scales on the gular pouch slightly smaller. No saw–toothed edge along the gular pouch. A low nuchal sail present; nuchal crest with triangular scales (height ≈ 1/2 Ø tympanum) in contact at the base and separated by a minute scale from each other. Dorsal crest separated by two insignificantly lower scales from a slightly higher nuchal crest; dorsal crest initially with similar continuously decreasing scales, approximately from the middle of the body only developed as saw–toothed scales. Dorsals homogeneous. Tail laterally moderately compressed.

Colour in alcohol.– Back and sides with three alternating light/dark bands (light bands reddish brown, dark bands dark brown); each band mottled with spots sometimes blending into each other. Gular pouch light reddish brown with dark reddish brown striped pattern. Ventrally dirty beige with several dark coloured scales. Sides of the neck with a large black spot, embedding smaller light brown, reddish and dark brown spots. The complete spot from the occiput to the base of the forelimbs bordered by a broad, semicircular reddish brown ring, embedding large dark brown dots.

Figure 28. Holotype of *Hypsilurus ornatus* sp. n. (ZSM 122/1979) from the Village Didessa, Mt. Bosavi, Southern Highlands Province, Papua New Guinea.

Distribution.– Known only from the type locality.

Etymology.– The species name *ornatus* (lat. adorned, decorated) relates to the conspicuous colourful spot on the sides.

KEY OF THE SPECIES OF THE GENUS *HYPSILURUS*

1. Dorsal scales small and homogeneous, TL/SVL > 2.3 4
   - Small dorsal scales mixed with larger ones, TL/SVL ≤ 2.3 2
2. Nuchal crest with high lanceolate scales 3
   - Nuchal crest with triangular scales . . . . *spinipes*
3. Below the tympanum some strongly enlarged conical scales with maximum size > 1/2 Ø tympanum . . . . *boydii*
   - Below the tympanum some feebly enlarged scales with max size < 1/2 Ø tympanum . . . . *dilophus*
4. Dorsal crest present 5
   - No dorsal crest . . . . *modestus*
5. A row of enlarged submaxillaries from mental to below angle of mouth present 9
   - No row of enlarged submaxillaries or only to middle of snout 6
6. Base of gular sac on mid chest behind axilla, pointed; no row of enlarged submaxillaries. 7
   - Base of gular sac near clavicle, rounded; a row of enlarged submaxillaries to middle of snout . . . . . . *tenuicephalus*

7. Large oval circle of feebly enlarged scales on sides of neck present . . . . *auritus*
   - No circle of enlarged scales on sides of neck 8
8. Scales of nuchal crest strongly separated (distance at least one scale), dorsal crest low . . . .*geelvinkianus*
   - Scales of nuchal crest hardly separated (distance about 1/2 scale), interspaces mostly with a small scale, dorsal crest normal . . . . *nigrigularis*
9. Scales of gular sac keeled and/or tubercular 17
   - Scales of gular sac smooth 10
10. Anterior edge of the gular sac with enlarged scales 11
    - Anterior edge of the gular sac without enlarged scales 12
11. Below the tympanum some large plates, maximum size > Ø tympanum. . . . .*schultzewestrumi*
    - Below the tympanum only feebly enlarged scales or few enlarged scales (mostly only one near angle of mouth), maximum size < Ø tympanum. . . . .*hikidanus*
12. V–shaped marking on nape 13
    - No V– shaped marking on nape. . . .14
13. Between row of enlarged submaxillaries and infralabials 3 scales; 5 or more light cross bars on back . . . . . *schoedei* (part.)
    - Between the row of enlarged submaxillaries and infralabials 4–5 scales; 4 light cross bars on back . *longii* (part.)
14. HW/SVL > 0.148, T/E < 0.8; base of tail of males laterally feebly compressed, not raised 15
    - HW/SVL < 0.148, T/E > 0.8; base of tail of males laterally strongly compressed, raised 16
15. maximum SVL < 150 mm, between row of enlarged submaxillaries and infralabials 3 scales, no cross bars on back. . . . .*bruijnii*
    - maximum SVL > 200 mm, between the row of enlarged submaxillaries and infralabials 4–5 scales, cross bars on back usually present. . . . . *magnus*
16. Anterior scales of gular sac heterogeneous, separated (skin between scales clearly visible); SVL > 140 mm . . . . *godeffroyi*
    - anterior scales of gular sac nearly homogeneous, rarely a little separated; SVL < 130 mm. . . . .*schoedei*
17. Vertebral crest clearly notched or separated 19
    - Vertebral crest continuous or with an indistinct notch 18
18. Cross bars on back present, HW/SVL > 0.150; T/E > 1.1 . . . . *ornatus*
    - No cross bars on back, HW/SVL < 0.145, T/E < 1.1 . . . . *binotatus*
19. Between the row of enlarged submaxillaries and infralabials 4–5 scales, T/E usually < 1.0 21
    - Between the row of enlarged submaxillaries and infralabials 3 scales or less, T/E > 1.0 .20
20. Base of the tail of males high (TH/TW ≥ 1.97), abruptly decreasing after first third of tail; TL/SVL < 3.3; (HLL + FL)/SVL < 0.81; FL/SVL < 0.36 . . . .*papuensis papuensis*
    - Base of the tail of males moderately high (TH/TW < 1.7), gradually decreasing after first third; TL/SVL usually > 3.6; (HLL + FL)/SVL > 0.83; FL/SVL > 0.37. . . . .*papuensis longicauda*
21. Dark blotch on either side of neck present . . . . *papuensis* ssp. A
    - No dark blotch on either side of neck 22
22. V–shaped marking on neck present (females, juv. males) or not; maximum SVL > 150 mm; base of tail of adult males strongly raised; anterior scales of gular sac of adults clearly keeled . . . . . . *longii*
    - No V–shaped marking on the neck; maximum SVL < 130 mm; base of tail of adult males not raised; anterior scales of the gular sac of adults more protuberant and in most cases keeled at the end . . . .*macrolepis*

A summary of morphometric data is presented in Appendix I.

In accordance to the species diagnoses presented here, the correct determination of several species, such as *H. bruijnii* (Southern Highlands, Papua New Guinea) and *H. nigrigularis* (Madang, Papua New Guinea) in Schulte et al. (2003) as well as *H. godeffroyi* from Irian Jaya, New Guinea (= West Papua Province, Indonesia) in Honda et al. (2000; 2002) have to be in doubt.

Judging from a morphological point of view, *Hypsilurus* does not seem to be a homogeneous unit. This has already been pointed out in several molecular genetic papers by Macey et al. (2000, 2000a) where *Arua modesta* was separated from the remaining *Hypsilurus* species on a generic level.

On the basis of morphological characteristics, we propose here a preliminary division of the genus *Hypsilurus* into the following groups:

1. ***modestus*–group**, containing only *modestus* Meyer, 1874. *Arua* Doria, 1874 is available as a genus name for this group. Species typica: *Gonyocephalus* (*Arua*) *inornatus* (= *modestus*) Doria, 1874.

   Diagnosis.– Long–tailed species (TL/SVL > 2.3 mostly > 2.5) with homogeneous dorsal scalation. Usually no row of enlarged submaxillaries; base of gular pouch rounded near the clavicle region, anterior and posterior scales on the gular pouch large approximately equal in size. No significantly enlarged scales at the angle of the mouth or below the tympanum.
2. ***nigrigularis*–group**, containing the species *nigrigularis* Meyer, 1874; *auritus* Meyer, 1874 and *geelvinkianus* Peters and Doria, 1878. Species typica: *Gonyocephalus* (*Hypsilurus*) *nigrigularis* Meyer, 1874

   Diagnosis.– Long–tailed species (TL/SVL > 2.8) with homogeneous dorsal scalation. No row of enlarged submaxillaries; base of gular pouch acute on the chest, anterior and posterior scales on the gular pouch large approximately equal in size. No significantly enlarged scales at the angle of the mouth or below the tympanum.
3. ***godeffroyi*–group**, containing the species *godeffroyi* Peters, 1867; *macrolepis* Peters, 1872; *binotatus* Meyer, 1874; *longii* Macleay, 1877; *papuensis* Macleay, 1877; *bruijnii* Peters and Doria, 1878; *schoedei* Vogt, 1932; *schultzewestrumi* Urban, 1999, as well as the species described as new in this paper: *magnus; hikidanus*; *tenuicephalus* and *ornatus*. *Hypsilurus* is available as a genus name for this group. Species typica: *Lophura* (*Hypsilurus*) *Godeffroyi* Peters, 1867.

   Diagnosis.– Long–tailed species (TL/SVL > 2.8 mostly > 3) with homogeneous dorsal scalation. A row of enlarged submaxillaries is always present; anterior scales on the gular pouch larger than posterior. Usually significantly enlarged scales at the angle of the mouth or below the tympanum.
4. ***dilophus*–group**, containing the species *dilophus* Duméril and Bibron, 1837; *spinipes* A. Duméril, 1851 and *boydii* Macleay, 1884. *Lophosaurus* Fitzinger, 1843 (nomen substitutum pro *Tiaris* Duméril and Bibron, 1837) is available as genus name for this group (see also discussion above). Species typica *Lophyrus dilophus* Duméril and Bibron, 1837.

   Diagnosis.– Short–tailed species (TL/SVL < 2.3 mostly < 2.0) with heterogeneous dorsal scalation.

Schulte et al. (2003) demonstrated in their analysis of phylogenetic relationships among amphibolurine lizards that *Hypsilurus* constitutes a monophyletic unit with *Chelosania* as the sister group. Although only seven species of this genus were studied, the single most parsimonious tree presented shows a significant agreement with the groups proposed here in this paper. *H. spinipes*, *dilophus* and *boydii* (here: the *dilophus*–group) turned out to be more closely related to each other than to other species within the genus as did *H. papuensis, bruijnii* and *nigrigularis* (suspected to be misidentified *H. magnus*) defined here as *godeffroyi*–group; *H. modestus* was placed between these two units and members of the *nigrigularis*–group, as defined in this paper, were not studied. If a possible misidentification of *H. nigrigularis* is taken into account, Schulte et al. (2003) recover three of the four groups proposed by us.

Hypsilurus constitutes an agamid lizard genus only present to the east of Wallace's line and has therefore, to be considered an element of the Melanesian–Australian radiation. The monophyly of this genus and its phylogenetic relationships remain ambiguous and further biochemical studies are needed to understand their interspecific relationships.

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APPENDIX I

Compilation of morphometric data and known clutch sizes

Hypsilurus	SVL max in mm	TL/SVL	HW/SVL	HW/HL	HLL/SVL	FL/SVL	HLL/FL	(HLL+FL)/SVL	T/E	Number of submaxillaries	Clutch size	size of eggs
auritus n = 6	male 130 female 127	2.85-3.11 m = 2.972	0.13-0.14 m = 0.136	0.54-0.59 m = 0.565	0.48-0.53 m = 0.504	0.36-0.40 m = 0.388	1.27-1.35 m = 1.297	0.85-0.93 m = 0.892	0.81-1.0 m = 0.94	0		
binotatus n = 4	male 195 female 157	3.40-3.51 m = 3.471	0.13-0.14 m = 0.138	0.55-0.59 m = 0.573	0.41-0.48 m = 0.454	0.37-0.40 m = 0.39	1.10-1.21 m = 1.16	0.78-0.88 m = 0.844	0.95-1.0 m = 0.988	2-4 m = 3		
boydii n = 1	male 147	1.85	0.17	0.61	0.57	0.39	1.45	0.96	0.93			
bruijnii n = 1	male 143	3.104	0.16	0.64	0.48	0.4	1.19	0.88	0.59	3		
dilophus n = 11	male 180 female 200	1.58-1.83 m = 1.708	0.15-0.19 m = 0.171	0.53-0.61 m = 0.561	0.56-0.72 m = 0.618	0.33-0.34 m = 0.356	1.59-1.89 m = 1.736	0.9-1.1 m = 0.975	0.73-1.0 m = 0.859	2-5 m = 3.36	2	15.3×33.6 15.8×33.3
geelvinkianus n = 3	86	3.00-3.14 m = 3.091	0.155-0.16 m = 0.157	0.6-0.63 m = 0.616	0.519-0.56 m = 0.539	0.41-0.43 m = 0.419	1.25-1.33 m = 1.283	0.93-0.98 m = 0.959	0.91-1.00 m = 0.96	0		
godeffroyi n = 2	male 151 female 143	3.38-3.52	0.125-0.127	0.52-0.54	0.49-0.50	0.4-0.41	1.22-1.23	0.89-0.92	0.84-0.88	3		
hikidanus sp. n. n = 5	male 147 female 139	3.14-3.36 m = 3.243	0.13-0.18 m = 0.157	0.49-0.63 m = 0.5836	0.4-0.45 m = 0.428	0.39-0.41 m = 0.398	1.01-1.13 m = 1.078	0.79-0.85 m = 0.824	0.93-1.13 m = 1.049	3		
longii n = 20; for TL/SVL n = 28	male 235 female 210	3.1-3.58 m = 3.371	0.14-0.17 m = 0.149	0.556-0.65 m = 0.587	0.47-0.57 m = 0.520	0.39-0.48 m = 0.427	1.11-1.3 m = 1.219	0.86-1.04 m = 0.948	0.76-1.01 m = 0.895	4-5 m = 4.28	1(2)	14×30.9
macrolepis n = 1	female 116	3.53	0.16	0.57	0.54	0.43	1.26	0.96	0.87	4		
magnus sp. n. n = 4; for TL/SVL n = 3	male 223 female 180	2.86-3.09 m = 2.979	0.15-0.17 m = 0.163	0.61-0.66 m = 0.640	0.42-0.48 m = 0.457	0.3-0.4 m = 0.355	1.2-1.43 m = 1.289	0.72-0.89 m = 0.813	0.61-0.75 m = 0.693	3-4 m = 3.9		
modestus n = 31; for TL/SVL n = 28	male 97 female 97	2.38-3.10 m = 2.775	0.14-0.17 m = 0.151	0.55-0.66 m = 0.600	0.49-0.64 0.532	0.32-0.45 0.402	1.17-1.67 1.328	0.85-1.05 m = 0.935	0.75-1.16 0.971	0-5 m = 0.66	1	
nigrigularis n = 1	male 141	2.93	0.13	0.53	0.48	0.36	1.32	0.84	1.1	0		
ornatus sp. n. n = 1	female 155	3.61	0.16	0.61	0.49	0.39	1.23	0.88	1.15	4		
p. papuensis n = 6	male 190 female 150	2.91-3.28 m = 3.193	0.14-0.15 m = 0.144	0.54-0.6 m = 0.563	0.41-0.48 m = 0.441	0.315-0.35 m = 0.328	1.27-1.52 m = 1.344	0.73-0.80 m = 0.769	1.05-1.22 m = 1.135	2-3 m = 2.5		

p. longicauda ssp. n. n = 4	male 205 female 190	3.26-3.70 m = 3.549	0.14-0.16 m = 0.147	0.55-0.63 m = 0.585	0.46-0.51 m = 0.49	0.37-0.38 m = 0.379	1.24-1.34 m = 1.279	0.83-0.89 m = 0.864	1.0-1.35 m = 1.188	2	1	16.2×36.8
p. ssp. A n = 1	female122	3.61	0.13	0.56	0.49	0.4	1.22	0.89	0.97	4	1	10,5×27,5
schoedei n = 35	male 128 female 122	3.07-4.03 m = 3.489	0.13-0.15 m = 0.137	0.49-0.57 m = 0.549	0.46-0.57 m = 0.509	0.39-0.47 m = 0.421	1.1-1.33 m = 1.209	0.86-1.01 m = 0.931	0.81-1.21 m = 0.973	3-4 m = 3.03	1	12×27.8
schultzewestrumi n = 2	male 160 female 119	3.24-3.44 m = 3.34	0.15-0.15 m = 0.154	0.56-0.61 m = 0.588	0.45-0.47 m = 0.458	0.38-0.39 m = 0.386	1.18-1.19 m = 1.187	0.83-0.86 m = 0.844	0.9 n = 1	3		
cf. *schultzewestrumi* n = 2	male 166 female 121	3.08-3.11 m = 3.095	0.16-0.18 m = 0.171	0.62-0.70 m = 0.651	0.41-0.44 m = 0.424	0.36-0.39 m = 0.371	1.08-1.23 m = 1.145	0.77-0.81 m = 0.795	0.81-1.0 m = 0.89	3		
tenuicephalus sp. n. n = 1	male 151	3.74	0.11	0.51	0.48	0.42	1.14	0.9	1.16	3		

APPENDIX II

Additional examined material (not mentioned in the text)

Hypsilurus auritus: ZMB 8782 (holotype); 9727 Soron (= Sorong 0° 53'S; 131° 15'E); 24857 Holl. Neu–Guinea; 48844 without locality; ZSM 512/1978 (two specimens) Misol Island (= Misool 1° 52'S; 130° 07'E), all West Papua Province, Indonesia.

Hypsilurus binotatus: ZMB 22225, Tami river (2° 38'S; 140° 56'E); RMNH 28957 Wasiox (= Wasior 2° 43'S; 134° 30'E); 28958 Aru Islands (6° 09'S; 134° 26'E) all Papua Indonesia; ZSM 121/1979 Weiru (= Veiru, 7° 29'S; 144° 15'E), Gulf Province; 120/1979 Gulf Province, all Papua New Guinea.

Hypsilurus boydii: ZMB 19900

Hypsilurus bruijnii: holotype (figures)

Hypsilurus dilophus: ZMB 9754 Andai (0° 56'S; 134° 53'E); 9755 Mansinam (= Pulau Mansinam 0° 54'S; 134° 06'E); 32380, two specimens Wasior 2° 43'S; 134° 30'E (Wandammen); 25793 and 22248 Deutsch Neuguinea; all West Papua Province, Indonesia; 18863 and 18864 Neuguinea; ZSM 240/2000 and 242/2000 without locality.

Hypsilurus geelvinkianus: ZMB 9729–30 (syntypes); ZMB without Nr. Wondiwoi mountains 2° 43'S; 134° 35'E; all West Papua Province, Indonesia.

Hypsilurus godeffroyi: lectotype and paralectotype as well as NMW 21049 (figures)

Hypsilurus longii: R 31935 (holotype); ZMB 39181 Kunna, Bougainville; 26657 and 14599 Ralum (4° 21'S; 152° 18'E), New Britain; 26576 (two specimens) Massawa (= Massava Bay 4° 13'S; 151° 49'E); 28391 (three specimens) and 28389 Bismarck Archipelago; 9362 (two specimens) and 9633 (two specimens) Duke of York Islands (4° 10'S; 152° 26'E), East New Britain Province; 36862, 36938, 50549, 50550 without locality.; ZSM 360/0 (two specimens) Herbertshöhe (4° 20'S; 152° 08'E), New Britain; all Papua New Guinea; ZMB 19898 Queensland, Australia.

Hypsilurus macrolepis: ZMB 7510 (holotype)

Hypsilurus modestus: ZMB 8783; 9728 Jobi (= Yapen 1° 44'S; 135° 49'E); 9726 Dorei Hum (= Teluk Dore Hum 0° 46'S; 131° 32'E); 25749 and 25765 Deutsch Neuguinea; 28085 Holl. Neuguinea; all Papua Indonesia; 21383 Sattelberg (6° 29'S; 147° 47'E), Huon Peninsula, Morobe Province; ZSM 129/1979 Village Didessa, Mt. Bosavi (6° 35'S; 142° 50'E), Southern Highlands Province; 130/1979 (three specimens) Gihiteri 7° 28'S; 143° 57'E, Gulf Province; 314/1992 (two specimens) Papua New Guinea; 217/1920 Herbertshöhe (4° 20'S; 152° 08'E), New Britain, ZMB 38622 (four specimens) Bismarck Archipelago; 14600 (two specimens) Ralum (4° 21'S; 152° 18'E), New Britain; all Papua New Guinea; ZMB 21229 (two specimens), 16374, 16375, 58572 New Guinea; *H. modestus carinatus*: lectotype and all paralectotypes; *H. inornatus*: ZMB 7941 (Syntype).

Hypsilurus nigrigularis: MTKD D 2967 (holotype)

Hypsilurus papuensis: R 31883 (holotype); ZSM 131/1979 (two specimens) Maegera Plantation, St. Joseph River (8° 42'S; 146° 34'E), Central Province, Papua New Guinea; *H. albertisii*: ZMB 9722, 9724–25 (syntypes).

Hypsilurus schoedei: ZMB 32205, 54474–500 (syntypes); 29506 (six specimens); 29507, all topotypical; 50551 Deutsche Südsee Expedition, 50548 w/o locality.

Hypsilurus schultzewestrumi: ZSM 132/1979/1, 132/1979/2 (holotype and paratype); 39/1990/1; as well as ZMB 53291, both w/o localities.

Incertae sedis: *Gonyocephalus modestus* (not *Gonyocephalus* (*Hypsilurus*) *modestus* Meyer, 1874) Vogt, 1911a: 415 = ZMB 22234; ZSM 123/1979; ZSM 124/1979.

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HERPETOFAUNAL ASSEMBLAGE IN A TROPICAL DRY FOREST MOSAIC OF WESTERN GHATS, INDIA: PRELIMINARY ANALYSIS OF SPECIES COMPOSITION AND ABUNDANCE DURING THE DRY SEASON

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(with four text-figures)

ABSTRACT.– **We examined the species composition and abundance of amphibians and reptiles in a tropical dry forest mosaic on the leeward side of Agasthyamalai Hills of Western Ghats, south-western India. Sampling was carried out in five habitat types using randomly placed strip transects. The riparian habitat in the dry forest mosaic supported the highest number of amphibian species and abundance. Overall, the tropical dry forest amphibian assemblage was species poor compared to the adjoining rainforest habitat and was composed of a mixture of rainforest elements and geographically widespread species. In contrast, the reptilian assemblage in the dry forest mosaic was species rich and that of lizards was comparable to the contiguous rainforest habitat. The dry deciduous habitats in the dry forest mosaic supported greater number of species of reptiles. The abundance of reptiles was greatest in the species impoverished scrub habitat. Principal component analysis revealed significant differences in the structure of the habitats sampled. Distance from water had a significant effect on the occurrence of amphibians in the samples. Moisture appears to be a significant factor influencing the species richness and abundance of amphibians in the tropical dry forest mosaic. For reptiles, a composite of variables including canopy cover, litter depth, shrub density and distance from water determined their occurrence in the samples. The availability of microhabitat appears to account for the difference in lizard species abundance across habitats. Due to the proximity of the dry forest habitats to human habitations and their inclusion in the buffer zone of the reserves, these habitats are severely threatened by anthropogenic activities. This study outlines the significance of dry forest habitats to the overall species richness of herpetofauna notably that of reptiles of the Western Ghats. The need for bringing greater extent of these habitats under current protected area network for an effective conservation of the herpetofauna of Western Ghats has been highlighted and discussed in the light of current human pressure.**

KEY WORDS.– **Tropical dry forests, amphibians, reptiles, assemblage, species composition, abundance, riparian, conservation, Western Ghats, India.**

INTRODUCTION

Amphibians and reptiles form an important component in tropical faunal communities. Studies on them at the assemblage level are largely restricted to the Neotropical region, with few studies in the Oriental region (e.g., Inger and Colwell, 1977). Western Ghats, a global biodiversity hotspot in the Oriental region, is characterized by high diversity of amphibians and reptiles (Groombridge, 1990; Das, 1996b). Around 121 species of amphibians and 180 species of reptiles occur in this mountain range (Molur and Walker, 1998a, b; Biju, 2001). This mountain range also exhibits a high level of heterogeneity in vegetation both at the local and landscape level, strongly influenced by the topographic complexity (Subramanyam and Nayar, 1974). The patterns of distribution of amphibians and reptiles in these vegetation communities in the Western Ghats are poorly known and ecological studies on amphibian and reptilian assemblages are few (Inger et al., 1987; Vasudevan et al., 2001; Ishwar et al., 2001). Vegetation zones are known to influence the distribution of amphibian and reptilian assemblage (Heyer, 1967). Determining the degree of the association between assemblage and habitat/vegetation categories is important for mapping and predicting species distribution at the landscape level (Williams et al., 1997). This type of data is vital for identifying and prioritizing habitats for effective conservation and management. Such information also forms the basis for computer based spatial analysis (Scott et al., 1993). We present and discuss data on species composition and abundance of the herpetofauna in a tropical dry forest mosaic in the Western Ghats in South India. The study outlines the significance of the threatened dry forest habitats to the overall species richness of herpetofauna notably that of reptiles of the Western Ghats.

STUDY AREA

The study was conducted in the Kalakad–Mundanthurai Tiger Reserve (KMTR– 08° 23'–52'N; 77° 16'–39'E), located on the leeward side of Agasthyamalai hills in the southern part of the Western Ghats, in Tamil Nadu State, southern India (Fig. 1). It covers an area of 887 sq. km with altitude ranging from 100–1,869 m (Agastyar Peak). The area receives rainfall from both the south-west and the north-east monsoon; the average annual rainfall based on 10 years of data (1974–84) ranges from 1189 mm (Lower Papanasam Reservoir Station) to 1,708 mm (Upper Papanasam Reservoir Station; see Joshua and Johnsingh, 1986). Both these stations are located within our study limits. The Reserve houses heterogeneity of vegetation types along the altitudinal gradient starting from scrub thorn forests on the foothills to low elevation dry deciduous forests, dry evergreen forests, mid-elevation semi evergreen forests, wet evergreen forests to high altitude grasslands and *Ochlandra* reed beds. The study was largely restricted to the dry forests in the buffer zones of the reserve below 300 m asl, where anthropogenic activity related disturbance factors are higher. However, a limited number of samples were taken between 300 and 700 m. We identified and sampled five major habitat categories: scrub, dry deciduous thicket, dry deciduous savannah, dry evergreen forest and riparian forest. Intensive sampling was carried out at five different zones in the Reserve (Fig. 1). These zones were selected such that all the major habitat categories were represented in our samples.

METHODOLOGY

Sampling was conducted in the months of May–June 1999 and during September 1999, for observing any additional species. Strip transects of length 50 m and width 4 m were laid and visually searched for active and hidden amphibians and reptiles in the forest habitats. Three persons (including the first two authors) were involved in sampling, walking parallel to each other, maintaining a distance of 2 m from one another, searching intensively in all possible microhabitats; mainly leaf litter, under rocks, fallen and decaying logs, tree bark, grass clumps, on shrubs (plants > 1 m and < 7 m in height), on herbs (plants < 1 m in height) and in tree holes. The person walking in the middle searched for arboreal species, while the other two persons searched in the litter. For each sampling unit the following variables were collected for each sample: Habitat type, start time, end time, weather conditions, canopy cover (using a spherical densiometer), leaf litter depth (at eight points along the transect, using a steel rule), altitude (using analogue altimeter, resolution 20 m), Number of shrubs (in four 1 x 1 sq. m quadrat), number of herbs (in four 0.25 x 0.25 sq. m quadrat), number of rocks (categorized into small, medium, large), number of logs (categorized into > 1 m and < 1 m), number of lopped trees, evidence of past fire, cattle presence (based on presence or absence of dung), distance from water (ordinal scale, ranged from 0 for stream edge to 6 for > 100 m from stream). Sampling of 110 strip transects was carried out during the day, between 0700 and 1700 h. Of these, five samples were in the wet evergreen forest and for

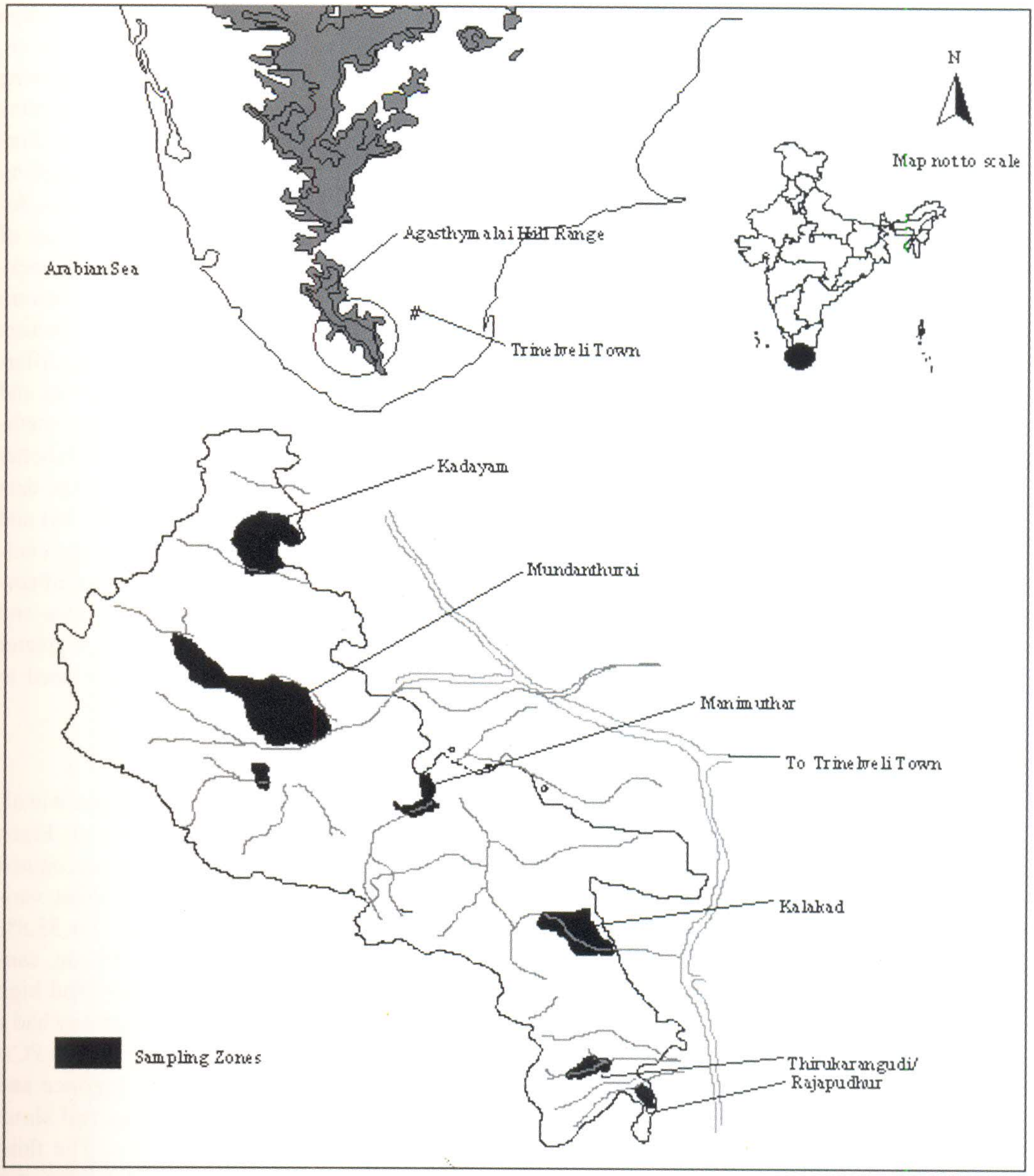

Figure 1. Intensive sampling zones for the study on the herpetofaunal assemblage in the tropical dry forest mosaic in the Kalakad - Mundanthurai tiger reserve (KMTR), Agathymalai Hills, Western Ghats.

11 the habitat identity was ambiguous. These samples were removed and the remaining 94 samples were used in the analysis. The number of strip–transects included for each habitat category were, dry deciduous thicket (n = 28), dry deciduous savannah (n = 22), dry evergreen (n = 27), riparian (n = 10), scrub (n = 7). At three zones, river sections were sampled at night using time–constrained technique. The same three persons were involved in sampling these sections. Each selected stream bank was searched for one hour with flashlights for recording nocturnal amphibians and reptiles. Opportunistic sightings and secondary reports of species were also taken into consideration while preparing a checklist (Appendix I). Opportunistic records were based on informal searches or sightings during daytime and at night hours between 2000

and 2300 h. All transects were placed randomly, by walking random number of steps (between 1 and 999, generated using a calculator, Casio FX 100D), from a reference point along forest trails, roads or riverbeds. Reference points were approximately 400 steps apart. Although our sampling effort was unequal for habitats, we determined from the existing vegetation maps that it was approximately proportional to the areal extent of habitat categories. Identification of amphibians and reptiles were done using keys provided in Boulenger (1890) and Smith (1931, 1935, 1943). We were unable to catch and identify gekkonids in the plot; individuals recorded in the plots were pooled and treated as single species in the analysis.

Voucher specimens were collected for most species of amphibians and reptiles encountered during the study. All the specimens have been deposited in the Bombay Natural History Museum (BNHS) and Zoological Survey of India Calcutta (ZSIC) (Kolkata) in India (Appendix IIa and IIb).

Data analysis.– Statistical analysis and tests were carried out using the SPSS software (Norusis, 1994). Principal component analysis (PCA) (Jongman et al., 1995) was used to explore and identify variables that differentiated habitats. Seven habitat related variables, canopy cover, leaf litter depth, shrub density, number of rocks, herb density, number of logs and altitude were used in the PCA. The following variables, canopy cover, herb density, rocks, log, altitude were transformed to approximate normal distribution. However, for two variables, number of logs and rocks, the transformation did not result in normality. Canopy cover (proportion) was squared, and other variables were log transformed. A value of one was added before logarithmic transformation to take care of zero values (Sokal and Rohlf, 1995). Differences in variables between habitat categories were tested using Mann–Whitney U–test.

The adequacy of sampling effort for each habitat was determined using species accumulation curves generated using EstimateS (Colwell, 1997). Samples were randomized 100 times to eliminate the influence of order in which the strip transects were sampled and to obtain a smooth curve (Colwell, 1997). The abundance of amphibians and reptiles were expressed as average number of individuals observed per 200 sq. m, the size of one sampling unit. For comparing species composition and abundance of anurans and reptiles across habitats, only data from diurnal strip transects were used. Since the sampling effort was unequal across habitat categories, for comparative purposes, we used an estimate of the following species richness estimator, Jackknife1 generated using EstimateS software (Colwell, 1997). We used discriminant function analysis to identify habitat variables that differentiated plots with and without amphibians and reptiles. Both stepwise and forced entry methods were used and the one that resulted in better discrimination was taken into account. The data from all the habitats were pooled (n = 94) and the Spearman non–parametric correlation coefficient was used to determine the degree of correlation between environmental variables and species abundance. Only species with greater than or equal to five individuals were used to calculate the correlation coefficient.

RESULTS

Habitat characteristics.–Principal component analysis resulted in three components with Eigen values greater than one and together accounted for 68.9% of the variance in the habitat variables. The first PCA axis accounted for 33.8% of the variance in the variables. Altitude, canopy cover, litter depth, shrub density had high positive loading on this axis. Herb density had a negative loading on this axis. The second PCA axis accounted for 20.1% of the variance and the variable number of rocks (+ve) and shrub density (–ve) had highest loadings. The third PCA axis accounted for 14.8% of the variance and number of logs (+ve) was the only variable with high loading on this axis. Scatter plots of samples grouped by habitat on the first two axes (Fig. 2a) showed the following patterns. Samples from scrub habitat were characterized by less canopy cover and low altitude and were clustered along the left end of axis one (Fig. 2a). Samples in riparian habitat were separated along the second axis from other habitats based on the rock cover. Samples from dry deciduous thicket and dry deciduous savannah largely overlapped, but greater altitudes characterized

Table 1. Abundance of anuran amphibians during the dry season in the tropical dry forests of the Agasthyamalai hills, southern Western Ghats.

	Amphibians	Habitat											
		Dry deciduous thicket		Dry deciduous savannah		Dry evergreen		Riparian		Scrub		Total	
		Number of individuals	Average per plot	Number of individuals	Average per plot	Number of individuals	Average per plot	Number of individuals	Average per plot	Number of individuals	Average per plot	Number of individuals	Average per plot
1.	*Bufo melanostictus*	1	0.04	2	0.09	4	.15	51	5.10	0	0.00	58	0.62
2.	*Euphlyctis cyanophlyctis*	0	0.00	0	0.00	0	.00	4	0.40	0	0.00	4	0.04
3.	*Fejervarya* aff. *limnocharis*	10	0.36	0	0.00	31	1.15	99	9.90	0	0.00	140	1.49
4.	*Micrixalus fuscus*	0	0.00	0	0.00	0	0.00	100	10.0	0	0.00	100	1.06
5.	*Nyctibatrachus* sp. *.	0	0.00	0	0.00	0	0.00	1	0.10	0	0.00	1	0.01
6.	*Rana temporalis*	0	0.00	0	0.00	0	0.00	89	8.9	0	0.00	89	0.95
7.	*Sphaerotheca rolandae*	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
8.	*Indirana* sp. *	0	0.00	1	0.05	0	0.00	2	0.20	0	0.00	3	0.03
9.	*Microhyla ornata*	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
10.	*Polypedates maculatus*	1	0.04	0	0.00	1	0.04	1	0.10	0	0.00	3	0.03
	Total / Average of Individuals	14	0.50	3	0.14	36	1.33	347	34.7	0	0.00	400	4.26
	Observed no. species	5		2		3		8		0		10	
	Expected no. species (SD)	8.86 (1.8)		2.95 (0.9)		3.96 (0.9)		10.7 (1.9)		–		–	
	Number of sampling units	**28**		**22**		**27**		**10**		**7**		**94**	

Table 2. Abundance of reptiles during the dry season in the tropical dry forests of the Agasthyamalai hills, southern Western Ghats.

	Habitat											
Reptiles	Dry deciduous thicket		Dry deciduous savannah		Dry evergreen		Riparian		Scrub		Total	
	Number of individuals	Average per plot	Number of individuals	Average per plot	Number of individuals	Average per plot	Number of individuals	Average per plot	Number of individuals	Average per plot	Number of individuals	Average per plot
1. *Calotes versicolor*	11	.39	8	0.36	0	0.00	1	0.1	0	0.00	20	0.21
2. *Calotes calotes*	1	0.04	0	0.00	1	0.04	0	0.00	0	0.00	2	0.02
3. *Psammophilus dorsalis*	0	0.00	1	0.05	0	0.00	4	0.40	0	0.00	5	0.05
4. *Sitana ponticeriana*	1	0.04	0	0.00	0	0.00	0	0.00	25	3.57	26	0.28
5. *Mabuya macularia*	7	0.25	2	0.09	6	0.22	0	0.00	0	0.00	15	0.16
6. *Lygosoma* sp.	1	0.04	0	0.00	0	0.00	2	0.20	0	0.00	3	0.03
7. *Ophisops* sp. 1. (high altitude savannah)	0	0.00	2	0.09	0	0.00	0	0.00	0	0.00	2	0.02
8. *Ophisops* sp. 2. (Scrub)	0	0.00	0	0.00	0	0.00	0	0.00	7	1.00	7	0.07
9. Unidentified Gekkonids	0	0.00	2	0.09	2	0.07	2	0.20	0	0.00	6	0.06
10. *Geckoella collegalensis*	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
11. *Ahaetulla nasuta*	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
12. *Hypnale hypnale*	0	0.00	1	0.05	1	0.04	0	0.00	0	0.00	2	0.02
13. *Typhlops* sp.	0	0.00	1	0.05	1	0.04	0	0.00	0	0.00	2	0.02

14. *Echis carinatus*	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
15. *Boiga beddomei*	0	0.00	1	0.05	0	0.00	0	0.00	0	0.00	1	0.01
16. Colubrid (U.I)	0	0.00	1	0.05	0	0.00	0	0.00	0	0.00	1	0.01
17. *Python molurus*	0	0.00	0	0.00	0	0.00	1	0.1	0	0.00	1	0.01
Number of individuals	25	0.89	18	0.82	11	0.41	11	1.10	32	4.57	97	1.03
Observed no. species	8		9		5		5		2		17	
Expected no. species (SD)	13.8 (2.1)		13.8 (3.1)		7.89 (1.6)		7.7 (1.9)		2 (0)		–	
Number of sampling units	**28**		**22**		**27**		**10**		**7**		**94**	

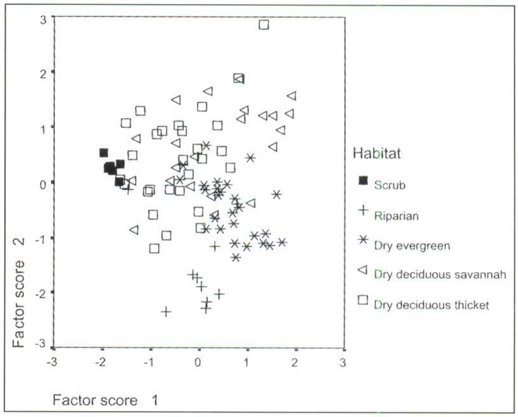

Figure 2a. Results of the Principal component analysis for the five dry forest habitat types identified. Scatter plot of the samples for the first two axes explains 53.9% of the variance in the variables. Altitude (+0.730), Litter depth (+0.681), Canopy cover (+0.670), herb density (–0.587) and shrub density (+0.565) represents the first axis. Number of rocks (–0.673) and shrub density (+0.612) represents the second axis. The values above represent the degree of correlation with the corresponding axis.

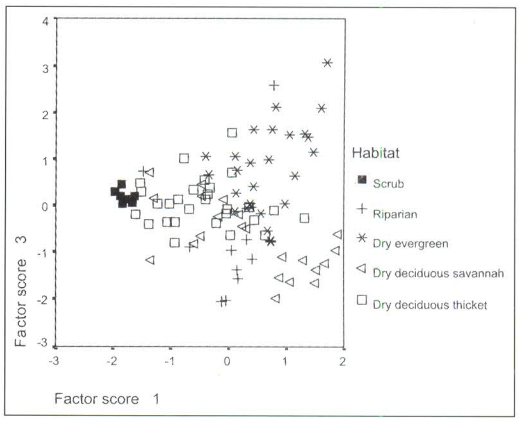

Figure 2b. Results of the Principal component analysis for the five dry forest habitat types identified. Scatter plot of the samples for the first and the third axis. The third axis explains 14.8% of the variance in the variables. Altitude (+0.730), Litter depth (+0.681), Canopy cover (+0.670), herb density (–0.587) and shrub density (+0.565) represents the first axis. Number of logs (+0.753) represents the third axis. The values above represent the degree of correlation with the corresponding axis.

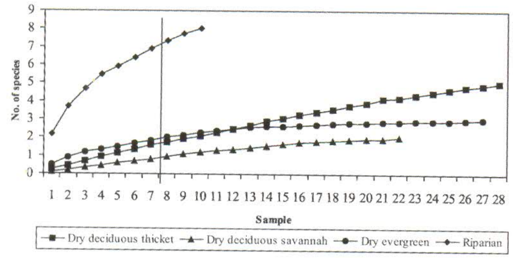

Figure 3a. Species accumulation curve for anurans in the tropical dry forest habitats of Agasthyamalai Hills during the dry season.

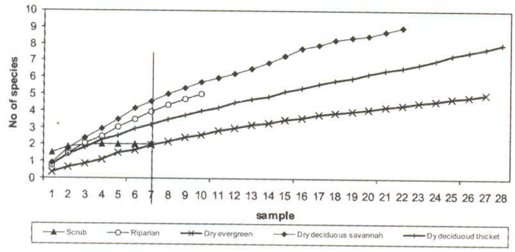

Figure 3b. Species accumulation curve for reptiles in the tropical dry forest habitats of Agasthyamalai Hills during the dry season.

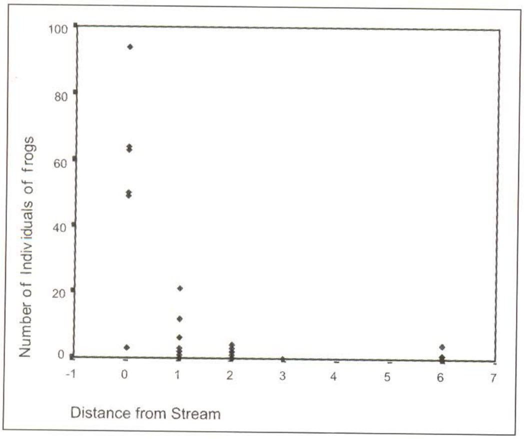

Figure 4. Decrease in the number of individuals of anurans with increasing distance from streams in the tropical dry forest mosaic during dry season in the leeward side of Agasthyamalai Hills in the Western Ghats.

samples from dry deciduous savannah (Fig. 2a). Dry evergreen habitat samples had relatively greater number of logs and were separated along the axis three (Figs 2b). Pair wise comparison of variables using Mann–Whitney U–test brought out significant ($0.05 < P < 0.001$) difference between habitats. Altitude was significantly different between DDT and DDS and between scrub and other habitats. The scrub habitat is restricted to the lower elevations of the reserve. Canopy cover was also significantly lower in the scrub compared to the other habitats. Riparian and dry evergreen habitats had the greatest canopy cover and were different from the other habitats. Riparian and dry evergreen significantly differed in the number of rocks (greater in riparian), litter depth, herb density and shrub density (greater in the dry evergreen).

Adequacy of sampling effort.– The species accumulation (SA) curve was based on data pooled from five zones. Except for scrub habitat, other habitats occurred in more than two zones. Dry deciduous thickets and riparian habitats were sampled in all the zones. Hence, there was an increasing trend in the species accumulation due to species turnover between zones. The species accumulation curve for anurans in the riparian habitat and dry deciduous thickets did not reach an asymptote (Fig. 3a). For other habitats, the sampling effort for anurans appears to be sufficient with the curves reaching asymptotes. In case of reptiles, except for scrub habitat, the SA curve did not reach an asymptote (Fig. 3b).

Species composition and abundance across habitats. Amphibians.– A total of 400 individuals of anurans comprising of 10 species were recorded in the samples (Table 1). The estimated species richness varied from 2.95 (SD = 0.95) to 10.7 (SD = 1.92) and was greater in riparian habitat compared to other habitats sampled (Table 1). No species were recorded in the scrub habitat samples. Of the total observed species (S = 10), five species (50%), *Rana temporalis, Micrixalus fuscus, Euphlyctis cyanophlyctis, Nyctibatrachus* sp. and *Indirana* sp. were found only in riparian habitat while two species (20%), *Sphaerotheca rolandae and Microhyla ornata* were found restricted to dry deciduous thicket (Table 1). Species composition of anurans in the dry evergreen and dry deciduous savannah habitats were found to be a subset of riparian habitat.

The abundance of anurans was also greater in riparian habitat, 34.7 individuals/200 sq. m, followed by dry evergreen, 1.33 individuals/200 sq. m. Dry deciduous habitats (thicket and savannah) were very low in abundance, 0.5 and 0.14 individuals/200 sq m, respectively. *Fejer-*

varya aff. *limnocharis* was the dominant species in dry deciduous thicket (n = 10) and dry evergreen (n = 31) assemblage. No single species was dominant in the riparian assemblage, four species, *Micrixalus fuscus* (n = 100), *F.* aff. *limnocharis* (n = 99), *Rana temporalis* (n = 89) and *Bufo melanostictus* (n = 51) accounted for a greater proportion of individuals recorded. Juveniles of *B. melanostictus* (100%), *R. temporalis* (> 90%) accounted for greater proportion of these species in the riparian habitat. Sixty percent (S = 6) of the anuran species recorded in the dry forest mosaic were represented by less than five individuals of which 30% (S = 3) had only one individual.

Reptiles.– A total of 97 individuals of reptiles comprising of lizards and snakes represented by 17 species were recorded in the 94 strip transects (Table 2). The estimated species richness varied from two (SD = 0) to 13.79 (SD = 2.13) across habitats. It was greatest in the dry deciduous thickets and dry deciduous savannah habitats and lowest in the scrub habitat. The greatest percentage of species (n = 8, 47%) was restricted to single habitat. No species were recorded from all habitats (Table 2).The reptilian abundance was greater in scrub habitat (4.57 individuals/200 sq m). The abundance in other habitats was comparatively low (Table 2). *Calotes versicolor* was the dominant species in the dry deciduous thicket (n = 11) and savannah (n = 8) assemblage. The skink, *Mabuya macularia* was dominant in the dry evergreen assemblage (n = 6) while the rock lizard *Psammophilus dorsalis* was the dominant species in the riparian assemblage. The terrestrial lizard *Sitana ponticeriana* was the dominant species in the species poor scrub assemblage. Almost 65% (S = 11) of the reptilian species in the sample were represented by less than five individuals, of which 35% (S = 6) of the species had one individual (Table 2).

Ecological correlates of anuran and reptile abundance.– Anurans were present in 29% (n = 27) of the strip transects while reptiles were present in 51% (n = 48) of the strip transects sampled. Discriminant function analysis (DFA) identified distance from water as the only variable that distinguished strip transects with anurans and without anurans ($\lambda = 0.574$, $\chi^2 = 47.973$; $P < 0.000$ df = 11) and 83% of the grouped cases were correctly classified. For reptiles, the variables canopy (+0.802), litter (–1.026), shrub density (+ 0.459), distance from water (+ 0.443) ($\lambda = 0.704$, $\chi^2 = 30.367$, $P = 0.001$, df = 11) distinguished samples with reptiles and without reptiles and 70.2% of the original variables were correctly classified.

There was a decrease in abundance of anurans with increasing distance ($r = -0.652$, $P < .001$) from the streams (Fig. 4). For reptiles, there was no effect of distance from water on the abundance ($P > 0.05$). Canopy cover ($r = -0.343$, $P<0.05$), altitude ($r = -0.240$, $P < 0.05$) and number of shrubs ($r = -0.284$) were negatively correlated with the abundance of reptiles. Rock cover ($r = +0.388$) was positively correlated with the abundance of amphibians. Leaf litter ($r = -0.222$, $P < 0.05$), shrub density ($r = -0.204$, $P < 0.05$) and herb density ($r = -0.252$, $P < 0.05$) were negatively correlated with abundance of amphibians.

At the species level there was a significant effect ($P < 0.05$) of the variables, altitude, litter depth, canopy cover, distance from water, rock cover, herb density, shrub density and number of trees on the abundance of anurans and reptiles. The abundance of *Fejervarya* aff. *limnocharis, Sitana ponticeriana* and *Ophisops* sp. 2 were negatively correlated with altitude. Litter depth was positively correlated with the abundance of *Mabuya macularia* and negatively correlated with *Ophisops* sp. 2, *S. ponticeriana, Micrixalus fuscus* and *Rana temporalis*. Canopy cover had a positive correlation with the abundance of *F.* aff. *limnocharis* and was negatively correlated with the abundance of the lizards, *Ophisops* sp. 2, *S. ponticeriana* and *Calotes versicolor*. Distance from water had a significant negative correlation with the anurans, *Bufo melanostictus, R. temporalis, M. fuscus* and *F.* aff. *limnocharis*. Rock cover was positively correlated with abundance of *Bufo melanostictus, R. temporalis, M. fuscus* and the lizard, *Psammophilus dorsalis*. Number of trees was negatively correlated with the abundance of the terrestrial lizard, *S. ponticeriana*.

Species richness in the tropical dry forests.– A total of 17 species of anurans and 35 species of reptiles (lizards and snakes) have been recorded so far from the tropical dry forest of Kalakad–

Mundanthurai Tiger Reserve (Appendix I). Only 59% (S = 10) of the total species of anurans and 48.5% (S = 17) of reptiles were recorded from the strip transects.

DISCUSSION

Tropical dry forest anuran assemblage.– The dry forest anuran assemblage was composed of a mixture of geographically widespread arid land elements and few endemic rainforest species. The assemblage was poor in species richness compared to the rainforests of Agathyamalai hills of the southern Western Ghats. Data from all sampling methods and publications indicate that only 17 species are known to occur in the tropical dry forests of Kalakad–Mundanthurai Tiger Reserve (KMTR) compared to the 32 species in the rainforests (Vasudevan et al., 2001) of KMTR. Endemism was also low in the tropical dry forests compared to the wet evergreen forests. Only three species, *Nyctibatrachus* sp., *Indirana* sp., and *Micrixalus fuscus* (compared to 23 species in the rainforests, Vasudevan et al., 2001) endemic to the Western Ghats was found in the dry forests and none are restricted to dry forests. There was a greater overlap in species composition of anurans between dry forest and that of peninsular plains. At least 10 species reported from the tropical dry forests has been reported elsewhere in the peninsular India (see Das, 1996a, Dash and Mahanta, 1993, Vijayakumar, 1998), which shows the widespread nature of many species of frogs occurring in the tropical dry forests.

In the dry forest mosaic, the riparian habitat supports a greater number of frog species occurring at relatively greater abundance compared to the other habitat patches. All rainforest elements were restricted to the riparian zone. Inger and Colwell (1977) reported similar pattern in the dry deciduous forests of Thailand, where amphibians from evergreen forest assemblage were restricted to the gallery forests. Distance from streams was the only variable that differentiated samples with and without anurans. Moisture significantly influences amphibians during different stages of their life cycle and is an important biotic factor influencing the assemblage (Duellman and Trueb, 1994; Heatwole, 1974). Even in evergreen forests of the Western Ghats, the amphibians were found in relatively greater abundance adjoining streams (Daniels, 1995, Vasudevan et al., 2001). Vasudevan et al. (2001) sampled in mid elevation rainforests of Agathyamali hills in the same drainage sampled by us. Species such as *Rana temporalis* was one of the dominant species in the riparian assemblage; this species is also the dominant member on the rainforests floor (Vasudevan et al., 2001). Riparian zones act as ecotones between the terrestrial and aquatic zones and are corridors across regions (Ceballos, 1995). Many species in the rainforests of the Western Ghats breed in streams and the dispersal of these rainforest elements from mid elevation rainforests to the low elevation tropical dry forests appears to be facilitated by the riparian zone. The riparian zone is also a seasonal refuge for many species during the dry season (Ceballos, 1995). The clustering of amphibians along stream banks in the dry forest mosaic is due to the dry season. During our second visit to the study area, we observed metamorphosed individuals of *Clinotarsus curtipes*, along the Seravalar River in the Mundanthurai zone. No adults were observed during our sampling in the months of May–June, only tadpoles were seen in large numbers in the rivers (Seravalar and Karayar). The reason for the complete absence of the adults of *C. curtipes* during May–June remains unclear.

Fossorial species of frogs such as *Microhyla ornata* and *Sphaerotheca rolandae* were found only in the dry deciduous thickets. These species, which breed in temporary rainwater pools (unpubl. observ.), appear to be less influenced by the riparian zone. Their reproductive mode combined with their adaptations to dry environment is probably responsible for their widespread distribution in Peninsular India. Most species of fossorial anurans are explosive breeders (Wells, 1977); their activity patterns are strongly influenced by rainfall. The under representation of this group of frogs in our samples is likely to be a seasonal effect.

Tropical dry forest reptile assemblage.– In contrast to the anurans, the reptilian assemblage in the tropical dry forest mosaic was relatively species rich (S = 35, Appendix I) and that of the lizard (S = 22) was comparable to that of rainforests (S = 23, Ishwar et al., 2001) of the Agathyamalai hills. Similar to anurans, the endemism of lizards was very low in the dry forests (S = 3) compared to rainforests (S = 12, Ishwar et al., 2001). Since the snake fauna is poorly known, no attempt was made to compare them. The five habitats sampled, dry deciduous thickets, dry deciduous savannah, dry evergreen, riparian and scrub differed in species richness and relative abundance of reptiles. Dry deciduous thickets and savannah had the greatest number of species. The scrub habitat had the lowest number of species with two species of lizards, *Sitana ponticeriana* and *Ophisops* sp. 2. The density of reptiles was greatest in the scrub. The species richness of dry evergreen and riparian was intermediate and the species were largely a subset of the dry deciduous habitats. The dry deciduous thicket and savannah habitats largely overlapped in species, but at least one species of lacertid, *Ophisops* sp. 1 was found restricted to the dry deciduous savannah habitat at high altitude (600–700m in Kalakad, enroute Segaltheri). Very few individuals of snake species were observed during the study and it is premature to discuss their habitat affinities.

Abundance of many species of lizards was strongly correlated with variables related to microhabitat and altitude. For example, the abundance of *Sitana ponticeriana* and *Ophisops* sp. 2 was negatively correlated with the litter depth, canopy cover and altitude. These species have the higher abundance in scrub forests compared to other habitat types. This habitat on the average had the lowest litter depth, canopy cover and was restricted to the low elevations. Similarly, greater abundance of *Psammophilus dorsalis* in the riparian forest can be related to the presence of greater rock cover, a preferred microhabitat for the species (Bhupathy and Kannan, 1997). *Mabuya macularia* was abundant in the dry deciduous forest and dry evergreen forests, which probably reflects the greater litter depth in these habitats. The abundance of this species was positively correlated with the litter depth. The above data shows the influence of availability of microhabitat on the abundance of some selected species of lizards in the dry forests, which probably accounts for their relatively greater abundance and dominance in different habitats. Our results concur with the hypothesis that availability of microhabitat determines the abundance of species in faunal communities (Seagle and McCracken, 1986).

Note on the data.– The results presented in this paper are based on data collected from a restricted period (dry season) and are preliminary in nature. In the absence of detailed information on the dry forest herpetofaunal assemblages, data presented in this study should further allow us to address more questions pertaining to their ecological organization and management in the Western Ghats.

Management and conservation implications: A preliminary insight.– Tropical dry forests are one of the extensive forest habitats in the tropics (Murphy and Lugo, 1986). Due to human preference for these zones, these forests are continuously under threat (Murphy and Lugo, 1986). These forests are found extensively in the lower reaches of the Western Ghats and other parts of the Peninsular India (Legris and Meher–Homji, 1977). Due to greater accessibility, these forests in the Western Ghats have been under continuous anthropogenic pressure for a long time (Pascal and Ramesh, 1995). Although there are many protected areas in the Western Ghats, much of the tropical dry forests are located in the buffer zones of the reserves. These zones are highly vulnerable to anthropogenic activities. This study was carried in the buffer zone of the Kalakad–Mundanthurai Tiger Reserve. The high frequency of disturbance in the buffer zone is mainly due to firewood collection by the local people and due to the grazing pressures by cattle and goats, within the boundaries of the reserve. There is also seasonally greater pressure on the riparian habitat due to tourism and pilgrimage activities (unpubl. obs.). Large areas of tropical dry forests in the KMTR have already been lost due to construction of dams (Ali, 1990). The 180 species of reptiles in the Western Ghats are not restricted to a single habitat such as rainforests (Ishwar et al., 2001). As shown in this study, habitats such as the tropical dry forests contribute significantly to the overall species richness of herpetofauna especially that of reptiles in the Western Ghats. There is a need for providing greater protection for this habitat in the Western Ghats. In addition, future management decisions should take into account the importance of this habitat and the need for bringing more areas of tropical dry forest under core areas of the Reserve.

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APPENDIX I

List of amphibians and reptiles recorded in the tropical dry forests of Kalakad – Mundanthurai Tiger Reserve (KMTR), Agasthyamalai hills southern Western Ghats (based on this study (May–June 1999, September 1999) * and published records (Ravichandran, 1996; Bhupathy and Kannan, 1997; Cherian et al., 1999) and secondary reports (Justus Joshua, pers. comm.).

AMPHIBIANS:
- Bufonidae
  - *Bufo melanostictus**
  - *Bufo scaber**
- Ranidae
  - *Clinotarsus curtipes**
  - *Fejervarya* aff. *limnocharis**
  - *Fejervarya keralensis**
  - *Euphlyctis cyanophlyctis**
  - *Hoplobatrachus tigerinus*
  - *Indirana* sp.*
  - *Micrixalus fuscus**
  - *Nyctibatrachus* sp.*
  - *Rana temporalis**
  - *Sphaerotheca rolandae**
  - *Sphaerotheca breviceps**
- Microhylidae
  - *Microhyla ornata**
  - *Microhyla rubra**
  - *Uperodon systoma*
- Rhacophoridae
  - *Polypedates maculatus**

REPTILES:
- Agamidae
  - *Calotes versicolor**
  - *Calotes calotes**
  - *Sitana ponticeriana**
  - *Psammophilus dorsalis**
  - *Draco dussumieri*
- Scincidae
  - *Mabuya carinata**
  - *Mabuya macularia**
  - *Mabuya* sp.*
  - *Lygosoma punctata**
  - *Lygosoma guentheri**
  - *Lygosoma* sp.*
  - *Dasia halianus*
- Lacertidae
  - *Ophisops* sp. 1. *(savannah)**
  - *Ophisops* sp. 2. *(scrub)**
- Gekkonidae
  - *Hemidactylus frenatus**
  - *Hemidactylus leschenaulti**
  - *Hemidactylus maculatus**
  - *Hemidactylus triedrus**
  - *Geckoella collegalensis**
  - *Cnemaspis* sp.*
- Chamaeleonidae
  - *Chamaeleo zeylanicus*
- Varanidae
  - *Varanus bengalensis*
- Colubridae
  - *Macropisthodon plumbicolor**
  - *Ptyas mucosa**
  - *Boiga beddomei**
  - *Boiga forsteni**
  - *Ahaetulla nasuta**
- Viperidae
  - *Echis carinatus**
  - *Hypnale hypnale**
- Boidae
  - *Python molurus**
- Typhlopidae
  - *Typhlops* sp.*
- Elapidae
  - *Naja naja*
- Bataguridae
  - *Melanochelys trijuga**
- Crocodylidae
  - *Crocodylus palustris*
- Testudinidae
  - *Geochelone elegans*

APPENDIX IIA

Voucher specimens for frogs sampled in the dry forests of KMTR (Agasthyamalai hills, Western Ghats)

ZSIC A 10251 *Fejervarya keralensis*, ZSIC A 10252 *Fejervarya keralensis*, ZSIC A 10253 *Bufo scaber*, ZSIC A 10254 *Nyctibatrachus* sp., ZSIC A 10255 *Micrixalus fuscus*, ZSIC A 10256 *Indirana* sp., ZSIC A 10257 *Fejervarya* aff. *limnocharis*, ZSIC A 10258 *Indirana* sp., ZSIC A 10259 *Fejervarya keralensis*, ZSIC A 10260 *Clinotarsus curtipes* (tail–bud stage), ZSIC A 10261 *Indirana* sp., ZSIC A 10262 *Indirana* sp., ZSIC A 10263 *Rana temporalis*, ZSIC A 10265 *Clinotarsus curtipes* (tadpole).

APPENDIX IIB

Voucher specimens for squamates sampled in the dry forests of KMTR (Agasthyamalai hills, Western Ghats)

BNHS 1665, 1666 *Psammophilus dorsalis,* BNHS 1679, 1681 *Mabuya carinata,* BNHS 1680 *Mabuya macularia,* BNHS 1677 *Lygosoma punctata,* BNHS 1678 *Lygosoma* sp., BNHS 1672, 1673 *Hemidactylus frenatus,* BNHS 1670, 1671 *Hemidactylus maculatus,* BNHS 1668, 1669, 1674 *Hemidactylus triedrus,* BNHS 1675 *Geckoella collegalensis,* BNHS 1676 *Cnemaspis* sp., BNHS 3269, 3271 *Boiga beddomei,* BNHS 3270 *Boiga forsteni,* BNHS 3272 *Typhlops* sp.

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NOTES ON THE DISTRIBUTION, NATURAL HISTORY AND VARIATION OF *HEMIDACTYLUS PRASHADI* SMITH, 1935

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(with three text-figures)

ABSTRACT.– **A recently collected specimen of the gecko *Hemidactylus prashadi* from Dorle extends the known range of this gecko significantly northwards in Maharashtra. Observations of *H. prashadi* in Maharashtra and Goa provide new insights into the habitat of this poorly known species. Data from these specimens and others in the collection of the Bombay Natural History Society permit the assessment of morphological variation with respect to published information on the species.**

KEY WORDS.– ***Hemidactylus prashadi*, Gekkonidae, habitat, range extension, colouration.**

INTRODUCTION

Despite its large size (at least 95 mm SVL, fide Sharma, 2002) and distinctive colouration, *Hemidactylus prashadi* is one of the most poorly known species of Indian geckos. Smith (1935) described the species on the basis of a series of specimens "collected by Drs. Prashad and Rao in November 1928, in the neighborhood of Jog, N. Kanara district, Bombay Presidency" (now part of Karnataka). Later, Tikader and Sharma (1992) and Sharma (2002) gave the distribution as Goa, Karwar and Jog. According to these authors, specimens from Nayavada village (near Mollem, Goa) were found in deserted buildings, where they shared crevices in the walls with wolf snakes, *Lycodon aulicus* and pit vipers, *Trimeresurus gramineus*. Jadhav et al. (1991) documented the first specimens from Maharashtra, from a high elevation (1500 m) forest at Amboli, in the extreme southern part of the state.

Recently, specimens of *Hemidactylus prashadi* were collected from Dorle in the Ratnagiri District and Amboli in the Sindhudurg District of Maharashtra and deposited in the collection of Bombay Natural History Society (BNHS) as BNHS 1577 and BNHS 1491-1494, 1540, respectively. The BNHS collection also houses nine older specimens of this species, of which four (BNHS 146, [three specimens] 146/2 [a single specimen]) were collected from Gersoppa Falls, North Kanara, Karnataka and five (BNHS 147 [two specimens], 147/1 [two specimens] and 147/2 [a single specimen]) from Shiroli forest bungalow, Belgaum, Karnataka. As the information about the natural history and morphological variation in this species is meager, we take this opportunity to provide some data derived both from the newly acquired specimens and the older museum material in Mumbai.

METHODS

Specimens of *Hemidactylus prashadi* were collected by hand, euthanised, fixed in 10% formalin, and transferred into 70% ethanol. Measurements were taken with a Mitutoyo dial caliper (to the nearest 0.05 mm). The following measurements were recorded for each specimen: snout-vent length (SVL); tail length (TL); axilla-groin length (AG); head length from posterior edge of mandible to snout tip (HL); maximal head width (HW); maximal head depth (HD); eye diameter

Figure 1. Adult specimen of *Hemidactylus prashadi* from Dorle, Maharashtra (BNHS 1577). Note the distinctiveness of the dorsal spots and the greyish-yellow background colour. Photo by Varad Giri and Sameer Kehimkar.

Figure 2. Adult specimen of *Hemidactylus prashadi* from Castle Rock, Karnataka, illustrating the colour pattern of the original tail. Photo by Ashok Captain, S. Mukherjee and N. Irani.

(ED); distance from posterior border of orbit to anterior margin of ear (EE); the distance from anterior border of orbit to tip of snout (ES). Characteristics of femoral pores (FP), number of supralabials (SL) and infralabials (IL) and number of lamellae under first toe (L 1st) and fourth toe (L 4th) were also recorded.

RESULTS AND DISCUSSION

Locality and habitat.– Specimens of *Hemidactylus prashadi* were collected from Dorle village, Ratnagiri District, Maharashtra (16° 46' 14"N; 73° 20' 48"E; altitude 15 m) on 18 October 2003 at ca. 2200 h and at Amboli, Kolhapur District, Maharashtra (15° 57' 37"N; 73° 59' 58"E; altitude 711 m) on several occasions between 2000 and 2003. This species had previously been recorded chiefly from a few localities in Karnataka and Goa (Smith, 1935; Murthy, 1985, 1990; Tikader and Sharma, 1992; Daniels, 2000), and from Amboli and Narendra (15°54'N, 73°49'E) in Maharashtra (Jadhav et al., 1991). Amboli is located in the northern Western Ghats, close to the border of Goa, Maharashtra and Karnataka in an area of semi-evergreen type forest. Dorle village is ca. 120 km north of Amboli and is surrounded by semi-evergreen forest with a coconut plantation in the village itself. The specimen from Dorle represents the northernmost locality for *H. prashadi*.

Hemidactylus prashadi is a nocturnal species. The single specimen form Dorle (Fig. 1) is an adult and was collected from hanging roots of a *Ficus* sp. in the village. In Amboli, this is one of the commonest gecko species. The specimens collected from Amboli include adults (BNHS 1492, 1494 and 1540) and juveniles (BNHS 1491 and 1493). The first specimen collected from Amboli

Table 1. Mensual and meristic data for *Hemidactylus prashadi* from Karnataka and Maharashtra in the collection of the Bombay Natural History Society (see text for localities). Abbreviations as in Materials and Methods. All mensural data in mm. Abbreviations: * = Tail regenerated; TB = Tail broken; ** = Approximately 60 mm of tail regenerated.

BNHS No.	SVL	TL	AG	HL	HW	HD	ED	EE	ES	FM	SL	IL	L1	L4
1577	92.00	102.00*	37.70	26.10	18.20	11.40	5.40	7.40	10.50	9-L 13-R	12	11	8	10
1491	31.20	45.00	14.50	12.10	7.40	3.90	3.00	3.10	4.40	-	11	10	9	10
1492	86.80	115.00	36.60	25.00	17.80	9.30	5.00	6.80	10.00	-	12	11	9	10
1493	42.00	62.00	17.50	14.60	9.50	5.90	3.30	4.00	6.10	-	11	10	9	11
1494	79.50	105.00	35.70	23.40	15.80	8.40	5.00	6.40	9.40	-	12	10	9	10
1540	91.80	125.00	39.20	25.80	19.20	11.50	5.10	7.80	10.70	19/19	12	11	8	10
146	79.50	120.00	31.60	23.20	15.90	8.70	5.30	6.50	9.10	-	11	10	8	10
146	87.00	125.00	39.70	25.60	17.40	9.30	5.50	7.50	9.30	-	11	10	8	11
146	96.90	125.00	42.20	26.40	19.70	11.20	6.00	7.50	11.00	19/19	12	9	8	10
146/1	72.00	110.00	33.20	21.50	15.50	7.50	5.10	6.30	9.00	-	12	10	8	10
146/2	70.50	90.00	29.80	20.70	13.80	7.70	4.70	5.90	8.60	-	12	10	8	10
147	108.30	135.00**	46.70	30.80	23.10	13.70	6.00	9.50	12.50	18/18	12	10	9	11
147	92.30	TB	40.10	25.70	18.80	11.10	5.80	8.20	11.00	-	11	10	8	10
147/1	94.30	TB	36.20	27.20	20.10	11.00	5.90	8.50	11.10	-	11	9	8	10
147/1	89.50	110.00	40.50	24.50	18.30	11.30	5.90	8.10	10.40	-	11	10	9	11
147/2	100.20	125.00*	43.00	30.40	21.10	13.00	6.20	8.90	11.80	18/18	11	9	9	11

Figure 3. Juvenile specimen of *Hemidactylus prashadi* from Amboli, Maharashtra. Photo by Varad Giri and Sameer Kehimkar.

was a juvenile (BNHS 1493), which was moving on a decaying tree in a semi-evergreen patch of forest near the village on 10 August 2000. The second specimen (BNHS 1494), an adult, was collected in October 2001 from a house in the village. This area was subsequently visited in different seasons. The juveniles were always seen during June to August, primarily on trees and only rarely in houses. Adults were seen in all seasons and inhabited abandoned houses in the forested areas and in the village, where they were mostly seen on walls, especially near light sources outside houses. In Goa, five adult specimens of this species were seen in a rest house inside the forest near Keri village in a single night during the first week on June 2003. Thus, apart from the crevices in the walls of abandoned houses, the microhabitat mentioned by Tikader and Sharma (1992), we can confirm that the juveniles of *H. prashadi* also utilise trees. Jadhav et al. (1991) found adults on lichen-covered black granite rocks in thick forest at Amboli.

Morphological features.– Sharma (2002) reported the maximum adult length for *Hemidactylus prashadi* as 95 mm SVL, with the tail length as much as 123 mm. Several of our specimens exceed this, and one specimen has an appreciably larger size of 108.30 + 135.00 mm (Table 1). According to published reports, the digits in *H. prashadi* are distinctly webbed at the base and moderately dilated with obliquely oriented lamellae (8 under the first toe and 10 under the fourth) (Smith, 1935; Tikader and Sharma, 1992; Sharma, 2002). Our observations of material from the BNHS collection confirm these ranges (Table 1), but the lamellae in our specimens are in a straight transverse series rather than oblique. Smith (1935), Tikader and Sharma (1992), and Sharma (2002) described males of *Hemidactylus prashadi* as having 17-20 femoral pores per thigh, with the left and right series separated by three scales. The BNHS material is largely consistent with this description, but in BNHS 1577 there are only nine femoral pores on the left thigh and 13 on the right.

Apart from the distinct lateral skin folds, which are weakly denticulate, there is also a sagittal fold of skin above the vertebral column (Figs. 1, 2). The size of the subtrihedral tubercles in the two most medial parasagittal rows is notably smaller than that of the tubercles on more lateral portions of the dorsum. Posterior to the sacrum, a shallow middorsal groove extends onto the basal one third of the tail.

Colouration.– Adult dorsal colouration of *Hemidactylus prashadi* has been described as brownish-grey, with faint narrow whitish bands on the trunk and tail (Smith 1935; Tikader and Sharma, 1992) or as dark brown to black with three to four rows of "medium sized white lunar shaped spots" (Jadhav et al., 1991). Smith (1935) described the colouration of juveniles as "marked with narrow, whitish, dark edged cross bars or series of spots, which are much narrower than their interspaces. The first mark is curved and upon the occiput, and extends forward through the eyes on to the snout. There is a second curved mark upon the nape and five or six, more or less straight ones on the back. Tail with black and white annuli; lower parts greyish". Tikader and Sharma, (1992) and Sharma (2002) followed Smith (1935) in their discussion of juvenile pattern.

In most of the live specimens we examined adults are yellowish-grey above, with a series of dark edged whitish spots arranged in four, more or less uniform longitudinal lines, two on either side of the vertebral fold (Figs. 1, 2). Those adjacent to the vertebral skin fold run from the tip of the snout, through the eyes and along the dorsum to the level of the hind limb insertions. The more lateral lines of spots begin on the supralabials and terminate near the base of the hind limbs. In some specimens, there are some extra spots on the head and vertebral region. In some cases, adjacent spots may contact or coalesce, yielding an incomplete transverse band. The juveniles are dark brown with yellowish spots but the pattern is more or less the same as in adults (Fig. 3). In all the live and preserved specimens, no true cross bands or bars on the dorsum, as described by Smith (1935) and Tikader and Sharma (1992), were observed. Although Smith (1935) noted that the white dorsal marks were very faint or absent in adults, we found that these were clearly evident, though faded, even in large specimens (to > 108 mm SVL). In contrast to the black and white annuli described by Smith (1935), the original tail of living specimens has 8-10 dark-edged whitish bands in adults (Fig. 2). In juveniles, these bands are thinner and the anterior ones may be yellowish (Fig. 3).

Hemidactylus prashadi has generally been considered a rare and endangered species (Molur and Walker, 1998; Bambardeniya and Samarasekara, 2001), due to its restricted distribution. The new records from Dorle, Maharashtra supplement existing records from extreme southern Maharashtra, Goa and Karnataka (Fig. 4) and suggests that this species may yet be found even further north. In addition to having a more widespread distribution than previously supposed, *H. prashadi* appears to be a rather common species, at least in some sites, such as Amboli and Goa. The apparent rarity of *H. prashadi*, despite its large size and high local density, may be due to its superficial resemblance (particularly of adults) to the common gecko *H. flaviviridis* or other large geckos, causing them to be overlooked in plain sight. Indeed, it is probable that records of *H. prashadi* from Srikakulam (Saratchandra and Narasimhamurti, 1980a), Visakhapatnam (Saratchandra and Narasimhamurti, 1981), and Waltair, Andhra Pradesh

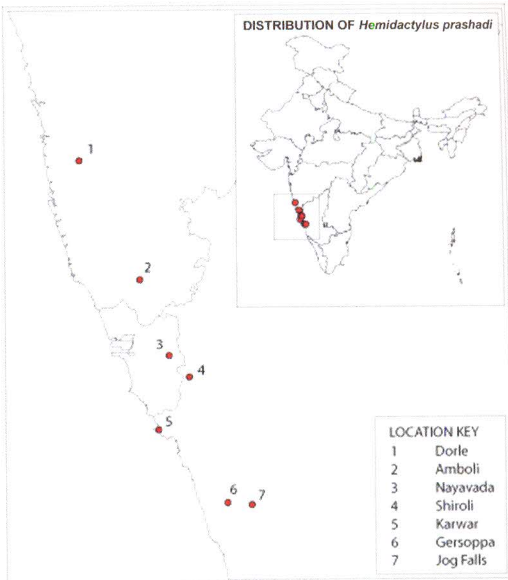

Figure 4. Map showing distribution of *Hemidactylus prashadi*.

(Saratchandra and Narasimhamurti, 1980b; Lakshmi et al., 1985) are based on such confusion, perhaps with *H. leschenaulti*. This situation parallels that of the golden gecko, *Calodactylodes aureus*, a large, brightly coloured and highly vocal gecko of the Eastern Ghats and giant forest gecko *Hemidactylus giganteus*, another large, widespread gecko in Andhra Pradesh, Karnataka and Maharashtra. Despite their conspicuousness and occurrence near human settlements, these species were until recently considered as among the rarest of Indian geckos (Bauer and Das, 2001; Giri et al., 2003).

Our observations suggest that juvenile *Hemidactylus prashadi* are probably chiefly inhabitants of trees in the forest and sometimes villages, and that adults are crevice dwellers, occupying rocks in deep forest (Jadhav et al., 1991) and house walls in villages, which may serve as sites of concentrated insect prey. As some *Hemidactylus* are cannibalistic (Mahendra, 1936; Zamprogno and Teixeira, 1998), it is possible that juveniles choose a different microhabitat in order to avoid predation, although such segregation may also reflect differential prey selection by different age classes. Our data on morphology and life colouration suggest that earlier descriptions, some based on preserved material only, may have overlooked or misinterpreted some features. These data, however, are preliminary and it is hoped that additional information on natural history, distribution, and variation will be collected from throughout the range of this large, regionally endemic gecko.

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CHECKLIST OF THE HERPETOFAUNA OF PULAU LANGKAWI, MALAYSIA, WITH COMMENTS ON TAXONOMY

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(with 19 text-figures)

ABSTRACT.– A checklist of amphibians and reptiles based on vouchered material (specimens and/or photographs) from Pulau Langkawi, located 38 km off the northwest coast of Kedah, peninsular Malaysia, is presented for the first time. Comments are provided to rectify errors in the literature concerning the composition and taxonomy of this island's herpetofauna. Although Pulau Langkawi is approximately three times larger than Pulau Tioman off the southeast coast of peninsular Malaysia, it currently has only 78% of the number of amphibian and reptile species. We interpret this as a strong indication that the species composition of Pulau Langkawi is not yet fully understood.

KEY WORDS.– Pulau Langkawi, Pulau Tioman, species checklist, Malaysia.

INTRODUCTION

The Langkawi Archipelago is the largest group of islands along the west coast of peninsular Malaysia. It encompasses 104 islands located 35 km off the northwest coast of the state of Kedah in the eastern Indian Ocean, immediately adjacent to the southern border of Thailand. Its islands range in size from 0.01–328 km^2 and for the most part, are covered entirely by primary forest (Norhayati et al., 2004). By far the largest island of the archipelago, Pulau Langkawi (328 km^2), is also the most environmentally diverse. Its interior is mountainous and covered with mixed dipterocarp forest and its highest peak, Gunung Raya, reaches 881 m above sea level. Its second highest peak, Gunung Machinchang, reaches 701 m and is one of the oldest geological formations in south-east Asia (Jones, 1981; Stauffer and Mantajit, 1981). Broad, flat, low-lying expanses fringe the interior mountains, providing suitable relief for agriculture as well as lowland dipterocarp forest, coastal vegetation, and mangrove communities.

The latest herpetological inventories of Pulau Langkawi (Ibrahim et al., 2005; Zimmerer 2000, 2004) collectively report a total of 17 species of frogs, five non-marine turtles, 16 lizards, and 28 snakes. None of these surveys, however, listed voucher specimens for any of the reptiles although the amphibian records of Ibrahim et al. (2005) were specimen based and Zimmerer (2000, 2004) presented some photographs. Additional records by Boulenger (1912) and Manthey and Grossmann (1997) also lacked vouchered material (specimens or photographs). Thus, owing to recent taxonomic revisions of some groups and the confusion caused by many, similarly-appearing species, some of the previously cited records are erroneous and others remain unverifiable. The intent of this report is to provide a consolidated, up-to-date, working checklist of the herpetofauna of Pulau Langkawi based on vouchered material which will serve as the foundation for future studies of the entire Langkawi Archipelago.

MATERIALS AND METHODS

During four trips to Pulau Langkawi on 1–3 September 2004, 16–21 March 2005, 2–6 May 2005 and 18–23 August 2005, we carried out surveys concentrated in a significant portion of the western half of the island, working in mangrove and coastal vegetation communities, lowland rice padi fields, and hill dipterocarp forests up to 881 m. Collecting was done on foot along forest trails and streams both during the day and night in beach habitats, padi fields, and by driving roads at night. Specimens were captured by hand or with the aid of blowpipes. Daytime digging of soil and humus to a depth of c. 30 cm was carried out in padi fields and forests. During these surveys, we discovered six species of frogs, four species of lizards (including one new to science), and eight species of snakes previously unknown from Pulau Langkawi and confirmed the presence of three other species reported by other authors. All specimens have been deposited at the Forest Research Institute Malaysia (FRIM), Kuala Lumpur; the La Sierra University Herpetological Collection (LSUHC) at La Sierra University, Riverside, California; or the Natural History Museum, London (BMNH, field tags MW). Additional specimens were examined from the Raffles Museum of Biodiversity Research (ZRC), National University of Singapore, and BMNH. Voucher photographs are deposited in the La Sierra University Digital Photographic Collection (LSUDPC).

RESULTS

A checklist of both confirmed and unconfirmed species from Pulau Langkawi is presented in Table 1. Below is a discussion of new species records and reassessments of the identifications of some of the photographs presented by Zimmerer (2000, 2004).

GYMNOPHIONA

Ichthyophiidae

Ichthyophis Fitzinger, 1826. A larval specimen of *Ichthyophis* sp. collected from Telaga Tuju was first reported and figured by Ng and Ng (1989:82). An adult *Ichthyophis kohtaoensis* Taylor 1960 was reported from Pulau Langkawi by Manthey and Grossmann (1997:Fig. 93) however, the specimen they photographed was lost before it could be examined in detail (Grossmann and Tillack 2000). The taxonomy of ichthyophiids is confused and unstable (Gower et al., 2002), and several striped taxa are known to occur in peninsular Thailand and Malaysia (Taylor 1968, Kupfer & Müller 2004), making identification from photographs extremely difficult.

During the evening of 20 March 2005, we collected five ichthyophiid larvae (LSUHC 7192–96) from a small, rocky stream draining one of the large pools at the Durian Perangin Waterfall. On the night of 3 May 2005 we collected another larva (BMNH field tag MW 4346) from a shallow forest stream at an altitude of c. 250 m on Gunung Raya. One adult ichthyophiid (BMNH field tag MW 4379) was dug out from loose soil beneath a rotting log at the same Gunung Raya locality, during the day of 18 August 2005. This specimen resembles, in colour, the specimen figured by Manthey and Grossmann (1997), and it has splenial teeth and can therefore be referred to the genus *Ichthyophis* rather than *Caudacaecilia* (Taylor, 1968). There is currently no larval taxonomy for caecilians, and the number and identity of species on Pulau Langkawi requires further study.

ANURA

Megophryidae

Leptobrachium Tschudi, 1838. Ibrahim et al. (2005) reported three larvae (Gosner stage 25) collected in rocky puddles from Sungai Perangin at the base of the Tuju Telaga waterfalls as

Table 1. Checklist of the confirmed (based on specimens or photographs) and unconfirmed species of amphibians and reptiles from Pulau Langkawi, Kedah, West Malaysia.

Taxon	Reporting author(s)	Status
GYMNOPHIONA		
Ichthyophiidae		
Ichthyophis sp.	Ng and Ng (1989)	Confirmed here as *Ichthyophis* sp.
ANURA		
Megophryidae		
Leptobrachium smithi	Reported as *L. hendricksoni* by Zimmerer (2004)	Confirmed here as *L. smithi*
Megophrys aceras	Zimmerer (2004)	Confirmed
Bufonidae		
Bufo asper	Zimmerer (2004)	Confirmed
Bufo melanostictus	Zimmerer (2004)	Confirmed
Microhylidae		
Kaloula pulchra	Zimmerer (2004)	Confirmed
Microhyla berdmorei	New record	Confirmed
Microhyla butleri	Ibrahim et al. (2005)	Confirmed
Microhyla fissipes	Reported as *Microhyla ornata* by Berry (1975)	Confirmed
Microhyla heymonsi	Ibrahim et al. (2005)	Confirmed
Rhacophoridae		
Philautus parvulus	New record	Confirmed
Polypedates leucomystax	Ibrahim et al. (2005)	Confirmed
Rhacophorus bipunctatus	New record	Confirmed
Ranidae		
Fejervarya cancrivora	Ibrahim et al. (2005)	Confirmed
Fejervarya limnocharis	Ng and Ng (1989)	Confirmed by Ibrahim et al. (2005)
Limnonectes blythii	Ibrahim et al. (2005)	Confirmed
Limnonectes macrognathus	New record	Confirmed
Occidozyga lima	Ibrahim et al. (2005)	Confirmed
Phrynoglossus laevis	Ibrahim et al. (2005)	Confirmed
Phrynoglossus martensii	New record	Confirmed
Rana erythraea	Ng and Ng (1989)	Confirmed
Rana glandulosa	Ibrahim et al. (2005)	Confirmed
Rana raniceps	Ibrahim et al. (2005)	Confirmed
Taylorana hascheana	New record	Confirmed
CHELONIA		
Trionychidae		
Amyda cartilaginea	Zimmerer 2000	Confirmed
Dogania subplana	Confirmed by Zimmerer (2004)	Confirmed by Zimmerer (2004)
Testudinidae		
Indotestudo elongata	Zimmerer (2000)	Confirmed
Bataguridae		
Cuora amboinensis	Zimmerer (2004)	Confirmed
Hieremys annandalei	Zimmerer (2004)	Confirmed
Siebenrockiella crassicollis	Ibrahim et al. (2005); no voucher	Confirmed here
SQUAMATA (LIZARDS)		
Agamidae		
Acanthosaura crucigera	Reported as *A. armata* by Zimmerer (2004)	Confirmed here as *A. crucigera*
Bronchocela cristatella	Zimmerer (2004)	Confirmed

Draco blanfordii	Zimmerer (2004)	Confirmed
Draco maculatus	Reported as *D. volans by* Zimmerer (2000)	Confirmed here as *D. maculatus*
Leiolepididae		
Leiolepis belliana	Boulenger (1912); no voucher	Confirmed by Chan-ard et al. (1999:133)
Gekkonidae		
Cosymbotus platyurus	New record	Confirmed
Cyrtodactylus pulchellus	Manthey and Grossmann (1997); no voucher	Confirmed by Chan-ard et al. (1999:113)
Cyrtodactylus quadrivirgatus	Manthey and Grossmann (1997)	Confirmed
Gehyra mutilata	New record	Confirmed
Gekko gecko	Zimmerer (2000)	Confirmed
Gekko monarchus	Zimmerer (2004)	Unconfirmed
Gekko smithii	Ibrahim et al. (2005)	Unconfirmed
Hemidactylus frenatus	Zimmerer (2000)	Confirmed
Ptychozoon kuhli	New record	Confirmed
Scincidae		
Dasia olivacea	Zimmerer (2004)	Confirmed
Eutropis macularia	Ibrahim et al. (2005)	Unconfirmed
Eutropis multifasciata	Zimmerer (2000)	Confirmed
Sphenomorphus sp.	New record	Confirmed
Lygosoma bowringii	New record	Confirmed
Varanidae		
Varanus nebulosus	Zimmerer (2000)	Confirmed
Varanus salvator	Zimmerer (2000)	Confirmed
SQUAMATA (SNAKES)		
Typhlopidae		
Ramphotyphlops braminus	New record	Confirmed
Cylidrophiidae		
Cylindrophis ruffus	New record	Confirmed
Pythonidae		
Python reticulatus	Zimmerer (2000)	Confirmed
Colubridae		
Ahaetulla fasciolata	Zimmerer (2000, 2004)	Unconfirmed
Ahaetulla nasuta	Zimmerer (2000, 2004)	Unconfirmed
Ahaetulla prasina	Chan-ard et al. (1999)	Confirmed
Boiga cyanea	Lim and Ratnam (1996)	Confirmed
Boiga cynodon	Ibrahim et al. (2005); no voucher	Confirmed by Zimmerer (2004)
Boiga dendrophila	Zimmerer (2000)	Confirmed
Calamaria pavimentata	New record	Confirmed
Chrysopelea ornata	New record	Confirmed
Chrysopelea paradisi	Zimmerer (2000)	Confirmed
Dendrelaphis caudolineatus	Zimmerer (2004)	Confirmed
Dendrelaphis cyanochloris	Zimmerer (2004)	Confirmed
Dendrelaphis formosus	Zimmerer (2004)	Unconfirmed
Dendrelaphis pictus	Zimmerer (2004)	Confirmed
Dryocalamus subannulatus	Reported as *D. davisonii* by Zimmerer (2004)	Confirmed here as *D. subannulatus*
Dryophiops rubescens	Chan-ard et al. 1999	Confirmed
Enhydris enhydris	Zimmerer (2004)	Confirmed
Elaphe flavolineata	Schulz 1996	Confirmed

Gonyosoma oxycephalum	Zimmerer (2004)	Confirmed
Homalopsis buccata	Ng and Ng (1989)	Confirmed
Oligodon cyclurus	Zimmerer (2004)	Confirmed
Pareas margaritophorus	New record	Confirmed
Rhabdophis chrysargos	Zimmerer (2000)	Confirmed
Xenochrophis trianguligerus	New record	Confirmed
Zaocys carinatus	New record	Confirmed
Xenopeltidae		
Xenopeltis unicolor	Zimmerer (2000)	Confirmed
Elapidae		
Bungarus candidus	Zimmerer (2000)	Confirmed
Calliophis maculiceps	Lim and Mohd. Sharef (1975)	Confirmed
Naja kaouthia	Zimmerer (2000)	Confirmed
Ophiophagus hannah	Zimmerer (2004)	Confirmed
Viperidae		
Calloselasma rhodostoma	Ibrahim et al. (2005); no voucher	Confirmed here
Cryptelytrops purpureomaculatus	Zimmerer (2000)	Confirmed
Cryptelytrops venustus	Zimmerer (2000)	Confirmed here
Popeia fucata	Reported as *Trimeresurus popeiorum* and *C. kanburiensis* by Zimmerer (2004)	Confirmed here as *P. fucata*
Tropidolaemus wagleri	Zimmerer (2000)	Unconfirmed

belonging to *L. nigrops* Berry and Hendrickson 1963. Given that the larvae of *L. nigrops* and *L. smithi* Matsui, Nabhitabhata, and Panha, 1999 are very similar in morphology and *L. nigrops* is not known any further north in peninsular Malaysia than Tasek Bera, Pahang (Berry, 1975), nor have any other *L. nigrops* (larvae or adults) been found on Pulau Langkawi, it is likely that these larvae were misidentified and belong to *L. smithi.* In a revision of *Leptobrachium* from Thailand, Matsui et al. (1999) indicated that populations from southernmost Thailand and northern Malaysia are referable to *L. smithi.* Zimmerer (2004) reports *L. hendricksoni* as occurring in the lowland rainforest of Pulau Langkawi but figures *L. smithi* (Plate 72; Fig. 251). During the evening of 1 September 2004 seven adult *L. smithi* (LSUHC 6847–53) were collected along a small stream at Lubuk Semilang and two more (LSUHC 6885–86) along the road to Gunung Raya. We currently consider all *Leptobrachium* from Pulau Langkawi to be *L. smithi.*

Microhylidae

Microhyla berdmorei (Blyth, 1856) (Fig. 2). On 1 September 2004, one specimen (LSUHC 6857) was found along the edge of a grassy pond at night at Lubuk Semilang. This is a new record for Pulau Langkawi.

Rhacophoridae

Philautus parvulus (Boulenger, 1892) (Fig. 3). Several specimens were heard calling from within dense vegetation along the road near the top of Gunung Raya on 2 and 3 September 2004 and one neonate (LSUHC 6821) was collected sitting on a leaf 8 cm above the ground. This is a new record for Pulau Langkawi.

Rhacophorus bipunctatus Ahl, 1927 (Fig. 4). During the evening of 19 August 2005 13 specimens (LSUHC 7540–52) of *R. bipunctatus* were collected from a deep, forested ravine at the top of Gunung Machinchang at approximately 600 m in elevation. All were calling males sitting 1–4 m above the ground in the branches of bushes and trees. All differ in coloration from peninsular *R. bipunctatus* in lacking dark markings on the flanks, although some individuals from Indochina also lack such markings (pers. obs. of LLG 2005).

Ranidae

Limnonectes macrognathus (Boulenger, 1917) (Fig. 5). Two specimens (LSUHC 6840–41) were collected at Lubuk Semilang from along the edge of a stream during the evening of 1 September 2004. On 2 September, three additional specimens (LSUHC 6854–56) were collected from within a drainage ditch along the road leading to Gunung

Raya approximately 300 m below the summit. Several others were heard calling from the edge of thick vegetation along this same road. This represents a new record for Pulau Langkawi.

Phrynoglossus martensii Peters, 1867 (Fig. 6). Three specimens (LSUHC 6881–82, 6884) were found on the evening of 3 September 2004 along side the road to Gunung Raya calling from the edge of tall grass during a rain shower. On 1 September 2004, a specimen (LSUHC 6883) was found at Lubuk Semilang in short grass at the edge of a small pond. This represents a new record for Pulau Langkawi.

Taylorana hascheana (Stolickza, 1870) (Fig. 7). Two juveniles (LSUHC 6858–59) were collected on the forest floor along the cable car trail at the base of Gunung Machinchang during the afternoon on 1 September 2004. Four others (LSUHC 7178–81) were found on the evening of 19 March 2005 at Tuju Telaga. This is a new record for Pulau Langkawi.

CHELONIA

Bataguridae

Siebenrockiella crassicollis Lindholm, 1929 (Fig. 8). Ibrahim et al. (2005) reported finding an individual from Sugai Lubok Semilang but listed no voucher specimen or photograph. On 15 August 2005 we found one individual (LSUDPC 1040–43) in a flooded padi field near Kadawang. Others were seen on 20 August 2005 and in padi fields at Jalan Bukit Belah on 16 and 17 August 2005.

SQUAMATA (LIZARDS)

Agamidae

Acanthosaura crucigera Boulenger, 1885. Zimmerer (2004) lists *A. armata* (Hardwicke and Gray, 1827) as being present on Pulau Langkawi although *A. crucigera* is the species figured (Plate 68; figs. 233–34). We collected an additional specimen of *A. crucigera* (LSUHC 6831) during the evening of 1 September 2004 at Lubuk Semilang while it was sleeping on a small branch approximately 1.5 m above the ground.

Draco maculatus (Gray, 1845). Zimmerer (2000) lists *D. volans* Linnaeus, 1758 as being present on Pulau Langkawi but figures *D. maculatus* (Plate 67; figs. 227–230). On 1 September 2004 we collected a specimen of *D. maculatus* (LSUHC 6791) in coastal vegetation near the mangroves at Telok Burau and on 3 September 2004, six additional specimens (LSUHC 6823–28) were collected from coconut palms along the beach at Telok Burau.

Gekkonidae

Gehyra mutilata (Wiegmann, 1834) (Fig. 9). One specimen (LSUHC 6871) was collected from a concrete drain along side the road to Gunung Raya on 3 September 2004. It represents a new record for the island.

Scincidae

Lygosoma bowringii (Günther, 1864). Two individuals of *L. bowringii* (LSUHC 6837–38) were found beneath a log on the beach at Telok Burau on 3 September 2004 and another (LSUHC 7590) beneath a rock at Lubuk Semilang on 21 August 2005. These constitute a new record for Pulau Langkawi.

Sphenomorphus sp. On 1 September 2004 a skink (LSUHC 6709) referable to the genus *Sphenomorphus* Fitzinger, 1843 (Lim, 1998) was collected from beneath a rock near the top of Gunung Machinchang along the cable car trail. Although the specimen was damaged during collection, it is still possible to confirm that it is not referable to any known species from the Sunda Shelf (see Grismer, 2005a: Table 2) and is probably a new taxon. This constitutes a new record for Pulau Langkawi.

SQUAMATA (SNAKES)

Typhlopidae

Ramphotyphlops braminus (Daudin, 1803). On 1 September 2004, one specimen was found beneath a rock at the summit of Gunung Raya but escaped collection. On 3 September 2004 another specimen (LSUHC 6839) was collected beneath a log on the beach at Telok Burau. This represents a new record for Pulau Langkawi.

Cylindrophiidae

Cylindrophis ruffus (Laurenti, 1768) (Fig. 10). This species was relatively common in wet (but not flooded) rice paddies as well as along the small canals associated with the rice

Figure 1. *Ichthyophis* sp. (BMNH field tag MW 4379) from the top of Gunung Raya. Photo by DJG.

Figure 2. *Microhyla berdmorei* (LSUHC 6857) from Lubuk Semilang. Photo by LLG.

Figure 3. *Philautus parvulus* (LSUHC 6821) from the summit of Gunung Raya. Photo by LLG.

Figure 4. *Rhacophorus bipunctatus* (LSUHC 7540) from just below the summit of Gunung Machinchang. Photo by LLG.

fields. Specimens were observed at night on the surface. Two specimens (LSUHC 7574–75) were collected in a padi field along the edge of a drainage canal in Kampung Kadawang on 20 August 2005. These specimens constitute a new record for Pulau Langawi.

Colubridae

Ahaetulla Link, 1807. Zimmerer (2000) indicates that *A. prasina, A. mycterizans,* the "Long Nosed Whip Snake" (*A. nasuta*), and the "Spotted Whip Snake" (*A. fasciolata*) all occur on Pulau Langkawi. Only the former can be confirmed based on photographs in Chanard et al. (1999:152) and Zimmerer (2004: Plate 61; Figs. 200–202). Zimmerer's (2004) figures 200 and 202 are not of *A. mycterizans* but *A. prasina,* as is his figure 201. Zimmerer (2004) mentions that *A. fasciolata* is rare on Pulau Langkawi but does not figure it or *A. nasuta*. Therefore, we consider their presence unconfirmed.

Calamaria pavimentata Duméril, Bibron and Duméril, 1854. On 3 May 2005 a single specimen (BMNH field tag MW 4352) was dug out from soft soil under rotting wood close to the top of Gunung Raya. This constitutes a new record for Pulau Langkawi.

Chrysopelea ornata (Merrem, 1820) (Fig. 11). Zimmerer (2000, 2004) lists *C. ornata* ("Golden Paradise Tree Snake") as occurring on Pulau Langkawi but provides no voucher. On 19 March 2005 an individual (LSUHC 7158) was found crawling through low shrubs in a garden area at the Langkawi Snake Sanctuary. It is unlikely that this specimen was a Sanctuary escapee, and an expert resident on Langkawi recognized it as a native species (O. Ayeb pers. comm., 2005). This constitutes a new record for Pulau Langkawi.

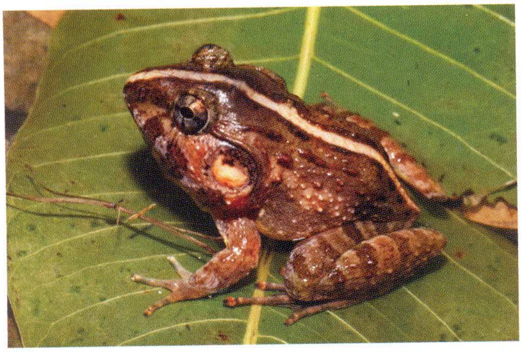

Figure 5. *Limnonectes macrognathus* (LSUHC 6854) from approximately 300 m below the summit of Gunung Raya. Photo by LLG.

Figure 6. *Phrynoglossus martensii* (LSUHC 6883) from Lubuk Semilang. Photo by LLG.

Figure 7. *Taylorana hascheana* (LSUHC 7178) from Tuju Telaga. Photograph by LLG.

Figure 8. *Siebenrockiella crassicollis* (LSUDP 783) from Jalan Bukit Belah. Photograph by DJG.

Dryocalamus subannulatus (Duméril, Bibron, and Duméril, 1854). Zimmerer (2004) reports the presence of *D. davisonii* (Blanford, 1878) but figures *D. subannulatus* (Plate 61; fig. 204). He also reports the possible presence of *Lycodon effraenis* Cantor, 1847 but figures another individual of *D. subannulatus* (Plate 61; fig. 203). During the evening of 1 September 2004 we collected a single specimen (LSUHC 6877) of the latter species while it was crawling down the trunk of a large tree approximately 4 m above the ground.

Dryophiops rubescens (Gray, 1835). Zimmerer (2004) reports the presence of *Dendrelaphis striatus* (Cohn 1906) but figures *Dryophiops rubescens* (Plate 62; fig. 208), a species previously reported from Pulau Langkawi by Chanard et al. (1999:163).

Homalopsis buccata (Linnaeus, 1758) (Fig. 12). Ng and Ng (1989) were the first to report and figure *H. buccata* from Pulau Langkawi. During the evenings of 15–20 August 2005, several individuals of *H. buccata* (LSUHC 7568–73) were observed in the narrow canals bordering padi fields at Jalan Bukit Belah. Most were juveniles that had anchored themselves in the water-flow by wrapping their tails around vegetation, presumably to aid in ambushing passing prey.

Oligodon Boie 1827. Zimmerer (2004) figures an unidentified species of *Oligodon* (Plate 65: fig. 221) from the interior of a cave on the eastern side of Pulau Langkawi. The specimen is dark brown and appears to have a faint, vertebral stripe on the anterior portion of the body. The photograph is not clear enough for a positive species identification. On the night of 18 August 2005 we found an *O. cyclurus* (Cantor, 1839) on the road at the base of Gunung Raya (LSUHC 7561; Fig. 13). We have observed a tendency

Figure 9. *Gehyra mutilata* (LSUHC 6871) from approximately 300 m below the summit of Gunung Raya. Photograph by LLG.

Figure 10. *Cylindrophus ruffus* (LSUHC 7574) from Kadawang. Photograph by LLG.

Figure 11. *Chrysopelea ornata* (LSUHC 7158) from Langkawi Snake Sanctuary. Photograph by LLG.

Figure 12. Upper; adult *Homalopsis buccata* (LSUDPC 1064). Lower; juvenile *H. buccata* (LSUDPC 1181). Specimens from Jalan Bukit Belah. Photographs by DJG.

Figure 13. *Oligodon cyclurus* (LSUHC 7561) from the base of Gunung Raya. Photograph by LLG.

for vertebral striping in other specimens of *O. cyclurus* from northern Malaysia and southern Thailand (also see Chanard et al., 1999:174) and believe that the specimen illustrated in Zimmerer (2004) is *O. cyclurus*. This constitutes a new record for Pulau Langkawi.

Pareas margaritophorus (Jan, 1866) (Fig. 14). On 3 September 2004 one specimen (LSUHC 6876) of this species was collected at night at the bottom of the road leading to the top of Gunung Raya. It represents a new species record for the island. Manthey and Grossmann (1997) report this species attaining a total length of 470 mm. LSUHC 6876 was a gravid female carrying three eggs and had a body and tail length of only 295 mm. This suggests that females from Pulau Langkawi might reach reproductive maturity at a smaller size.

Figure 14. *Pareas margaritophorus* (LSUHC 6876) from the base of Gunung Raya. Photograph by LLG.

Figure 15. *Xenochrophis trianguligerus* (LSUHC 6830) from Lubuk Semilang. Photograph by LLG.

Figure 16. *Zaocys carinatus* (LSUHC 7600) from Tuju Telaga. Photograph by LLG.

Figure 17. *Calloselasma rhodostoma* (LSUDPC 785) from near Langkawi Snake Sanctuary. Photograph by LLG.

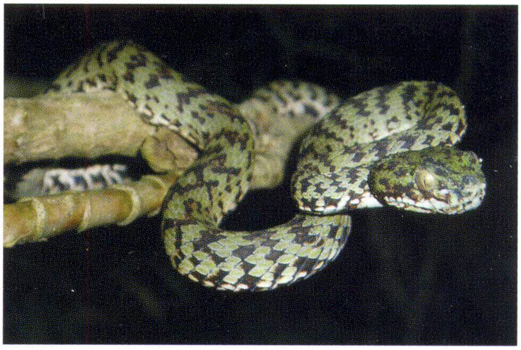

Figure 18. *Cryptelytrops venustus* (LSUDPC 975) from summit of Machincang. Photograph by PLW.

Xenochrophis trianguligerus (Boie, 1827) (Fig. 15). On 1 September 2004, a single specimen (LSUHC 6830) was collected at night from a small stream at Lubuk Semilang. It represents a new record for the island.

Zaocys carinatus (Günther, 1858) (Fig. 16). During the day on 19 August 2005 an adult *Z. carinatus* (LSUHC 7600) was found crossing the foot path at Telaga Tuju. This constitutes a new record for Pulau Langkawi.

Viperidae

Calloselasma rhodostoma (Boie, 1827) (Fig. 17). Ibrahim et al. (2005) reported finding a single specimen in an open field at Telok Datai but provided no voucher material. On 20 March 2005 we photographed a captive specimen (LSUDPC 783–87) at the Langkawi Snake Sancutary that was collected by one of the curators, Ms. Noraini Ismail, near the Sanctuary during February 2005.

Trimeresurus Lacépede, 1804. Asian pitvipers of the genus *Trimeresurus* (*sensu stricto*)

Figure 19. Variation observed in *Popeia fucata* taken from the road to Gunung Raya. Upper left (LSUHC 6874; female, SVL 533 mm): iris red, postorbital stripe absent, body bands absent, white ventrolateral stripe, tail with red bands. Upper right (LSUHC 7564; female, SVL 472 mm): iris red, postorbital stripe absent, body bands absent, ventrolateral stripes absent, tail unicolor red. Middle left (LSUHC 7566; female, SVL 546 mm): iris red, postorbital stripe present, body banded, red and white ventrolateral stripes, tail with red bands. Lower right (LSUHC 7067; female, SVL 353 mm): iris yellow, postorbital stripe absent, body banded, red and white ventrolateral stripes, tail unicolor red. Lower left (LSUHC 6832; female, SVL 585 mm): iris green, postorbital stripe present, body banded, red and white ventrolateral stripes, anterior one-half of tail with red bands and posterior one-half unicolour red. Photographs by LLG.

have a long and confusing taxonomic history. The latest revision (Malhotra and Thorpe, 2004) provides solid molecular and morphological evidence for partitioning *Trimeresurus* into a number of monophyletic genera. Of significance to this survey are the genera *Cryptelytrops* (formerly referred to as the *T. albolabris* group) and *Popeia* (formerly the *T. popeiorum* group) because *P. popeiorum* Smith, 1937, *C. venustus* Vogel, 1991, and *C. kanburiensis* Smith, 1943 have been reported from Pulau Langkawi (Zimmerer, 2000, 2004: Figs. 215 and 216 for *P. popeiorum* and *C. kanburiensis*). Gumprecht et al. (2004) also report *C. venustus* from Pulau Langkawi, though apparently based on correspondence with J. Zimmerer.

David et al. (2004) confirmed the specific validity of *Cryptelytrops kanburiensis* and its distinction from *C. venustus* and noted that the former only occurs in the southern Thai provinces of Krabi, Nakhon Si Thammarat, and Surat Thani. Zimmerer (2000: Fig. 130) reported *C. venustus* as occurring on Pulau Langkawi. On 18 August 2005 we photographed a specimen of

C. venustus at the Langkawi Snake Sanctuary that was captured by Ms. Noraini Ismail during February 2005 (LSUDP 974–75; Fig. 18) from the upper elevations of Gunung Machinchang.

During our September 2004 and August 2005 surveys, we collected nine specimens of *Popeia* on the road to the top of Gunung Raya (LSUHC 6793, 6832–34, 6872, 6874, 7564–66; Fig. 19) which showed considerable colour pattern variation within the range of that reported for *P. fucata* (*fide* Vogel et al., 2004). They also matched *P. fucata* in squamation (Vogel et al., 2004). Therefore, we confirm the presence of *Popeia fucata* and *Cryptelytrops venustus* on Pulau Langkawi and consider the presence of *C. kanburiensis* unproven.

Unconfirmed species.

Zimmerer (2004) reports that *Dendrelaphis formosus* (Boie 1827), *Naja naja* (Linnaeus, 1758), and *Tropidolaemus wagleri* Wagler, 1830 occur on Pulau Langkawi but provided no voucher material. Although the presence of *D. formosus* and *T. wagleri* is possible, their occurrence is unconfirmed. *Naja naja* is not known from southern Thailand and northern Malaysia (Wüster and Thorpe, 1989). Further field-work is planned to ascertain the status of these species.

DISCUSSIONS

This report brings the total number of confirmed species of amphibians and reptiles on Pulau Langkawi to 80; one caecilian, 23 frogs, six non-marine turtles, 17 lizards, and 33 snakes (Table 1). Certainly the herpetofauna of Pulau Langkawi is not completely known and a logical comparison with that from Pulau Tioman of the Seribuat Archipelago off the southeast coast of Pahang is useful in bearing this out. Both islands are landbridge islands of similar age yet Pulau Langkawi (328 km^2) is approximately three times the size of Pulau Tioman (110 km^2) but has only 92% of the number of amphibians, 53% of the lizards, and 84% of the snakes (Grismer et al., 2006). Furthermore, these percentages may be over estimations because they assume all the unconfirmed species for Pulau Langkawi are present. Pulau Langkawi does however have five species of non-marine turtles versus one on Pulau Tioman. Additionally, there are at least 12 endemic species of amphibians and reptiles on Pulau Tioman (Grismer, 2006; Grismer et al., 2006) and only one on Pulau Langkawi (reported here for the first time). Thus, overall, Pulau Langkawi has only 78% of the herpetofauna of the much smaller Pulau Tioman. We believe this to be the result of a lack of field work. Pulau Tioman has been intensively investigated since 1999 (see Grismer, 2006; Grismer et al., 2006 and references therein) whereas Pulau Langkawi has received comparatively little attention (Ibrahim et al., 2005) even when compared to Pulau Pinang just 100 km to the south whose herpetofauna was reasonably well surveyed by the turn of the century (see Boulenger, 1912). Furthermore, the work that has been done on Pulau Langkawi has been restricted to only a few areas and very little of the island's pristine interior has been thoroughly investigated.

The remaining 103 islands that compose the Langkawi Archipelago range in size from 0.01–102 km^2. With the exception of Pulau Singa Besar (Norsham Y., unpubl.), the vast majority of these remain virtually unexplored herpetologically. We expect the satellite islands surrounding Pulau Langkawi to have additional species not found on Pulau Langkawi, as well as their own endemics. A similar situation is found in the satellite islands surrounding the major islands of the Seribuat Archipelago (Grismer et al., 2006). Field-work is currently being planned to survey all these islands.

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THE HERPETOFAUNA OF THE SOUTH-EAST PAHANG PEAT-SWAMP FOREST

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(with two text-figures)

ABSTRACT.– A range of different sites and habitats within the south-east Pahang peat-swamp forests were surveyed for amphibians and reptiles. Habitats included river bodies, open marshes, and peat-swamp forests proper. A total of 17 species of amphibians, 6 species of lizards and 9 species of snakes were directly observed during surveys across all sites and habitats. These observations include the first record of *Bufo kumquat* Das and Lim, 2001, outside its type locality. In addition photographs and other evidence (e.g., carapaces) established the presence of 7 species of turtles, as well as of heavy harvesting and trade pressures on local populations of these species.

KEYWORDS.– Amphibians, reptiles, Malaysia, peat-swamp forests, wetlands, *Bufo kumquat*.

INTRODUCTION

This paper reports the results of a herpetofaunal survey of the south-east Pahang peat-swamp Forest. The south-east Pahang peat-swamp forest comprises four Forest Reserves - Pekan Forest Reserve (43,797 ha), Nenasi Forest Reserve (20,546 ha), Kedondong Forest Reserve (1,818 ha) and Resak Forest Reserve (9,681 ha) - located in Pahang, in eastern Peninsular Malaysia.

There have been no previous published peer-reviewed herpetological studies of this area. However, the preliminary documentation for a Global Environment Facility (GEF) project recorded the presence of four species of snakes, one species of lizard and two species of turtles (Sebastian, 1998). In addition, the report also noted anecdotal evidence of *Crocodylus porosus* (the saltwater crocodile), as well as the possibility of the presence of *Tomistoma schlegelii* (the false gharial). Another unpublished survey was carried out in 2002 in the RIMBAKA concession, in the Pekan Forest Reserve, which was one of the sites targeted in the present study. The species recorded in this study together with those recorded by Sebastian (1998) are given in Appendix 1.

METHODOLOGY

Sites.– A total of 10 sites were surveyed between 4–7 June and 29 June – 8 July, 2003 (see Table 1). The early survey period (4–7 June) was characterized by very dry weather, and no rains had been noted in the area for close to a month. The second survey period was considerably wetter in some of the survey areas, with brief, heavy thunderstorms towards the late afternoon and evenings during the surveys; however, the weather in general, relative to the rainy season, was still predominantly dry.

Pekan Forest (RIMBAKA logging concession).– The site surveyed is an active logging concession located in the north of the peat-swamp forest complex, in the Pekan Forest Reserve. The habitat includes both logged as well as unlogged peat-swamp forest. No streams as such run through this area, though logging operations and associated activities have greatly modified the drainage, and the network of logging roads are lined with ditches. The entire area is reported to flood during the primary wet season (i.e., the Northeast Monsoon). Surveys were conducted both in disturbed and undisturbed forest (Compartments 71: N3.43847; E103.31566, 69: N3.43725; E103.28485, 75: N3.42836; E103.35415, and 98: N3.42358; E103.35475), as well as along logging roads and skid trails.

Lower Bebar River.–The lower portion of the Bebar River was explored by boat, from the mouth up to N3.20747; E103.36061. The lower stretches of this river were mostly mangrove or nipah swamp, with brackish water. The upper portions of the river are generally freshwater, with *Barringtonia conoidea* and *Pandanus* spp. stands dominating the vegetation.

Upper Bebar River.–The lower portion of the Bebar River was explored by boat, and around the DANIDA survey campsite.

Upper Bebar Forest.–This is an undisturbed peat-swamp forest area within the Pekan Forest Reserve.

Lower Merchong River.–This river was surveyed at night by boat, from its mouth to N3.03386; E103.37442. The lower reaches of the surveyed area consists of mangrove or nipah swamp, while the upper reaches are freshwater, with stands of *Barringtonia conoidea* and *Pandanus*.

Upper Merchong River.–The stretch of the Merchong between N3.01405; E103.37228 and N3.04539; E103.33950 was surveyed at night by boat. This reach of the river is dominated by *Pandanus* stands, and ran through peat-swamp forest.

Upper Merchong Forest.–This was unlogged peat-swamp forest surrounding the Merchong River between E103.36126 and E103.33760. A newly-constructed logging road running from N3.05147; E103.35802 provided access to the forest. The road was walked at night, up to N3.05211; E103.33932. In addition, the forest on the other side of the river was reached by boat at N3.04539 E103.33950 and surveyed.

Padang Camung.– This is a large expanse of open herbaceous marshland in the peat-swamp forest complex in the Nenasi Forest Reserve. A maintenance track for power pylons provided access into the area. Alongside each of the maintenance tracks, there were large standing bodies of blackwater.

Nenasi Forest.–This forest was surveyed from a track leading in from the Padang Camung area at N3.21451; E103.27094 for about 750 m.

Api Larat.–This is a rather unique habitat - a dryland forest "island" within the peat-swamp forest.

SAMPLING METHODOLOGY

Search technique varied depending largely on whether the surveys were conducted in a primarily aquatic or terrestrial habitats (i.e., rivers vs. forest). In all cases, surveys were conducted at night. Aquatic sites were surveyed by boat, aided by large spotlights, while terrestrial sites were surveyed using headlamps and hand-held flashlights. Voucher specimens were collected from each of the sites for most species, except where the individuals could not be captured (noted in Results, below). In addition, incidental collections and/or observations were made in transit between and to and fro between the various sites. Liver tissue was taken from representative specimens and preserved in 100% ethanol. Tissues and specimens were deposited at FRIM.

IDENTIFICATION AND NOMENCLATURE

Identification was made on the basis of standard references applicable to the area (Berry, 1975; Boulenger, 1912; Cox et al., 1998; Inger, 1966; Manthey and Grossman, 1997; Parker, 1934; Smith, 1930; Taylor, 1962; Tweedie, 1953). Nomenclature for amphibians follows that of Frost (2004). Nomenclature for reptiles follows that of the EMBL Reptile Database (http://www.reptile-database.org/).

RESULTS

Amphibia.– A total of 17 species across all five families of West Malaysian anurans were documented in the sites over the course of the surveys (see Table 2).

Bufonidae

Bufo kumquat Das and Lim, 2001

Material.– FRIM 0692

A single individual of this species was collected from the Api Larat area, though a number of them were heard calling in the vi-

Table 1. Details of sites surveyed in south-east Pahang, and principal survey methodology employed.

Sites	Dates surveyed	Habitat type	Sampling methodology
Pekan Forest (RIMBAKA logging concession)	June 4 -7	Peat-swamp forest	Walking surveys through forest and down logging roads at night with headlamps and/or hand-held flashlights.
Lower Bebar River	July 2, 3	River	Boat-based surveys at night with spotlights.
Upper Bebar River		River	Walking surveys at night along riverbanks.
Upper Bebar Forest		Peat-swamp forest	Walking surveys through forest at night with head-lamps and/or hand-held flashlights
Lower Merchong River	June 30, July 1	River	Boat-based surveys at night with spotlights.
Upper Merchong River	July 5,6 and 8	River	Boat-based surveys at night with spotlights.
Upper Merchong Forest	July 6, 7	Peat-swamp forest	Walking surveys along logging roads through forest at night with headlamps and/or hand-held flashlights.
Padang Camung	July 4	Open marshes	Walking surveys along pylon track at night with headlamps and/or hand-held flashlights
Nenasi Forest	July 4	Peat-swamp forest	Walking surveys along logging roads through forest at night with headlamps and/or hand-held flashlights
Api Larat	July 6, 7	Dryland forest	Walking surveys along logging roads through forest at night with headlamps and/or hand-held flashlights

cinity. Some of the frogs were apparently calling from nearby pools of water. This represents the first record of *Bufo kumquat* from outside its type locality (i.e., the north Selangor peat-swamp).

Bufo melanostictus Schneider, 1799

Material.– FRIM 0639–0641

This toad, usually associated with anthropogenic or heavily modified/disturbed habitats, was only recorded in the Api Larat area.

Pseudobufo subasper Tschudi, 1838

Material.– FRIM 0631–0638

Large numbers of this peat-swamp specialist were observed along all the rivers surveyed in the area. They were absent from other bodies of water, such as the ditches of water along logging roads, or the standing bodies of water in the Padang Camung marshes (however, from the pylon track at Padang Camung, at about N3.21278; E103.25980, a loud calling aggregation was heard due north). In general, the calling of these toads as observed during the course of this survey was somewhat scattered and sporadic. The locals, however, report that during the rainy season, the loud vocalizations of this species can be deafening.

This toad appears to be almost fully aquatic, and none were encountered in terrestrial areas. Larger individuals were almost invariably found in the water, usually floating vertically (with just the head above the water, the arms spread out horizontally just below the surface and the rest of the body and legs hanging down) underneath or at the base of aquatic or semi-aquatic vegetation (such as *Pandanus* or *Barringtonia*). Smaller individuals (snout-vent length < 3 cm), however, were also frequently encountered perched on the branches, stems and leaves of the aforementioned vegetation.

Megophryidae

Leptobrachium nigrops Berry and Hendrickson, 1963

Material.– FRIM 0642

Individuals of this species were collected from the leaf-litter at two forest sites, the Upper Bebar Forest and the Api Larat forest.

Microhylidae

Kaloula baleata (Müller, 1836)

Individuals of this species were heard calling from water table underneath skid trails and partially constructed roads in the Pekan Forest. None were encountered anywhere else, including water-logged ditches and other standing bodies of water in the Pekan Forest or elsewhere. This is the first record of this species in a peat-swamp habitat or any swamp forest habitat. Unfortunately, no specimens could be retrieved, due to the inaccessibility of their location.

Microhyla butleri Boulenger, 1900

Material.– FRIM 1386–1387

Individuals of this species were collected from the Api Larat forest area.

Ranidae

Fejervarya cancrivora (Gravenhorst, 1829)

Material.– FRIM 0643–0645

In the brackish stretches of rivers such as the Bebar and the Merchong, this frog was the only species encountered, usually sitting on mud banks within nipah or mangrove vegetation. This species was also observed calling from the standing bodies of water in the Padang Camung open marshes.

Fejervarya limnocharis (Gravenhorst, 1829)

Material.– FRIM 0646–0647

This species was observed in the sand quarry just outside the Pekan Forest, along newly constructed logging roads in the Merchong Forest, the heath forest in around the Orang Asli village (Kampung Padang) by the Merchong river, and around the standing bodies of water along the pylon track in the Padang Camung marshes. The largest concentration observed was by the marshes of Padang Camung, where they formed calling aggregations.

Limnonectes paramacrodon (Inger, 1966)

Material.– FRIM 0648–0656

This frog was collected from the banks of the Upper Bebar and Upper Merchong rivers. None were encountered in the forest nearby.

Rana baramica Boettger, 1903

Material.– FRIM 0037–0038, 0526, 0528–0530, 0535, 0541, 0667–0674

There are at least two species in the southeast Asian region that are commonly referred to *Rana baramica* Boettger, 1903 (Leong et al., 2003). *Rana baramica*, in the strict sense, is described from the Baram River in Borneo (Sarawak), while *Rana laterimaculata* Barbour and Noble, 1916, described from the Sadong River region, also in Borneo (Sarawak). However, *Rana laterimaculata* has been recently re-established as a full species following work by Leong et al. (2003). The species documented in this survey conforms to *Rana baramica* Boettger, 1903 (*sensu stricto*, following Leong et al., 2003). In Peninsular Malaysia, this form has thus far only been observed in one other locality, the North Selangor peat-swamp, in Sabak Bernam (pers. obs.), and thus appears to be a peat-swamp habitat specialist in this region. In other regions, both forms have been noted to be sympatric in some swampy areas (e.g. Singapore; Indraneil Das, pers. comm.).

This was by far the most common frog encountered in the peat-swamp forest proper, and, indeed, on a number of nights, it was the only frog documented in the forest. They were active, and their vocalizations were often heard from the evening onwards in all of the peat-swamp forests. Large numbers were also observed around the ditches along the logging tracks and open bodies of water in the Pekan Forest, many of which were calling. They were, however, absent from many of the other habitats surveyed (e.g., the Padang Camung marshes, or along rivers or the forest area immediately next to the rivers).

Rana erythraea (Schlegel, 1837)

Material.– FRIM 0099, 0658–0662

This frog was abundant along the Upper Merchong and Upper Bebar Rivers, and, to a lesser extent, along the ditches by the logging roads in the RIMBAKA forest. In the Upper Merchong River, in particular, along with *Pseudobufo subasper*, this species dominated the anuran fauna. Along the rivers, they were most often noted perched on streamside vegetation.

Rana miopus Boulenger, 1918

Individuals of this species were noted calling from the Api Larat area by the third author.

Rana raniceps Peters, 1871

Material.– FRIM 0663–0666

One individual of this species was encountered in the forest in the RIMBAKA area, while a few were collected from the streamside vegetation along the Upper Merchong River.

Rhacophoridae

Polypedates colletti (Boulenger, 1890)

Material.– FRIM 0098, 0237, 0533–0534, 0538–0540, 0675–0680

This frog was frequently encountered in the peat-swamp forest proper. No calls were noted.

Polypedates leucomystax (Gravenhorst, 1829)

Material.– FRIM 0525,0683–0684

This common edge species was observed in vegetation along the logging roads in both the RIMBAKA forest as well as the Upper Merchong forest area. In addition, they were heard calling from the scrub vegetation alongside the pylon track in the Padang Camung area.

Polypedates macrotis (Boulenger, 1891)

Material.– FRIM 0681–0682

Individuals of this species were collected from the edge of the forest in the Upper Merchong area.

Rhacophorus aff. *appendiculatus* (Günther, 1859 "1858")

Material.– FRIM 0623–0627

Individuals of this species were collected from the Upper Bebar, Upper Merchong and Api Larat forests. They were only noted while they were vocalizing during and immediately after rains from vegetation just inside the forest. While reported here as "*Rhacophorus* aff. *appendiculatus*", preliminary results of work on the systematics of the *Rhacophorus verrucosus* group has indicated that the Malayan members of this complex (as represented by specimens collected during the course of the current work) may, in fact, be distinct (Bryan Stuart, pers. comm.).

Other anurans.– Vocalizations of *Rana glandulosa* Boulenger, 1882, were also noted from a distance, just outside the Api Larat area, but it is impossible to specify with certainty whether the calls originated from inside the designated survey area (i.e., the peat-swamp forests) or otherwise.

Squamata (Sauria).– A total of six species of lizards were noted during the course of the survey (see Table 2).

Scincidae

Eutropis multifasciata (Kuhl, 1820)

Material.– FRIM 0536

An individual of this species was collected from the RIMBAKA forest area. There were a number of other skinks observed in the daytime, but none were caught. The paucity of the skink fauna as reported here is a reflection of the survey time and techniques. Use of pit-fall traps or targetted searches during the day in future searches may increase this fauna.

Agamidae

Aphianotus fusca (Peters, 1864)

Material.– FRIM 0688

Individuals of this species were collected from trees in the RIMBAKA forest are as well as the Padang Camung area.

Leiolepis belliana (Hardwicke & Gray, 1827)

Material.– FRIM 1388–1389

This species was not only observed in the sandy heath forest adjacent to the Upper Merchong Forest, but also along large area of loose sand. They are highly stenotypic in their habitat type, strongly associated with sandy areas.

Gekkonidae

Cyrtodactylus quadrivirgatus Taylor, 1962

Material.– FRIM 0532, 0537, 0685–0687, 0691

This gecko was frequently encountered in wood, vegetation and logging debris alongside the logging rides in the Pekan Forest, as well as inside the peat-swamp forests proper in RIMBAKA, Nenasi, and around the upper Sungai Merchong. In addition, this species was encountered in the Api Larat area.

Gekko smithii Gray, 1842

Material.– FRIM 0689

One individual of this species was collected from the Api Larat area. Calls of this species were periodically heard from the RIMBAKA and Upper Bebar forest.

Varanidae

Varanus salvator (Laurenti, 1768)

This species was fairly commonly observed in the RIMBAKA and Upper Merchong forest areas, along the logging roads.

Squamata (Serpentes).– A total of nine species of snakes were documented during the surveys (see Table 2).

Acrochordidae

Acrochordus javanicus Hornstedt, 1787

Two dead individuals were noted in the Upper Merchong River, washed up and entangled in debris by the side of the river. In an unsurveyed area nearby (the Pekan Virgin Jungle Reserve), one live individual was observed trapped in a fishing net. The local Orang Asli do not explicitly harvest or otherwise kill this snake, so the mortalities and by-catch are presumed to be incidental.

Colubridae

Boiga dendrophila (Boie, 1827)

This snake was abundant in both the lower and upper reaches of the two rivers (Merchong and Bebar). Individuals were noted in the water as well as on vegetation on the banks (from low saplings to high up on trees).

Boiga nigriceps (Günther, 1863)

A single adult was observed moving along the logging road in the Upper Merchong forest one night.

Elaphe radiata (Boie, 1827)

A single adult was found dead on the side of the road leading to the jetty near Kampung Runchang, in the Upper Bebar forest.

Enhydris enhydris (Schneider, 1799)

Material.– FRIM 0523

One individual was observed crossing the main road late at night just outside the Pekan Forest, apparently moving from the forest toward a flooded scrub area on the other side of the road.

Macropisthodon flaviceps (Duméril, Bibron & Duméril, 1854)

Material.– FRIM 0690

Four individuals of this species were observed swimming in the water on separate occaisions during the night surveys of the Upper Sungai Merchong. One individual was collected next to a fishing trap in a river in the Nenasi peat-swamp forest.

Ptyas korros (Schlegel, 1837)

One roadside mortality of this species was noted on the main road, just outside the RIMBAKA forest area.

Elapidae

Bungarus candidus (Linnaeus, 1758)

A single individual was observed swimming in the Upper Merchong River during a night boat survey.

Xenopeltidae

Xenopeltis unicolor (Reinwardt, 1827)

A large (> 1 m) individual was observed on the logging road in the Pekan Forest. It was quite sluggish, and did not move until it was touched.

Chelonii

No turtles were directly observed in the wild during the herpetological surveys. However, it appears that the freshwater turtles in the area are heavily harvested by the local Orang Asli, and in most villages large piles of discarded carapaces were observed. Based on carapaces, two species were identified: *Cyclemys dentata* (Gray, 1831) and *Orlitia borneensis* Gray, 1873. In addition, live captive individuals (harvested by the Orang Asli) of four species were photographed - *Cuora amboinensis* (Daudin, 1802), *Heosemys grandis* (Gray, 1860), *Heosemys spinosa* (Gray, 1831) and *Siebenrockiella crassicollis* (Gray, 1831).

DISCUSSION

Diversity.– All the amphibian species documented previously in this area were observed in the present study. In addition, another 12 species were added, for a total of 17 species of amphibians (see Appendix 1). Of the lizard species, two of the four species previously documented were observed in this study, with an additional five species recorded, resulting in a total of nine species of lizards (see Appendix 2). Although only one of the five snake species previously noted was observed during this study, an additional eight species were documented, for a total of 13 species of snakes (see Appendix 3). The two species of turtles noted in previous work were not observed during this study, but an additional six species were, for a total of eight species of turtles (see Appendix 4).

The amphibian fauna documented in this survey include a number of habitat specialists (see Table 3). Three of the species – *Pseudobufo subasper*, *Bufo kumquat* and *Rana baramica* (in the Peninsula) – are generally limited to peat-swamp habitats (Inger, 1966; pers. obs.). Six other species, while found in other macrohabitats, are known to be more common in swampy areas (Inger, 1966).

Amphibian assemblages.– A Principal Component Analysis (PCA) of amphibian species composition of the 10 sites surveyed (see Table 2), based on correlations of species presence/absence in each of the sites, using SPSS (version 12) is presented in Figure 1. An alternate analysis of site affinities based on anuran faunal composition is given by a Hierarchical Cluster Analysis using Pearson's correlation index, as presented in Figure 2.

As can be seen, five assemblages can be distinguished based on the clustering patterns:

A lower river assemblage.– the Lower Bebar and Merchong River assemblages: *Pseudobufo subasper* and *Fejervarya cancrivora*.

An upper river assemblage.– the Upper Bebar and Upper Merchong River assemblages: mainly *Pseudobufo subasper*, *Limnonectes paramacrodon* and *Rana erythraea*, with the *Rana raniceps* also observed on the Upper Merchong River.

A peat-swamp forest assemblage.– the Upper Bebar Forest, Upper Merchong Forest and Pekan Forest assemblages: species common to all sites include *Rana baramica*, *Rana erythraea*, *Polypedates leucomystax*; while species found in common at least at two sites include *Fejervarya limnocharis*, *Polypedates colletti*, and *Rhacophorus appendiculatus*. The Hierarchical Cluster Analysis groups the Nenasi Forest assemblage here along with the other peat-swamp forest sites, but the Principal Components Analysis clusters the Nenasi Forest assemblage with the Padang Camung site. As discussed below, we suggest that the affinities indicated by the PCA are attributable to an artifact of sampling.

An open marsh assemblage.– essentially, the Padang Camung assemblage. In this case, the Principal Component Analysis (but not the Hierarchical Cluster Analysis) groups the Nenasi Forest with Padang Camung. We suggest that this is probably an artifact of sampling. The brief survey time (one night) in the forest recovered only one species (*Rana baramica*); a slightly increased survey effort would probably yield some of the common peat-swamp rhacophorids (such as *Polypedates colletti*) which would tend to cluster the Nenasi forest with the "peat-swamp forest" assemblage).

A dryland "island" assemblage.– the Api Larat assemblage. This assemblage stands isolated and distinct from any of the other assemblages. It indeed presents a unique habitat within the peat-swamp forest complex. It is one of the numerous dryland "islands" in the peat-swamp mosaic, and thus presents completely different ecological regimes to the rest of the area.

The presence of these five distinctive assemblages is indicative of the mosaic of habitat-types that are found within the south-east Pahang peat-swamps, and peat-swamp forest *per*

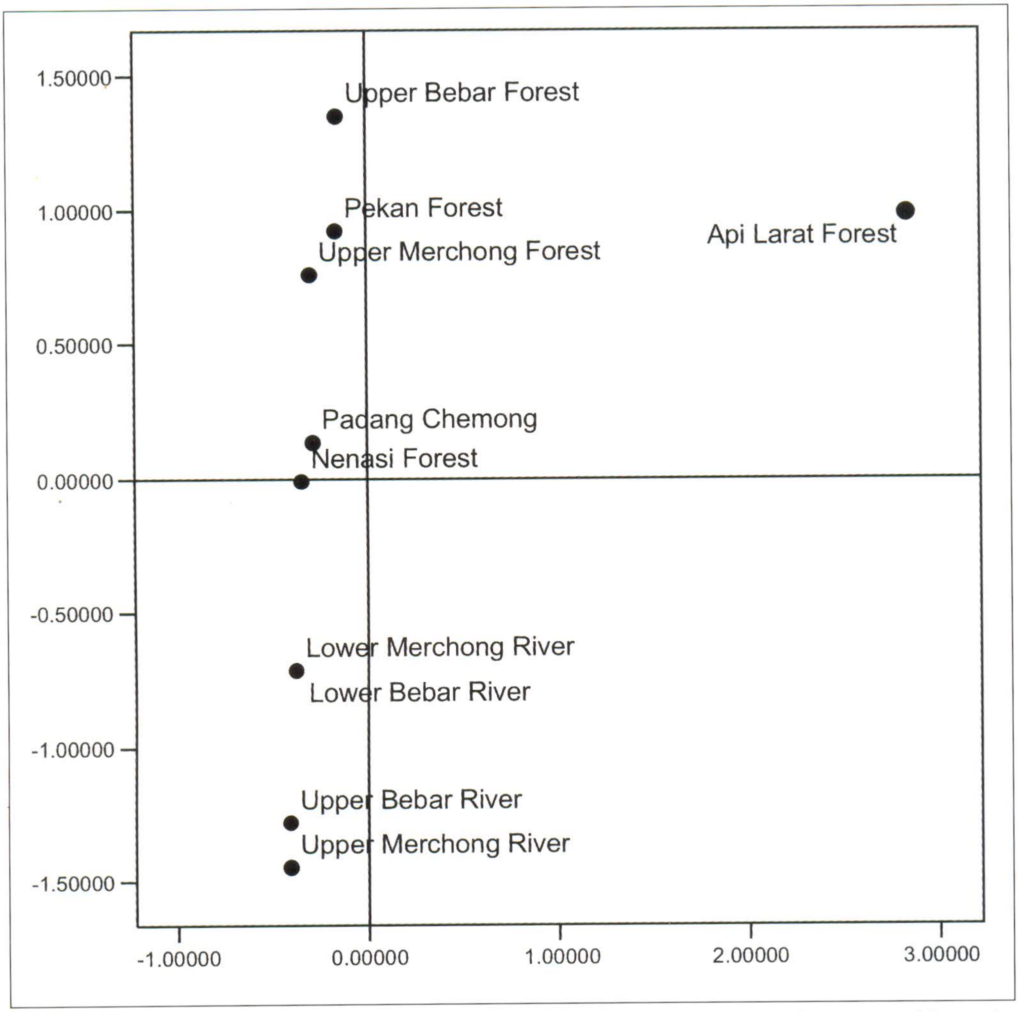

Figure 1. Principal Component Analysis (PCA) of species compositions at the 10 sites surveyed in south-east Pahang, based on correlations of species presence/absence, to show clustering of sites as given amphibian assemblage similarity in species.

se is only one of the many habitat types found in the area.

THREATS TO BIODIVERSITY

Logging and land conversion.– The south-east Pahang peat-swamp forests administratively fall into one of two categories - stateland forest and forest reserves. Both types of forests are being actively exploited for timber, but stateland is subject to changes in land use (land conversion), while forest reserves are not.

However, even without considering land conversion, there are differences in how the timber resources of these two forest categories are exploited that have an impact on the herpetofauna. Timber extraction in forest reserves is subject to a suite of policies, guidelines and protocols, that appear to not apply (at least in practice) to timber extraction in stateland forests. Furthermore, the logging as practiced in the Pekan Forest Reserve, by RIMBAKA, appears to have a much more reduced impact on the forest's biodiversity when compared to that practiced in the stateland forests at Merchong.

The Pekan Forest Reserve, including the logged areas, apparently continues to support a relatively more rich assemblage, as is evidenced by similarities in species observed in both logged and unlogged forest, both within the concession (i.e., observations made within

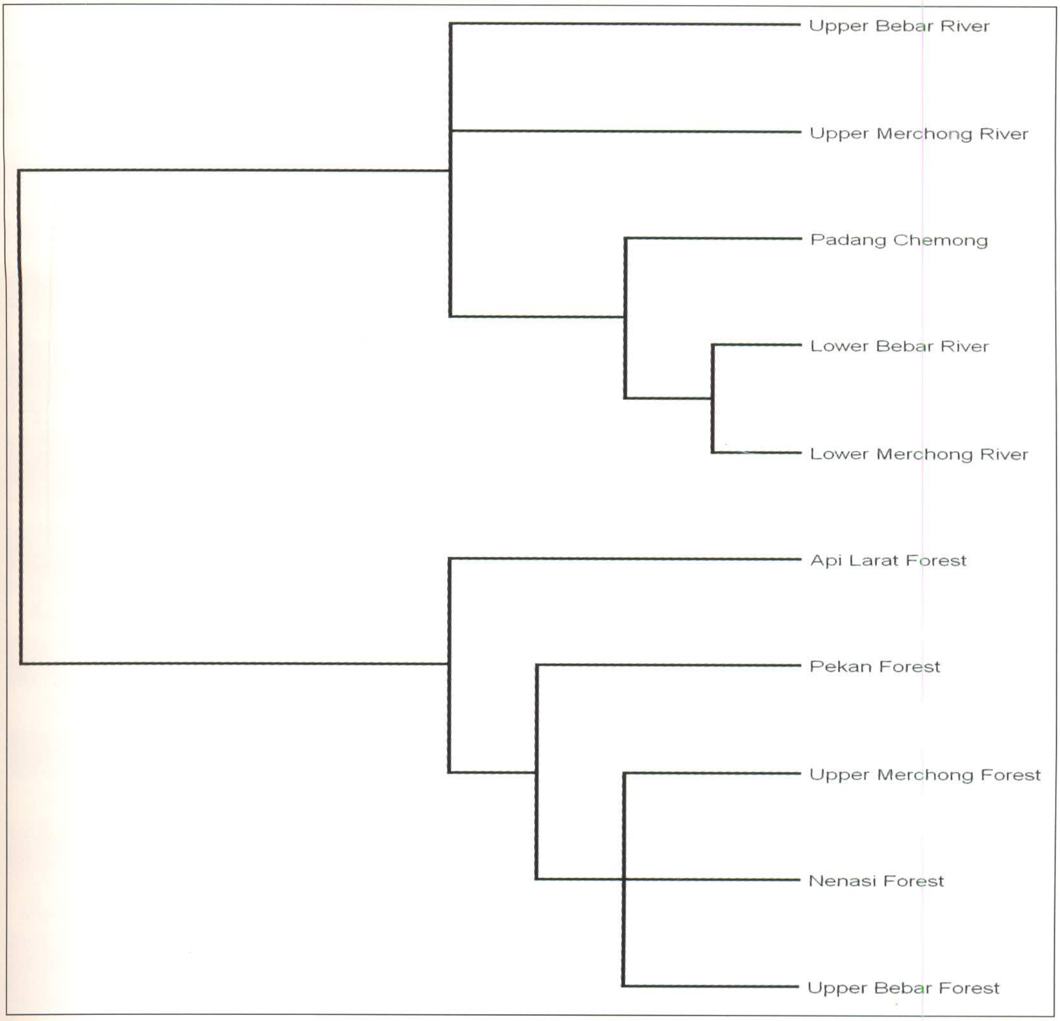

Figure 2. Hierarchical cluster analysis of sites based on Pearson correlation of the anuran faunal compositions at each site in south-east Pahang.

logged compartments compared to unlogged compartments in the RIMBAKA concession) as well as outside (i.e., observations made within the concession as compared to observations in unlogged forests, such as the DANIDA transect). The stateland forests, on the other hand, showed heavy impact, and most of the amphibians and reptiles observed there were invasives and commensals.

In natural peat-swamp forest, the dominant amphibian species observed was *Rana baramica*. Throughout the survey period, regardless of weather, their calls were heard from most of the peat-swamp forest areas, including the Pekan Forest Reserve RIMBAKA logging concession. These calls, however, were conspicuously absent from the logging areas just outside the Upper Merchong forest (though they were observed within the Upper Merchong Forest itself, which is only just being opened up for logging, with the initial roads being constructed). The logging areas in the stateland forest had many invasive commensals present. The differences in the forests of the RIMBAKA concession and the stateland logging areas can be attributed almost completely to the differences in logging practices, as the undisturbed forests in both areas yielded similar assemblages. Further studies are required to quantitatively document the differences in fauna, and concretely identify specific differences in logging practices that may lead to the faunal differences.

Table 2. Species documented during surveys of the south-eastern Pahang peat-swamp forest, showing details of occurrence by site.

Species	Pekan Forest	Upper Bebar Forest	Upper Bebar River	Lower Bebar River	Lower Merchong River	Upper Merchong River	Upper Merchong Forest	Padang Chenomg	Nenasi Forest	Api Larat
ANURA										
Bufonidae										
Bufo kumquat Das and Lim, 2001										X
Bufo melanostictus Schneider, 1799										X
Pseudobufo subasper Tschudi, 1838			X	X	X	X		X		
Megophryidae										
Leptobrachium nigrops Berry and Hendrickson, 1963		X								X
Microhylidae										
Kaloula baleata (Müller, 1836)	X									
Microhyla butleri Boulenger, 1900										X
Ranidae										
Fejervarya cancrivora (Gravenhorst, 1829)				X	X			X		
Fejervarya limnocharis (Gravenhorst, 1829)	X						X	X		X
Limnonectes paramacrodon (Inger, 1966)			X			X				
Rana baramica Boettger, 1903	X	X					X	X	X	X
Rana erythraea (Schlegel, 1837)	X	X	X			X	X	X	X	X
Rana miopus Boulenger, 1918										X
Rana raniceps (Peters, 1871)	X					X				
Rhacophoridae										
Polypedates colletti (Boulenger, 1890)	X	X								X
Polypedates leucomystax (Gravenhorst, 1829)	X	X					X	X		
Polypedates macrotis (Boulenger, 1891)							X			
Rhacophorus aff. *appendiculatus* (Günther, 1859 "1858")		X					X			X
SQUAMATA - SAURIA										
Agamidae										
Aphionotus fusca (Peters, 1864)	X							X		

Leiolepis belliana (Hardwicke & Gray, 1827)							X			
Gekkonidae										
Cyrtodactylus quadrivirgatus Taylor, 1962	X	X						X	X	
Gekko smithii Gray, 1842	X								X	X
Scincidae										
Eutropis multifasciata (Kuhl, 1820)	X									
Varanidae										
Varanus salvator (Laurenti, 1768)	X						X			
SQUAMATA - SERPENTES										
Acrochordidae										
Acrochordus javanicus Hornstedt, 1787						X				
Colubridae										
Boiga dendrophila (Boie, 1827)				X	X	X				
Boiga nigriceps (Guenther, 1863)							X			
Elaphe radiata (Boie, 1827)		X								
Enhydris enhydris (Schneider, 1799)	X									
Macropisthodon flaviceps (Duméril, Bibron & Duméril, 1854)						X			X	
Ptyas korros (Schlegel, 1837)	X									
Elapidae										
Bungarus candidus (Linnaeus, 1758)						X				
Xenopeltidae										
Xenopeltis unicolor (Reinwardt, 1827)	X									

Harvesting.– A number of species documented in this survey are of international or national conservation significance. Pythons and monitor lizards, for example, are scheduled both under the Wildlife Act of 1972 and CITES; thus, in theory, harvesting and trade in these animals should be controlled. Other species can be considered to be of significant conservation concern on the basis of their extreme stenotopic habitat preference coupled with the critical status of their habitats, as with, for example, *Pseudobufo subasper* and peat-swamp forests.

Turtles that occur in peat swamps are threatened due to unregulated, intensive, widespread and targetted harvesting. This situation is alarming, given that seven out of the eight turtles reported from this area are of international conservation concern, with IUCN listings ranging from Critical, to Endangered and Vulnerable (see Table 4), while the eighth (*Cyclemys dentata*) is considered Near Threatened.

At the moment, the full extent of the trade chain is completely unknown. The large midden-piles of discarded carapaces observed around most of the villages at the site are indicative of large-scale local consumption, but it remains to be determined if any of the turtles are traded or exported for consumption elsewhere. Since external trade has been noted for almost every other non-timber forest product from the

Table 3. Known habitat associations of amphibian species identified in this survey. Information on habitat associations is based on published localities (Inger, 1966; Berry, 1975; Manthey and Grossmann, 1997) and personal observations. "Exclusive swamp association" indicates species only documented in peat-swamps; "Strong swamp association" indicates species that are found in other habitats, but seem to be dominant or more commonly found in wetland habitats; "No particular swamp association" indicates species that are found with equal (or more) probability in other natural habitats, such as lowland dryland forests; "Commensals/edge species" indicates species commonly encountered in anthropogenic habitats.

Species	Exclusive swamp association	Strong swamp association	No particular swamp association	Commensals/ edge species
Bufonidae				
Bufo kumquat Das and Lim, 2001	X			
Bufo melanostictus Schneider, 1799				X
Pseudobufo subasper Tschudi, 1838	X			
Megophryidae				
Leptobrachium nigrops Berry and Hendrickson, 1963		X		
Microhylidae				
Kaloula baleata (Müller, 1836)			X	
Microhyla butleri Boulenger, 1900			X	
Ranidae				
Fejervarya cancrivora (Gravenhorst, 1829)		X		
Fejervarya limnocharis (Gravenhorst, 1829)				X
Limnonectes paramacrodon (Inger, 1966)		X		
Rana baramica Boettger, 1903	X (see text)			
Rana raniceps (Peters, 1871)			X	
Rana erythraea (Schlegel, 1837)			X	
Rana miopus Boulenger, 1918			X	
Rhacophoridae				
Polypedates colletti (Boulenger, 1890)		X		
Polypedates leucomystax (Gravenhorst, 1829)				X
Polypedates macrotis (Boulenger, 1891)			X	
Rhacophorus aff. *appendiculatus* (Günther, 1859 "1858")		X		

area (including ferns, birds, mammals, fishes, etc.), it is highly likely that turtles, too, are traded externally.

Two factors in turtle biology lead to making them particularly vulnerable to rapid extirpation when subjected to intense harvesting pressure: (a) a very low recruitment rate (low annual clutch size); and (b) long growth period before reproductive maturity.

Immediate measures need to be undertaken to halt the harvesting of turtles. Unfortunately, this is probably an intractable situation, as there

Table 4. Conservation status of turtles documented in the south-east Pahang peat-swamp forests.

Species	IUCN Red List Category
Callagur borneoensis (Schlegel and Müller, 1844)	CR A1bcd
Cuora amboinensis (Daudin, 1802)	VU A1d+2d
Cyclemys dentata (Gray, 1831)	LR/nt
Heosemys grandis (Gray, 1860)	VU A1d+2cd
Heosemys spinosa (Gray, 1831)	EN A1bcd
Orlitia borneensis Gray, 1873	EN A1d+2d
Siebenrockiella crassicollis (Gray, 1831)	VU A1cd+2cd
Amyda cartilaginea (Boddaert, 1770)	VU A1cd+2cd

is little middle ground. "Sustainable harvesting" of freshwater turtles in the current context is not feasible, and there have been no documented cases of sustainable harvesting of turtles. There are too many gaps and conflicts in the legislation protecting the turtles of Malaysia, and freshwater turtles are not protected under the Wildlife Act of 1972.

Moreover, even if legislative and policy changes were to be effected in time, enforcement would be practically impossible under the current context, with the primary harvesters (the Orang Asli) living in the forest and next to the rivers, and enforcement agencies are not only based outside, at a great distance, but also under-funded and under-staffed to monitor such a large area.

The only practical approach would be to zone selected linear segments of the rivers, and associated forest areas as Totally Protected Areas, ensuring compliance of the locals through a set of measures (including education, community commitment, sharing of benefits and/or financial recompense, as well as strict enforcement). These areas could then serve as sanctuaries to ensure a stable core population of the freshwater turtles in the area.

CONSERVATION RECOMMENDATIONS

Follow-up monitoring.– Without a doubt, the two biggest limitations of this study are the short survey time, and the extremely circumscribed survey period. In most of the sites, the survey time was no more than two nights. It would be difficult to defend this as sufficient time to provide anything more than a preliminary or cursory assessment of each site. Furthermore, the primary seasonal regimes governing herpetofauna activity are the monsoons, and dramatically different assemblages might be observed if surveys were carried out in the rainy season. Ideally, assessments should be carried out at the beginning and end of the rainy season as well as during the middle of the dry season, as this one was.

The assemblage analysis presented in this paper indicates that due to faunal similarities, particular sites can be taken as representative of a group of sites. As such, follow-up surveys could concentrate time and effort in a much smaller subset of these representative sites, but investing longer search times in the fewer sites, and, ensure that surveys are conducted in different seasons (most especially the rainy season).

These surveys would provide a much better understanding of the herpetofauna, which would greatly benefit any management planning. If properly structured and when combined with data from similar surveys on other taxonomic groups, they would be able to provide an insight into specific practices that could be implemented by logging operations to minimize their impact on biodiversity.

Targeted assessment of the status of freshwater turtles.– The rampant harvesting of turtles, as evidenced by the discarded carapaces found in most villages in the peat-swamp area, is currently unmonitored. However, these midden piles provide for a convenient means to gather some critical scientific and conservation data. Almost nothing is known of some of these turtle species (e.g., *Orlitia borneensis*). A short-term study to assessing turtle conservation information should be conducted involving visits to these villages, and inspecting and enumerating the species in midden piles. Coupled with interviews with the villagers, to determine harvesting period, declines in catches (if any), harvest areas and/or seasons, etc., it would be possible to provide critical data on the population status of these turtles that would be fundamental to any conservation planning for the area. Results of such a study could also provide important scientific and ecological information that would fill in many gaps in our understanding of these species biology, and this would, in turn, aid conservation efforts of these species throughout their range. A longer term ecological study could also be undertaken, aimed at elucidating the important features of the life cycles of the different species; i.e., breeding areas and periods, migrations (if any), nursery areas, diet, and so on.

Establishment of riparian sanctuaries.– The most immediate and beneficial measure that needs to be undertaken is the establishment of Totally Protected Areas (TPAs) along selected segments of the peat-swamp rivers. These TPAs would not only include the rivers per se, but also the associated forests zones adjacent to either side of the river and connecting to undisturbed peat-swamp forest on either side. Within these TPAs, there should be no harvesting or exploiting of any element of the ecosystem, biotic or abiotic. It needs to be emphasized that the Orang Asli should not be exempt from this restriction, and, indeed, such a scheme could only work if the Orang Asli understand the logic and reasoning behind it, and commit themselves as a community to help maintain it. These TPAs could then serve as sources that will ensure the future of their own livelihood.

Targeted searches for *Tomistoma schlegelii*.– Throughout the surveys, numerous anecdotal reports of the presence of *T. schlegelii*, were obtained from the local Orang Asli. However, none were observed during these surveys. The global conservation status of this species is extremely tenuous - it is listed as 'Endangered' by the IUCN, and the agency estimates that there are only about 2,500 mature individuals in the wild. The national conservation status of this species is even more of a cause for concern. The only known population of this species in Peninsular Malaysia was in Tasek Bera, but a preliminary survey of the lake in 1997 did not record any individuals, and it is quite possible that it has been extirpated from the area due to intensive hunting. Under these circumstances, if a population of this species does indeed exist in the peat-swamps of south-east Pahang, then it needs to be identified and immediate measures should be taken to secure its status.

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APPENDIX 1

Comprehensive list of amphibian and reptile species documented in the south-east Pahang peat-swamp complex.

Species	This Study	Sebastian, 1998	RIMBAKA, 2000
AMPHIBIA			
Bufonidae			
Bufo kumquat Das and Lim, 2001	X		
Bufo melanostictus Schneider, 1799	X		
Pseudobufo subasper Tschudi, 1838	X		
Megophryidae			
Leptobrachium nigrops Berry and Hendrickson, 1963	X		
Microhylidae			
Kaloula baleata (Müller, 1836)	X		
Microhyla butleri Boulenger, 1900	X		
Ranidae			
Fejervarya cancrivora (Gravenhorst, 1829)	X		
Fejervarya limnocharis (Gravenhorst, 1829)	X		X
Limnonectes paramacrodon (Inger, 1966)	X		

Rana baramica Boettger, 1903	X		X
Rana erythraea (Schlegel, 1837)	X		X
Rana miopus Boulenger, 1918	X		
Rana raniceps (Peters, 1871)	X		
Rhacophoridae			
Polypedates colletti (Boulenger, 1890)	X		X
Polypedates leucomystax (Gravenhorst, 1829)	X		X
Polypedates macrotis (Boulenger, 1891)	X		
Rhacophorus aff. *appendiculatus* (Günther, 1859 "1858")	X		
SQUAMATA – SAURIA			
Agamidae			
Aphionotus fusca (Peters, 1864)	X		X
Draco formosus Boulenger, 1900			X
Draco quinquefasciatus Hardwicke and Gray, 1827			X
Leiolepis belliana (Hardwicke & Gray, 1827)	X	X	
Gekkonidae			
Cyrtodactylus quadrivirgatus Taylor, 1962	X		
Gekko smithii Gray, 1842	X		
Hemidactylus frenatus Duméril and Bibron, 1836			X
Scincidae			
Eutropis multifasciata (Kuhl, 1820)	X		
Varanidae			
Varanus salvator (Laurenti, 1768)	X		
SQUAMATA – SERPENTES			
Acrochordidae			
Acrochordus javanicus Hornstedt, 1787	X		
Boidae			
Python reticulatus (Schneider, 1801)		X	X
Colubridae			
Boiga dendrophilia (Boie, 1827)	X	X	
Boiga nigriceps (Günther, 1863)	X		
Dryocalamus subannulatus (Duméril, Bibron and Duméril, 1854)			X
Elaphe radiata (Boie, 1827)	X		
Enhydris enhydris (Schneider, 1799)	X		
Macropisthodon flaviceps (Duméril, Bibron & Duméril, 1854)	X		
Ptyas korros (Schlegel, 1837)	X		
Elapidae			
Bungarus candidus (Linnaeus, 1758)	X		
Naja sp.		X	
Ophiophagus hannah (Cantor, 1836)		X	
Xenopeltidae			
Xenopeltis unicolor (Reinwardt, 1827)	X		

TESTUDINES		
Bataguridae		
Callagur borneansis (Schlegel and Müller, 1844)		X
Cuora amboinensis (Daudin, 1802)	X	
Cyclemys dentata (Gray, 1831)	X	
Heosemys grandis (Gray, 1860)	X	
Heosemys spinosa (Gray, 1831)	X	
Orlitia borneensis Gray, 1873	X	
Siebenrockiella crassicollis (Gray, 1831)	X	
Trionychidae		
Amyda cartilaginea (Boddaert, 1770)		X

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STUDIES ON PAKISTAN LIZARDS: OBSERVATIONS ON THE SCINCID LIZARD *EURYLEPIS TAENIOLATUS* (BLYTH, 1854)

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(with three text-figures)

ABSTRACT.– **A collection of 18 *Eurylepis taeniolatus* from Pakistan provides additional data on the species' morphology and biology. Among scincids, the species is generally primitive in its morphology. The scale pattern around the nostril (supranasal, postnasal and nostril between anterior and posterior nasals) is at one end of a morphocline for these scales and is shared with other generally primitive scincids. The species' two clearly derived features are the fused paravertebral scales on the body and the elevated number of presacral vertebrae 36-38 (26 is primitive for skinks). The combination of a relatively elongate body with primitive limb morphology makes it a good species in which to study the environmental circumstances in which limbed locomotion and axial locomotion (lateral undulation) may be used. The number of maxillary teeth is positively correlated with head length. The snout-vent length is in isometry with head length (but just).**

KEY WORDS.– ***Eurylepis taeniolatus*, elongation, morphology, Pakistan, Scincidae.**

INTRODUCTION

The University of Florida (UF) holds a small collection of reptiles from Pakistan, which was made primarily by Sam R. Telford, Jr. in the 1970s and by Walter Auffenberg in the late 1980s and early 1990s. These specimens provide a potentially important contribution to the herpetology of Pakistan, but to date only a few taxonomic groups have been examined in detail. We have begun an analysis of the scincid lizards in the collections and have previously reported on the genus *Mabuya* (Greer et al., 2004). In this paper, we report on the scincine scincid genus *Eurylepis* (see Taylor, 1936 for the concept of the taxon and Griffith et al., 2000 and Schmitz et al., 2004 for its current taxonomic rank). This taxon is especially important, because like other taxa previously grouped under the genus *Eumeces*, it is probably near the base of the scincid phylogenetic tree (see Greer and Broadley, 2000 and Harris et al., 2001 for arguments and analysis, respectively, supporting the basal placement of at least some previous members of *Eumeces*, but see Whiting et al., 2003 for a slightly higher placement). All of our examined specimens are referable to the widespread species *Eurylepis taeniolatus* and include 17 whole specimens in alcohol and one dried skeleton.

MATERIALS AND METHODS

Snout-vent length was measured to the nearest 0.5 mm by pressing the ventral surface of the head and body to a steel ruler. Head length was measured to the nearest 0.1 mm by applying digital calipers to the distance between the tip of the snout and the centre of the external ear opening. Hind limb length was made with a steel ruler applied against the posterior edge of the limb between the base of the tail and the tip of the claw.

Most head scales can be identified by reference to Fig. 1. The nuchals are defined as the very wide paravertebrals just posterior to the parietals.

Paravertebral scales were counted in one row starting with the first paravertebral falling posterior to an imaginary line connecting the posterior surfaces of the rear legs (held normal to the body) forward to and including the anteriormost nuchal.

The "heel" scales were evaluated subjectively as being relatively larger or smaller compared to the adjacent scales (Fig. 2). These evaluations were made prior to the sexing of the specimens.

Midline characters and single sides of a bilateral character are reported as "n"; both sides of a bilateral character are reported as "cases".

Sex, reproductive state and other aspects of internal morphology were assessed through a longitudinal slit in the ventrolateral body wall. There are only three females among the 17 alcoholic specimens so we are unable to assess statistically many aspects of sexual dimorphism.

Osteological observations were based on one complete dried skeleton (UF 68751) and both direct and radiographic examination of the alcoholic specimens. In the alcoholic specimens, the number of premaxillary and maxillary teeth was counted after gently reflecting the rostral and supralabial skin, respectively.

All statistical analysis was done with Systat Version 9. Statistical tests are named in the text. The level of significance was 0.05. Logarithms are base 10.

The genus *Eumeces* is used here in a restricted sense, but restricted to the original type species and its near relatives and not to the group proposed recently (Griffith et al., 2000). We disagree with the argument that the well-known name *Eumeces* should be transferred to the group to which the name *Pariocela* should properly apply in order to preserve the greatest historical use of the more familiar name. The argument underestimates both the number and significance of the references to true *Eumeces* species in the literature and seeks to suppress an aesthetically pleasing name properly coined and applied (Schmitz et al., 2004).

RESULTS

Taxonomy. Two species are currently recognised in the genus *Eurylepis*. *Eurylepis taeniolatus* Blyth, 1854) ranges widely, but disjunctly, throughout south-west Asia with three subspecies: *E. t. taeniolatus* in Pakistan; *E. t. parthianicus* (Szczerbak, 1990) in Turkmenistan, Iran and Afghanistan, and *E. t. arabicus* (Szczerbak, 1990) in the western part of the Arabian Peninsula (Fig. 3; see also Khan and Khan, 1997 for point distribution map for Pakistan). These subspecies have been recognised primarily on colour pattern, especially in the mid-dorsal area of the body.

Our specimens are from a few widespread localities in Pakistan and do not fit comfortably into either of the subspecies identified outside the Arabian Peninsula. In general, we find that our smaller specimens have a pattern resembling that described for *E. t. parthianicus* and adults have a pattern resembling that of *E. t. taeniolatus*. Furthermore, we see no local or regional variation within our specimens that would warrant taxonomic recognition.

The status of *Eurylepis poonaensis* (Sharma, 1964), known from only a single specimen from Pune in south-central India, is problematic in our view. The slightly higher number of paravertebral scales (85 vs. usually 72-80) is somewhat convincing. However, the three other diagnostic characters are not. The third digit of the pes being longer than the fourth digit and the rough vs. smooth dorsal scales could be post-mortem artefacts. And the tail being shorter than the body vs. longer is clearly dependent on the state of tail regeneration.

Morphology. The important morphological features in the 17 specimens we have examined are summarised here. Snout-vent ranges 56.5-135.5 mm (mean = 88.9 mm; n = 17); head length ranges 9.2-21.2 mm (mean = 14.5 mm, n = 17); ratio of snout-vent length to head length (index of elongation) ranges 5.1-7.1 (n = 17); hind limb length as proportion of snout-vent length ranges 21.4-29.3% (n = 15) and as a proportion of head length ranges 136-171% (n = 15).

Supranasals present and in contact; prefrontals in contact; supraoculars usually four (97.1% of 34 cases) but rarely three (2.9%) due to fusion of third and fourth, when four, first three invariably in contact with frontal; frontoparietals usually separated (73.3% of 15 specimens), occasionally in contact (20%) and sometimes in

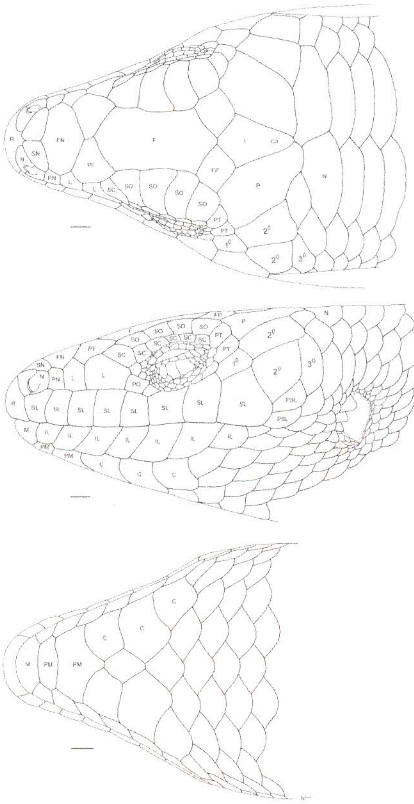

Figure 1. The head of *Eurylepis taeniolatus* (UF 70873) with the taxonomically important scales labelled. For abbreviations for the head scales, see Greer at al. (2004).

point contact (6.7%); single frontoparietal scale occasionally partially fused to frontal (11.8% of 17 specimens); parietal eye spot present; parietals usually separated posterior to interparietal (95.1% of 17 specimens) but rarely in contact (5.9%); nuchals on each side usually four (64.7% of 34 cases) but often three (29.4%) and rarely two (2.0%) or five (2.9%).

Nasal scale vertically divided through anterior edge of nostril into distinct anterior and posterior parts; postnasal present; loreals two; presubocular single; preoculars two; supraciliaries usually six (94.4% of 32 cases) but sometimes seven (15.6%); supraciliaries and supraoculars separated by a series of small scales; pretemporals usually two (94.1%) but occasionally one (5.9%) due to fusion of lower with primary temporal; primary temporal single; secondary temporals two, upper overlaps lower; lower eyelid

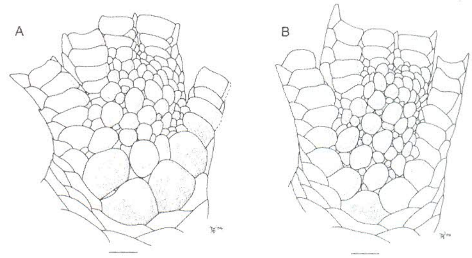

Figure 2. The "heel" scales in a male (A, UF 70871) and female (B, UF 70872) *Eurylepis taeniolatus* of similar snout-vent length, 132 mm and 135 mm, respectively.

moveable and scaly; supralabials eight, sixth below centre of eye; postsupralabials two; external ear opening vertically oval with usually three large auricular lobules on anterior edge.

Infralabials seven; postmentals usually two (94.1% of 17 specimens) but occasionally one (5.9%); three pairs of large chin scales, members of first pair in contact, members of second pair separated by one scale row and members of third pair separated by three scale rows; third pair of chin scales flush with infralabials, that is, genials do not extend forward between large chin scales and infralabials.

Longitudinal scale rows at mid-body 19-23 (mean = 20.9, n = 17); paravertebral scales 75-80 (mean = 77.3, n = 17); fused paravertebrals 52-65 (mean = 56.5, n = 17), and inner preanals overlap outer. There is a strong positive correlation between the number of paravertebral scales and the number of presacral vertebrae (below) ($r^2 = 0.71$, $P < 0.001$, $n = 16$) and between the number of fused paravertebral scales and the number of all paravertebrals ($r = 0.74$, $P < 0.0008$, $n = 17$).

Scales of digits consist of single dorsal and ventral rows, which inter-digitate and are imbricate; ventral row of scales on fourth digit of pes, that is, subdigital lamellae smooth and numbering 13-17 (mean = 14.5, cases = 30).

Scales on "heels" of pes noticeably larger in size and rougher in surface texture than surrounding scales in all specimens, and based on a subjective binomial measure of relative size, larger and rougher scales occur in males of significantly larger snout-vent length than in males of smaller snout-vent length (Mann-Whitney

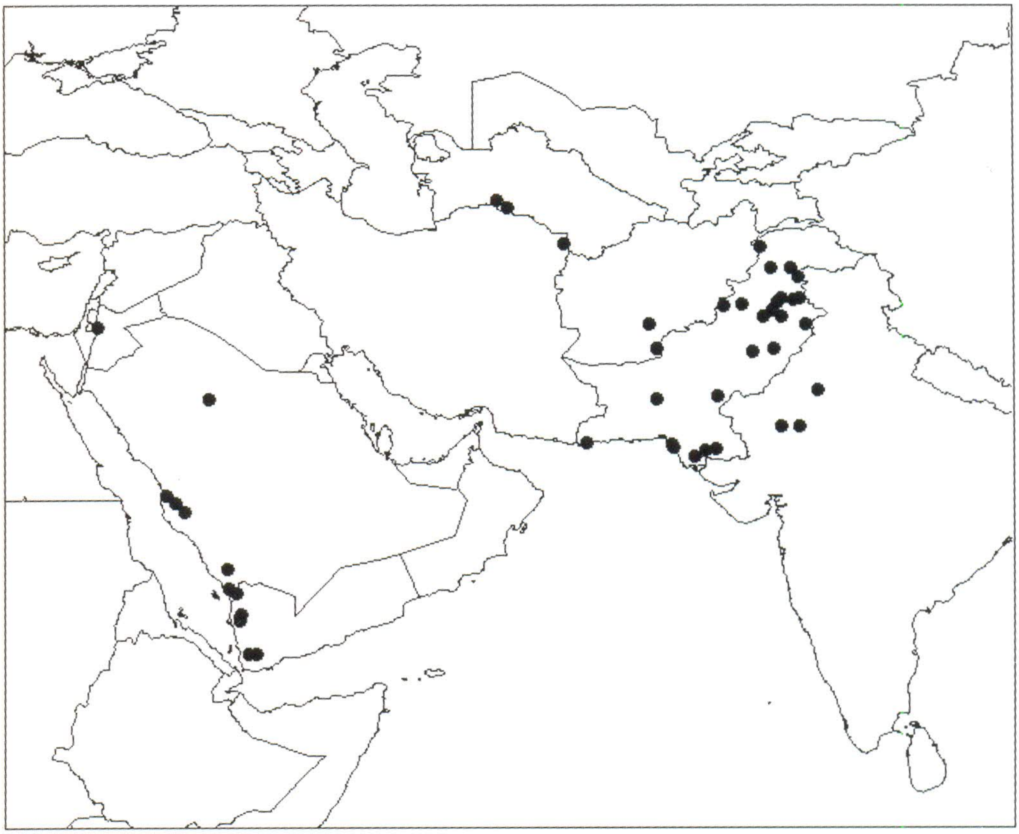

Figure 3. The general distribution of the genus *Eurylepis*.

= 36.5, P = 0.02, n = 14). These modified heel scales are also noticeably larger in males than in comparably sized females (Fig. 2).

Tongue (n = 2), parietal peritoneum (n = 17) and lungs (n = 1) pale throughout. Lungs approximately equal in length (n = 1).

Osteology. Premaxillae distinct; nasals distinct; prefrontal contacts nasal; palpebral present; frontal divided; prefrontal process of frontal extends to palatine; postorbital present; supratemporal foramen open; vomers distinct; palatines with sinusoidal medial shelves, which project toward midline but remain well separated (incomplete secondary palate); maxilla and palatal ramus of pterygoid enter infraorbital vacuity broadly; angular distinct; splenial distinct; Meckel's groove open anterior to splenial; scleral ossicles 14 (UF 68751).

Premaxillary teeth 5-7 (mean = 6.0, n = 3); maxillary teeth 13-17 (mean = 14.9, n = 8); pterygoid teeth present (n = 3), 5/6 in one specimen (UF 68751). There is a significant positive relationship between the number of maxillary teeth and the head length (r^2 = 0.69, P = 0.011, n = 8).

Presacral vertebrae 36-38 (mean = 36.7, n = 16); cervical vertebrae 8 (n = 9); sacral pleurapophyses fused in adults (UF 68751); postsacral vertebrae 59-60 (mean = 59.5, n = 2); postsacral with most basal autotomy plane, fifth (UF 68751); autotomy plane passes through anteromedial part of postsacral transverse processes (UF 68751, 79233); intercentra five, and haemal arches attached to posterior ends of postsacral vertebrae (UF 68751).

Sternal/mesosternal ribs 3/2, attached to presacral vertebrae 9-11/12-13; complete inscriptional chevrons 3 (n = 6); free ribs usually begin on fourth presacral (95% of 18 specimens) but rarely on third presacral (5%).

Scapular and posterior coracoid fenestrae absent, scapulocoracoid and anterior coracoid fenestrae present.

Second ceratobranchial present.

Carpus with pisiform, intermedium, centrale, radiale, ulnare and distal carpals 1-5 and manus with metacarpals 1-5 and phalanges 2.3.4.5.3; tarsus with astragalus and calcaneum fused (at least in adults), distal tarsals 4 and 5 and pes with metatarsals 1-5 and phalanges 2.3.4.5.4 (UF 68751 and radiographs).

Soft anatomy. Inguinal fat bodies present.

Allometry. Snout-vent length is in isometry with head length but only just. The relevant equation is: log snout-vent length (mm) = 1.11 log head length (mm) + 0.65 (95% confidence interval of slope = + 0.12, $r^2 = 0.96$, $P < 0.0001$, $n = 17$).

Colour pattern. Three trends, one ontogenetic and two geographic, are immediately evident when the specimens from the different major geographic areas are laid out in series of increasing size. First, smaller specimens, at least from the Punjab Province and the vicinity of Karachi, Sindh Province, tend to be more diffusely patterned with dark blotches and pale spots, whereas larger specimens tend to be more definitively patterned with dark and pale stripes, the dark blotches and pale spots in juveniles being lost in the emergence of definitive dark medial and pale dorsolateral stripes and dark flanks in adults. As mentioned above, this juvenile colour pattern resembles a figure given for *Eurylepis taeniolatus parthianicus* and the adult colour pattern, at least the striped body if not the patternless tail, resembles a figure given for *E. t. taeniolatus* (Szczerbak, 1990: Figs 1-2).

Second, the two (large) specimens from the higher elevations of Balochistan are pale and almost patternless, retaining only a slight suggestion of the dark flanks of specimens from elsewhere and having only plain or pepper-spotted tails. A figured specimen from Balochistan has darker flanks, but it does have a plain-patterned tail similar to our specimens (Szczerbak, 1990: Fig. 1, 3).

Third, the one large specimen from the Northwest Frontier Province (UF 82074) is darker in colour than any other specimen.

Reproduction. There are only three females. The smallest female (UF 79233) has a snout-vent length of 88 mm and is either reproductively quiescent or perhaps not yet mature (small ovaries and oviducts). It was collected in early autumn (24 September). The largest female (UF 70872) has a snout-vent length of 135.5 mm and contains four large follicles, two in each ovary. It was collected in late spring (28 May). The intermediate-sized female (UF 82074) has a snout-vent length of 126.5 mm and thin, wispy oviducts and small ovaries indicating no reproductive activity. As this female was collected on 13 June, a date when signs of imminent reproduction might have been expected, an interpretation of disease or senescence may be more likely than one of reproductive quiescence.

Sex ratio. Of the 17 alcoholic specimens, 14 are males and 3 are females. This is a highly significant bias in favour of males ($\chi^2 = 7.1$, $P = 0.008$).

Ecological notes. Some field notes accompanying the specimens provide some insight into the ecology of the species. Four specimens from Karachi (UF 70867-70868, 70873-70874) were found in a residential housing area; one was found on the Karachi University campus (UF 70875), and one (UF 81306) on the grounds of a hotel.

One specimen (UF 78464) was found under a stone and another (UF 82074) under boulders, suggesting that the species shelters under rocks.

One specimen (UF 81306) was found on a rocky, pine-covered hillside and another (UF 82657) in a dry grassy nullah (a dry wash or streambed).

One specimen (UF 70868) had eaten an *Ablepharus grayanus*, which seems to have been swallowed tail first, as it was lying in the stomach with its head anteriormost and with the posterior part of the body partially digested.

Several specimens come from near sea level, e.g., Karachi, and one (UF 82074) comes from an elevation of 1100 m in the Northwest Frontier Province.

DISCUSSION

Morphology. The nasal, supranasal and postnasal scales in *Eurylepis* form what could be considered the most complex end of a morphocline of scale arrangements in this area in skinks. In *Eurylepis* the nasal scale is vertically divided through the anterior edge of the nostril such that the nasal consists of clear anterior and posterior parts, and it is bordered dorsally by a distinct supranasal and posteriorly by a distinct postnasal (Taylor, 1936). The opposite end of the morphocline would be an undivided nasal with a nostril in its centre and no supranasal or postnasal. There are a number of intermediate conditions in the morphocline and the cline is likely to be reticular rather than linear. This same complex morphology also occurs in some other generally primitive skinks, i.e., the scincines *Eumeces*, *Mesoscincus*, many *Pariocela* (Taylor, 1936; AG, pers. obs.), *Scincopus* and *Scincus* (AG, pers. obs.).

The fused body paravertebrals are one of the most distinctive features of *Eurylepis*. However, they are by no means unique in skinks. Fused body paravertebrals have long been known to occur in the scincine *Mesoscincus* (Taylor, 1936, as *Eumeces schwartzei* group). And similar fusions, albeit further posteriorly on the body, also occur in the lygosomine *Emoia impar* (Ineich and Zug, 1991). And fusion of the caudal paravertebrals in an apparent posterior to anterior direction (to just short of the base of the tail) is common within some lygosomine taxa, e.g., *Mabuya*. In *Eurylepis*, the fused paravertebral scales are limited to the trunk region, that is, the region between the front and rear legs. The function of the fused paravertebrals is unclear. The loss of the mid-dorsal suture line between the two rows of paravertebrals would imply a loss of flexibility, and hence, perhaps a slight stiffening of the trunk region. But what function such stiffening might serve is unclear. Be that as it may, the fused paravertebrals do suggest just how "easy" it is to fuse two longitudinal rows of scales that meet along the midline of the trunk, and this may have implications for the evolution of the large ventral scales of snakes.

The distinctive heel scale morphology in *Eurylepis* is unusual in skinks. A similar heel scale morphology, at least in adults, has also been noted in the scincine skink *Mesoscincus* (Taylor, 1936) and in the lygosomine skinks *Apterygodon*, *Dasia* (Greer, 1970; Grossmann, 2002: fig. 3), *Lamprolepis smaragdina* (fide Gandolfi, 1907; Alcala, 1966; Greer, 1970: fig. 5) and some southeast Asian *Mabuya* (Greer, 1970). However, the reported examples of the distinctive morphology may just focus on the more extreme cases. More subtle forms may have gone unappreciated. It is even possible that some very subtle precursor condition occurs in the heel scales with unexceptional morphology. The heel scales have been investigated histologically only in *Lamprolepis smaragdina,* by Gandolfi (1907) and despite the pore-like ultrastructure, were interpreted simply as providing a rough surface to prevent the male's foot from slipping on the female's smooth scales during mating.

The pale tongue of *Eurylepis* is intriguing, because a pale tongue is unusual in skinks. In most other skinks, the tongue is either uniformly dark or, most commonly, dark distally and pale basally (AG, pers. obs.).

The pale parietal peritoneum of *Eurylepis* is also seen in some other scincines, i.e., *Mesoscincus* (AG, pers. obs.), *Pariocela* (Hunsaker and Johnson, 1959) and *Scincopus* (AG, pers. obs.) but not all, i.e., *Scincus* in which the peritoneum is moderately pigmented (AG, pers. obs.). In lygosomines, a pale pigment is associated with crepuscular, nocturnal and fossorial habits and a dark pigment with diurnal, basking habits (AG, pers. obs.).

Osteology. Perhaps the most striking aspect of the species' osteology is its combination of a high number of presacral vertebrae with the primitive (for lizards) complement of limb bones. The species' 36-38 presacral vertebrae represent an increase of between 38 and 46% over the probable primitive number of presacral vertebrae for skinks - 26 (Greer et al., 2000). In skinks in general, there is a strong positive interspecific correlation between the mean number of presacral vertebrae and an index of body elongation (snout-vent length/head length) (Greer and Wadsworth, 2003). And body elongation is perhaps the most indicative morphological indicator of the potential for axial locomotion, that is, lateral undulation. Hence, this species combines the highest degree of body elongation, as measured by the number of presacral vertebrae, with a completely primitive limb structure. With this combination of features, the species would make an excellent model organism in which to examine the conditions under which each locomotory mode is used and the interactions between the two.

The fact that the number of presacral vertebrae is variable, but the number of vertebrae in the neck and attached to the pectoral girdle is stable, suggests that vertebral additions or losses, as the case may be, are limited to the trunk region, where the functional importance of each vertebra may be less than in the neck and thorax.

The number of premaxillary teeth (5-7, mean = 6.0, n = 3) in the species is unusually variable and low for skinks. Most species have a constant number of premaxillary teeth and usually more than seven. Seven premaxillary teeth is probably primitive for skinks, as this is the number in cordylids (Edmund, 1969), the probable sister group of skinks.

The positive correlation between the number of maxillary teeth and head length is the usual condition in skink species (AG, pers. obs.) and is primarily due to the addition of teeth at the posterior end of the maxillary tooth row with increasing size.

Colour pattern. The basic trend in the Pakistan *Eurylepis* for the colour pattern to change ontogenetically from somewhat diffuse blotches and spots to more distinct longitudinal stripes is unusual in skinks, but the ecological and systematic significance of this colour change are unknown.

The geographic variation in colour pattern in the Pakistan *Eurylepis* is intriguing but is difficult to discuss in the absence of more detailed habitat information. One might expect darker patterns in cooler and more moist areas and paler patterns in warmer and drier areas. Indeed, the specimen with the darkest colour pattern in our Pakistan material was collected from Swat District, a region with cooler and wetter climatic conditions than those areas to the south where pale patterns prevail. Furthermore, an earlier report on a collection of this species (as *Eumeces scutatus*) from northern Pakistan, noted that specimens from higher elevations were "noticeably darker and more heavily striped than specimens of equal size" from lower elevations (Ingoldby and Proctor, 1923).

Reproduction. Despite the skink's large size, relative commonness in collections, and potentially important phylogenetic position, very little is known about its reproduction. The collection date of 28 May for the one reproductively active female (yolking follicles) examined in this study suggests that at this specimen's locality of Kalat District in Balochistan Province, reproduction occurs in late spring. In the Punjab Province, the species has been asserted to breed from March to June and to lay 4-8 eggs (Khan and Khan, 2000) but no supporting data have been reported.

Sex ratio. The strong bias in the sex ratio in favour of males is intriguing but difficult to explain without further information. The bias is so strong that it suggests there may be a behavioural difference between the sexes in their exposure to standard collection techniques.

Ecology. The limited field notes accompanying our specimens confirm previous observations that the species is ground dwelling (Ingoldby and Proctor, 1923, as *Eumeces scutatus*; Khan and Khan, 1997, 2000; Minton, 1966) and occasionally shelters under rocks (Minton, 1966) and stones (Khan and Khan, 2000).

The species has been found in burrows (Ingoldby and Proctor, 1923 as *Eumeces scutatus*), and it has been described as digging its own burrow (Khan and Khan, 2000). However, neither a direct observation of burrow digging nor the basis for the inference of burrow digging has been published. And in at least one instance, the burrows occupied by the skink are thought to have been dug by another animal, the Indian gerbil, *Tatera indica* (Ingoldby and Proctor, 1923 as *Eumeces scutatus*). As the ability to dig a permanent burrow may involve genetically based behaviour and has implications for patterns of movement, it is important to clarify whether this species actually digs its own burrow or not.

The occurrence of the species in residential areas suggests that the species can persist in areas of light development. Indeed, the species was recorded as "commonly seen among hedges in and around gardens" in the Sindh Province more than a century ago (Murray, 1886).

The occurrence of one specimen on a rocky, pine-covered hillside and another in dry grassy nullah suggests a wide habitat range. The species has previously been recognised as occurring in areas of sparse grasslands (Minton, 1966), scrubby vegetation (Khan and Khan, 2000), open mesic fields (Khan and Khan, 2000), tropical dry deciduous forest in foothills (Khan, 1999), and riverine tracts on the Indus Plains (Khan, 1999). It is said to occur in proximity to water courses (Khan and Baig, 1988; Khan, 1999; Khan and Khan, 2000).

The observation of a small skink in the stomach of one individual is the first record of a vertebrate food item for the species. All other reports indicate that it eats arthropods and "worms" (Minton, 1966; Prakash, 1972; Sharma and Vazirani, 1977; Makeev et al., 1983; Khan and Khan, 2000).

In Pakistan, the species is widely distributed in the drainage system of the greater Indus Valley. Elsewhere in Pakistan, it occurs in the drainage systems emptying into the Arabian Gulf west of the mouth of the Indus River (Minton, 1966; Mertens, 1969; Khan, 1987; Khan and Baig, 1988; Khan and Khan, 1997: fig. 1; Khan, 1999, 2002; fig. 3). In Pakistan, the species has a wide altitudinal distribution, ranging from near sea level to at least 2090 m (6800 ft; Minton, 1966).

Diagnostic characters of *Eurylepis*. *Eurylepis* shows very few characters that are likely to be derived within skinks, and therefore, diagnostic of the taxon. The only two characters that are almost certainly derived within skinks are: paravertebral scales on body fused into single medial row, and presacral vertebrae 36-38 in comparison to the primitive 26 for skinks.

Correction. Further to the map of the distribution of *Eurylepis* (Fig. 3), we are advised that the important range extension of the taxon into Jordan (Werner, 1998) was accompanied by an incorrect UTM coordinate. The correct UTM coordinates are 7510/3480 (not 7510/7470). From a map, this location is at: 31°27' 16" N, and 35° 37' 57" E (Y. Werner, pers comm.).

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APPENDIX 1

Material examined

We have examined the following material (all UF) of *Eurylepis taeniolatus*. All localities are in Pakistan.

49043: Las Bela, Las Bela District, Balochistan Province.

68751: Ormana area, Gwadar District, Balochistan Province.

70869–70870: Las Bela, Las Bela District, Balochistan Province.

70871–70872: Hazara Gunji Game Preserve, Kalat District, Balochistan Province.

70789: Gwadar, Gwadar District, Balochistan Province.

81306: Murghazar Hotel grounds, Murghazar, Swat District, Northwest Frontier Province.

82074: Paras, Kaghan River valley, Manshera District, Northwest Frontier Province.

78464: Tributary of Soan River, at bridge on Rawalpindi-Lahore Road, near Islamabad Airport, Rawalpindi District, Punjab Province.

79233: Kallar Kahar, Chakwal District, Punjab Province.

82657: 1 km W Walo, or 11 km W Jhellum, Jhellum District, Punjab Province.

70867–70868, 70873–79874: Karachi, Karachi District, Sindh Province.

70875: Karachi University campus, Karachi, Karachi District, Sindh Province.

88069: Natha Khan Goth, NW Brigh Colony, Karachi District, Sindh Province.

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AN INVENTORY OF THE AMPHIBIANS OF PASOH FOREST RESERVE, NEGERI SEMBILAN, PENINSULAR MALAYSIA

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ABSTRACT.– **An updated inventory of the amphibian fauna of Pasoh Forest Reserve, central southern Peninsular Malaysia, is presented here, based on two surveys carried out in 2004, examination of previously unreported museum material, as well as with reference to previously published inventories or species records from this area. A total of 43 anuran species are recorded as occuring in this area, including six species that have not been documented here previously. However, of these 43 species recorded, only 25 have verifiable voucher specimens, while recent taxonomic and nomenclatural revisions may require re-examination of some reported species records (such as *Rana baramica*).**

KEY WORDS.– **Amphibia, Anura, frogs, Pasoh Forest Reserve, Peninsular Malaysia, inventory.**

INTRODUCTION

Pasoh Forest Reserve (2° 59′ N, 102° 19′ E, altitude 75-150 m ASL) is located in central southern Peninsular Malaysia, adjacent to the southern tip of the Main Range. This 2,500 ha. area consists of both primary as well as regenerating lowland mixed dipterocarp forest. The regenerating forest areas were selectively logged in the 1950s (Appanah and Mohd Rasol, 1990; Manokaran and Swaine, 1994).

Numerous biological studies, mostly non-herpetological, have been carried out in this area, much of which is reported in Okuda et al. (2003). Previous herpetological assessments of Pasoh have cumulatively documented a total of 35 species of known amphibians from this area, with initial four species of rhacophorids by Berry (1975), another 17 species reported by Kiew (1978), nine more later by Kiew et al. (1996), followed by a further four by Lim and Norsham (2003). In addition, Kiew (1984) described a new species of the microhylid frog, *Kalophrynys palmatissimus* from this area, bringing the total number of species in the anuran fauna of this area to 36.

This paper reports the current status of the anuran amphibian fauna of Pasoh, as updated based on: (a) surveys carried out on two occasions, January 2 and July 20 of 2003; and (b) examination of specimens from Pasoh deposited in the Zoological Reference Collection of the Raffles Museum of Biodiversity Research of the National University of Singapore (ZRC) and the Forest Research Institute Malaysia Herpetological Collection (FRIM), some of which were previously unreported.

MATERIALS AND METHODS

The surveys reported here were confined to the 50 ha plot Nature Trail and along a tributary of the Sungai Marong Kanan which passes through a primary forest area and close to the compound of the field station. The January survey was carried out by the authors. The July survey was carried out by the authors, and with the additional assistance of 18 participants of the International Field Biology Class (IFBC) of 2003. On both occasions, surveys were carried out at night with flashlights and/or headlamps. In addition, during the second survey, the forest trails were also searched during the day time. Specimens were euthanized in the field by immersion in dilute chlorobutanol, fixed in 10% buffered formalin and stored in 70% ethanol. Liver tissue was taken from representative specimens and preserved in 100% ethanol. Tissues and specimens were deposited at FRIM.

Identification was made on the basis of standard references applicable to the area (Berry, 1975; Inger, 1966; Manthey and Grossman, 1997; Taylor, 1962). Nomenclature follows Frost (2004) except for *Rana nicobariensis*, which we retain arrangement by Manthey and Grossman (1997).

OBSERVATIONS
ORDER ANURA

Family Bufonidae

Bufo asper Gravenhorst, 1829

This species was not recorded in either of the surveys, but was reported from Pasoh by Kiew (1978) and Lim and Norsham (2003).

Bufo melanostictus Schneider, 1799

Material: FRIM 0549, ZRC.1.11195

This toad was previously reported by Kiew et al. (1996) and Lim and Norsham (2003). One individual was collected on the ground near the trail entrance towards 50 ha. plot during the July daytime survey.

Bufo parvus Boulenger, 1887

Material: FRIM 0008, 0226-0229, 0557, ZRC.1.11194.

This toad was observed on low vegetation along the trail during the night surveys (both the January and July surveys), as well as on the forest floor during the day survey (July survey). Previously, this species was recorded by Kiew (1978) and Lim and Norsham (2003).

Leptophryne borbonica (Tschudi, 1838)

Material: FRIM 0224-0225.

This species had been reported by Kiew et al. (1996) and Lim and Norsham (2003). Males were found congregating and calling near banks of the Sungai Marong Kanan tributary during the January survey.

Family Megophyridae

Leptobrachium hendricksoni Taylor, 1962

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew (1978) and Lim and Norsham (2003).

Leptobrachium nigrops Berry and Hendrickson, 1963

Material: FRIM 0233, 0570

This species was recorded during both the January as well as the July survey efforts. It was relatively common around the swampy area off the Nature Trail. Previously, Kiew (1978) and Lim and Norsham (2003) reported this species from the area.

Megophrys nasuta (Schlegel, 1837)

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew (1978) and Lim and Norsham (2003).

Family Microhylidae

Chaperina fusca Mocquard, 1892

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew (1978).

Kalophrynus pleurostigma Tschudi, 1838

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew (1978).

Kalophrynus palmatissimus Kiew, 1984

Material: FRIM 0556, ZRC.1.11205

This new microhylid species was described by Kiew (1984). During the July survey, one individual of this species was found at night on the forest path.

Kaloula baleata (Müller, 1836)

Material: FRIM 1066

One juvenile was collected from the forest floor by Chew Ming Yee on 10 March 2004, and deposited in the FRIM collection. This species had not previously been documented in Pasoh.

Kaloula pulchra Gray, 1831

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew et al. (1996).

Microhyla berdmorei (Blyth, 1856 "1855")

This species was not recorded during either of the present surveys, but was reported from Pasoh by Lim and Norsham (2003).

Microhyla butleri Boulenger, 1900

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew et al. (1996).

Microhyla borneensis Parker, 1928

Material: FRIM 0569

One individual was found on the forest floor during the July surveys. This represents a new record for this species from Pasoh.

Microhyla heymonsi Vogt, 1911

Material: FRIM 0239, 0551

This species was recorded by Kiew et al. (1996) and Lim and Norsham (2003). This species was common within the compound of the field station, and was also observed within the forested area during both the January as well as July surveys.

Microhyla superciliaris Parker, 1928

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew (1978).

Micryletta inornata (Boulenger, 1890)

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew (1978).

Family Ranidae

Fejevarya limnocharis (Gravenhorst, 1829)

Material:FRIM 0240, 0548, ZRC.1.11196.

This species was observed within the field station's compound during both the January as well as July surveys This species was also reported by Kiew et al. (1996) and Lim and Norsham (2003).

Limnonectes blythii (Boulenger, 1920)

Material: ZRC.1.11197

This species was reported by Kiew (1978) and Lim and Norsham (2003). This species was observed near the Sungai Marong Kanan tributary, either resting on the bank, or few metres away from the stream, during both the January as well as July surveys. No specimens were collected during either survey period.

Limnonectes laticeps (Boulenger, 1882)

This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew (1978) and Lim and Norsham (2003).

Limnonectes paramacrodon (Inger, 1966)

Material: FRIM 0235, 0562, 0563, 0577

This species was reported by Kiew (1978) and Lim and Norsham (2003). This species was observed in the swampy area off the Nature Trail during both the January as well as July surveys.

Limnonectes plicatellus (Stoliczka, 1873)

Material: FRIM 0551, 0564-0567.

This species was recorded during the 20 July survey. One individual was collected from the forest floor during the day, while another two individuals were collected from the forest floor near the Sungai Marong Kanan tributary at night. This represents a new record for this species from Pasoh.

Occidozyga sumatrana (Peters, 1877)

Material: FRIM 0238, 0554.

This species was reported by Kiew (1978), Kiew et al. (1996) and Lim and Norsham (2003). One individual was collected from the pond area during the January survey and another from the forest floor during the July daytime survey.

Rana baramica Boettger, 1903

This species was not recorded during either of the present surveys, but was reported from Pasoh by Lim and Norsham (2003).

Rana erythraea (Schlegel, 1837)

This species was not recorded during either of the present surveys, but was reported from

Pasoh by Kiew (1996) and Lim and Norsham (2003).

Rana glandulosa Boulenger, 1882
Material: FRIM 0230, 0571
This species was observed as well as heard calling from around the swampy areas off the Nature Trail and around the Sungai Marong Kanan tributary. One individual was collected during each of the two surveys. This species was also reported by Kiew (1978) and Lim and Norsham (2003).

Rana hosii Boulenger, 1891
This species was not recorded during either of the present surveys, but was reported from Pasoh by Kiew (1978) and Lim and Norsham (2003).

Rana luctuosa (Peters, 1871)
This species was not recorded during either of the present surveys, but was reported from Pasoh by Lim and Norsham (2003).

Rana laterimaculata Boettger, 1900
Material: FRIM 0243, 0572.
This species was found around the swampy areas off the Nature Trail as well as around the stream areas during each of the two surveys.

Rana miopus Boulenger, 1918
Material: FRIM 0236, 0552, 0578, ZRC.1.11198.
This species was observed around the swampy areas off the Nature Trail as well as around the Sungai Marong Kanan tributary stream areas during both surveys. This observation represents the first reported record of this species from Pasoh. Large numbers of this species was also observed along both sides of the trail from the main entrance to the field station by the first author on 29 October 2004.

Rana nicobariensis (Stoliczka, 1870)
Material: FRIM 0234, 0573.
This species was observed in the swampy area off the Nature Trail during both the January as well as July surveys. Calling activity was noted on both occasions. This species was recorded by Lim and Norsham (2003).

Rana raniceps (Peters, 1871)
Material: FRIM 0236, 0576.
This species was reported by Kiew (1978), Kiew et al. (1996) and Lim and Norsham (2003). This species was found in the field station compound, along the forest trail, and along the Sungai Marong Kanan tributary during both the January and July surveys.

Rana picturata Boulenger, 1920
Material: FRIM 0574.
One individual of this species was collected from the Sungai Marong Kanan tributary during the 20 July survey. Previously, this species was reported by Kiew (1978).

Family Rhacophoridae

Nyctixalus pictus (Peters, 1871)
Material: ZRC.1.11204
This species was reported by Kiew et al. (1996). No specimens were sighted during the January and July surveys. However, one male of the species, collected from Pasoh on 27 November 2003, is deposited in the Raffles Museum of Biodiversity Research.

Polypedates colletti (Boulenger, 1890)
This species was not recorded during either of the present surveys, but was reported from Pasoh by Berry (1975), Kiew (1978) and Lim and Norsham (2003).

Polypedates leucomystax (Gravenhorst, 1829)
Material: FRIM 0241, 0242, 0558-0560.
This species was reported by Kiew et al. (1996) and Lim and Norsham (2003). This species was found in the field station compound, along the entrance to the field station as well as around the pond off the Nature Trail just before the Sungai Marong Kanan tributary during the both January and July surveys.

Polypedates macrotis (Boulenger, 1891)
Material: FRIM 0231, 0232, 0561
This species was reported by Berry (1975) and Lim and Norsham (2003). Relatively large numbers of this species were observed aggregating around the pond off the Nature Trail just before the Sungai Marong Kanan tributary during the both January and July surveys.

Rhacophorus appendiculatus (Günther, 1858)

Material: ZRC.1.11199-11203.

This species was reported by Berry (1975), Kiew (1978) and Lim and Norsham (2003). This species was not observed during either the January and July surveys. However, the Raffles Museum of Biodiversity collections have five males of this species that were collected from Pasoh on 27 November 2003. In addition, on 29 Oct 2004, one individual of this species was observed along the trail from the main entrance to the field station, perched about 5 cm above the ground on a small seedling, but was not collected.

Rhacophorus cyanopunctatus Manthey and Steiof, 1998

Material: FRIM 0268

This species was reported by Kiew (1978). This species was not observed during either the January and July surveys. However, on 27 April 2002, an individual was collected from the vegetation overhanging the Sungai Marong Kanan tributary by the second author and deposited in the FRIM collection.

Rhacophorus nigropalmatus Boulenger, 1895

This species was not recorded during either of the present surveys, but was reported from Pasoh by Berry (1975), Kiew (1978) and Lim and Norsham (2003).

Rhacophorus pardalis Günther, 1859 "1858"

Material: FRIM 0247 and 0248.

Two individuals of this species were collected from the pond off the Nature Trail just before the Sungai Marong Kanan tributary. This represents a new record of this species from Pasoh.

Rhacophorus prominanus Smith, 1924

This species was not recorded during either of the present surveys, but was reported from Pasoh by Lim and Norsham (2003).

DISCUSSION

Six new records (*Kaloula baleata, Limnonectes plicatellus*, *Microhyla borneensis*, *Rana laterimaculata*, *Rana miopus* and *Rhacophorus pardalis*) from this study are added to the known anuran fauna of the area. This brings the total number of species of frogs and toads known from Pasoh to 43 representing five families. However, only 25 of these species are confirmed by voucher material. *Microhyla butleri* was found during the 20 July survey but was released. The record of *Rana baramica* needs to be verified due to the prior conflation of this species and *R. laterimaculata* (Leong et al., 2003).

The sampling of anurans from Pasoh has only taken place within the vicinity of the field station and major trail leading to the 50 ha. plot. Thus, the diversity recorded may only partly represent that of the reserve as a whole. Additional, systematically designed long term investigations on amphibian diversity should be initiated to include ecological monitoring across seasonal, elevational, and temporal gradients.

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RECORD OF THE LITTLE-KNOWN *RANA NIGROTYMPANICA* DUBOIS, 1992 (AMPHIBIA: RANIDAE) FROM NORTHERN LAOS

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(with three text-figures)

ABSTRACT.– *Rana nigrotympanica* is a poorly known species that was originally named based on a literature review rather than on specimen examination. Here we refer to this species 12 male specimens from northern Laos, near the type locality in Yunnan, China, and supplement the original description using the Laos specimens. This is the first report of *R. nigrotympanica* outside of China.

KEYWORDS.– Laos, China, amphibians, taxonomy, *Rana nigrotympanica*.

INTRODUCTION

Liu and Hu (1959, 1961) reported an adult female frog and tadpoles from Yunnan, southern China, as *Rana varians* Boulenger, 1894, a species with type locality of Palawan, Philippines. Dubois (1992) doubted this identification and named *Rana nigrotympanica* as a new species based on Liu and Hu's (1959, 1961) accounts of *R. varians*. Dubois (1992) referred the diagnosis and description of the new species to the text accounts of *R. varians* provided by Liu and Hu (1959, 1961) and Fei et al. (1990) and designated the holotype to be the adult female from Mengyang, Yunnan illustrated as a line drawing in Liu and Hu (1959, 1961).

To our knowledge, new data have been published for only two additional adult specimens of *R. nigrotympanica*, both females from Yunnan (Yang, 1991; as *R. varians*). Fei (1999) reported the species (as *Hylarana nigrotympanica*) from localities across southern China, but did not provide specimen information to support this range. Zhao and Adler (1993) questioned the status of *R. nigrotympanica* and chose to not include it as part of the Chinese amphibian fauna. Clearly this species is poorly known.

Here we supplement the original description of *R. nigrotympanica* using 12 male specimens collected from northern Laos, near the type locality in Yunnan. These Laos specimens represent the first record of the species outside of China.

MATERIALS AND METHODS

Specimens were caught in the field by hand, preserved in 10% buffered formalin and later transferred to 70% ethanol. Tissue samples were taken by preserving pieces of liver in 95% ethanol before the specimen was fixed in formalin. Specimens were deposited in the Field Museum of Natural History (FMNH). Measurements were made with dial calipers to the nearest 0.1 mm. Abbreviations used are: SVL = snout-vent length; HDL = head length from tip of snout to rear of the jaws; HDW = maximum head width; SNT = snout length from tip of snout to anterior corner of the eye; EYE = diameter of the exposed portion of the eyeball; IOD = interorbital distance at narrowest point; TMP = maximum diameter of tympanum; TIB = tibia length; IMT = length of inner metatarsal tubercle.

SYSTEMATICS

Rana nigrotympanica Dubois, 1992

Rana (Sylvirana) nigrotympanica Dubois, 1992: 326, 341.

Rana varians Liu and Hu, 1959: 518; Liu and Hu, 1961: 201; Yang, 1991: 159.

Hylarana (*Hylarana*) *varians* Fei, Ye and Huang, 1990: 139-141, 232-234.

Hylarana (*Hylarana*) *nigrotympanica* Fei, 1999: 172.

Material Examined.– Laos, Phongsaly Province, Phongsaly District, Phou Dendin National Biodiversity Conservation Area, hilly evergreen forest, coll. B. L. Stuart and H. F. Heatwole: FMNH 258269, 258352-55, near Nam Khang River, near 22°09'04"N 102°12'19"E, 600 m elev., 12-14 Oct.1999; FMNH 258351, near Nam Ou River, 22°05'38"N 102°12'50"E, 600 m elev., 07 Oct.1999; FMNH 258356-57, near Nam Khang River on Nam Kaw stream, near 22°09'39"N 102°11'07"E, 600 m elev., 15 Oct.1999; FMNH 258358-61, confluence of Nam Ou and Nam Sa Rivers, 22°05'31"N 102°06'19"E, 600 m elev., 18-21 Oct.1999 (figs. 1-2).

Description (composite of 12 males).– Habitus slender; head narrow, longer than wide; snout obtusely pointed in dorsal view, projecting beyond lower jaw, round in profile, slightly depressed from level of nostril to tip of snout; nostril slightly closer to tip of snout than eye; canthus distinct, slightly constricted behind nostrils; lores concave and oblique; eye diameter 72-89% the snout length; interorbital distance less than or greater than width of upper eyelid; pineal body visible or not visible; distinct, round tympanum, 68-82% the eye diameter, not depressed relative to skin of temporal region; vomerine teeth on two oblique ridges, about equal in distance from each other as to choanae; tongue deeply notched posteriorly, free for approximately two-thirds its length; vocal sac opening at corner of mouth; no gular pouch.

Tips of outer three fingers slightly expanded, tips of outer two fingers with circummarginal grooves; relative finger lengths II < IV< I < III; one subarticular tubercle on fingers I and II, two subarticular tubercles on fingers III and IV; supernumerary tubercle at base of all four fingers, that on finger I much elongated; two palmar tubercles large, oval, in contact; velvety nuptial pad material covering bulbous structure formed by hypertrophied muscle on medial surface of forearm, extending onto dorsal and medial surface of finger I to the level of the distal edge of the subarticular tubercle; forearm robust.

Tips of all toes expanded, with circummarginal grooves, toe discs larger than finger discs; toe III shorter than toe V; toes I, II and V fully webbed to base of discs; preaxial side of toe III webbed to distal subarticular tubercle, postaxial side of toe III webbed to base of disc; toe IV fully webbed to distal subarticular tubercle with narrow extension to base of disc; heels overlapping when legs are held at right angles to body; tibia length greater than foot length; elongate, oval inner metatarsal tubercle; large, round outer metatarsal tubercle.

Figure 1. *Rana nigrotympanica* from Phongsaly Province, Phongsaly District, Laos, in life.

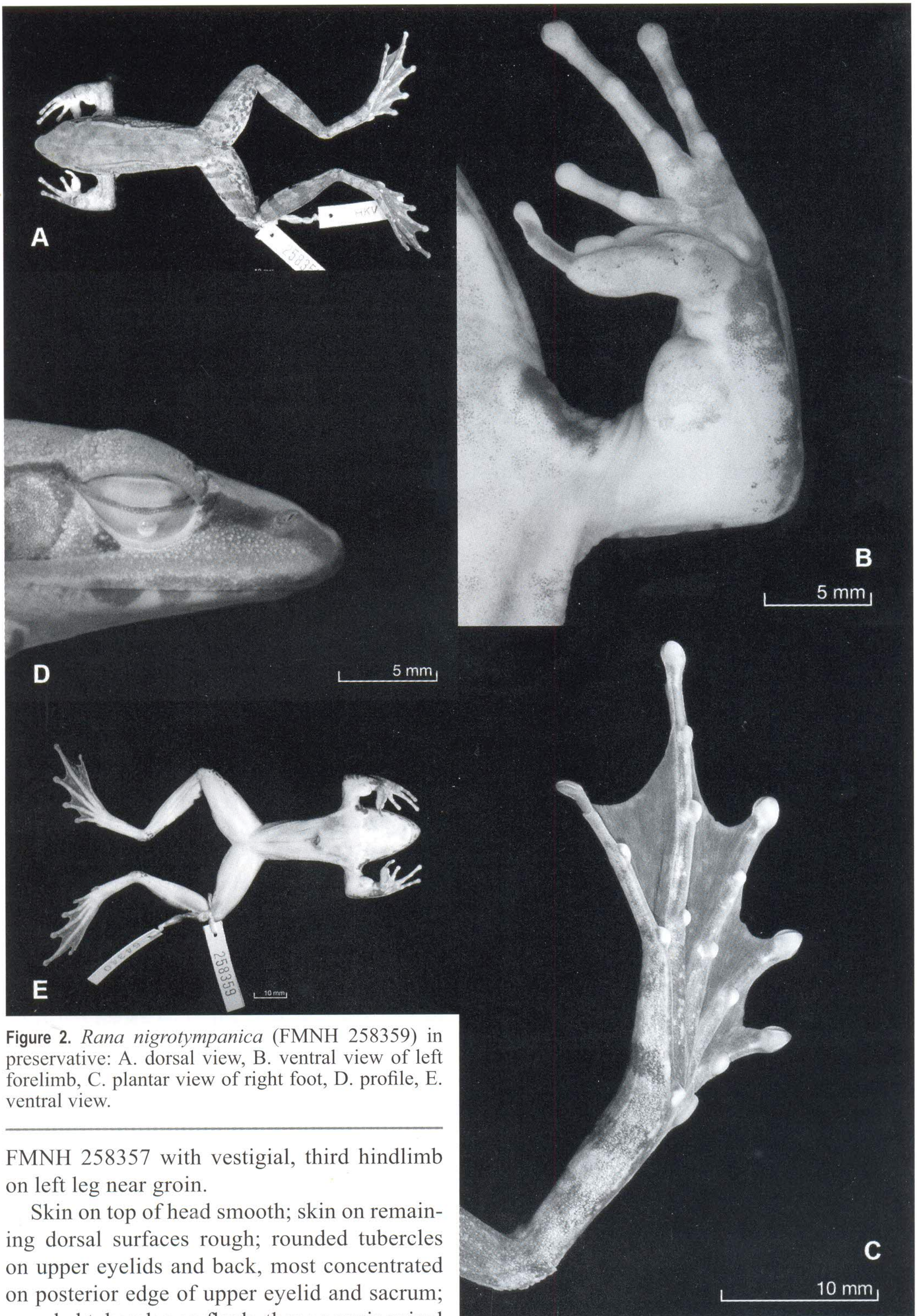

Figure 2. *Rana nigrotympanica* (FMNH 258359) in preservative: A. dorsal view, B. ventral view of left forelimb, C. plantar view of right foot, D. profile, E. ventral view.

FMNH 258357 with vestigial, third hindlimb on left leg near groin.

Skin on top of head smooth; skin on remaining dorsal surfaces rough; rounded tubercles on upper eyelids and back, most concentrated on posterior edge of upper eyelid and sacrum; rounded tubercles on flank, those near inguinal region larger and more ovoid; tubercles forming longitudinal ridges on dorsal surface of forearm and hindlimbs; distinct dorsolateral fold from rear of eye to sacrum; elongate rictal

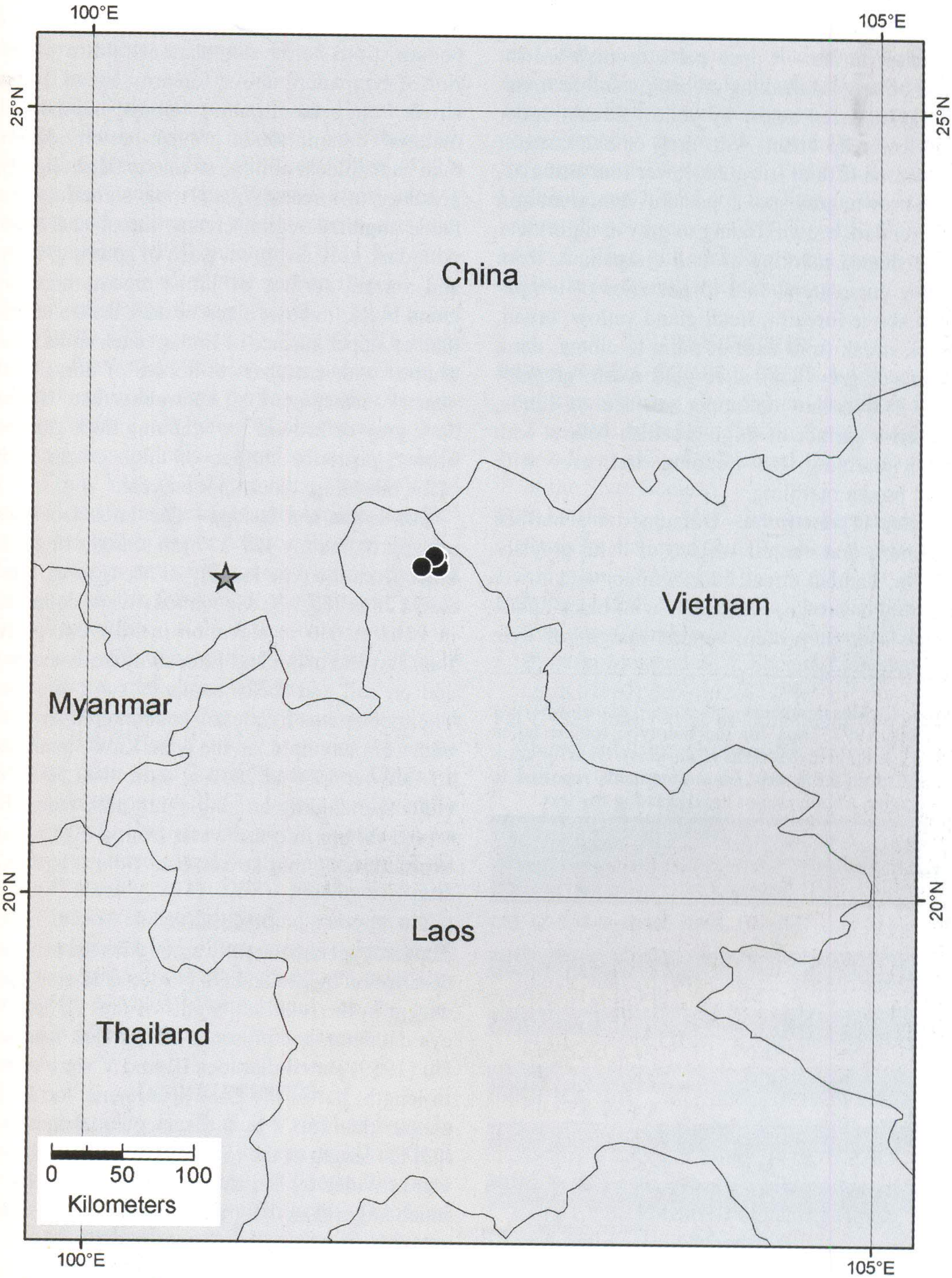

Figure 3. Map showing type locality (star) of *Rana nigrotympanica* at Mengyang, Yunnan, China, and new localities (circles) of specimens from Phongsaly Province, Phongsaly District, Laos.

gland above insertion of forearm; large, rounded humeral gland near corner of throat; ventral surfaces smooth; posterior surface of thigh granular; fine, whitish spinules on all upper surfaces and underside of feet, those on flank concentrated on tubercles.

Measurements summarized in Table 1.

Colour in life.– Upper parts reddish-brown, with olive-gold flecking on back; canthal streak black, bordered below by yellow streak; upper and lower lip cream with grey or black spots; upper one-fifth of iris gold, lower four-fifth reddish-brown; grey spot at postero-ventral margin of eye; dark brown (fading to grey at night) tear drop-shaped marking around tympanum, from below dorsolateral fold to posterior of tympanum above forearm; rictal gland yellow; broad, black streak from base of palm to elbow; flank cream or grey with olive-gold wash; greyish-brown crossbars on upper surface of limbs; posterior surface of thigh greenish-yellow with black marbling; toe webbing dark grey with light brown marbling.

Colour in preservative.– Dorsum, dorsal surface of limbs, and ventral surface of hand greyish-brown; canthal streak black; upper and lower lip grey or brown, sometimes with black spots; black spot at postero-ventral margin of eye; black, tear drop-shaped marking around tympanum, from below dorsolateral fold to posterior of tympanum above forearm; broad, black streak from base of palm to elbow; nuptial pad material cream; flank greyish-brown, darker than back; black, oblique streak on flank slightly posterior to forearm; black spots sometimes on flank; inguinal region cream; throat and chest with dark grey or brown wash or spotting, belly and ventral surface of limbs cream; humeral gland black; distinct black or dark brown crossbars on upper surface of limbs; black spots continuous with crossbars at border of dorsal and ventral surface of tibia; ventral surface of foot dark grey or brown; toe webbing dark grey or brown; posterior surface of thigh cream with black marbling; black spot on vent.

Table 1. Measurements of *Rana nigrotympanica* Dubois, 1992. Data for the holotype female taken from Liu and Hu (1959; as *R. varians*). Data for adult males taken from new Laos specimens reported in this paper. Abbreviations are defined in the text.

Measurement	Holotype female (Yunnan)	Adult males (Laos)
	n = 1	range; mean ± S.D. n = 12
SVL	61.0	51.0-59.3; 55.0 ± 2.7
HDL	22.1	18.4-21.1; 19.9 ± 0.8
HDW	18.9	15.7-17.9; 16.8 ± 0.7
SNT	8.0	7.2-8.7; 8.2 ± 0.4
EYE	8.4*	6.0-6.8; 6.5 ± 0.3
IOD	4.3	4.0-5.0; 4.7 ± 0.3
TMP	5.2	4.5-5.5; 4.9 ± 0.3
TIB	38.0	28.4-33.5; 31.4 ± 1.5
IMT	2.3	2.1-3.0; 2.5 ± 0.2
	n = 1	range; median n = 12
HDL:HDW	1.17	1.15-1.22; 1.19
SNT:HDL	0.36	0.39-0.42; 0.41
TMP:EYE	0.62*	0.68-0.82; 0.77
EYE:SNT	1.05*	0.72-0.89; 0.80
TIB:SVL	0.62	0.54-0.60; 0.58

* Eye diameter might have been measured differently by Liu and Hu (1959) and the present authors.

Distribution and Ecology.– The Laos localities are approximately 127-137 km straight-line distance from the type locality of Mengyang, Yunnan, China (Fig. 3). Specimens were collected in Laos at 600 m elevation in hilly evergreen forest on and under leaf litter away from streams and on soil and rocky banks of swift streams. The species was frequently encountered day and night. For example, on the Nam Kaw Stream on 15 October 1999 at 2030 h, more than 50 individuals, including an amplexing pair, were observed diving into the water from a 10 m long exposed rocky mid-stream bar.

DISCUSSION

The Laos specimens fully agree with the original description by Liu and Hu (1959; as *R. varians*), except in the relative lengths of toes III and V, eye diameter, and presence of spinules. Liu and Hu (1959) stated that toes III and V were equal in length, but in the Laos specimens, toe III is shorter than toe V by a distance equal to about half the length of the toe III disc. The eye diameter provided by Liu and Hu (1959) is relatively much larger than that of the Laos specimens (for example, it exceeds the snout length; Table 1), but this is a "soft measurement" that is taken differently by different workers and is usually not explicitly defined. The presence of spinules in the Laos males might be a male secondary sexual characteristic, which would explain why they were not mentioned in the original description of the Yunnan female. Other species of ranid frogs are known to have spinules in males, but few or none in females (Bain and Stuart, in press).

Previous descriptions in the literature on males of this species are brief and uncertain in origin. Liu and Hu (1961) and Yang (1991) stated that males have internal vocal sacs, a nuptial pad on finger I and a coarse, muscular forearm. Fei (1999) mentioned only the internal vocal sacs and nuptial pad on finger I. The coarse, muscular forearm reported by Liu and Hu (1961) and repeated by Yang (1991) might refer to the distinct bulbous structure covered by nuptial pad material on the forearm that was observed in the Laos males. However, the source of these data on males is unclear, as Liu and Hu (1961) and Yang (1991) provided voucher information and measurements only for females. Despite the lack of explicit description of the distinct bulbous structure covered by nuptial pad material on the forearm or the humeral gland, our observations on the Laos males are not inconsistent with these earlier statements on male secondary sexual characteristics.

Rana nigrotympanica may be closely related to *R. cubitalis* Smith, 1917, a species with type locality "Doi Nga Chang," northern Thailand. The descriptions of the two species generally agree, notably in that males of *R. cubitalis* have "a large rounded gland on the inner side of the elbow" (Smith, 1917: 278). However, Smith (1917) reported that the type and paratype males of *R. cubitalis* have gular pouches (absent in *R. nigrotympanica*) and SVL 66-68 (51.0-59.3 in *R. nigrotympanica*). Further study on the relationship of these two species is warranted.

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DRYOCALAMUS DAVISONII TUNGSONGENSIS NUTPHAND, 1986 AND *LYCODON SURATENSIS* NUTPHAND, 1986 (SERPENTES: COLUBRIDAE): TRANSLATION OF THEIR ORIGINAL DESCRIPTION AND TAXONOMIC STATUS

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ABSTRACT.– **The original descriptions in Thai of *Dryocalamus davisonii tungsongensis* Nutphand, 1986 and *Lycodon suratensis* Nutphand, 1986 (Serpentes: Colubridae) are translated into English. The taxonomic position of these two taxa is discussed. We place the first taxon in the synonymy of *Dryocalamus subannulatus* (Duméril, Bibron & Duméril, 1854) and the second one in the synonymy of *Lycodon subcinctus subcinctus* Boie, 1827. Their types being lost, we designate a neotype for each taxon in order to fix their status.**

KEYWORDS.– **Serpentes, *Dryocalamus*, *Lycodon*, Surat Thani, Nakhon Si Thammarat, Thailand, neotype designation, synonymy.**

INTRODUCTION

Taylor (1965) recorded from Thailand four species of the genus *Lycodon* Boie *in* Fitzinger, 1826, namely *L. capucinus* Boie, 1827, *L. fasciatus* (Anderson, 1879), *L. laoensis* Günther, 1864, and *L. subcinctus subcinctus* Boie, 1827, and one species of *Dryocalamus* Günther, 1858 (*D. davisonii* (Blanford, 1878)). Nutphand (1986) published an undocumented revision of these colubrid genera in Thailand, in which he recognized the following taxa: *Dryocalamus davisonii davisonii*, *Dryocalamus davisonii tungsongensis* (as a new subspecies), *Lycondon* (sic) *capucinus*, *Lycodon fasciatus*, *Lycodon laoensis*, *Lycodon subsinctus subsinctus* (sic), and *Lycodon suratensis* (as a new species). All Nutphand's snake species descriptions were superficial and did not refer to any material registered in scientific collections. They were moreover published in semi-popular publications in Thai language with a limited readership, mostly distributed in a private zoological garden in Bangkok. Nevertheless, although largely overlooked by most herpetologists, these works were printed and distributed, and hence are considered to be valid publications in regards to Art. 8.1 of the International Code of Zoological Nomenclature (ICZN, 1999; hereafter referred to as "*The Code*").

The status of Nutphand's two new taxa has never been discussed. The lack of type specimens is in this case, as in other taxa described by Nutphand (see David et al., 2004), a problem for discussing their validity. For instance, Pauwels et al. (2005a) had to designate a neotype for *Boiga siamensis* Nootpand, 1971, an overlooked junior synonym of *Boiga ocellata* Kroon, 1973 (Nootpand and Nutphand are two transliterations of his name that he used in his publications over the years). The specimens used for the description of *Naja naja isanensis* Nutphand *in* Thumwipat & Nutphand (1982) were not preserved, which led Wüster et al. (1997) to designate a neotype for that taxon. Nutphand et al. (1991a) had to designate a lectotype for *Boiga saengsomi* Nutphand, 1985. Other complications linked to Nutphand's taxonomic work were presented by Nutphand et al. (1991b) and David et al. (2004).

In the present paper, we make the original descriptions of *Dryocalamus davisonii tungsongensis* and *Lycodon suratensis* available to the herpetological community by providing their translations into English. The taxonomic status of these taxa is discussed. In order to reduce the possible confusion generated by the undocumented descriptions by Nutphand, and in agreement with the *Code*, we here designate neotypes for *Dryocalamus davisonii tungsongensis* and *Lycodon suratensis*. A list of the material examined for this study is given in Appendix I.

Museum abbreviations. IRSNB: Institut Royal des Sciences Naturelles de Belgique, Brussels; MNHN: Muséum National d'Histoire Naturelle, Paris; QSMI: Queen Saovabha Memorial Institute, Thai Red Cross Society, Bangkok; SERS: Sakaerat Environmental Research Station, Sakaerat; THNHM: Thai Natural History Museum, Patumthani.

RESULTS

DRYOCALAMUS DAVISONII TUNGSONGENSIS NUTPHAND, 1986

Translation of the original description.– p. 159 *in*: Nutphand, W. 1986. Ngoo plang chanuan. Wolf snakes [in Thai]. *Thai Zoological Center*, Bangkok, 1 (9): 153-159.

7. Yellow stripe Wolf Snake (New subspecies)

Dryocalamus davisonii tungsongensis Nutphand

Size: Midbody diameter like that of a pencil. Length from tip of snout to end of tail 70 cm.

Distribution: Obtained from Nakhon Si Thammarat Province.

Colour: Head exactly like that of Ngoo plang chanuan ban [translators' note: i.e., *Dryocalamus davisonii davisonii*]. Body brown with one dorsal stripe, and one lateral stripe on each side. The three stripes golden yellow, beginning from the neck down to the end of the tail. Belly white.

Taxonomic status.– Cox (1991a) mentioned only *Dryocalamus davisonii* (Blanford, 1878) and *Dryocalamus subannulatus* (Duméril, Bibron & Duméril, 1854) as occurring in Thailand. The presence of this latter species in Thailand was first mentioned by Nabhitabhata (1989: 202), i.e. several years after Nutphand's revision. Interestingly, Cox (1991a: 202) briefly stressed the extreme similarity between *Dryocalamus davisonii tungsongensis* and *Dryocalamus subannulatus*. According to Cox (1991a), *D. subannulatus* presents two very different colour morphs: a cross-banded variety similar to *D. davisonii* from which it can, however, easily be distinguished by scalation characters, and a striped variety. *D. subannulatus* was described on the basis of a single specimen of the cross-banded variety. The two varieties of *D. subannulatus*, well illustrated by Cox et al. (1998: 65), are regarded as conspecific on the basis of their similarity in scalation. In fact, both specimens represented by Cox et al. (1998: 65) originate from Thung Song (Gernot Vogel, pers. comm. to OSGP, March 2001), i.e., the exact type locality of *D. davisonii tungsongensis*. The few elements presented in the concise description of *D. davisonii tungsongensis* and the photography of the species agree very well with the striped form of *Dryocalamus subannulatus*, and we here synonymize these taxa.

D. subannulatus is already known from Nakhon Si Thammarat Province (Cox, 1991a: 203; Manthey and Grossmann, 1997: 340) and has also been recorded from two other southern Thai provinces: Phang-Nga (Pauwels et al., 2000: 141; banded variety) and Surat Thani (Bulian, 1999: 67; banded variety), as well as from West Malaysia, Singapore, Borneo, Sumatra and the Philippines (Palawan). If *D. davisonii* is widespread in Thailand north of latitude 11°N (Taylor, 1965) its presence in southern Thailand is more controversial. It is attested to only by the picture of a living specimen from Thung Thao, Surat Thani Province (see Chan-ard et al., 1999: 162). However, K.-D. Schulz (comm. pers. to OSGP, Feb. 2001), who shot this picture, informed us that the specimen was released without any meristic count done. The possibility that this specimen is in fact a cross-banded *D. subannulatus* cannot be excluded. Moreover, the picture was taken in the garden of J. Bulian (Schulz, pers. comm. to OSGP) who, in the list of the snakes found in his garden (Bulian, 1999), quoted only *D. subannulatus* (indeed the cross-banded form). Cox et al. (1998: 64), however, stated that *D. davisonii* occurs in Thailand as far south as Krabi.

The subspecific nomen *tungsongensis* refers to the city of Thung Song (8°17'N, 99°50'E), Thung Song District, in the Province of Nakhon Si Thammarat, southern Peninsular Thailand. The original description is accompanied by a picture, representing a single specimen that has to be considered the holotype by monotypy. According to Nutphand (pers. comm. to OSGP, 1999), this specimen is definitely lost. As a consequence, in agreement with Art. 75.3 of the *Code*, we designate a neotype for this species:

Designation of a neotype for *Dryocalamus davisonii tungsongensis*.– A specimen of *Dryocalamus subannulatus*, from the same locality as the type locality of *D. davisonii tungsongensis*, agrees both with the original description and the requirements of Art. 75.3 of the *Code*.

THNHM 3242, presumably an adult female (not dissected), from "Lansaka District, Nakhon Si Thammarat, Khao Luang National Park, caught on tree trunk, 2 m above forest floor, at 10 P.M., 19 July 2003, in the vicinity of Karoam Falls, Headquarters of the park."

Habitus.– Total length 684 mm (SVL 515 mm; tail length 169 mm). Body very elongate, laterally compressed, with a distinct head; midbody width 8.0 mm. Head length 16.0 mm; maximum width of head: 10.4 mm. Eye moderate (horizontal diameter 2.3 mm) with vertically elliptical pupil; eye-tip of snout distance: 4.9 mm; eye-nostril distance: 3.1 mm.

Body scalation.– 2 preventrals + 236 keeled ventrals; 105 paired, keeled, subcaudals. Dorsal scales in 15-15-15 rows, all smooth. No apical pits. Supracaudals smooth.

Head scalation.– Rostral clearly visible from above, posteriorly pointed, forming an anterior notch between the internasals; 2/2 internasals; 2/2 prefrontals, of ca. same length as, but wider than internasals (contact between internasals 1.4 mm; contact between prefrontals 1.8 mm); nasal undivided; nostril in its middle; 1/1 preocular; 2/2 postoculars (the upper one the smallest); loreal scale ca. twice as long as high, in contact with the eye, the preocular, the prefrontal, the nasal, and the 2nd-3rd supralabials; 7/7 supralabials, of which the 3rd-4th enters orbit; 1/1 large, undivided, supraocular; 2+2 temporals on each side; length of frontal (4.1 mm) slightly less than contact between interparietals (4.3 mm); 8/8 infralabials of which the first four on each side border the anterior pair of sublinguals; anterior sublinguals much wider and longer than posterior ones.

Colouration in alcohol.– Body dark brown, with a mediodorsal light stripe beginning above 7th ventral, uninterrupted, limited to vertebral row, becoming indistinct on the last fifth of the tail. Anterior to the 50th ventral, the mediodorsal light stripe shows a median dark brown spot on each vertebral scale; posteriorly, these median spots fuse and form a median thin brown line (same brown as background dorsum colour) within the light stripe. Two lateral stripes on body, also uninterrupted, becoming indistinct posteriorly along the second half of the tail. On the body, the lateral stripes are mostly limited to row 4 on each side of the body; along the tail, they are limited to between supracaudal rows 1 and 2. The lateral light stripes show a dark brown longitudinal irregular median stripe, indistinct along the forebody, slightly widening posteriorly (limited to scale row 1), but not continuing onto the tail.

Head dorsum dark brown; lateral head light brown spotted with whitish-yellow, becoming progressively lighter towards supralabials, which are ivory; the two colours separated by a whitish border.

Chin, venter and subcaudals uniformly white. In life, the three dorsal light stripes were golden yellow.

LYCODON SURATENSIS NUTPHAND, 1986

Translation of the original description.– pp. 157-158 *in*: Nutphand, W. 1986. Ngoo plang chanuan. Wolf snakes [in Thai]. *Thai Zoological Center*, Bangkok, 1 (9): 153-159.

5. Black Wolf Snake (New species)

Lycodon suratensis Nutphand

Size: Midbody diameter like that of the ring finger. Length from tip of snout to end of tail 80 cm.

Distribution: Occurs in the South in Nakhon Si Thammarat Province and Surat Thani Province.

Colour: Head with pale colour, white in some specimens. Body black to the end of the tail, with 2-3 white rings on the anterior half of the body, totally black posteriorly. Belly greyish white.

Taxonomic status.– *Lycodon suratensis* has been totally overlooked in the western literature and was not even mentioned by Nabhitabhata (1989). Besides this species, seven *Lycodon* species are currently known to be present in Thailand: *Lycodon butleri* Boulenger, 1900 (see Cox, 1991b-c), *L. capucinus* Boie, 1827, *L. cardamomensis* Daltry & Wüster, 2002, *L. effraenis* (Cantor, 1847), *L. fasciatus* (Anderson, 1879), *L. laoensis* Günther, 1864, and *L. subcinctus* Boie, 1827) (see Cox, 1991a; Pauwels et al., 2005b). The same species, with the exception of *L. cardamomensis* and *L. fasciatus*, occur in Peninsular Malaysia.

Besides the few characters provided in the description of *Lycodon suratensis*, one can note in the picture that the scales seem smooth or at most slightly keeled, the eye is of moderate size, the flat head slightly distinct; the habitus is definitely that of a *Lycodon*. The description of *L. suratensis* seems to exclude a conspecificity with *L. butleri* notably because of the venter colouration, with *L. capucinus* notably because of the wide white cross-bands on anterior body, with *L. effraenis* and *L. fasciatus* because of the head and venter colouration (the latter species not being known from southern Thailand), with *L. laoensis* notably because of the large size (see Cox et al., 1998: 63). *L. cardamomensis* retains distinctly contrasting light cross-bands throughout body and tail in adult specimens (more precisely, above the size of 80 cm of total length given in the description of *L. suratensis*; see Pauwels et al., 2005b). On the contrary, the description of *L. suratensis* could apply to *L. s. subcinctus* in every respect. We therefore synonymize *Lycodon suratensis* with *Lycodon subcinctus subcinctus*.

It should, moreover, be noted that Nutphand (1986) illustrated *L. subcinctus* with a picture of an adult *L. effraenis*, this latter species being not listed by him from Thailand. *L. effraenis* was not quoted among Thai snakes by Nabhitabhata (1989) nor by Cox (1991). Jintakune & Chanhome (1995) indicated that the first Thai *L. effraenis* was found in Krabi Province in 1990, but Grossmann (1989) recorded it from southern Thailand, this first mention being anyway subsequent to Nutphand's revision. *Lycodon s. subcinctus* has been repeatedly reported from the province of Nakhon Si Thammarat (Taylor, 1965: 739; Chan-ard et al., 1999: 172; Manthey and Grossmann, 1997: 364) and is widely distributed from China to the Philippines (Manthey and Grossmann, 1997). In his 2001 synthesis of the snakes of Thailand, Nutphand demonstrated an extreme confusion in his concepts of Thai *Lycodon* species, all the pictures he presented but those of *L. laoensis* misidentified (see David et al., 2004). For instance, *L. subcinctus* was illustrated by pictures of *L. effraenis*, and *L. fasciatus* was depicted using both *L. subcinctus* and *Lepturophis albofuscus*. His *Lycodon capucinus* account was illustrated using *Dryocalamus davisonii* and *Lycodon subcinctus*.

The specific nomen of *Lycodon suratensis* refers to the Province of Surat Thani, southern Peninsular Thailand. The original description is accompanied by a picture of a single specimen. Since the description infers that several specimens were examined by Nutphand, and since Nutphand did not designate a holotype, the specimen illustrated must be regarded as one of the syntypes. In agreement with the *Code*, we select the specimen depicted in Nutphand (1986) as the lectotype of *Lycodon suratensis*. However, according to Nutphand (1999, pers. comm. to OSGP), this specimen and the others on which the description was based are confirmed as lost. As a consequence, in agreement with Art. 75. 3 of the *Code*, we designate a neotype for this species.

Designation of a neotype for *Lycodon suratensis*.– The following specimen of *Lycodon subcinctus subcinctus*, from a locality close to the type locality of *Lycodon suratensis*, agrees both with the original description and the requirements of Art. 75.3 of the *Code*.

IRSNB 2610, an adult female, from "Thung Song, Nakhon Si Thammarat Province". Collector unknown, 2004. Donation Kiraty Kunya and Olivier S. G. Pauwels.

Habitus.– Total length 724 mm (SVL 596 mm; tail length 128 mm). Body elongate, laterally compressed, with a flat, subrectangular head, distinct from the neck; snout squarrish, depressed; midbody width 10.8 mm. Head length 21.4 mm; maximum width of head: 11.3 mm; eye moderate (horizontal diameter 2.7 mm) with vertically elliptic pupil; eye-tip of snout distance: 6.0 mm; eye-nostril distance: 3.7 mm.

Body scalation.– 2 preventrals + 215 ventrals, not keeled; 73 divided subcaudals. Dorsal scales in 17-17-17 rows, narrowly keeled on the 6^{th}-9^{th} scale rows. No apical pits visible. Supracaudals distinctly keeled on all rows.

Head scalation.– Rostral barely visible from above, short, posteriorly pointed, barely forming a notch between the internasals; 2 internasals; 2 prefrontals, 1.7 longer and 1.4 wider than internasals, entering orbit; nasal undivided, with a large, elliptical nostril in its middle; no preocular, 2/2 postoculars (the lower one the smallest); 1/1 loreal scale, slightly curved downward on its anterior part, ca. twice as long as high, in broad contact with the eye and the nasal, in contact with the prefrontal and 2^{nd}-3^{rd} supralabials; 8/8 supralabials, of which the 3^{rd}-5^{th} enter orbit; 1/1 large, undivided, supraocular; 1+2 temporals on each side; frontal (length 4.3 mm) shorter than the contact between interparietals (4.9 mm), but longer than the contact between prefrontals (length 3.6 mm); 9/9 infralabials, of which, on each side the four first are in contact with the anterior pair of sublinguals; anterior sublinguals 1.2 wider and 1.5 longer than posterior ones.

Colouration in alcohol.– Overall body surface dark brown, with only three visible broad cross-bands on the anterior part of the body, about 7 scales long and widening at their base; the first cross-band, ivory, is very distinct, the third one, dark reddish-brown, is barely distinct; the posterior half of the body and the tail are uniformly dark brown; a wide ivory nuchal collar, narrow on the top of the neck, wider at its base.

Head dorsum dark brown, with posterior supralabials a lighter yellowish-brown; some ivory blotches on the occipital region near the anterior margin of the nuchal collar.

Venter and subcaudals rather dull, anterior half of each ventral plate dark greyish-brown, posterior half light brownish-grey. Chin and throat uniformly whitish-yellow.

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APPENDIX I
SPECIMENS EXAMINED

The following list does not include the neotypes designated above. It includes only specimens whose meristic and other characters were studied in detail by at least one of us. See the Introduction for the museum abbreviations.

Dryocalamus davisonii: QSMI 595 (Hin Chang See Nature Park, Ban Fang District, Khon Kaen Province, Thailand); SERS (unnumbered; Sakaerat Environmental Research Station, Sakaerat, Nakhon Ratchasima Prov., Thailand); see also Chanhome et al. (2001: 54), Pauwels et al. (2003: 31).

Dryocalamus subannulatus: see Chanhome et al. (2001: 54; striped form), Pauwels et al. (2000: 141; banded form).

Lepturophis albofuscus: IRSNB 16991 (Thung Song, Nakhon Si Thammarat Prov., Thailand); see also Chanhome et al. (2001: 55).

Lycodon capucinus: IRSNB 16988 (Sakaerat, Nakhon Ratchasima Prov., Thailand); SERS (unnumbered; Sakaerat Environmental Research Station, Sakaerat, Nakhon Ratchasima Prov., Thailand); see also Chanhome et al. (2001: 55), Pauwels et al. (2003: 32), Pauwels and Kheowyoo (2004).

Lycodon cardamomensis: see Pauwels et al. (2005 b).

Lycodon effraenis: see Chanhome et al. (2001: 55).

Lycodon fasciatus: see Pauwels & Chan-ard (2005).

Lycodon laoensis: IRSNB 16989 (Sakaerat, Nakhon Ratchasima Prov., Thailand); MNHN 1998.8549 (Chiang Mai city, Chiang Mai Prov., Thailand); QSMI 593 (Hin Chang See Nature Park, Ban Fang District, Khon Kaen Province); see also Chanhome et al. (2001: 55), Pauwels et al. (2000: 142).

Lycodon s. subcinctus: IRSNB 16557 (southern Thailand); IRSNB 16990 (Sakaerat, Nakhon Ratchasima Prov., Thailand); SERS (unnumbered; Sakaerat Environmental Research Station, Sakaerat, Nakhon Ratchasima Prov., Thailand); see also Chanhome et al. (2001: 55-56), Pauwels et al. (2000: 142).

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FIRST RECORD OF *RHABDOPHIS NUCHALIS* (BOULENGER, 1891) (SERPENTES: COLUBRIDAE) FROM INDIA, WITH NOTES ON ITS DISTRIBUTION AND NATURAL HISTORY

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(with three text-figures)

ABSTRACT.– Nineteen species of the genus *Rhabdophis* are known from Eastern Himalayas, northeastern India, China, northern Myanmar and northern Vietnam. We report here a population of *Rhabdophis* belonging to the species *Rhabdophis nuchalis*, for the first time in India from Nagaland State. A series of specimens were recorded from degraded and secondary subtropical broadleaf forest in the month of April 2004 at an elevation of 1500-1750 m asl. Its distribution range has been considerably extended west by ca. 450 km from the nearest locality in Myanmar. There is no record of this species in Myanmar since Smith (1943). We compare the species with its Indian congeners and discuss its habitat and natural history, as observed in the field.

KEY WORDS.– Serpentes, Colubridae, *Rhabdophis nuchalis*, distribution, natural history, Nagaland, north-east India.

INTRODUCTION

Nineteen species of natricine snakes of the genus *Rhabdophis* are reported from the Indo-China, Indo-Malayan and Indian regions (Boulenger, 1891; Wall, 1923; Malnate, 1960; Malnate and Underwood, 1988; Zhao, 1995; 1997). A list of *Rhabdophis* taxa is provided in Appendix I. Two species were previously known to occur in India, *Rhabdophis himalayanus* and *R. subminiatus*, both from north-eastern India (Smith, 1943; Das, 2003). We carried out a rapid herpetofauna inventory of Khonoma village forest in Nagaland State, and collected *Rhabdophis nuchalis*, a species hereto before not known from India. This record considerably extended its range by 450 km to India.

The north-eastern Indian hills, that are covered with tropical evergreen and subtropical broadleaf forests, are a poorly known, unexplored region within the Indo-Burma biodiversity hotspot (Myers et al., 2000). Nagaland State to the south of Assam plain, which extends to the Rakhine (formerly Arakan) Range, is rich in biodiversity. Inhabited by several indigenous tribal communities, the Angami tribe dominates southern Nagaland. Traditionally, the tribe conserves forests on hill slope and terrace cultivation. The village council declared an important watershed at Khonoma village (25° 38.927'N; 94° 01.617'E; elevation 1,900–2,750 m asl) covering an area 25 km^2 as Khonoma Nature Conservation and Tragopan Sanctuary (KNCTS). The area is covered with primary and secondary evergreen and subtropical broadleaf forest with an average annual rainfall ca. 2,000 mm and minimum and maximum temperature ranges from subzero to 30°C. The terrace is used for cardamom and ginger cultivation and planted with alder trees (*Alnus nepalensis*). The terrace forest provide suitable habitat for different species of reptiles and amphibians, birds, mammals and other forms of biodiversity.

We visited Khonoma (16 km from Kohima town) and Dzüleke villages, in Nagaland State

Table 1. Meristic and mensural characters of *Rhabdophis nuchalis* from Nagaland, India.

Characters	ZSI 25591/ MFA 50077	MFA 50029	MFA 50031	MFA 50036	MFA 50056
Dorsal scale rows	17:17:15	17:17:15	17:15:15	17:15:15	17:15:15
Ventrals	156	154	155	152	-
Subcaudals (paired)	49	49	59	64	-
Preocular	?	1/1	2/2?	1/2	-
Postocular	3/3	3/3	3/3	3/3	-
Loreal	1	1	1	1	-
Snout-vent length (mm)	620	530	470	490	490
Tail length (mm)	135	130	180	170	160
Sex	Female	Female	Male	Male	Male

(see below in 'Distribution') in April 2004. Walking across the terrace cultivation, on the road and small bamboo-brake, we came across a number of live *Rhabdophis nuchalis,* mainly between 1000–1800 h. Villagers guided us to a spot, where we found hundreds of eggs that were reported to be laid by this species. A few specimens were brought dead to us and we found a few smashed on the road or on the terraces.

MATERIALS AND METHODS

Two specimens, one adult female (ZSIC 25591) and a juvenile (MFA 50026) preserved and deposited in the museum. Other live specimens were measured, photographed and released. Specimens were fixed in 8% formalin and later preserved in 70% alcohol. Sex of the preserved specimens was determined by dissection, and in live animals by examining the tail base for presence or absence of hemipenis. Measurements, scalation and other important details are provided in Table 1. Dorsal scales were counted at two head-length behind head, the mid-body and before vent.

Abbreviations: MFA= M Firoz Ahmed, ZSIC= Zoological Survey of India, Calcutta.

GENERAL CHARACTERISTICS

Body stout, cylindrical; dorsal scale formula 17:15(17):15 rows, keeled except the outer row, which is smooth. Distinct nuchal groove with enlarged nuchal scales; head flat, distinct from neck; eyes moderate, pupil round; rostral wider than high; internasals truncated anteriorly, nostrils lateral. 6 supralabials (3rd and 4th touching eye), 5th longest, separated from eye by lower postocular. Infralabials 8, first four pairs touching the anterior chin shield. Two pairs of chin shields. Loreal 1, slightly higher than broad. The maxillary teeth are 18/19 in count and are gradually enlarged posteriorly, no abruptly enlarged maxillary teeth. The females are stouter than the

Table 2. Comparisons of taxonomic characters of *Rhabdophis nuchalis* with closely related *R. angeli, R. himalayanus* and *R. subminiatus*, based on Smith (1943) and present observations. All measurements in mm.

Characters	*R. nuchalis*	*R. angeli*	*R. himalayanus*	*R. subminiatus*
Maxillary teeth	18–23	22–23	26–29	24–26
Dorsal scale rows	17:15:15	15	19	19
Ventrals	139–160	117–126	157–176	144–173
Subcaudals (paired)	41–65	39–46	79–95	72–96
Supralabials	6 (3–4)	6 (3–4)	8 (4–5)	8 (3–5)
Preocular	1	1	1	1
Postocular	3/3	3	3	3
Temporal	1+2	1+2	2+2/3	2+2/3
Snout-vent length (♂/♀)	483/575	355	605/945	570/565
Tail length (♂/♀)	170/132.5	75	215/305	180/185

males. Males have longer tail than females, with hemipenis extending to the 12–13 caudal plates, sulcus forked. Ventrals 139–160. Subcaudals 52–65 in males and 41–52 in females (Smith, 1943; also see Table 1)

It was observed that a narrow mid-dorsal scale-line appears as the nuchal groove disappears (after 16 or 17 scale rows behind head) and extends through the rest of the body length. However, the enlarged paired nuchal scales (as described by Smith, 1943) are two lines of separated dorsal scales extending from behind the head throughout the body length.

Colouration.– In life: Neck reddish-brown from angle of jaw posteriorly for 11–12 scale rows. Dorsal colour light brown, checkered with pale reddish-brown spots. Head shields brown, thinly speckled with red. Iris golden, speckled with brown. Two slightly oblique black stripes, one between supralabials 4 & 5, and another between 5 & 6. Alternate rows of body scales are red and brown (broken alternately after one or two scales, shows pattern); as the pattern fades away progressively, the tail becomes more red. Skin in between scales bluish-black. Fine, oblique, black lines on dorsolateral scales at midbody (see Fig. 1 for live colouration).

In formalin: Light to dark brown dorsally, first two rows lighter; ventrals lighter in colour while posterior edge powdered with black, which increases towards tail; indistinct reddish collar (2–3 mm wide) usually observed in males.

Juvenile.– We found a juvenile within talus (small rocks accumulated at the base of a land slide or hill slope) 25 meters away from a communal breeding (see natural history below) site. The juvenile (snout-vent length 162 mm and tail length 37 mm) is dark brown or black with lighter ventrals and labials. A distinct bright reddish-yellow collar, 7 rows behind head is present. Distinct red tinge on the scales immediately behind the collar (see Fig 2).

COMPARISONS

Jiang and Zhao (1983) described a subspecies, *Rhabdophis nuchalis pentasupralabialis* from Mount Gongga, Sichuan Province, China. This taxon was raised to specific level by Zhao (1995). *Rhabdophis pentasupralabialis* has five supralabials where the 5th is the longest while the nominal *R. nuchalis* has six supralabials and 5th is the longest. The first two to three dorsal scale rows of the former taxon are smooth while only one row (rarely two) in the later one. Again former taxon is shorter (500 mm) than the later (600 mm). We are unable to compare specimens from China, but, according to description provided in the literature, we refer our specimens to *Rhabdophis nuchalis*.

Rhabdophis nuchalis is similar to *Rhabdophis angeli*, but differs in the number of ventrals (117–126 in *angeli* vs. 139–169 in *nuchalis*), number of subcaudals (39–46 in *angeli* vs. 49–64 in *nuchalis*) (data from Smith, 1943 and Zhao et al., 1998 and P. David pers. comm.). Moreover, *R. angeli* has 15 rows of scales throughout vs. 17:15(17):15 in *R. nuchalis*.

R. nuchalis has six supralabials, while the Indian congeners *Rhabdophis himalayanus* and *Rhabdophis subminiatus* have eight. Further, the body is covered with 17:15(17):15 scale rows in *R. nuchalis,* while there are 19 scale rows through out in both the Indian congeners. Maxillary teeth in *R. nuchalis* are gradually enlarged posteriorly, while the last two are abruptly enlarged in *R. himalayanus* and *R. subminiatus*.

DISTRIBUTION

According to Smith (1943), Zhao and Adler (1993), Nguyen and Ho (1996) and Zhao et al. (1998), *Rhabdophis nuchalis* is known from northern Myanmar (Nam-Tamai (27° 55′N; 97° 45′E; 1,050–1,500 m asl), Sinlum-Kaba (24° 16′N; 97° 31′E) and Adung Valleys, in Kachin State), People's Republic of China (south-east Xizang [Tibet], Gansu, Yunnan, Sichuan, Guizhou, Guangdong, Guangxi, Hubei and Shaanxi) and Vietnam (Provinces of Lao Cai and Bac Thai in northern Vietnam). Comprehensive reviews of snakes of India by Smith (1943), Das (1997, 2003) and Whitaker and Captain (2004) did not report this species from India. It was also not included in a recent review of reptile fauna of Nagaland (Ao et al., 2004). Zug et al. (2003) listed this species in the list of herpetofauna of Myanmar based on records by Smith (1943) and Wall (1923).

All the specimens we observed or collected in Nagaland were on or close to the (NEC) road in between Khonoma (25° 38.927′N; 94°

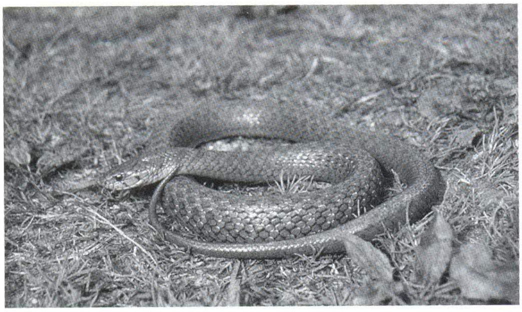

Figure 1. *Rhabdophis nuchalis* (ZSI 25591), female, from Nagaland, north-eastern India. Photo: M Firoz Ahmed.

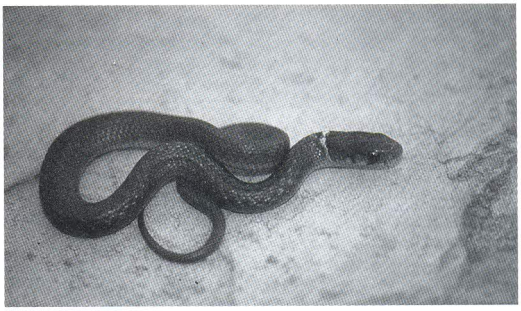

Figure 2. *Rhabdophis nuchalis*, juvenile (MFA 50026), from Nagaland, north-eastern India. Photo: M Firoz Ahmed.

01.617′E) and Dzüleke village (25° 37.166′N; 93° 57.541′E), elevation ranging from 1,500–1,750 m. This is a common species in this locality. According to Smith (1943) this is a hill species apparently common in some places. Fig. 3. shows the known distribution of *R. nuchalis*.

HABITAT AND NATURAL HISTORY

The typical observed habitat of *Rhabdophis nuchalis* is leaf litter as most individuals were found in or around the abandoned terrace cultivation areas and secondary forest floor having thick (2–5 cm) layers of leaf litter. Local people reported frequent encounters while cleaning cardamom gardens and other crops grown under canopy shade in the terrace, and also while preparing new terraces for cultivation. We observed the first live snake on 21 April 2004 at 1300 h, while it was basking at an opening of a bamboo brake at Dzüleke village. The female was kept

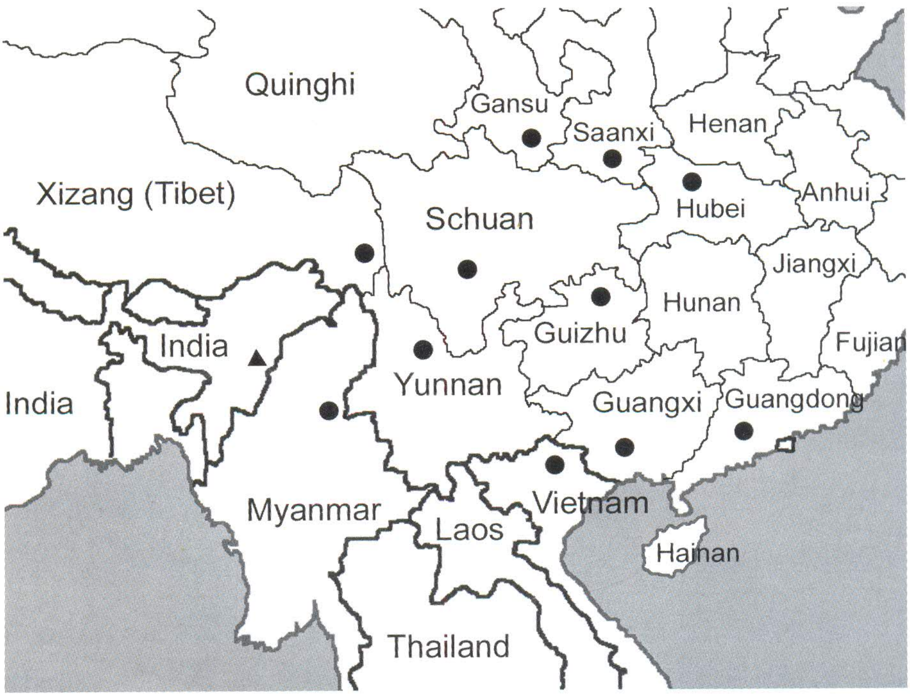

Figure 3. Map showing distribution of *Rhabdophis nuchalis* in India, Indo-Chinese Peninsula and China. Current record from Nagaland state in India is indicated by a solid triangle. Solid circles indicate other known provinces and localities in China, Myanmar and Vietnam.

under observation in the field laboratory. Another female was seen resting on a roadside log at dusk (1845 h), indicating that the snake may be active both during day and night.

According to the local people, this species (*'Nhyüvo'* in Angami dialect, meaning 'smelling snake': the nuchal gland secretion has a pungent smell) is sometimes seen basking in groups close to the roadside culverts and retention rock-walls (not cemented) with crevices and gaps between June and July. One villager showed us such a habitat, where we found several hundreds of snake eggshells between one or two years old. All eggs laid in clusters of more than eight, packed in gaps between rocks. Though there were no direct observations, we were convinced that only a common species like this could only lay eggs in such huge numbers, suggesting a communal breeding behaviour. The local villagers, who have remarkable natural history knowledge on this snake, also suggested this behaviour.

The female (ZSI 25591) that was kept under observation that laid 15 elongated eggs on 11 May 2004. Average length and diameter of the eggs were 26 x 13 mm, respectively. Another female killed by villagers in early April 2004 had eight (unshelled) ova, while another killed on 21 April 2004 had 19 ova.

While handling the female kept under observation, it 'blast-discharged' a creamy substance with pungent smell from its nuchal gland. According to local people (confident on identity of the species), sometimes many individuals of this species congregate if one is killed (note: they generally kill snakes by severely beating its head and anterior part of the body, thus rupturing the nuchal gland). This indicates that the nuchal gland and its secretion are associated with communication and probably for breeding, as known in natricine snakes (Smith, 1943:15) or for defense (as suggested by the discharge while handled).

We handled both sexes of this extremely docile snake, which never attempted to bite, even when provoked. In contrast, it preferred to escape, though movement was rather slow. While released, the snake probed the ground for soft leaf litter strongly pressing its snout and concealed itself under thick leaf litter. This species is found only on community lands as far. However, other than occasional killing by villagers we did not see any serious threat to this species. Further, the community initiated Khonoma Nature Conservation and Tragopan Sanctuary encompassing its suitable habitat is a positive sign in the state towards conservation of this species along with other herpetofauna and biodiversity.

The herpetological diversity of north-eastern India is high and remains to be adequately evaluated (Power and Birand, 2001). Nagaland State in particular, is little explored. Recently, Ao et al. (2003) reported five species of amphibians from Nagaland as new for India. Ao et al. (2004) also reported 19 reptile species new for the state. On the basis of Ao et al. (2004) and the present report, 42 snake species are now known from Nagaland. The remote and less disturbed remaining tropical evergreen and subtropical broadleaf forests in Nagaland and Manipur state bordering Myanmar will undoubtedly reveal many new records and perhaps taxa new to science. A more detailed list of herpetofauna of the area studied is currently being prepared.

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APPENDIX I

List of known species of the genus *Rhabdophis* in the world.

1. *Rhabdophis adleri* Zhao, 1997
2. *Rhabdophis angeli* Bourret, 1934
3. *Rhabdophis auriculata* Günther, 1858
4. *Rhabdophis barbouri* Tyalor, 1922
5. *Rhabdophis callichroma* Bourret, 1934
6. *Rhabdophis chrysargoides* Günther, 1858
7. *Rhabdophis chrysargos* Schlegel, 1837
8. *Rhabdophis conspicillatus* Günther, 1872
9. *Rhabdophis himalayanus* Günther, 1864
10. *Rhabdophis leonardi* Wall, 1923
11. *Rhabdophis lineatus* Peters, 1861
12. *Rhabdophis murudensis* Smith, 1925
13. *Rhabdophis nigrocinctus* Blyth, 1856
14. *Rhabdophis nuchalis* Boulenger, 1891
15. *Rhabdophis pentasupralabialis* Jiang & Zhao, 1983
16. *Rhabdophis spilogaster* Boie, 1827
17. *Rhabdophis subminiatus* Schlegel, 1837
18. *Rhabdophis swinhonis* Günther, 1868
19. *Rhabdophis tigerinus* Boie, 1826

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INTRASPECIFIC VARIATION IN THE GIANT ASIAN POND TURTLE, *HEOSEMYS GRANDIS* (GRAY, 1860)

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(with four text-figures)

ABSTRACT.– **Examination of museum and pet trade specimens of *Heosemys grandis* from Myanmar suggests that they differ from specimens from the rest of the species range in Thailand, Cambodia, Vietnam, Laos, and Malaysia. Myanmar specimens (all from the Ayeyarwady drainage basin) have a relatively shorter interpectoral seam, interfemoral seam, and interanal seam, and a relatively longer interabdominal seam. However, due to the large body size of this species, relatively few adult museum specimens were available for study. Hence, we presently refrain from naming the form in Myanmar until more vouchered specimens are available, or until molecular comparisons have been made.**

KEY WORDS.– ***Heosemys*, Geoemydidae, Asia, taxonomy, variation, morphology, Myanmar.**

INTRODUCTION

The Giant Asian Pond Turtle (also known as the Orange-headed temple turtle; Nutaphand, 1979; Lim and Das, 1999), *Heosemys grandis* (Gray, 1860) is the largest semi-terrestrial geoemydid turtle known (to 435 mm CL; Günther, 1864). Until recently, this turtle was believed to range from Malaysia to Thailand and Cambodia to southern Myanmar (Smith, 1931; see also Fig. 1).

Many references have mentioned its occurrence in "Burma" (Theobald, 1868, 1882; Boulenger, 1890; Fea, 1897; Annandale, 1906; Siebenrock, 1909; Smith, 1931), but all are apparently based on three shells and two eggs (The Natural History Museum, London, BMNH 67.12.30.66, 1887.3.11.8, 68.5.11.6, 68.5.18.1, and 1961.174, respectively) purchased by W. Theobald, and apparently originating from near Pegu (ca. 17°18N; 96°31E). Only one additional specimen (BMNH 1920.9.15.6), from the Me Wang Forest, Burmo-Siam Frontier (Smith 1931; catalogued as "Mewong, Burma, Siam border"), emerged from Myanmar (formerly Burma) over the subsequent century. A second supposed specimen of *H. grandis* from "Kachin, Myitkyina" in northern Burma was collected in 1945 and deposited in the U.S. National Museum (USNM 122187; mapped in Iverson, 1992; questioned by van Dijk, 1993; Platt, 2001). However, this specimen is actually a *Cyclemys* (*dentata* complex; JBI, pers. observ.). In 1993, two *H. grandis* were kept at the Yangon zoo along with several other locally-native turtle species (van Dijk, 1993).

Between 1991 and 1995, one of us (WPM) obtained a total of 12 adult *Heosemys grandis* from Hong Kong reptile dealer Oscar Shiu, purportedly from "northern Burma" and shipped from markets in Ruili, in Yunnan Province, People's Republic of China (see also McCord and Philippen, 1998). The turtle trade through the Ruili markets at that time was described by Kuchling (1995), although he reported no specimens of *H. grandis*. Subsequently Platt (2001) and Platt et al. (2005) reported eight additional specimens from Shwegu (24°14N; 96°48E, near Bhamo), finally establishing its presence in northern Myanmar. Because the live WPM specimens seemed to exhibit differences in scute proportions from live Malaysian material that we had previously examined, and because they were believed to have originated from >

600 km north of the early records, we undertook a preliminary investigation of intraspecific variation in this species.

MATERIALS AND METHODS

Shell and scute measurements (to the nearest 0.1 mm) were recorded from adult or subadult museum and pet trade specimens of *Heosemys grandis* from Myanmar, Thailand, and the Malay Peninsula (see Appendix 1). Measurements included maximum (not midline) carapace length (CL), maximum carapace width (CW), maximum (not midline) plastron length (PL), maximum (not midline) length of the plastral forelobe from the interabdomino-interpectoral junction to a line across the anterior ends of the gular scutes (FL), maximum (not midline) length of the plastral hindlobe from the interabdomino-interfemoral junction to a line across the posterior ends of the anal scutes (HL), minimum (median) length of the plastral hindlobe from the interabdomino-interfemoral junction to the anal notch (NHL), anterior plastral hindlobe width at the level of the junction of the abdomino-femoral seam and the plastral margin (PWC), posterior plastral hindlobe width at the level of the junction of the femoro-anal seam and the plastral margin (PWD), left bridge length from axillary notch to inguinal notch (BL), maximum ventral width across gular scutes (GW), maximum (not midline) length of right gular scute (GL), and lengths of right interhumeral (IH), interpectoral (IP), interabdominal (IAB), interfemoral (IF), and interanal (IAN) seams. Because of sexual dimorphism (observed by the authors) in some of these characters, females and males were analyzed separately. Only adults and sub-adults (> 200 mm CL) were included in this preliminary analysis.

The data were standardized for body size by division by carapace length. Although concerns have been expressed about the statistical validity of using ratios rather than residuals in quantitative analyses (Atchley et al., 1975, 1976; among others), multivariate analyses of ratios of turtle morphometric data have not yielded results that differed from those employing residuals (Berry, 1978; McCord and Iverson, 1991; among others). In addition, the use of ratios offers the advantage of working with parameters that can be directly measured and/or compared; it is not possible to compare raw measurements directly to mean values of a residual. The 15 character ratios produced by this standardization were then submitted to discriminant function analysis (DFA) with SPSS software (SPSS, Inc., 1999).

RESULTS

The discriminant function analysis (DFA) of all populations (Fig. 2) demonstrated that specimens of *Heosemys grandis* from Myanmar are morphometrically the most distinct of all populations. Myanmar specimens tended to have a relatively shorter interpectoral seam, interfemoral seam, and interanal seam, and a relatively longer interabdominal seam, compared to other populations of *H. grandis*. Untransformed data for the characters that varied most significantly in the DFAs were recombined into new character ratios and plotted to summarize variation across populations (Table 1; Fig. 3). These data further illustrate the morphometric distinctiveness of the Myanmar population.

Plastral images of *H. grandis* outside of Myanmar are in Günther (1864; Cambodia), Bourret (1941; Vietnam), Pritchard (1979; uncertain provenance), Nutaphand (1979; Thailand), Sharma (1998; uncertain provenance), Stuart et al. (2001; Thailand), Lehr and Holloway (2003; Cambodia) and Stuart and Platt (2004; Cambodia). All support the patterns in relative scute proportions reported here.

DISCUSSION

The largest recent specimens of *Heosemys grandis* have all been less than 375 mm carapace length (Platt, 2001; Stuart and Platt, 2004; this study), whereas early specimens reached 435 mm (Günther, 1864; Flower, 1899; Smith, 1931). In addition, at least two recent popular sources (Cox et al., 1998; Lim and Das, 1999) report maximum size of 480 mm carapace length. Because this species reaches such a large size, adult specimens are under-represented in most museum collections.

Thus, small samples and incomplete geographic sampling hinder a complete analysis of intraspecific variation. However, despite these constraints, specimens of *H. grandis* from Myanmar are consistently different from

Table 1. Character ratios demonstrating significant intraspecific variation in *Heosemys grandis*. Character abbrevations are carapace length (CL), interpectoral seam length (IP), interabdominal seam length (IAB), interfemoral seam length (IF), and interanal seam length (IAN).

Sample	Sex	n	CL (mm)	IAB/IP	IAN/IF
Myanmar	M	7	306 (226-370)	1.498 (1.246-1.762)	0.604 (0.459-0.726)
	F	7	282 (202-317)	1.468 (1.263-1.687)	0.570 (0.454-0.648)
Thailand	M	3	350 (323-364)	1.193 (1.053-1.332)	0.368 (0.324-0.446)
	F	1	237	1.152	0.518
Malaysia	M	2	329	1.225 (1.064-1.387)	0.367 (0.336-0.398)
	F	8	277 (217-320)	1.205 (0.986-1.687)	0.480 (0.404-0.632)

those in the rest of the range. Nevertheless, we refrain from formally naming this population until more material is available, or until molecular comparisons have been made. Should more complete study support the taxonomic recognition of the Myanmar population of *H. grandis*, a single specimen with relatively complete data is currently available (BMNH 1920.9.15.6) to serve as the holotype (though it is a carapace only without plastron). Until that time, efforts should be directed toward documenting the range and status of this turtle in Myanmar, as well as toward its protection (Platt et al., 2000).

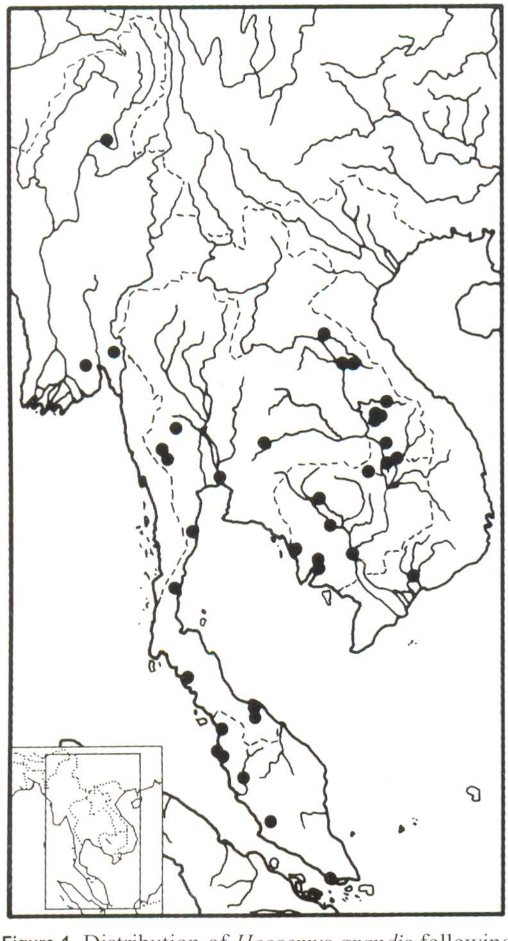

Figure 1. Distribution of *Heosemys grandis* following Iverson (1992), and supplemented by Thirakhupt and van Dijk (1995), Stuart (1999), Platt (2001), and Stuart and Platt (2004).

Other turtle taxa endemic or nearly endemic to this drainage include *Cuora amboinensis lineata* (distribution based on McCord and Philippen, 1998), *Heosemys depressa* (Iverson and McCord, 1997; Platt, 2000; Platt et al., 2003), *Kachuga trivittata* (Platt, 2001; Platt et al., 2005), *Melanochelys trijuga edeniana* (Smith, 1931; Platt et al., 2005), *Morenia ocellata* (Smith, 1931; Platt et al., 2005), *Geochelone platynota* (Platt and Win Ko Ko, 2001; Platt et al., 2003), *Chitra vandijki* (McCord and Pritchard, 2002; Platt et al., 2005), *Lissemys scutata* (Smith, 1931; Engstrom et al., 2004), and *Nilssonia formosa* (Meylan, 1987; Engstrom et al., 2004; Platt et al., 2005). In addition, the Myanmar population of *Amyda cartilaginea* originally described as *Trionyx phayrei* (Theobald, 1868), should be further investigated to determine if it deserves recognition at least at the level of subspecies. Four other widespread freshwater south-east Asian turtles are distributed in Myanmar (*Batagur baska, Cyclemys dentata* complex (see Guicking et al., 2002), *Cuora mouhotii* (see Fritz et al., 1998), and *Pelochelys cantorii* (Iverson, 1992; Webb, 2002), but their distinctiveness therein has not yet been conclusively investigated.

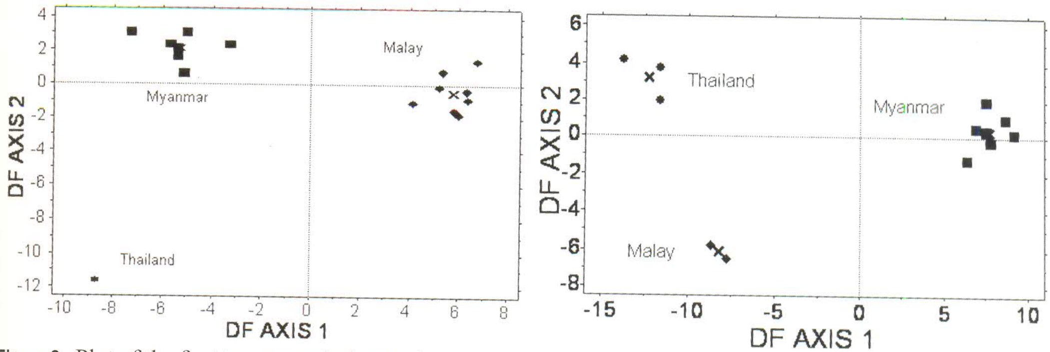

Figure 2. Plot of the first two canonical axes for specimens of *Heosemys grandis* based on discriminant function analysis of the ratios of 15 characters (see Methods) for females (left) and males (right). First and second axes account for 76% and 24% of the variation, respectively, in females, and 90% and 10%, respectively, in males. Sample means are indicated with an X.

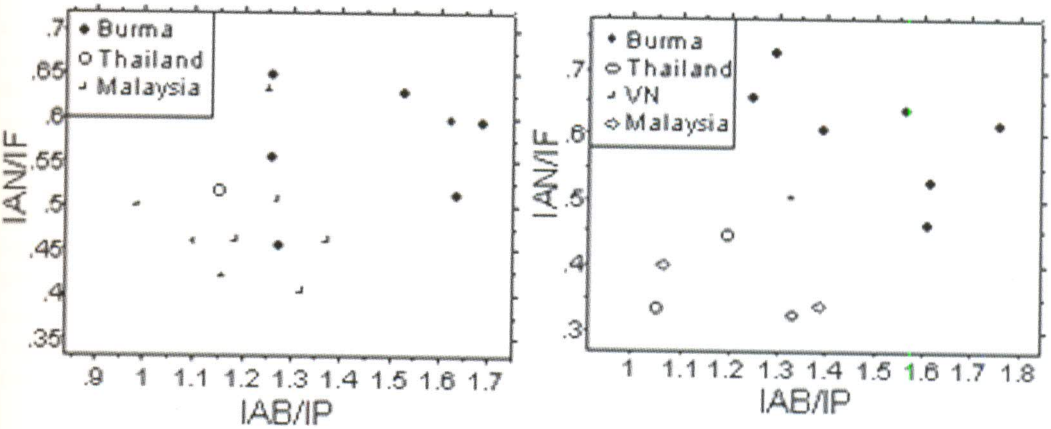

Figure 3. Bivariate plot of relationships among specimens of *Heosemys grandis* based on the characters IAN/IF (interanal seam length/interfemoral seam length) and IAB/IP (interabdominal seam length/ interpectoral seam length) for females (left) and males (right).

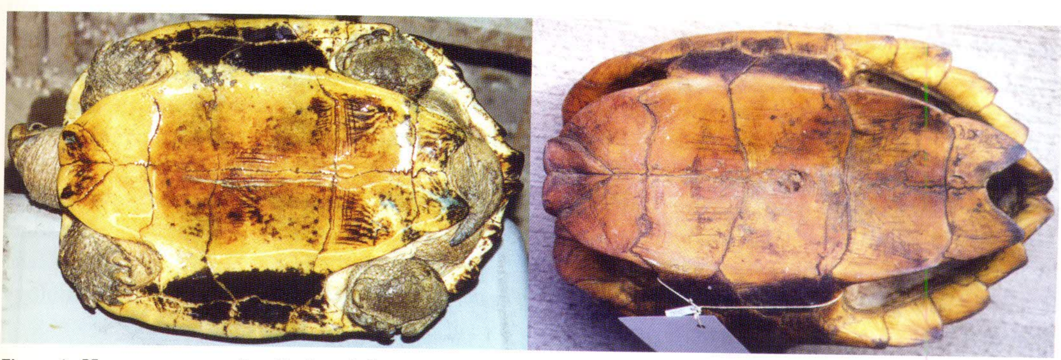

Figure 4. *Heosemys grandis*. Left: adult male carapace, WPM G (live), 352 mm carapace length (CL), from "northern Burma" [Myanmar]; right: FMNH 224043, 367 mm CL, from Malaysia. Note relatively short interpectoral seam, interfemoral seam, and interanal seam, and relatively long interabdominal seam on Myanmar specimen.

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APPENDIX 1

Specimens examined

Myanmar: British Museum of Natural History (BMNH) 1887.3.11.8, 68.5.11.6; William P. McCord private collection (WPM) A1-A12 (live). Cambodia: BMNH 1947.3.4.55 (syntype; photographs only). Thailand: BMNH 1947.3.4.56 (possible syntype; photographs); Field Museum of Natural History (FMNH) 199754; Museum of Comparative Zoology at Harvard (MCZ) 29522-29523; United States National Museum (USNM) 23108, 71479. Malaysia: BMNH 99.1.12.2, 99.1.12.3, 99.1.12.5, 99.1.12.6 (photographs); FMNH 142495, 224037-224038, 224041-224043, 251496, WPM B1-B2 (live).

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RETRACTION OF *PTYODACTYLUS* GOLDFUSS FROM THE FAUNA OF IRAN AND ITS REPLACEMENT BY A NEW SPECIES OF *ASACCUS* DIXON AND ANDERSON (REPTILIA: SAURIA: GEKKONIDAE)

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(with three text-figures)

ABSTRACT.– **The voucher specimen on which the inclusion of the gekkonid genus *Ptyodactylus* in the fauna of Iran had been based, turns out to belong to the genus *Asaccus* and to represent a new species, described here. *Asaccus nasrullahi* sp. nov. from western Iran is diagnosed chiefly by its relatively large size (at least 70 mm rostrum-anus); scales across the preorbital and supraorbital region coarse; granules between eye and ear tiny; tubercles on back small, circular, conical, in 7–8 longitudinal rows at mid-trunk, none on occiput or upper arm; subtibial scales enlarged, keeled; digital scansors extend beyond claw; phalangeal formula of manus and pes 2-3-4-4-3; subcaudal expanded scales do not quite reach cloaca; back with pattern of irregular broad dark cross-bands.**

KEY WORDS.– ***Asaccus nasrullahi*, *Phyllodactylus*, *Ptyodactylus*, Iran, Zagros Mountains, misidentification.**

INTRODUCTION

The gekkonid genus *Ptyodactylus* Goldfuss, 1820 apparently first entered the herpetofaunal list of Iran through the second edition of the Fauna of British India. Here, innovating upon Boulenger's (1890) first edition, Smith (1935) says, "Genus *Ptyodactylus* … Two species … *P. hasselquistii* = *lobatus*, is widely distributed over the arid districts of Persia, Arabia, and N. Africa". Neither specimens nor localities were mentioned. Twenty years later Schmidt (1955), then director of the Chicago Natural History Museum, identified as *Ptyodactylus hasselquistii* a gecko brought from western Iran by members of the Danish Scientific Investigations in Iran. He commented, "I do not readily find references to its occurrence in Persia, nor in Iraq. From its great abundance farther to the west, it should certainly be found in these countries." Accordingly, Anderson (1963) listed the species for Iran (without detailing the source); Anderson (1966) briefly cited the record without comment; Anderson (1968:321–322) briefly listed *Ptyodactylus hasselquistii* among the Saharo-Sindian elements inhabiting the western foothills of the Zagros Mountains in Iran; and Anderson (1974) included the species as definitely recorded from the Khusestan-Lorestan Division (ostan) of Iran. Naturally, the record was accepted by Schleich (1977).

However, Anderson (1999) discussed the case in greater detail. He remarked, first, that he could not examine Schmidt's specimen (ZMUC 3447), because it had been misplaced in the Copenhagen museum; second, that in view of more recent taxonomic revision, the specimen was more likely to belong to *P. puiseuxi* than to *P. hasselquistii.* I, too, have been asking for some decades in vain to see this lost specimen, related to past and ongoing investigations of *Ptyodactylus* in Asia (Werner and Frankenberg, 1982; Werner and Sivan, 1994; Petr et al., 2004; Moravec and Werner, unpublished). Consequently, recently Jens B. Rasmussen of the Zoological Museum, University of Copenhagen, most kindly informed me that the specimen has been found, and sent it to me for inspection. A glance at the underside of the toes revealed that this was not a *Ptyodactylus* but an *Asaccus*. Further examination showed that it significantly differed from each of the seven known species of *Asaccus*; accordingly, the new taxon is described below.

MATERIAL AND METHODS

Material.– For comparison, I examined *Asaccus elisae* (n = 8): HUJ–R 1685, 1686, 6004–6007 from Iraq and HUIJ–R 10607, 10608 from Syria. Other species were not readily available but this material clarified the interpretation of published character descriptions.

Characters.– The ethanol-preserved specimen was fairly hard, a little shrunken, a little bent, and with deep-sunk eyes. Apparently it had been dry for a while. Characters were selected to optimize comparisons with data in Dixon and Anderson (1973), Arnold and Gardner (1994), Rastegar-Pouyani (1996) and Anderson (1999). Bilateral measurements and counts were taken on both sides. Measures are presented as averages of the left and right sides, in mm and in PERCRA, percents of RA, rostrum-anus distance (Werner, 1971). Counts are presented L/R. To the extent necessary, the characters are defined where presented. Skeletal characters were derived from radiographs kindly made and supplied by the Zoological Museum, University of Copenhagen.

TAXONOMY

Asaccus nasrullahi sp. nov.

(Figs. 1–3)

Holotype and type locality.– ZMUC–R 3447, Shah Bazan, 12 km NNE of (km 347 on the railway), near the small affluent Ab-I-Khornos, 600 m, 30 April 1937, female. Apparently collected by E. Kaiser of the Danish Scientific Investigations in Iran (Schmidt, 1955).

Diagnosis.– A gecko of the genus *Asaccus*, relatively large for the genus (at least 70 mm RA); scales across the preorbital and supraorbital region coarse, granules between eye and ear tiny (Fig. 1); tubercles on dorsum small, circular, conical (7–8 longitudinal rows at mid-trunk), on occiput and upper arm absent; subtibial scales enlarged, keeled; digital scansors clearly extend beyond claw; phalangeal formula of manus and pes, 2-3-4-4-3; subcaudal series of expanded scales does not quite reach cloaca; dorsum with pattern of irregular, broad, dark cross-bands (Fig. 2).

Description of the holotype.– A medium sized gecko with depressed body and much depressed head; head length one third of RA. Premaxillary teeth, 9. Presacral vertebrae, 26 (and 2 sacrals). Limbs relatively long, forelimb reaching over 90% of the distance to the groin, and hind limb reaching over the shoulder, when adpressed to the body. Phalangeal formula for both manus and pes, 2-3-4-4-3. Tail regenerated from the middle of the 7th caudal (first autotomous) vertebra.

Rostral scale two and a half times as wide as high, entire, slightly biconcave above to accommodate the two internasals, which broadly meet behind the rostral. Nostril elevated, between rostral, internasal, two postnasals (one dorsal to the nostril) and first supralabial. Supralabials 12/12 (the last 3/3 under the eye very small); infralabials 7/7 (the first 3/3 abruptly larger). Scales between the nostril and the eye, 12 in a row, about twice the diameter of supraorbital scales between the eyes. Across the snout, at the level of the 3rd supralabial, 18 scales from supralabial to supralabial, and at the preorbital level, 18 scales from the anterior "corner" of the eye to its counterpart. Between the orbits, dorsally, 21 scales. Across the head between the ears, 54 granules from the top of one ear to its counterpart. Granules between eye and ear tiny, 22 between mid-eye and mid-ear (excluding the skin-fold accompanying the eye). Granules in a transverse row across the widest part of the back (half-way between fore- and hind-limbs), 88; smooth cycloid ventral scales in a transverse row at the widest part of the venter, 40.

Back with 7–8 rows of small tubercles among the granules. The tubercles, circular, conical, measuring approx. 0.5–0.66 mm, about twice as large as the granules, which measure approx. 0.25–0.33 mm. Successive tubercles in a row separated by 4–6 granules; each tubercle commonly surrounded by 9 granules (Fig. 3). No

Figure 1. Photograph of the holotype of *Asaccus nasrullahi*, female, 70 mm RA, from the lateral aspect, to show the general habitus and head shape.

Figure 2. Photograph of the holotype of *Asaccus nasrullahi*, female, 70 mm RA, from the dorsal aspect, to show the dorsal colouration pattern.

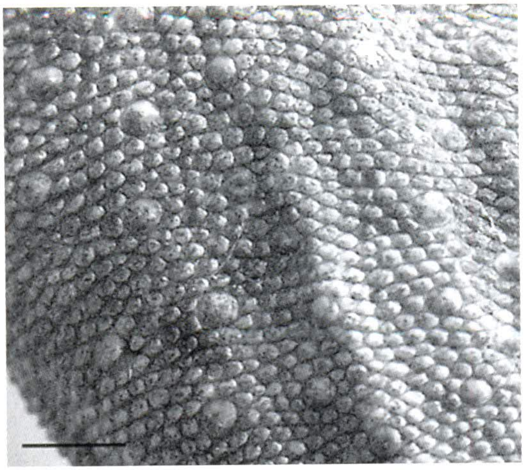

Figure 3. Photograph of a small portion of dorsal skin of the specimen in Figures 1–2 (in the left-posterior area of the back), to show the tubercles and granules and their inter-relations. Orientation, head up. Scale bar, 2.5 mm.

distinct tubercles on the head or occiput; the mid-dorsal rows begin on the neck.

Tail regenerated from the base, the original stump covered dorsally with unclear indications of apparently a single whorl of small tubercles per segment; ventrally with small cycloid scales, 15 between the cloaca and a first pair of markedly enlarged subcaudals. The regenerated portion covered dorsally irregularly with cycloid scales, ventrally with a single row of 58 wide subcaudals that, except towards the tip, appear paired because of a deep median furrow. Forelimbs without tubercles, hind limbs with some small tubercles. Subtibial scales distinctly larger than subfemorals or dorsal tibial scales, elongate and conspicuously keeled. Digital scansors extend a little beyond the claws. Lamellae under the fourth toe, 10/11, followed apically by 5/4 transverse rows of granules up to the terminal scansor.

Measurements, in mm (PERCRA).– RA, 70.0. Head length (taken axially to the rear border of the ear, using the Goren and Werner (1993) calipers), 23.15 (33.1); head width, 13.0 (18.6); head depth, 12.4 (17.7); head index (100*length/width), 178; head flatness (100*length/depth), 186.7; snout width at 3rd supralabial, 7 (10); eye (horizontal) diameter, 4.5 (6.4); ear (vertical) diameter, 3.15 (4.5); nostril-eye distance, 12.15 (17.4); eye-ear distance, 4.9 (7); nostril-ear distance, 21 (30).

Tail, 5+64 (7.1+91.4, original + regenerate). Forelimb (including fingers), 30.5 (43.6); hind limb (including toes), 40 (57.1); axilla-groin distance, 33.5 (47.9).

Colouration.– In ethanol, the general colour is beige, with inconspicuous but sufficiently distinct darker brownish cross-bands, about as wide as the lighter interspaces, with irregular borders (Fig. 2); six cross-bands between the shoulder and groin, extending sideways down the flanks, where they become narrow with a darkish blotch in the interspace; two even less regular cross-bands precede these on the neck and shoulder, and two other irregular ones follow them over the pelvis and cloaca. Head and limbs also mottled with brownish blotches, partly forming rings on the limbs. Ventrally, all parts uniformly light-coloured.

Comparisons and phylogeny.– The new taxon most conspicuously differs from all species described in Arnold and Gardner (1994), Rastegar-Pouyani (1996) and Anderson (1999), as follows: From *A. caudivolvulus,* through having < 9 tubercle rows (rather than 14–18), and coarse scales across the supraorbital region; from *A. elisae* in being much larger, having dorsal tubercles that are small, and lacking tubercles on the upper forelimb; from *A. gallagheri* in being much larger, possessing dorsal tubercles, and having coarse scales across the supraorbital region; from *A. griseonotus* in that the dorsal tubercles are circular, conical, not keeled, in 7–8 rows rather than 10–13, and the colouration is cross-banded rather than spotted; from *A. kermanshahensis* in having 2 rather than 4 pairs of postmentals, much smaller dorsal tubercles relative to the ear opening, and a cross-banded rather than spotted colouration; from *A. montanus* in being much larger, with small dorsal tubercles in 7–8 rather than 14 rows, and lacking tubercles on the upper forelimb; from *A. platyrhynchos* in having coarse scales across the supraorbital region, enlarged and keeled subtibial scales, and a colouration of dorsal cross-bars that are not narrow.

Arnold and Gardner (1994) used 16 characters to estimate a phylogeny of *Asaccus*. Only 11 of these characters were available from the present specimen. In 10 out of the 11, the specimen agreed with *A. griseonotus*, differing from the latter in having the tail base covered ventrally by small scales. It differed from all other species in a greater number of characters. Hence tentatively *A. nasrullahi* sp. nov. belongs in the dendrogram of Arnold and Gardner (1994: Fig. 5) right next to *A. griseonotus*.

Remarks.– The specimen ZMUC–R 3447 resembles *Asaccus griseonotus* in many characters and differs from it only in a few. There is no information on the variation of the quantitative characters in the two populations that could indicate whether these are subspecies or species. But some of the differences are in qualitative characters, such as the basic shape of the dorsal tubercles or the colour pattern, that tend to be associated with species differences, for example in *Ptyodactylus* (Werner and Sivan, 1993, 1994). Therefore, the latter solution has been adopted here.

The present condition of the specimen precluded easy identification of the sex, the more so since *Asaccus* lacks femoral or preanal pores and cloacal sacs and bones (Arnold and Gardner, 1994). But at the time, Schmidt (1955) had identified this specimen as a female, and this seems compatible with the appearance of preserved male and female *A. elisae* specimens examined for comparison.

Schmidt's (1955) having mistaken this specimen for a *Ptyodactylus* seems surprising, considering that in the same paper he reported on *Phyllodactylus* (equivalent to *Asaccus*) *elisae* from the same area. The mistake may have resulted from an expectation of finds specimens geographically bridging between *Ptyodactylus "hasselquistii"* in Syria and *P. homolepis* in Pakistan. This was not the first time that *Phyllodactylus* (sensu lato) was misidentified as *Ptyodactylus*, stimulating biogeographical interest. Steindachner (1902) described *Ptyodactylus socotranus* based on specimens from Socotra island, initially regarded as *P. homolepis* of Pakistan (Steindachner, 1899), differing mainly in the scales bordering the nostril. Loveridge (1947) listed it as *P. homolepis sokotranus*. But as explained in Eiselt's (1962) footnote, these specimens belonged to *Phyllodactylus riebecki*, later *Haemodracon riebecki* (Bauer et al., 1997; Kluge, 2001).

Biotope and ecology.– The area of origin of this specimen is in the Zagros Mountains, with temperate climate, and the dominant vegetation is mostly Zagrosian oak (*Quercus brandti*) forest (Nasrullah Rastegar-Pouyani, pers. comm.), described as xerophilous deciduous steppe-forest of *Queecus brandti* by Zohary (1973). From this locality the following additional reptile species were recorded: *Laudakia nupta, Cyrtopodion scabrum, Hemidactylus turcicus, Asaccus elisae, Ophisops elegans elegans* and *Natrix tessellata* (see Schleich, 1977).

Etymology.– *Asaccus nasrullahi* is named for Nasrullah Rastegar-Pouyani, in recognition of his contribution to the knowledge of the herpetology of Iran, including the genus *Asaccus*. Moreover, "nasrullah" means "victory of God" which concept seems appropriate for the survival, discovery and rediscovery of this gecko species.

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A NEW SPECIES OF *ASACCUS* (SAURIA: GEKKONIDAE) FROM KURDISTAN PROVINCE, WESTERN IRAN

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(with three text-figures)

ABSTRACT.– A new and distinctive species of the gekkonid lizard of the genus *Asaccus* Dixon and Anderson, 1973 is described from the Zagros Mountains, Sarvabad region, between Sanandaj and Marivan, Kurdistan Province, western Iran, at an elevation of ca. 1,850 m. This new species is distinguishable from all its relevant congeners in showing the following characters: three distinct and large pairs of postmental shields, a relatively large body size, extension of dorsal tubercles onto the head region as well as upper surfaces of the hind limbs, presence of large, mucronate and tubeculate scales on sides of tail segments, and a distinct colour pattern. Taxonomy and historical biogeography of the genus *Asaccus* are briefly discussed, and a key to the species of this genus is provided.

KEY WORDS.– Gekkonidae, *Asaccus kurdistanensis*, new species, taxonomy, biogeography, Zagros Mountains, Kurdistan Province, Iran.

INTRODUCTION

One of the least known genera within the Gekkonidae is the genus *Asaccus* Dixon and Anderson, 1973 (formerly allocated to *Phyllodactylus* Gray, 1828), which is distributed in parts of the Middle East. In 1973, Dixon and Anderson described a new species and genus of gecko from an unidentified locality around Islamabad, Kermanshah Province, western Iran. These workers suggested the generic name *Asaccus,* based on the absence of cloacal sacs, and named their new taxon as *Asaccus griseonotus.* About one month later (in December 1973), Eiselt described a new species of *Asaccus* and named it as *Phyllodactylus ingae*, based on a single specimen from ca. 110 km south-west of Khorram Abad city, Lorestan Province, south-western Iran (Eiselt, 1973). Due to reasons of priority, subsequently it was shown that Eiselt's new species is a junior synonym of *Asaccus griseonotus* (Anderson, 1999: 136). Prior to the erection of *Asaccus* as a new generic name, all the gekkonid lizards with the same generic characters were regarded as belonging to the genus *Phyllodactylus* Gray, 1828 with just one described species in Iran (i.e., *Phyllodactylus elisae* Werner, 1895, from western and south-western regions of the Iranian Plateau (Kluge, 1991, 1993, 2001; Bauer et al., 1997). Since then, several new species of *Asaccus* have been described based on distinctive species-specific characters: *Asaccus montanus* Gardner, 1994 (from the mountainous regions of United Arab Emirates); *A. platyrhynchus* Arnold and Gardner, 1994 (from Tanuf, Oman); *A. caudivolvulus* Arnold and Gardner, 1994 (from Jebel Ras, United Arab Emirates) and *A. kermanshahhensis* Rastegar-Pouyani, 1996 (from 45 km n Kermanshah city, Kermanshah Province, western Iran). Among all species of *Asaccus*, it seems that *A. elisae* is the most widespread taxon, being distributed in Iran, Iraq, Turkey and Syria (Dixon and Anderson, 1973; Martens and Kock, 1991; Leviton et al., 1992; Rastegar-Pouyani, 1996; Varol et al., 1997, 2002; Arnold and Gardner, 1994; Baran et al., ms).

Based on long-term study and field work in the Zagros Mountains, western Iran, in this paper a new and distinctive species of the genus *Asaccus* is reported and described from 10 km north-west of Sarvabad, between Marivan and Sanandaj, Kurdistan Province, western Iran (Figs. 1–2).

Material examined is in Appendix I.

Abbreviations: FMNH– Field Museum of Natural History, Chicago, U.S.A.; GNHM– Gothenburg Natural History Museum, Gothenburg, Sweden; NMW– Naturhistorishches Museum Wien, Vienna, Austria; TUZM– Tehran University Zoological Museum, Tehran, Iran; RUZM– Razi University Zoological Museum, Kermanshah, Iran.

SYSTEMATICS

Asaccus kurdistanensis sp. nov.

Figs. 3–7.

Holotype.– An adult male, (RUZM 1999), collected by the senior author on 13 June 2004, at ca. 1,850 m elevation, in the Zagros Mountains, 10 km north-west of Sarvabad, between Marivan and Sanandaj, Kurdistan Province, western Iran (46° 17′ E; 35° 08′N).

Diagnosis.– A relatively large-sized gecko (maximum SVL is 63.5 mm), with three pairs of postmentals, extension of dorsal tubercles onto the head region and upper surfaces of the hindlegs, presence of large, mucronate and tubeculate scales on sides of tail segments and a relatively distinct colour pattern.

Description of holotype.– A gekkonid of the genus *Asaccus* Dixon and Anderson, 1973, preserved in 75% ethyl alcohol, sharing with its congeners: absence of cloacal sacs and bones, phalangeal formulae for manus and pes, 2–3–4–4–3 and 9–10 premaxillary teeth. It is distinguishable from other species of the genus in a combination of the following characters: body relatively robust, having three pairs of postmentals, first pair the largest and in contact with each other behind the mental, also in contact with first and second pairs of postmentals, which are less than half of first pair in size; the right shield of first pair of postmentals in contact with second and third infralabials, the left one just in contact with second infralabial; the second pair of postmentals separated from each other by five granules; the third pair of postmentals smaller, about 1/4 of the second pair, separated from each other by a row of about 18 granules, and in contact with the second pair and also with third infralabial; mental huge, larger than first pair of postmentals together, more or less triangular; 9 supra- and 8 infralabials to a point just below the centre of eye; rostral shield broad and in contact with first supralabial on each side as well as with internasals and nostril, the latter is surrounded by five scales: rostral, internasals (nasals), two postnasals and first supralabial; internasal (nasal) shields large, swollen about twice as large as postnasals; tympanum vertically elliptical, much smaller than orbit; head and frontal region concave; scattered roundish tubercles on nape and head, their diameter about 2–3 times those of adjacent granules; some of these tubercles weakly trihedral and pointed; dorsum covered by granular scales, and among them, large, roundish, smooth tubercles, their diameter at least 3 times those of the adjacent granules; each tubercle separated from the adjacent tubercles by 3–5 granules; tubercles in 8–11 longitudinal rows on the dorsum; the tubercles having tendency to becoming more trihedral, relatively pointed towards the tail; tail complete, with distinct whorls comprising large, relatively flat, smooth scales (tubercles) above, interrupted by 4–5 transverse rows of small scales (granules); the large scales on the sides of tail pointed and keeled (unlike the shields on dorsal side of tail), this is one of the most unique characteristic of this new taxon; ventral surface of tail covered by a single series of large, smooth plates that are anteriorly approaching the vent area; about 5–6 large shields on fourth caudal whorl; upper surface of lower part of forelegs as well as whole upper parts of hind limbs covered by large tubercles almost as large as tubercles on dorsum; gular scales granular, smooth, ventral scales smooth, rounded, subimbricate and larger than gulars; 56–57 gular scales in a single longitudinal row from the level of second pair of postmentals to gular line; 104–107 granules in a single longitudinal row from gular line to vent; 42–46 scales in a transverse row across widest part of venter; 37–39 granules across gular region at the level of fifth infrala-

Figure 1. Map showing location of Kurdistan Province on the Iranian Plateau.

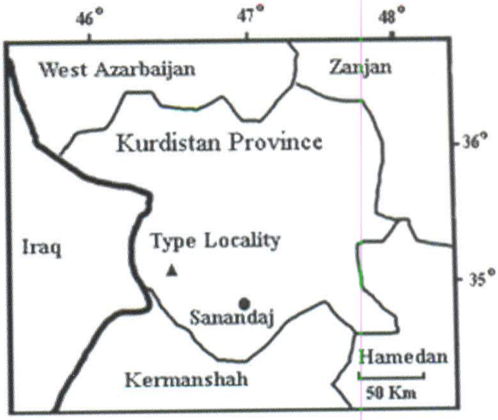

Figure 2. Map showing location of Kurdistan Province. ▲- Type locality of *Asaccus kurdistanensis* sp. nov.

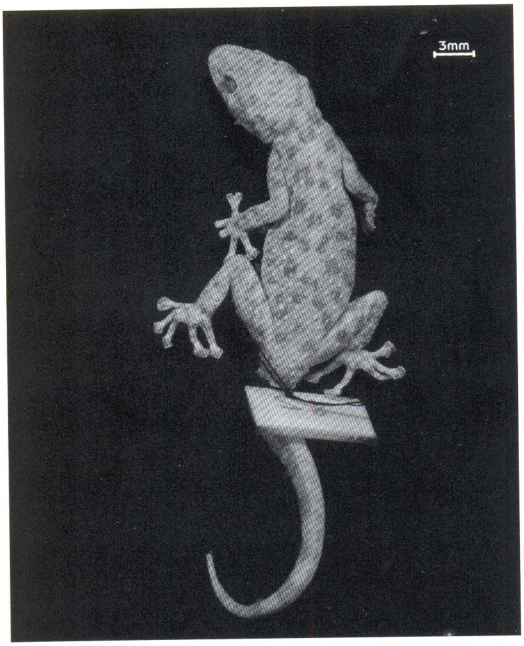

Figure 3. Holotype of *Asaccus kurdistanensis* sp. nov. (RUZM 1999).

bial; 21–23 scales in midorbital region; 73–78 scales across the widest part of dorsum; 35–40 tubercles on head.

Colouration and colour pattern.– Dorsum ash-sandy-grey with about 35 dark large spots (blotches) scattered throughout; upper surfaces of limbs the same colour as dorsum; dorsal surface of head the same pattern as dorsum but slightly lighter and with smaller dark spots scattered throughout; snout and labial regions suffused by dark-grey; all of the ventral surfaces whitish-cream; in life and immediately after death ground colour of dorsum usually whitish-grey with almost irregular shining olive ocelli from tail area to tip of snout but after removal into a 75% alcohol solution, this colour changed to dark brown ocelli; the pads of foot and hand are shining white in life; ventral surface yellowish-white; the scales of venter slightly overlapping posteriorly; ground colour of upper surface of limbs like dorsum; lower surface of tail and limbs, like ventral surfaces, uniformly yellowish-white in life.

Measurements (mm).– (RUZM 1999): snout-vent length (SVL) = 63.5; tail length (TL) = 69.5; head length (HL) = 16.0; head width (HW) = 11.9; head height (HH) = 6.4; length of forelimb: 21.4; length of hind limb: 31.5; from tip of snout to forelimb: 25.0.

Paratypes.– Three adult specimens, one adult male (RUZM 2000) and two adult females (RUZM 2001–2) approximate the holotype in almost all pertinent details, however there are some minor differences between the paratypes and holotype as follows:

Male paratype: 10 supra- and 8 infralabials but third infralabial in each side is broken into two overlapping parts; three pairs of postmentals bordered by 16–20 granules; 102–105 small, granular scales in a single longitudinal row between gular line (fold) and vent; 37–40 scales in a transverse row across widest part of venter; 24–25 scales in midorbital region; 75–80 scales across the widest part of dorsum; 30–35 tubercles on head; diameter of largest

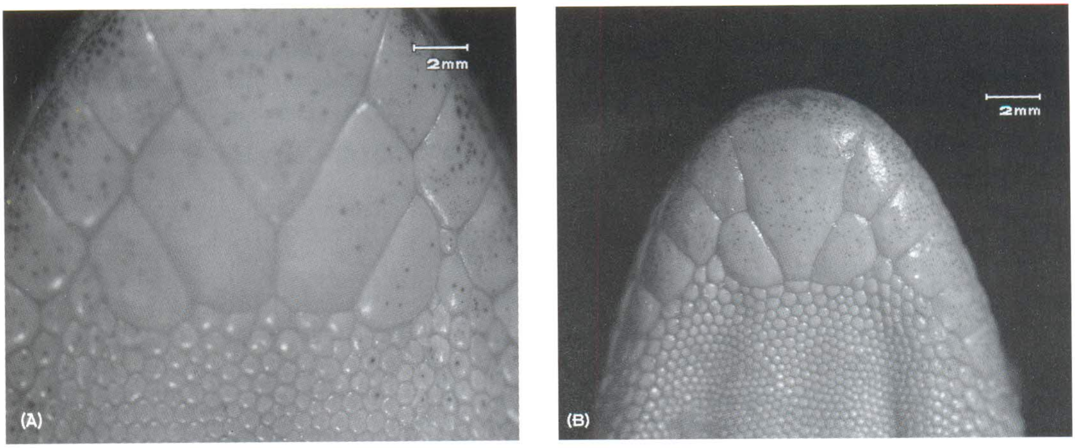

Figure 4. Comparison of submaxillary region of *Asaccus kurdistanensis* sp. nov., with three pairs of postmentals (A), and *A. griseonotus* with two pairs of postmentals (B). Note distinct differences in the shape and size of mental and postmental shields.

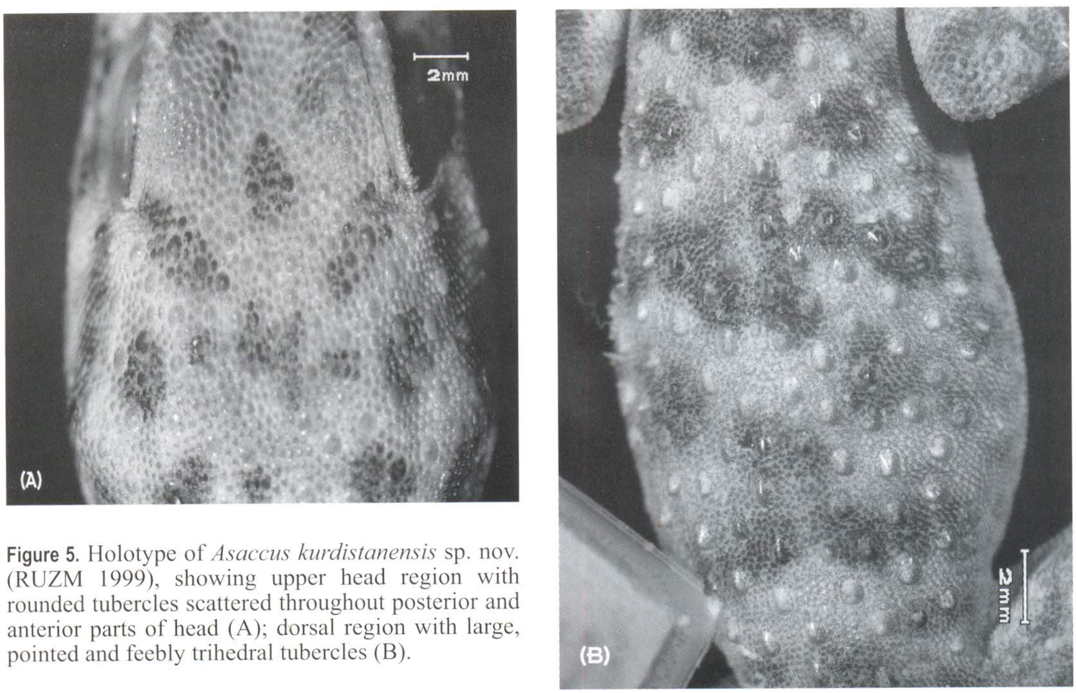

Figure 5. Holotype of *Asaccus kurdistanensis* sp. nov. (RUZM 1999), showing upper head region with rounded tubercles scattered throughout posterior and anterior parts of head (A); dorsal region with large, pointed and feebly trihedral tubercles (B).

dorsal tubercle less than height of ear opening; cloacal tubercles relatively small; 8–10 longitudinal rows of tubercles on dorsum; expansion of dorsal tubercles towards the head area is distinctly more than those of *A. griseonotus* and *A. kermanshahensis*; subdigital scales, moderately tuberculate and about 10 lamellae under the forth toe and 7–8 under the fourth finger; digital scansors expanding well beyond the claws; tail with 9 grey to black transverse bars, grey bars proximal, black bars distal; upper arms (elbow to shoulder) almost without tubercles; *Asaccus elisae* having 2–12 enlarged tubercles on the same area.

Measurements (mm).– RUZM 2000: SVL: 61.2; TL: 61.0; HL: 15.5; HW: 11.3; HH: 7.0; length of fore limb: 21.61; length of hind limb: 29.8; from tip of snout to fore limb: 22.02.

Female paratypes.– Second pair of postmentals separated by five granules in one paratype

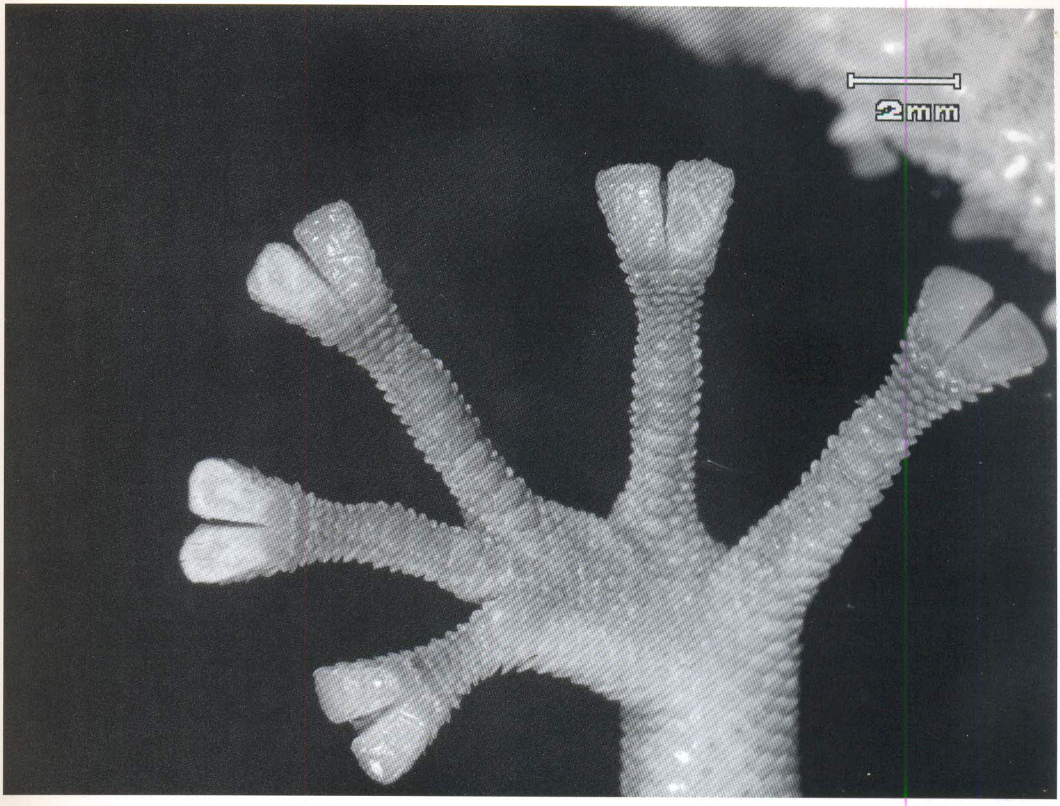

Figure 6. Holotype of *Asaccus kurdistanensis* sp. nov. (RUZM 1999), showing scansors that extend beyond the claws.

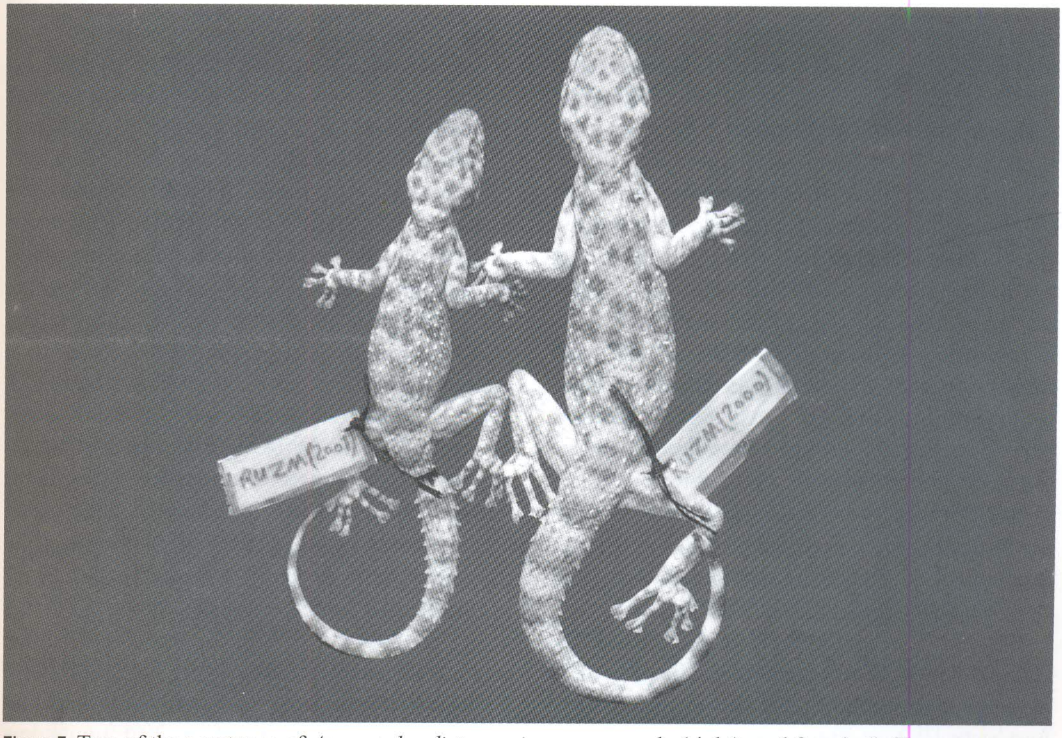

Figure 7. Two of the paratypes of *Asaccus kurdistanensis* sp. nov.: male (right), and female (left).

Figure 8. Habitat and type locality of *Asaccus kurdistanensis* sp. nov., in the Zagros Mountains between Marivan and Sanandaj, ca. 1,850 m elevation (46° 17' E, 35° 08' N).

(RUZM 2001) and 9 granules in the other (RUZM 2002); postmentals surrounded by 20 granules; 42–44 scales across widest part of venter; 95–98 scales in a single longitudinal row from gular line (fold) to vent; 58–62 gular scales in a single longitudinal row from the level of second pair of postmentals to gular line; 8–10 longitudinal rows of tubercles in mid-dorsal region; tail with 10 grey transverse bars with interspaces of equal width; the size of dorsal tubercles in females smaller than those of males; ear opening about 2.35 times larger than the largest dorsal tubercles; 10 lamellae under the fourth toe and 8 under the fourth finger.

Measurements (mm).– RUZM 2001: SVL: 42.2; TL: 53.8; HL: 12.5; HW: 8.9; HH: 5.0; length of fore limb: 17.7; length of hind limb: 22.2; from tip of snout to fore limb: 19.5.

RUZM 2002: SVL: 45.4; TL: 47.5; HL: 12.5; HW: 9.7; HH: 5.34; length of fore limb: 15.2; length of hind limb: 23.4; from tip of snout to fore limb: 19.9.

Comparisons.– The following species of *Asaccus* have been reported from Iran: *Asaccus elisae* (Werner, 1895); *A. griseonotus* Dixon and Anderson, 1973, and *A. kermanshahensis* Rastegar-Pouyani, 1996, all from western and south-western Iran. The new species, *A. kurdistanensis*, is easily distinguished from the above species based on having several species-specific morphological characters (See 'Key to the species of *Asaccus*).

Habitat.– The area is a part of the northern Zagrosian oak forest with scattered *Quercus brandtii* and *Q. persica* as dominant plant species. As well, various species of the families Rosaceae and Graminaceae are among the dominant plant species in the region. The type locality is situated in a mountainous area with large boulders and rocks intermixed with above-mentioned vegetation types at ca. 1,850 m above sea level (46° 17′E, 35° 08′N) (Fig. 8). The holotype was collected at about 1200 h (midday air temperature of ca. 20°C) outside a small cave; all paratypes were collected during the night near the mouth of two small caves. It seems that in each small cave, at least one male and one female occur. At this high altitude locality, *Asaccus kurdistanensis* sp. nov. is sympatric with *Euprepis aurata transcaucasica*, *Laudakia nupta nupta* and *Lacerta cappadocica urmiana*.

Etymology.– *Asaccus kurdistanensis* is named for the Zagros Mountains, Kurdistan Province, western Iran. This taxon is apparently restricted to the northern portion of this range.

TAXONOMIC ACCOUNT

The distinctive lizards of the genus *Asaccus* Dixon and Anderson 1973 (formerly allocated to *Phyllodactylus* Gray, 1828) include at least nine known species (*Asaccus kurdistanensis* sp. nov., *A. elisae, A. griseonotus, A. kermanshahensis, A. gallagheri, A. montanus, A. platyrhynchus, A. caudivolvulus* and the newly described *Asaccus nasrullahi* based on material deposited in the Copenhagen Museum, Copenhagen, Denmark, and previously identified as *Ptyodactylus hasselquisti* (Y. Werner, pers. comm.). Of these, *A. elisae* occurs in western Iran, Iraq, Turkey, and Syria; and *A. griseonotus* occurs in the western foothills of the Zagros Mountains, western Iran, and north-eastern Iraq, and the recently described species, *A. kermanshahensis*, is restricted to the type locality in the central Zagros Mountains, Kermanshah Province, western Iran. On the other hand, *Asaccus nasrullahi* Werner was reported from Lorestan Province, southwestern Iran (Y. Werner, pers. comm.). Arnold and Gardner (1994) revised *Asaccus* based mainly on material from the southern parts of the range in Oman and United Arab Emirates and described two new species (*Asaccus platyrhynchus* and *A. caudivolvulus*). In their phylogeny based on morphology, on a matrix of 16 characters, Arnold and Gardner (1994) divided *Asaccus* species into four monophyletic groups. In their tree, *Asaccus griseonotus* is a separate taxonomic and phylogenetic entity and the two species, *A. elisae* and *A. montanus*, comprised a monophyletic group (Arnold and Gardner, 1994: 439).

With regard to this tree, the position of the two new species, *Asaccus nasrullahi* Werner and *A. kurdistanensis* sp. nov., remains to be determined, although Werner (pers. comm.) regards his new species of *Asaccus* as being phylogenetically closest to *A. griseonotus.*

Further field work and collecting more material in different parts of the Zagros Mountains and neighboring regions (which is now being carried out by us, and has lead to the collection of additional unknown species of *Asaccus* from the central Zagros Mountains in Kermanshah and Lorestan Provinces that await description) will shed more light on taxonomic, biogeographic, and phylogenetic status of this disjunct and vicariant taxon.

HISTORICAL BIOGEOGRAPHY

The study of biogeography is important in understanding distribution patterns of plants and animals (Brown and Lomolino, 1998). The distribution pattern shown by the Iranian Plateau lizards (including the genus *Asaccus*), to a great extent, have been affected by dramatic vicariant events, especially the uplifting and evolution of the Zagros and Elburz Mountains in the Late Tertiary, about 15–9 MYBP (million years before present) (Macey et al., 1998, 2000; Rastegar-Pouyani, 1999a, b, c; Rastegar-Pouyani & Nilson, 2002). These two mountain systems have played the most important role in shaping the past and present distribution patterns of various taxa.

Relevant to the study of historical biogeography of the vicariant and disjunct, lizards of the genus *Asaccus*, few scenarios have been proposed regarding the centre of origin and diversification of this mainly petricolous genus (Anderson, 1968; Rastegar-Pouyani, 2003). For instance, Rastegar-Pouyani (2003) suggested that either the Zagros mountains or the mountains of Oman and United Arab Emirates can be regarded as the centre of origin and diversification for *Asaccus*. As mentioned earlier, the genus *Asaccus*, as a vicariant taxon, has now been divided into two distinct lineages:

1) a northern lineage, encompassing at least five known species, which are mainly distributed on the Zagros Mountains and its neighboring regions (see above).
2) a southern lineage, consisting of four described species which are distributed in the eastern and south-eastern regions of

Arabian peninsula, mostly in the mountains of northern Oman and United Arab Emirates (see above).

Since most described species of *Asaccus* are now occurring in the Zagros Mountains and neighbouring areas, we are now inclined to consider the Zagros Mountains as the centre of origin and diversification for this taxon.

The ancestor of this taxon was probably distributed in the mountains and small caves. Then through one or more dispersal waves, this ancestral taxon expanded its range towards the high mountains of the south. Due to the occurrence of geomorphic events and climatic fluctuations which led to increasing progression of the Persian Gulf and the Oman Sea, the previously contiguous ancestral populations became disjunct in distribution: one branch restricted to the southern mountains, south of the Persian Gulf and Oman Sea, and the other branch confined to the northern mountains (the Zagros and its western foothills).

With regards to the above-mentioned account, it is obvious that the present distribution patterns of *Asaccus*, as a disjunct genus, is the result of both dispersal waves from the centre of origin in the northern parts of the range (e.g., the Zagros Mountains) towards the south (e.g., Oman and United Arab Emirates mountains), as well as vicariant events (e.g., plate tectonics, and evolution and increasing progression of the Persian Gulf and Oman Sea), in the Late Tertiary (about 15–9 MYBP).

In short, based on available evidence, the separation of the high mountain ranges of the Iranian Plateau and the mountains of eastern and south-eastern Arabian peninsula, through evolution and progression of the Persian Gulf and Oman Sea, has had drastic effects in the isolation, speciation, and subsequent evolution of *Asaccus*. Further field work and collection of additional material, as well as morphological and molecular analysis of relationships among different taxa of *Asaccus* may help shed light on the evolutionary history of this south Palearctic gekkonid genus.

KEY TO THE SPECIES OF *ASACCUS*

(after Arnold and Gardner, 1994; Rastegar-Pouyani, 1996; Anderson, 1999; this paper):

1a. Tail tip uncompressed; narrow dark transverse dorsal bars visible in preserved material; dorsal tubercles small or absent (northern Oman only) 2

1b. Tail tip laterally flattened and often expanded vertically; no narrow dark transverse dorsal bars in preserved material; dorsal tubercles relatively large (Musandam, east Syria, Iraq, Iran). 3

2a. Small (up to 40 mm from snout to vent); scansors on toe tips do not project beyond claws; no dorsal tubercles. . . . . *Asaccus gallagheri* (Arnold, 1972)

2b. Large (adult up to 63 mm from snout to vent); scansors on toe tips extend well beyond claws; small dorsal tubercles present in about 12 longitudinal rows at midbody . . . . *Asaccus platyrhynchus* Arnold and Gardner, 1994

3a. Scansors on toe tips extending well beyond claws; dorsal tubercles moderate or small; series of expanded subcaudal scales extending forwards to vent area .4

3b. Scansors on toe tips not extending clearly beyond claws; dorsal tubercles very large; series of expanded subcaudal scales not extending forwards to vent area. 8

4a. Dorsal tubercles moderate, some present on occiput, five phalanges in the fourth digit of the pes; tail with a light tip preceded by one or more broad dark bars extending to the ventral surface (Musandam and eastern United Arab Emirates) . . . . *Asaccus caudivolvulus* Arnold and Gardner, 1994 (7)

4b. Dorsal tubercles relatively small to moderate; four phalanges in the fourth digit of the pes 5

5a. Tubercles none on occiput; tail without conspicuous light tip preceded by dark bars extending to ventral surface (Iran and Iraq). . . . . *Asaccus griseonotus* Dixon and Anderson, 1973

5b. Tubercles present on occiput; tail with conspicuous light tip preceded by dark bars extending to ventral surface 6

6a. Four pairs of postmentals bordered by 21–24 granules. . . . .

. . . . *Asaccus kermanshahensis* Rastegar-Pouyani, 1996

6b. Three pairs of postmentals bordered by 16–20 granules . . . . *Asaccus kurdistanensis* Rastegar-Pouyani, Nilson and Faizi, 2005

7a. Relatively robust, tubercles present on upper arm . . . . *Asaccus caudivolvulus* (Jebel Ras population) Arnold and Gardner, 1994

7b. Relatively slender, no tubercles on upper arm . . . . . *Asaccus caudivovulus* (Khasab population) Arnold and Gardner, 1994

8a. Small (less than 40 mm from snout to vent); extremely tuberculate; scaling coarse; scales from postnasal to orbit 9–11; scales across snout at level of third upper labials 12–14; tail tip flattened and strongly expanded vertically (Jebel Akhdar) . . . . *Asaccus montanus* Gardner, 1994

8b. Larger (up to 57 mm from snout to vent); less tuberculate; scaling coarse; scales from postnasal to orbit 11–16; scales across snout at level of third upper labials 14–19; tail tip somewhat flattened and not strongly expanded vertically (Turkey, east Syria, Iraq and Iran) . . . . *Asaccus elisae* (F. Werner, 1895)

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APPENDIX I

In recent years, from 1995, we (especially the senior author), have examined the following species of *Asaccus*:

Asaccus elisae (n = 6): NMW 17529 (1–4), all from Mesopotamia; GNM.Re.ex. 5108–9, from Sare-Pole-Zahab, Kermanshah Province, western Iran.

Asaccus griseonotous (n = 8): FMNH 170817–23, 61.6 km from Shahabad (Islamabad Gharb), Kermanshah Province, western Iran; FMNH, 74553, from Palegawara Cave, Sulaimanyah Liwa, north-eastern Iraq.

Asaccus kermanshahensis (n = 3): TUZM 164R (holotype), from Mianrahan region, Kermanshah Province, western Iran; GNM. RE.ex. 5106–7 (paratypes), locality as in holotype.

Asaccus kurdistanensis (n = 4): RUZM 1999 (holotype), from the Zagros Mountains, ca. 1,850 m elevation, from 10 km north-west of Sarvabad, between Marivan and Sanandaj, Kurdistan Province, western Iran; RUZM 2000, 2001, 2002 (paratypes), localities as in holotype.

Furthermore, during long-term field work in various parts of the Zagros Mountains, we have been studying and collecting some more material and unknown specimens of *Asaccus* (n = 8) that are currently under examination and their relevant descriptions will be published in the near future.

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SIGNIFICANT NEW RECORDS OF THE JUNLIAN ODOROUS FROG, *ODORRANA JUNLIANENSIS* HUANG, FEI, AND YE, 2001

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(with three text-figures)

ABSTRACT.– *Odorrana junlianensis* was originally described from Sichuan and Guizhou Provinces in China, and has since been reported from Xizang Province. We refer nine specimens from Yunnan Province in China, Vietnam, and Laos to this species. We supplement the original description using the new specimens, and provide an English translation of the original description. The new specimens of *O. junlianensis* represent the first provincial records from Yunnan and the first country records from Vietnam and Laos.

KEYWORDS.– Ranidae; Laos; Vietnam; Yunnan; south-east Asia; *Rana*

INTRODUCTION

Odorrana junlianensis Huang, Fei, and Ye, 2001 was originally described from Sichuan and Guizhou Provinces, China (Huang et al., 2001) and has since been reported from Xizang Province, China (Fei et al., 2005). The species inhabits swift mountain streams and is distinguished by its large size, enlarged digital discs, and having males with white chest spines that form a figure '8'. Recent herpetological surveys in Yunnan Province of China, Vietnam, and Laos have resulted in the discovery of populations that closely agree with the original description of *O. junlianensis* and which share identical or very closely related mitochondrial DNA haplotypes (B. L. Stuart, in preparation). Herein we refer nine specimens from Yunnan, Vietnam, and Laos to *O. junlianensis*, supplement the original description with these new specimens, and provide an English translation of the original description (Appendix 1). The new specimens of *O. junlianensis* represent the first provincial records from Yunnan and the first country records from Vietnam and Laos.

MATERIALS AND METHODS

Specimens were caught in the field by hand, preserved in 10% buffered formalin, and later transferred to 70% ethanol. Tissue samples were taken by preserving pieces of liver, heart, and/or thigh muscle in 95% ethanol before the specimen was fixed in formalin. Specimens were deposited in the American Museum of Natural History, New York (AMNH) and the Field Museum of Natural History, Chicago (FMNH). Specimens were also examined from the holdings of the Royal Ontario Museum, Toronto (ROM).

Measurements were made with dial calipers to the nearest 0.1 mm. Abbreviations used are: SVL = snout-vent length; HDL = head length from tip of snout to rear of the jaws; HDW = maximum head width; SNT = snout length from tip of snout to anterior corner of the eye; EYE = diameter of the exposed portion of the eyeball;

IOD = interorbital distance at narrowest point; TMP = maximum diameter of tympanum; TEY = tympanum-eye distance from anterior edge of tympanum to posterior corner of the eye; TIB = tibia length; FEM = femur length, from vent to outer edge of knee; HND = hand length, from base of palm to tip of finger III; FTL = foot length, from proximal edge of inner metatarsal tubercle to tip of fourth toe.

Odorrana has been used at both the genus rank and as a subgenus of *Rana* (Frost, 2004). Recent phylogenetic analyses of Asian ranid frogs have recovered a monophyletic *Odorrana*, and the authors of both studies recognized the clade at the genus rank (Jiang and Zhou, 2005; Chen et al. in press). However, neither study included *O. junlianensis*, and so the phylogenetic position of this species remains uncertain. In the interest of taxonomic stability, we follow the original authors (Huang, Fei and Ye, 2001) in treating *junlianensis* as a member of the genus *Odorrana*, pending a phylogenetic analysis that includes this species.

Specimen localities in China, Vietnam, and Laos are shown in Figure 1. Measurements are summarized in Table 1.

SYSTEMATIC ACCOUNT

Odorrana junlianensis Huang, Fei, and Ye, 2001

Figures 2–3

Material Examined.– CHINA, Yunnan Province, Simao Prefecture, SE of Simao City, 22°42.392'N, 101°3.671'E, 1,500 m elevation, 16 June 2002, N.L. Orlov, R.W. Murphy, D.Q. Rao, and S.Q. Lu: ROM 41475, 41477, subadults; 12 km SSW of Simao City, 22°40.800'N, 100°55.601'E, 1,120 m elevation, N.L. Orlov, R.W. Murphy, D.Q. Rao, and S.Q. Lu: ROM 41480, subadult; and Nanxianhe, 1,200 m elevation, 3 January 2002, D.Q. Rao: ROM 41479, adult female. VIETNAM, Lao Cai Province, Sapa, 22 August 1997, D. R. Frost and C. J. Raxworthy: AMNH 161440, adult male, on a trail beside a large stream; ~ 4 km W of Sapa Village, on tributary of Golden River (=Suoi Vang), 22°18'59"N, 103°49'16"E, 1,200 m elevation, 15 May 1995, R. W. Murphy, N. L. Orlov, T. Mason, R. O. de Sa, A. Lathrop: ROM 38632, subadult. LAOS, Huaphahn Province, Vieng Tong District, Phou Louey National Biodiversity Conservation Area, Phou Louey Mountain, hilly evergreen forest, 20°14'N 103°12'E, 1,200 m elevation, 30 April–02 May 1998, B. L. Stuart: FMNH 255155, adult female, jumped from tree branch 1.5 m above ground into stream pool during the day; FMNH 255156, adult female, in shallow water of rocky stream in forest; FMNH 255157, adult female, on rocky stream bank in forest.

Habitus moderately slender; head length greater than head width; snout obtusely pointed in dorsal view, projecting well beyond margin of lower jaw, round in profile, depressed; nostril lateral, one-half to three-fourths distance from eye to tip of snout; canthus rostralis distinct, slightly constricted behind nares; loreal region concave and oblique; eye diameter 63–70% snout diameter in females, 76% in males; width of upper eyelid greater than interorbital distance; pineal body visible; tympanum distinct, 32–52% eye diameter, separated from eye by distance less than tympanum diameter, tympanic rim elevated relative to skin of temporal region; choanae ovoid; vomerine ridges oblique, posteroventral to choanae, equal in distance from each other as to choanae, each with numerous teeth; tongue cordiform, distinctly notched posteriorly, free for approximately two-thirds its length; male with vocal sac opening on floor of mouth at corner.

Tips of all four fingers expanded into discs, width of finger III disc less than 2 times width of phalanx, approximately one-third tympanum diameter; all fingers with lateral grooves on disc, that on finger I with a wide gap between the lateral grooves, those on fingers II–IV almost touching to form a horseshoe shape; relative finger lengths II < I < IV < III; medial callous pads on all fingers from distal edge of proximal subarticular tubercle to base of disc; moveable flap of skin on preaxial side of fingers II and III; subarticular tubercles large, round, one on fingers I and II, two on fingers III and IV; one supernumerary tubercle proximal to proximal subarticular tubercle on fingers II, III, and IV; two palmar tubercles, oval, barely in contact; male with grey nuptial pad along entire dorsal surface of finger I proximal to articulation of proximal phalanx, along medial surface from proximal end of thenar pad to

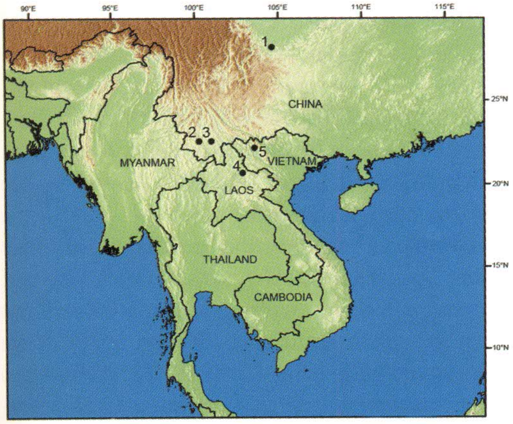

Figure 1. Localities of the holotype and referred specimens of *Odorrana junlianensis*. 1) type locality: Junlian, Sichuan Province, China; 2) Nanxianhe, Yunnan Province, China; 3) Simao, Yunnan Province, China; 4) Phou Louey Mountain, Phou Louey National Biodiversity Conservation Area, Vieng Tong District, Huaphahn Province, Laos and 5) Sapa, Lao Cai Province, Vietnam.

Table 1. Measurements (mm) of *Odorrana junlianensis* from Yunnan, Vietnam, and Laos. Abbreviations defined in the text.

Measurement	Adult females Yunnan and Laos Range; Mean ± S.D. (N=4)	Adult male Vietnam N=1
SVL	88.8–98.4; 94.29 ± 4.13	69.2
HDL	31.7–37.1; 34.6 ± 2.19	26.0
HDW	31.2–33.5; 34.6 ± 2.19	23.4
SNT	14.7–16.1; 15.3 ± 0.98	10.8
EYE	9.2–10.6; 10.2 ± 0.66	8.2
IOD	7.6–8.9; 8.2 ± 0.54	7.0
TMP	3.4–4.8; 4.2 ± 0.68	3.8
TEY	3.8–4.8; 4.4 ± 0.51	3.4
TIB	56.3–63.9; 60.2 ± 3.39	41.3
FEM	46.3–46.9; 48.7 ± 1.67	37.8
HND	25.1–28.5; 26.8 ± 1.64	18.0
FTL	50.3–55.7; 53.1± 2.26	36.6
	Range; Median	
HDL:HDW	1.00–1.11; 1.09	1.11
SNT:HDL	0.42–0.48; 0.43	0.42
TMP:EYE	0.32–0.52; 0.41	0.46
EYE:SNT	0.63–0.70; 0.67	0.76
TIB:SVL	0.59–0.70; 0.64	0.60

base of disc; forearm robust in male, not robust in females.

Toes expanded into large triangular disks; width of all toe discs equal to each other, larger than those of fingers, width of toe III disc about 2 times that of base of phalanx; toe V shorter than or equal to toe III; toes I, II, III, and V fully webbed to base of discs; toe IV fully webbed to base of disc or to distal subarticular tubercle, reaching disc as a fringe; movable flap of skin on preaxial side of toe I from disc to proximal subarticular tubercle and on postaxial side of V

Figure 2. Dorsal view of AMNH 161440, male *Odorrana junlianensis*.

Figure 3. Ventral view of AMNH 161440, male *Odorrana junlianensis*.

from disc to level of proximal subarticular tubercle; large, oval inner metatarsal tubercle, no outer metatarsal tubercle; legs long, heels meet when legs at right angle to body.

Skin smooth on dorsum and venter; rictal gland present; tympanic rim formed by tubercles; weak supratympanic fold from posterior corner of eye above tympanum, continuing obliquely posterior of tympanum to above level of arm insertion, sometimes absent; thick, elongate granulations on dorsolateral aspect of flanks; posterior surface of thigh granular to ventral surface; adult male without humeral gland; adult male with prominent white spinules on upper eyelid, anterior portion of tympanic rim, sacrum, hind limb, flank, proximal half of forelimb, dorsolaterally on large tubercles, ventrolaterally from arm insertion to thigh, and along outer margins of belly; adult male with fine white spinules on underside of jaw, as a figure '8' on the pectoral region, fanning out to sides at anterior portion of belly; females without spinules; anus unmodified, directed posteriorly at upper level of thighs.

In preservative, dorsum of male dark green-grey, females rusty-red with bluish-grey mottling; lips dirty cream with dark grey spots; upper surface of forelimbs not banded in male, dark crossbars weakly visible in females; flank grey, mottled with white near venter; inguinal region white with large black spots; anterior portion of thigh brown with dark brown spots in male, with distinct crossbars in females; posterior portion of thigh brown with cream reticulations; throat and pectoral region dark brown; belly creamy white, sometimes with brown flecking; females bear creamy white eggs with dark melanic pole.

DISCUSSION

The Yunnan, Vietnam, and Laos specimens fully agree with the original description of *O. junlianensis* (Huang et al., 2001) except in the grooves on the fingertips. The original description states that "all fingers and toes have grooves on the ventral surface, except for the first finger, where it is not noticeable; the grooves are relatively short and the distance between the groove and the tip of the finger is relatively wide" (Huang et al., 2001). However, in the specimens we examined, the lateral groove is distinct on all fingers, and the gap between the lateral grooves on fingers II–IV are much smaller than that on finger I. Consequently, the finger disc groove illustrated by Fei et al. (2005:Fig. 262A) resembles the condition of finger I, but not that of fingers II–IV in our specimens.

To our knowledge, the males of only two other *Odorrana* species, *O. margaretae*, and *O. grahami,* also possess white spinules on the chest in a form similar to the figure '8' of *O. junlianensis* (Fei et al. 2005:Pl. 41, 42). *Odorrana margaretae* exhibits white spinules that form a crescent shape, with the apex pointing anteriorly on the chest (not a complete figure '8' as in *junlianensis*) and can further be differentiated by having webbing that does not reach the disc on the preaxial side of toes III and IV (webbing full to disc on preaxial side of III in *junlianensis*) (after Liu, 1950:303–305). *Odorrana grahami* has white spinules completely covering the belly, with some reaching the chest in a non-uniform shape (not a complete figure '8' as in *junlianensis*) and can further be differentiated by lacking expanded discs on the digits (present in *junlianensis*) and having fingers I and II equal in length (finger I > II in *junlianensis*) (after Boulenger 1920:91–93).

Recent fieldwork in northern Vietnam and northern Laos has resulted in the discovery of a number of other frogs previously known only from neighboring regions in China: e.g. the genus *Vibrissaphora* (Dubois and Ohler, 1998); *Megophrys brachykolos*, *M. jingdongensis, M. kuatunensis, M. pachyproctus, Ophryophryne pachyproctus, Calluella yunnanensis*, *Amolops chunganensis, A. viridimaculatus, Philautus albopunctatus, Ph. jinxiuensis, Ph. longchuanensis* (Orlov et al., 2002); *Bufo cryptotympanicus* (Liu et al., 2000); *Rana nigrotympanica* (Stuart et al., 2005); *Philautus rhododiscus* (Bain and Nguyen 2004); *Polypedates dugritei*, and *Po. omeimontis* (Orlov et al., 2001). Our report of *O. junlianensis* from northern Vietnam and northern Laos is yet another example of the close biogeographic affinities of southern China with adjacent northern Indochina. The new records of *O. junlianensis* increase the known range of the species to more than 1,100 km between Sichuan and northern Laos, and illustrate the need for increased biodiversity inventory efforts in these border areas.

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APPENDIX 1

"Original description of *Odorrana junlianensis* (translated from the Chinese; Huang, Fei and Ye *In* Fei and Ye, 2001). Several localities within Sichuan and Guizhou Provinces are provided in the original description, but have been omitted here because we were uncertain about the phonetic spellings of these place names."

"Diagnosis: Males SVL 68–80 mm (mean 73.3); females 87.2–102 mm (mean 97.5); head flat; head length greater than head width; snout length greater than eye diameter; snout blunt, round; pupil horizontally oval; tympanum distinct, approximately 50% of the eye diameter."

"Dorsum relatively smooth, with small tubercles scattered from snout to vent; small white spinules on side of head, close to jaw, and around tympanum; flank with enlarged warts, relatively widely distributed; dorsolateral folds absent."

"Fingers with weakly developed discs on tips, only slightly noticeable; finger pad length greater than finger pad width; all fingers and toes have grooves on the ventral surface, except for the first finger, where it is not noticeable; the grooves are relatively short and the distance between the groove and the tip of the finger is relatively wide."

"Hindlimb long; tibiotarsal articulation reaches beyond snout when legs extended forward against body; tibia approximately 60% of snout-vent length; ankles cross when thighs held 90 degrees to body; toe V shorter than or equal to toe III; webbing well-developed between toes; no tarsal fold."

"Dorsum olive-green, usually dispersed with brownish dots; flanks light brown with dark brown spots; forelimbs banded in different colours; venter light yellow or earthly-yellow; throat and chest with greyish-brown tiny spinules; ventral surface of thigh with deep olive to grey-brown spots."

"Males with light grey, velvety nuptial pad; throat and chest with two triangular spinous clusters in a figure '8' pattern; vocal sac internal, lateral, low; dorsolateral masculinae."

"Eggs approximately 2.5 mm in diameter, measured in situ; animal pole dark green, almost black, vegetable pole milky yellow."

"Found from 650–1150 m asl among the vegetation of mountain stream areas. They are associated with large and medium-sized streams. Diurnally, the frog hides between rocks, in stone caves, and in mud burrows near water. At night it is active (air temperature 17 degrees C, water 14 degrees C) within 3–10 m of the stream, and usually alongside it. Breeding season is May to September, hibernation between November to February. It eats insects (Lepidoptera, beetles), so it is important as pest control. It has a 41.8% 'usefulness rating for the ecosystem'. Found in Junlian, Sichuan and inland to [sic] Guizhou."

"Holotype CNHM 900073, a female, SVL 102 mm; collected at 104°31′E, 28°11′N at 680 m asl, on May 7, 1990; paratype CIB 590059 a male from Guizhou at 1128 m asl, collected on May 14, 1959."

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CHECKERED KEELBACKS (*XENOCHROPHIS* - REPTILIA: SERPENTES: NATRICIDAE) AT THE MOYINGYI WETLAND BIRD SANCTUARY, MYANMAR

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(with six text-figures)

ABSTRACT.– **Two colour morphotypes of *Xenochrophis* occur syntopically at the Moyingyi reserve in south-central Burma (Myanmar). A mensural and meristic analysis indicates that these two colour morphs represent distinct species: *X. flavipunctatus* and *X. piscator*. In Myanmar, the former is the smaller (adult females 440-694 mm SVL) of the two (*piscator* females 540-800 mm). The two species share scalation traits but are readily distinguished by a plain venter in *X. piscator* and black-lined ventral scales in *X. flavipunctatus*. Preliminary distributional data suggest that south-central Myanmar is the western limits of *X. flavipunctatus*, a predominantly south-east Asian species; the eastern limits of *X. piscator*, a predominantly South Asian species, appears to occur in western Laos.**

KEYWORDS.– **Squamata, Natricidae, *Xenochrophis*, morphological analysis, species differentiation, taxonomy, nomenclature, distribution, Myanmar (Burma).**

INTRODUCTION

The Moyingyi Wetland Bird Sanctuary lies about 80 km northwest of Yangon in the deltaic area of the Waw River. This small oasis of semi-natural wild rice marsh hosts several kinds of aquatic snakes: *Enhydris enhydris*, *Homalopsis buccata*, *Amphiesma* sp., and seemingly two species of *Xenochrophis*. The latter two are the most frequently seen snakes owing to their superficial, terrestrial foraging.

Because one of the *Xenochrophis* morphs appears more slender and brighter coloured and possesses black-lined ventral scales, we identified this morph as *X. flavipunctatus*, and the heavier-bodied and duller snake as *X. piscator*. Our search of the herpetological literature to confirm our species assignments did not yield confirmation owing to the lack of a consensus on the status of *X. flavipunctatus* as either a distinct species or a colour variant of *X. piscator*.

Xenochrophis flavipunctatus was described from the Pearl River, presumably in the vicinity of Hong Kong (Hallowell, 1861). This name has been variously used since then. Boulenger (1893) placed it in the synonymy of *X. piscator*. Malcolm Smith (1943) recognized it as a subspecies of *X. piscator*, and in 1965, Taylor declared it a distinct species with both species occurring in the same streams and ponds of northern Thailand. Subsequently and more recently, it has been variously recognized as a distinct species (e.g., Manthey and Grossmann, 1997; Gruber, 2002) or as colour variant, hence a synonym (e.g., Zhao and Adler, 1973; Cox et al., 1998).

The presence of both morphologies at the Moyingyi reserve and their syntopic occurrence suggested that we had two species; nonetheless, we were not totally convinced or satisfied with this ad hoc conclusion. We decided to examine the question further and present here our observations and interpretations.

MATERIALS AND METHODS

Our examination of variation in the morphology of these two colour types focuses on our Moyingyi sample with a few additional specimens from other parts of Myanmar (n = 11) and a few from elsewhere in Asia (n = 12; see Appendix I: Specimens examined). We selected a set of mensural and meristic characters of external morphology that encompassed most of the traits used in previous studies and descriptions of *Xenochrophis*. These traits consist of 9 head and body measurements (millimeters, usually to 0.1 mm), 16 features of scalation (present & absence characters as binary and quantitative ones as integers), and 8 aspects of colour pattern (present and absent as binary, multistate as unordered numeric values); these are detailed in Appendix I: Characters examined. The condition of each bilaterally symmetrical character was recorded from the right side unless damaged. All individuals were sexed and maturity determined by dissection and examination of the gonads. Mature females possess vitellogenic follicles >2.0 mm, oviducal eggs/embryos, or stretched but empty oviducts; mature males have enlarged testes and strongly convoluted epididymides. Determination of maturity for female is more reliable for individuals in transition owing to the discreteness of virginal versus nonvirginal oviducts in females compared to the recognition of "enlarged" testes in males. Nevertheless, we are confident on the accuracy of the minimum adult size of our samples. All analyses were performed with SYSTAT 10.2

Table 1. Summary of select characters in adults of the two morphotypes of *Xenochrophis "piscator"*. Values are means ± standard deviation and range; measurements are in millimeters.

	n	SVL	TailL	HeadL	Ventral	Subcaud
flavipunctatus						
Moyingyi						
females	3	536.3 ± 137.6	193.0 ± 45.3	21.8 ± 4.4	139.0 ± 2.8	75.0 ± 1.0
		440-694	162-245	19.2-26.9	137-143	74-76
males	1	434	191	24.4	129	80
Hong Kong						
females	1	577	.	30.2	136	.
males	3	428.7 ± 38.4	191.5 ± 41.7	24.4 ± 2.5	127.0 ± 1.0	70.0 ± 14.1
		394-470	162-221	22.7-27.3	126-128	60-80
piscator						
Moyingyi						
females	5	646.8 ± 61.2	220.3 ± 17.1	33.7 ± 2.8	140.6 ± 2.7	76.5 ± 2.4
		565-714	201-237	29.6-37.5	137-147	74-79
males	1	555	239	30.1	134	86
Myanmar						
females	9	647.4 ± 85.7	212.4 ± 20.3	34.0 ± 4.1	142.8 ± 3.3	76.4 ± 2.4
		540-800	186-237	29.4-41.0	137-147	73-79
males	5	464.4 ± 87.3	210.2 ± 39.5	26.1 ± 3.9	136.4 ± 1.8	88.4 ± 2.3
		320-555	142-239	19.8-30.1	134-139	86-92

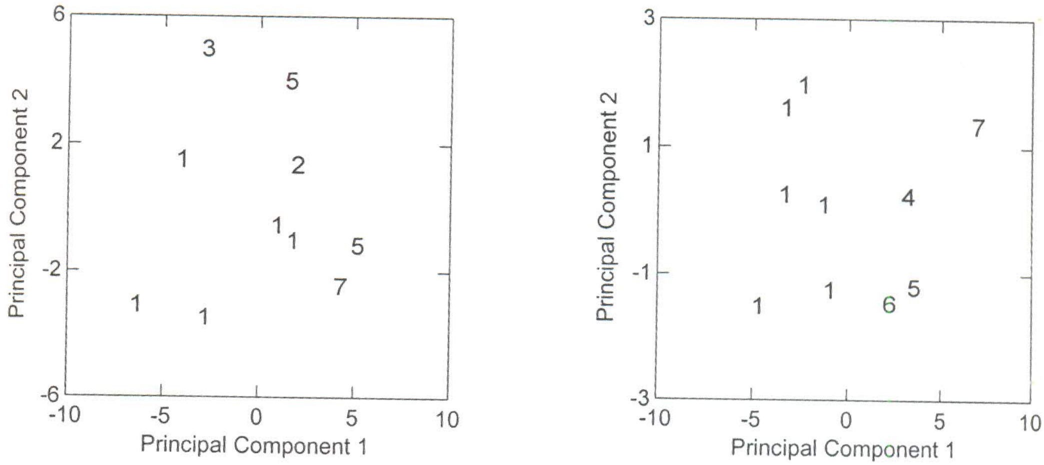

Figure 1. Principal components comparison (scalation) of Moyingye *Xenochrophis piscator* females (left) and males (right) with conspecifics from other Myanmar localities. Symbols: 1, Moyingyi; 2, Bago Yoma; 3, Mwe Hauk; 4, Shwe-Settaw; 5, Shwe-U-Daung; 6, Le Kiang; 7, Pyin-Oo-Lwin.

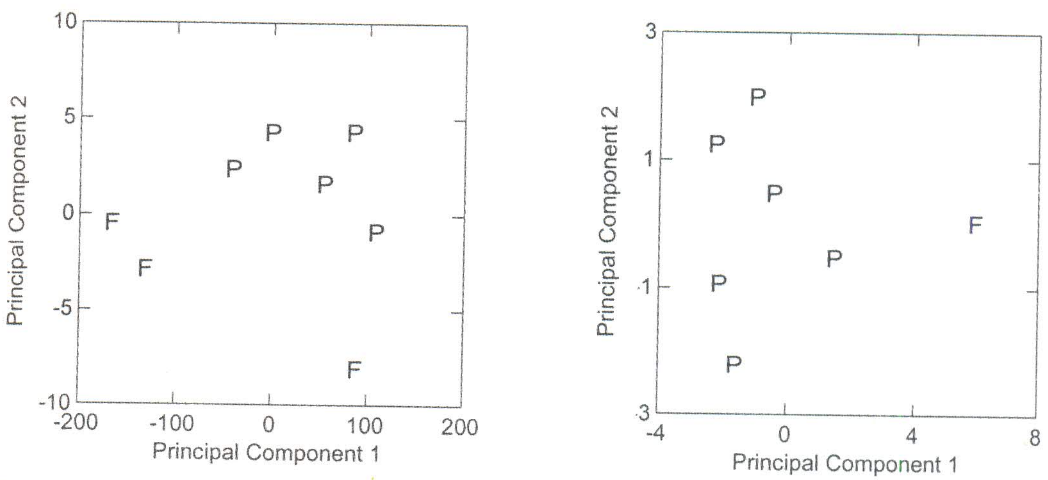

Figure 2. Principal components comparison of female (left; measurements) and male (right; scalation) *Xenochrophis flavipunctatus* and *X. piscator* from the Moyingyi Wetland Bird Sanctuary. Symbols: F, *flavipunctatus*; P, *piscator*.

statistical software; all principal components analyses (PCA) used covariance matrices and no rotation of axes.

RESULTS

Within sample variation.– Our sample sizes are small and do not permit statistically valid tests of character dimorphism between adult females and males. Sexual dimorphism, nevertheless, is indicated for some characteristics (Table 1) in both colour morphs: SVL and other measurements; Ventral; Subcaud. This dimorphism is the same for the *flavipunctatus* and the *piscator* morphs and in all samples. Females average larger, have more Ventral and fewer Subcaud. Increasing sample size by combining all adult and juveniles of Myanmar *piscator* (n = 15, 10; female, male, respectively) confirms the scalation dimorphism: Ventral 142.8, 137-147 & 133.8, 130-139 (t = 7.13 df 23 p<0.01); Subcaud 78.1, 73-83 & 87.4, 84-92 (t = 7.27 df 18 p < 0.01), respectively.

Owing to small sample sizes for adults, variance of the mensural characters is generally high within the Moyingyi *flavipunctatus* and the *piscator* samples. Coefficient of variation

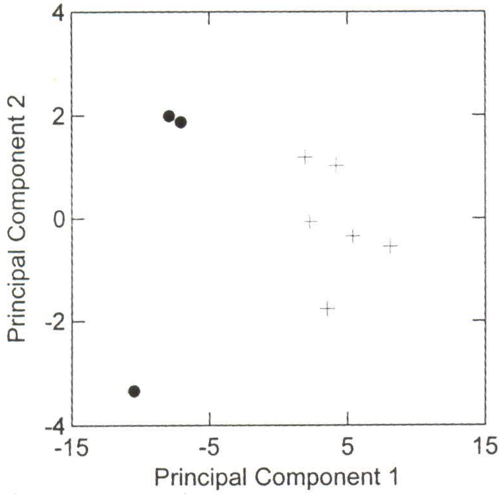

Figure 3. Principal components comparison (scalation) of Hong Kong and Moyingyi *Xenochrophis flavipunctatus*. Symbols: plus, female; circle, male.

(V) for SVL of female *flavipunctatus* is 24%; the other mensural parameters are slightly lower and about the same for SVL, OrbD, Intorb, and Intnar of the two adult males and 10-15% for the males' TailL, HeadL HeadW, SnEye, and NarEye. For Moyingyi *piscator* females, V falls within the usual range of populational variation, that is, V = 9.5% for SVL and 7.8-11.9% for the other mensural characters.

For scalation, V for adult female *flavipunctatus* from Moyingyi ranges from 0 to 40%. Many of the scalation traits are invariant (V = 0%, e.g., Suplab) or rarely variable (40%, LorS; a single deviation in an otherwise uniform trait generates a high V). Ventral and Subcaud have low variation, V = 2.0 & 2.9%, respectively. Adult female *piscator* show the same levels and patterns of variation as the female *flavipunctatus*. The combined Myanmar *piscator* sample (juveniles and adults from all Myanmar localities) has the same level of variance (e.g., female Ventral V = 2.2%) as for the Moyingyi sample.

Variance, as expressed by V, for colouration traits is either 0% or extreme (e.g., 62.5% PaSpot for all Myanmar *piscator* females). Both the artificial coding and the infrequent occurrence of one state result in high V.

The Hong Kong adult males (n = 3) show a low variance: V = 9% SVL, 10% HeadL, 15% HeadW, SnEye 7%. The pattern of variation matches that of the Moyingyi and all-Myanmar *piscator* samples.

Among sample variation.– The all-Myanmar sample of *piscator* derives from several distant localities and possibly may represent different species. Although this study cannot address the possibility of geographic differentiation, we used principal components analyses (PCA) to examine how members of the sample were distributed in multi-character space. PCA results of adult males and females separately each for mensural and scalation suggest homogeneity within this sample. The analyses identifies SVL with the highest component loading (85.7, 66.4; female, male) in both sexes, HeadL and HeadW as distant seconds in loading (range 2.0-4.0), and the other measurements < 0.9. The first component accounts for 99.9% of variance in both sexes, hence placement in PC space is largely by size/length of the individual snakes. For scalation of juveniles and adults of the all-Myanmar sample, females and males have Ventral, Subcaud, and Preven as the traits loading highest on the first component. Subcaud and Ventral loadings (-2.9, -2.2, respectively) are nearly equal in females, and Ventral (3.0) and Subcaud (1.8) loadings are less similar in males. Preven (0.5, -1.4) loading is less strong in females. For the second component loading, Ventral and Subcaud are the major loading traits for females and all three for males. The first component accounts for 60% of the scalation character-set variance in females and 84 % in males, 35% and 10%, respectively, for the second component. We note that component scores (Fig. 1) show some segregation of the Moyingyi snakes from those of other localities.

PCA comparison of the two Moyingyi morphotypes by measurements reveals SVL, HeadL, and HeadW as the traits with the major loading on the first component, and the first component accounts for 99.9% of the variance. Size provides a strong segregation of the *flavipunctatus* and *piscator* samples (Fig. 2). PCA of scalation does not demonstrate a segregation of the two morphotypes (Fig. 2). As in the all-Myanmar *piscator* sample, Ventral and Subcaud have the highest loading in both the first and second components. The first component accounts for 65% of sample variance, the second for 30%.

Figure 4. Morphology of Moyingyi *Xenochrophis flavipunctatus* (left; USNM 562757) and *X. piscator* (right; USNM 562766). Top, dorsal views; bottom, ventral views.

Comparison of Moyingyi and Hong Kong *flavipunctatus* rests mainly on scalation, because SVL weighs so heavily on the first and second components. Although the average SVLs differ somewhat (Table 1), the differences are not great, and the ranges of SVL for the adults of each sex from the two localities strongly overlap. PCA of scalation for a combined female-male sample identifies Ventral with the highest loading (5.8) on the first component (91% of

Figure 5. Reproduction of plate 20 from Russell's "Account of Indian serpents..." (1796). This illustration is the holotype of *Hydrus piscator* Schneider, 1799.

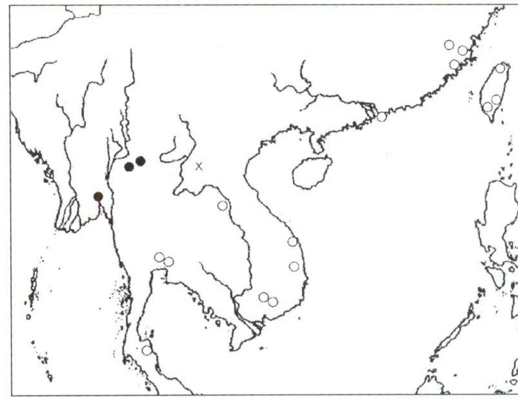

Figure 6. General occurrence of *Xenochrophis fla vipunctatus* (open circles) and *X. piscator* (X) i south-east Asia; a solid circle denotes the sympatri occurrence of the two taxa. Localities based on an ex amination of *Xenochrophis* specimens in the USN herpetological collection.

variance), Subcaud (3.2) as second, and Inflab (0.2) as a distant third factor in loading. Loading on the second component (6% of variance) reverses the loading weights of Subcaud (-1.05) and Ventral (-.6), and elevates the influence of Inflab (1.11). The distribution of females in PC space (Fig. 3) clusters the Moyingyi and Hong Kong females. Similarly, a Hong Kong and a Moyingyi male are close (upper middle of Fig. 3); the male syntype (USNM 7387, Hong Kong) is strongly segregated from all females and the other two males, although it shares a similar valued negative PC 1 as the other males. The outlier status of the syntype probably derives from possession of 85 Subcaud, 5 more than any other *X. flavipunctatus* specimens; its other characters are within the range of the other *flavipunctatus* specimens.

Our sample of two male *X. piscator* from Orissa suggest that this population is similar in size and proportions to the Myanmar *X. piscator*. Scalation is also similar, although the Orissa males have 135, 130 Ventral and 76, 83 Sub caud (CMNH 96315-316); these values are a the lower end of the range for these traits in th Myanmar males.

Our quantification of colouration shows n differences between the two morphotypes othe than black-lined ventral and subcaudal scales o *flavipunctatus* contrasting to the plain venters o *piscator*. Similarly in none of the samples ca we detect any sexual differences in colouration Within the Moyingyi samples, more (71%) o the *flavipunctatus* have PaSpot and NucStr than *piscator* (36%). The proportion decrease slightly for PaSpot (30%) for the all-Myan mar sample and increases slightly for NucStr (40%). In Moyingyi *flavipunctatus*, BodyLat ranges from 20 to 73 (median = 56), whereas th range for *piscator* is 48-57 (52); however, Bod yLatN variation increases (10-65) in the all-My anmar sample even though the median remain unchanged. The Hong Kong and Moyingyi *fla vipunctatus* share similar colouration values, in cluding the median and range of BodyLatN.

A visual comparison of Moyingyi *flavipunc tatus* to Moyingyi and all-Myanmar *piscato* demonstrates a few colouration differences th are not evident from our quantification. Bo morphotypes possess distinct subocular a postocular dark stripes (Fig. 4), but in *flavipun tatus*, the NucStrp is truly nuchal in positic arising on the last Inflab, just posteriorad to t

PosttmpStr and immediately curving dorsally on the first dorsal scale row. In contrast, the NucStrp of *piscator* arises on the fourth or fifth dorsal scale row and curves upward. Dorsally, the NucStrp of *flavipunctatus* forms a parallel-sided loop (Fig. 4) extending anteriorly onto the posterior surface of the parietal scales. This anterior loop is uncommon in *piscator*, and if present, the loop is not a continuous dark line. Another difference is the shape of the BodyLatS: narrow (one scale row in width or less) vertical bars in *flavipunctatus*; blotches or spots (about 2 scale row in width) in *piscator*. Most *flavipunctatus* have many dorsal scales narrowly edged in cream; this edging is absent in *piscator*.

DISCUSSION

The goal of our study focused on the question of intraspecific polymorphism or speciation of the *flavipunctatus* and *piscator* morphotypes. The study confirmed our visual impression of a modest level of morphological differentiation of these morphotypes at the Moyingyi reserve and the persistence of the difference when the *piscator* sample is enlarged to include representatives of *piscator* from elsewhere in Myanmar. We interpret these differences to support the recognition of the black-lined ventral morphotype as a distinct species, *Xenochrophis flavipunctatus*. Subsequent comments proceed from this hypothesis.

Variation at Moyingyi and within Myanmar.– We used PCA as an exploratory tool because we wished its assistance in examining the relationship of individuals in multi-character space. Without PCA of mensural traits, Moyingyi adult *Xenochrophis flavipunctatus* are on the average smaller than co-occurring *X. piscator* in all traits (Table 1). Our samples are too small to test, via covariance analysis, whether proportional differences exist between the two taxa. Both taxa display sexual dimorphism with females larger than males. The preceding size difference are strengthened by enlarging the *X. piscator* sample with individuals from other Myanmar localities.

The PCA of mensural data emphasizes size, SVL with highest loading and greatest contributor to overall variance, and this size component readily segregates Moyingyi *X. flavipunctatus* and *X. piscator*. Scalation shows no striking difference between the two species at Moyingyi and Moyingyi *flavipunctatus* from "all" Myanmar *piscator*. Ventral and Subcaud have nearly matching ranges and means (Table 1) for females and more Ventral and fewer Subcaud in male *X. flavipunctatus*. A concordance occurs in all other scalation traits. A PCA of scalation results in a segregation of males of the two taxa (Fig. 2, right) with highest loading on Ventral and Subcaud.

We did not perform PCA on colouration owing to our arbitrary coding of character states. Colouration does differentiate the two taxa, at first glance by the brighter appearance of *X. flavipunctatus* with its lighter coloured head and neck with hints of red and yellow. In hand, the plain venter of *X. piscator* contrasts sharply with the black-lined ventral scales of *X. flavipunctatus*. Less apparent, but no less distinct, are the position of the nuchal collar, middorsal shape of collar, and ventrolateral body marks between the two taxa in Myanmar and elsewhere in Asia. These colouration differences re-enforce our interpretation of the two taxa being distinct phylogenetic lineages.

Although less apparent from our analysis, the *X. piscator* from multiple and distant localities in Myanmar hint at geographic differentiation among this lineage. Both the PCAs (scalation) of females and males place the non-Moyingyi specimens in different quadrates of the graph (Fig. 1). Individuals from more northern Myanmar localities have a less large-spotted pattern. This geographic variation requires a more detailed investigation.

Variation elsewhere in southern Asia.– The type locality of *Hydrus piscator* Schneider is eastern India, likely the Coromandel Coast (roughly 10° 30'N to 16° 20'N) where Russell worked. Specimens from this latter area were not available to us to compare directly with Moyingyi *piscator*. Two males *X. piscator* (CNMH 69315-316; Orissa - Puri) from further north have size and scalation characteristic that lie within the range of the Moyingyi sample. As noted in the comparison of Myanmar *X. piscator*, there is a possibility of colouration differences among populations, but comments beyond this observation are unwarranted from our samples.

Although our study does not address *X. piscator* as a single or several species, we offer a few observations derived from our review of the literature and superficial survey of specimens in the USNM herpetological collection. The taxon *piscator* is based on an illustration in Russell's account of Indian serpents (1796: plate 33, text pp. 38-39). The illustration bears the name "Neeli Koea," which represents a local vernacular name. This diagrammatic illustration (Fig. 5) shows a dorsal pattern of five rows of equal-sized spots on the trunk. This pattern is similar to the dorsal patterns of M. Smith's *Natrix piscator* (1943: fig. 96 C & D), Whitaker and Captain's photographs (2004: 223), and other illustrations of Indian *X. piscator*. This regular spotted pattern is matched by the Moyingyi and many other Myanmar specimens, and as in the Russell illustration, the spotted pattern becomes reduce or amorphous on the posterior two-thirds of body and tail. The venter is not displayed in the Russell illustration, although his remarks in the text (1796: 39) indicate a plain "yellowish white" venter. These observations confirm our use of *piscator* for the Myanmar immaculate-bellied Myanmar morphotype. Associating the name *piscator* with this morphotype yields a distribution (Fig. 6) for the *X. piscator* taxon extending from the Indus valley (Minton, 1962) through the Indian subpeninsula and Myanmar into northern Thailand and western Laos (USNM 68133 [Laung Prabang]).

At present, we have seen voucher specimens of Myanmar *X flavipunctatus* only from Moyingyi. We expect this taxon to occur more broadly in Lower Burma (i.e., lowlands and coastal areas S of 19°N) and through the Thaninthary Division. *X. flavipunctatus* is the common *Xenochrophis* across south-east Asia and southern China to Taiwan (Fig. 6). Our cursory survey of all USNM "*piscator-flavipunctatus*" specimens suggests that the Javanese population requires close examination to determine its relationship to the mainland populations. Others (e.g., David and Vogel, 1996) have noted the differentiation of Sumatran and Javanese populations from the mainland ones. There is a similar need to confirm the distribution of these snakes in other Sundaic islands.

Taxonomic comments.– Although the preceding results are preliminary in the evaluation of geographic variation of *Xenochrophis flavipunctatus* and *X. piscator*, and are hampered by small samples, we are confident that the trends reveal the basic patterns that will emerge from a broader and larger sampling of both taxa across the breadth of southern Asia.

We draw two conclusions from our analysis: 1) *flavipunctatus* and *piscator* morphotypes represent distinct evolutionary lineages; and 2) *piscator* "group" populations display geographic differentiation, thus suggesting multiple separate genetic "entities." These conclusions have broader implications for the taxonomy of *Xenochrophis piscator* group snakes throughout southern Asia. We address only one taxonomic item associated with the recognition of *Xenochrophis flavipunctatus* as a broadly distributed south-east Asian species.

Recognition of *Xenochrophis flavipunctatus* as a distinct species requires the resolution of a nomenclatural matter: fixation of the type specimen for this taxon. Hallowell (1861: 503) based his description of *Amphiesma flavipunctatum* on a single specimen from the Canton River. His second specimen derived from the "Island of Hong Kong," but owing to the Hong Kong specimen being "somewhat injured" and smaller than the Canton R. one, he chose to base his description exclusively on the Canton R. specimen. Having noted both in the description and referring to the Hong Kong as a type denote that the two specimens are syntypes. The Hong Kong specimen still exists as USNM 7387. The Canton River specimen, presumably ANSP 6616, was not located when Malnate prepared the Academy's herpetological typelist (1971). This specimen's absence was confirmed by N. Gilmore (in litt., 15 June 2004). The catalog entry for ANSP 6616 gives the locality as "Canton River" and denotes "Dr. Ruschenberger" as collector or donor. The original catalog entry for USNM 7387 is solely the locality "Hong Kong." Sex, taxonomic identity, collector/donor, and its identification as a type were entered in the catalog register subsequently in pencil (not dated) by Doris Cochran (identified by handwriting). She (Cochran, 1961) listed this specimen erroneously as a holotype and without reference to the ANSP specimen. Because USNM 7387 appears to be the sole survivor of the two syntypes noted by Hallowell, we designate this specimen as the lectotype of *Amphiesma flavipunctatum* Hallowell, 1861.

USNM 7387 is a juvenile male; viscera are somewhat macerated, so determination of sex is uncertain although a small testis and a straight segment of a sperm duct were tentatively recognized. Its measurements are: 273 mm SVL; 125 mm TailL; 16.7 mm HeadL; 6.6 mm HeadW; 4.1 mm SnEye; 2.9 mm NarEye; 3.3 mm OrbD; 4.2 mm Intorb; 1.9 mm Intnar; 9 Suplab; 7 Inflab; 1 LorS; 1 Preoc; 4 Postoc; 2 Tempor1; 2 Tempor2; 19 DorsalAnt; 19 DorsalMidb; 17 DorsalPost; 128 Ventral; 85 Subcaud; 1 Preven; 1 Anal; 1 KeelD; 0 KeelVnl. Colouration: distinct postocular black-lined eye stripe; dark nuchal collar dorsally from angle of mouth upward along rear of temporals to midline, anterior loop indistinct although white spot with dark edge on nuchal scales; dorsal spots small and indistinct except for ventrolateral ones on anterior quarter of trunk; numerous clusters of bright beige scales (2-4); ventrals from neck onto tail transversely black-lined at scale attachment.

ACKNOWLEDGEMENTS

We wish to acknowledge and thank a number of individuals and institutions for their help in our research on *Xenochrophis*. The Research & Training Program of the National Museum of Natural History (M. Sangrey) provided administrative support. Several herpetological collections and their staffs (CAS, J. Vindum; CNMH, S. Rogers; MCZ, J. Rosado and J. Hanken) provided specimens for examination; N. Gilmore, ANSP, examined records associated with the described syntype of *X. flavipunctatus* and confirmed its absence. M. Cox reviewed an early draft of our manuscript; subsequent reviews by A. Captain and P. David were especially helpful. Our research on the Myanmar herpetofauna is supported by NSF DEB997186 and the Biodiversity Survey & Inventory Program of the Smithsonian's National Museum of Natural History. Survey and monitoring at the Moyingyi Wetlands Bird Sanctuary received funding assistance from Harold A. Dundee (New Orleans, LA) and the NMNH's BSI Program.

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Appendix I

A. Definition of characters.

Mensural. [mm; all bilateral measurements recorded from the right side.] Snout-vent length (SVL): distance from tip of snout to vent. Measurement taken with side of the snake pressed against meter rule. Head length (HeadL): straight-line, horizontal distance from tip of snout to posterior corner of jaws. Head width (HeadW): straight-line, transverse distance from left to right edges of head at posterior edges of last supralabials. Internarial distance (Intnar): transverse distance between left and right nares. Interorbital distance (Intorb): transverse distance between left and right antero-dorsal (anteromedial) edges of orbits. Naris-eye distance (NarEye): distance between naris and anterior corner of orbit. Orbit diameter (OrbD): distance from anterior medial to posterior medial edge of orbit (maximum horizontal diameter). Snout-eye distance (SnEye): distance between middle/tip of snout to anterior corner of orbit. Tail length (TailL). distance from vent to tip of tail.

Scalation. [All bilateral characters recorded from right side.] Anal (Anal): anal scale entire (0) or divided (1). Rows of dorsal scales anteriorly (DorsalAnt): number of rows dorsal scales at one head length behind head. Rows of dorsal scales at midbody (DorsalMidb): number of dorsal scale rows at midbody. Rows of dorsal scales posteriorly (DorsalPost): number of dorsal scale rows at one head length in front of vent. Infralabials (Inflab): number of scales edging mouth (lower mandible) from first touching mental to last enlarged scale below last supralabial. Keeling middorsally (KeelD): relative amount of keeling of first parasagittal dorsal scale at middle of body: none (0); distinct but moderate height (1); strongly elevated (2). Keeling ventrolaterally (KeelVnl): keeling of second dorsal scale from ventrals; coding as for KeelD. Loreal shape (LorS): height > length (0), H = L (1), H < L (2). Postoculars (Postoc): number of postocular scales. Preoculars (Preoc): number of preocular scales. Preventral scales (Preven): number of enlarged scales anterior to first ventral scale. Subcaudals (Subcaud): number of subcaudal scales, excluding tip scale. Supralabials (Suplab): number of scales edging upper mandible from first touching rostral to last enlarged scale at posterior edge of mouth. Primary temporals (Tempor1): number of primary temporal scales. Secondary temporals (Tempor2): number of secondary temporal scales. Ventrals (Ventral): number of ventral scales (Dowling, 1951, definition).

Colour pattern. [All observations on colour pattern derive from preserved specimens and recorded from right side if pattern is bilateral.] Number of ventral lateral spots or stripes (BodyLatN): number of lateral spots or stripes posterior to head and anterior to vent. Shape of ventral lateral body markings (BodyLatS): shape of lateral body markings: spots (0); transverse stripes (1). Nuchal stripe (NucStrp): black or dark-coloured transverse stripe on rear of head and sides of neck, absent [0] or present [1]. Parietal spot (PaSpot): white or light-coloured spot or pair in mid-parietal area, absent [0] or present [1]. Postocular stripe (PostocStr): black stripe extending from bottom posterior edge of eye to bottom of 6th-7th supralabial, absent [0] or present [1]. Post-temporal stripe (PosttmpStr): black stripe extending diagonally from posterior medial edge of eye to last supralabials, absent [0] or present [1]. Colour of subcaudal scales (SubcaudC): ventral scales same colour throughout [0] or with dark transverse border at scale insert [1]. Colour of ventral scales (VentralC): ventral scales same colour throughout [0] or transverse black border at insertion of ventral, i.e., "black-lined" [1].

B. Specimens examined

Xenochrophis flavipunctatus: China – Hong Kong MCZ R-176026, 176030, 176035, 176037-041, USNM 7387. Myanmar – Moyingyi Wetland Bird Sanctuary CAS 210529, USNM 562756-759.

Xenochrophis piscator: India – Puri CMNH 69315-316; Calcutta USNM 129715. Myanmar – Moyingyi Wetland Bird Sanctuary CAS 210747, USNM 562760-570, 562772, 562781-782; Bago Yoma, USNM 562771; Le Kaing USNM 562779; Mwe Hauk USNM 562778; Pyin-Oo-Lwin USNM 562773-775; Shwe-Settaw USNM 562780, 562784; Shwe-U-Daung USNM 562776-777, 562783.

CAS, California Academy of Sciences; CMNH, Carnegie Museum of Natural History; MCZ, Museum of Comparative Zoology, Harvard University; USNM, National Museum of Natural History, Smithsonian Institution.

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A SECOND SPECIMEN OF *PARAHELICOPS ANNAMENSIS* BOURRET, 1934 (SERPENTES: COLUBRIDAE: NATRICINAE)

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(with three text-figures)

ABSTRACT.– *Parahelicops annamensis* is a natricine colubrid snake known only from the holotype described in 1934 from central Vietnam. Here, I report on a second specimen collected in 1999 in the mountains of southern Laos, ca. 105 km from the type locality. I use the Laos specimen to provide the first information on morphological variation, colouration in life and habitat usage.

KEYWORDS.– Laos, Vietnam, taxonomy, *Parahelicops annamensis*, *Opisthotropis*.

INTRODUCTION

Bourret (1934) described a new genus and species of natricine colubrid snake, *Parahelicops annamensis*, on the basis of a single specimen of unreported sex from Bana (= Ba Na, Danang Province, according to Orlov et al., 2003), central Vietnam. The species has not been reported since the collection of Bourret's type specimen (Smith, 1943; Campden-Main, 1970; Orlov et al., 2003). Bourret (1934, 1936) provided no information on the ecology of the type specimen, such as the habitat or elevation from which it was obtained, and consequently *P. annamensis* remains one of the least known colubrid snakes in Indochina.

In July 1999, I collected a specimen of *P. annamensis* in the mountains of southern Laos. This specimen represents the second known record of the species, and the first from Laos. Here I use the Laos specimen to supplement the original description of the species with data on variation, colouration in life and habitat usage.

MATERIALS AND METHODS

The Laos specimen was caught in the field by hand, preserved in 10% buffered formalin, and later transferred to 70% ethanol. A tissue sample was taken by preserving a piece of liver in 95% ethanol before the specimen was fixed in formalin. The specimen was deposited in the Field Museum of Natural History (FMNH). Measurements were made after preservation with a soft measuring tape to the nearest mm. Maxillary tooth positions were counted from a x-ray radiograph of the skull. Data on the type specimen were taken from Bourret (1934, 1936).

SYSTEMATICS

Parahelicops annamensis Bourret, 1934

Parahelicops annamensis Bourret, 1934:6; Bourret, 1936:122; Taylor & Elbel, 1958:1158; Campden-Main, 1970:46; Orlov, Darevsky & Murphy, 1998:61; Orlov, Ryabov, Nguyen & Nguen, 2003:232.

***Opisthotropis annamensis* Smith, 1943: 334.**

(Figs. 1, 2)

Material examined.– FMNH 258637, female, Laos, Xe Kong Province, Kaleum District, Xe Sap National Biodiversity Conservation Area, 16° 04' 10"N 106° 58' 45"E, 1,280–1,500 m elev., coll. B. L. Stuart, 5 July 1999.

Description.– Head distinct from neck. Approximately 27 maxillary tooth positions, the posterior tooth largest. Eye small, pupil round. Nostril directed dorsally. Rostral broader than high, slightly visible from above; nasal weakly divided; two internasals narrowed anteriorly; two prefrontals, slightly broader than long (one prefrontal in the type); frontal about as broad as long, equal to its distance from the snout tip, shorter than the length of the suture of the parietals, about half the length of the parietals; one large loreal; two preoculars; two postoculars (three in the type), the upper largest; eight supralabials on both sides (eight on right, nine on left in the type), fourth and fifth touching the eye, the sixth prevented from touching the eye by the lower postocular (referred to as a subocular by Bourret, 1934); 1 + 1 + 2 temporals on the left, 1 + 2 on the right (1 + 3 temporals on the left, 1 + 1 + 2 on the right in the type); ten infralabials on both sides (eight on left, nine on right in the type), fifth and sixth touching posterior chin shield; anterior pair and posterior pair of chin shields about equal in length, the second pair separated from each other by an elongated scale; body scales in 17 : 15 : 15 rows, median rows feebly keeled anteriorly, becoming more strongly keeled posteriorly; tail scales very strongly keeled, eight longitudinal keel rows at base of tail, reducing to four rows distally; 167 ventrals (169 in the type); 117 paired subcaudals (123 in the type); total length 558 mm (460 in the type), tail length 180 mm (160 in the type).

Colour in life.– Eye black; body above iridescent purplish-brown, sides brown; irregular orange markings on top of head; orange stripe from posterior margin of eye to neck, continuing onto body as broken dorsolateral stripe, becoming less distinct posteriorly; indistinct longitudinal rows of dark brown spots; tail iridescent purplish-brown.

Colour in preservative.– Purplish-brown fading to dark brown; orange fading to cream; venter cream, dark speckling on chin, outer margin of ventrals dark brown.

Distribution, ecology and behaviour.– *P. annamensis* is known only from the type locality of Bana in Danang Province, Vietnam, and from Xe Sap National Biodiversity Conservation Area in Xe Kong Province, Laos. These two localities are ca. 105 km straight-line distance apart (Fig. 3). The Laos specimen was collected at night (2030 h) in steep terrain covered by wet evergreen forest between 1,280–1,500 m elevation. The snake was first observed on land on a rock ledge 50 cm from a small, swift, rocky stream. When startled, the snake dove into the water and swam under a rock on the stream bottom, where it was captured.

DISCUSSION

The Laos specimen matches Bourret's (1934) type specimen of *Parahelicops annamensis* so closely that there is little question as to its identification. The most significant discrepancy is the presence of two prefrontals in the Laos specimen, as Bourret (1934) considered a single prefrontal to be diagnostic for the genus *Parahelicops*.

Although *Parahelicops annamensis* has not been doubted in the literature to be a distinct species, the validity of the genus *Parahelicops* remains uncertain. Bourret (1934) noted in his description the morphological similarity of *Parahelicops* with the aquatic natricine genus *Opisthotropis* Günther, 1872, and Smith (1943) treated *Parahelicops* as a junior synonym of *Opisthotropis*. Taylor and Elbel (1958) resurrected the genus *Parahelicops* with their description of a second species, *P. boonsongi*, from northeastern Thailand, but this species has been returned to the genus *Opisthotropis* by some authors (e.g. Brown and Leviton, 1961; Cox et al., 1998; Chan-ard et al., 1999). No species of *Opisthotropis* have been reported from Laos with certainty, but several species are likely to occur there owing to their known distributions in neighboring parts of Thailand, Vietnam, and China (Bourret, 1936; Deuve, 1970; Orlov et al., 1998). *Opisthotropis* occur in swift mountain streams, where they spend most of their time underwater beneath rocks and in rock crevices (Orlov et al., 1998). *Parahelicops annamensis* probably has a similar ecology, as the Laos specimen tried to escape beneath a rock on the bottom of a swift mountain stream. Studies on the phylogenetic relationship of *P. annamensis* with *Opisthotropis* are clearly warranted.

The lack of any records for at least 65 years after the original description of *Parahelicops*

Figure 1. *Parahelicops annamensis* (FMNH 258637), female, from Xe Kong Province, Kaleum District, Laos, in life. A. Dorsal view; and B. Dorsolateral view.

Figure 2. *Parahelicops annamensis* (FMNH 258637), female, in preservative: A. Dorsal view; B. Ventral view; C. Dorsal view of head; and D. Lateral view of head.

annamensis is probably due to a combination of limited collecting by herpetologists within the range of the species, and the secretive (aquatic or semi-aquatic) nature of the species. The presence of *P. annamensis* in Xe Sap National Biodiversity Conservation Area, Xe Kong Province, Laos, is not surprising, given that it and the type locality are in the same mountain block and only about 105 km apart. However, its presence within Xe Sap, a large area designated for biodiversity conservation by the government of Laos, bodes well for the continued survival of the species.

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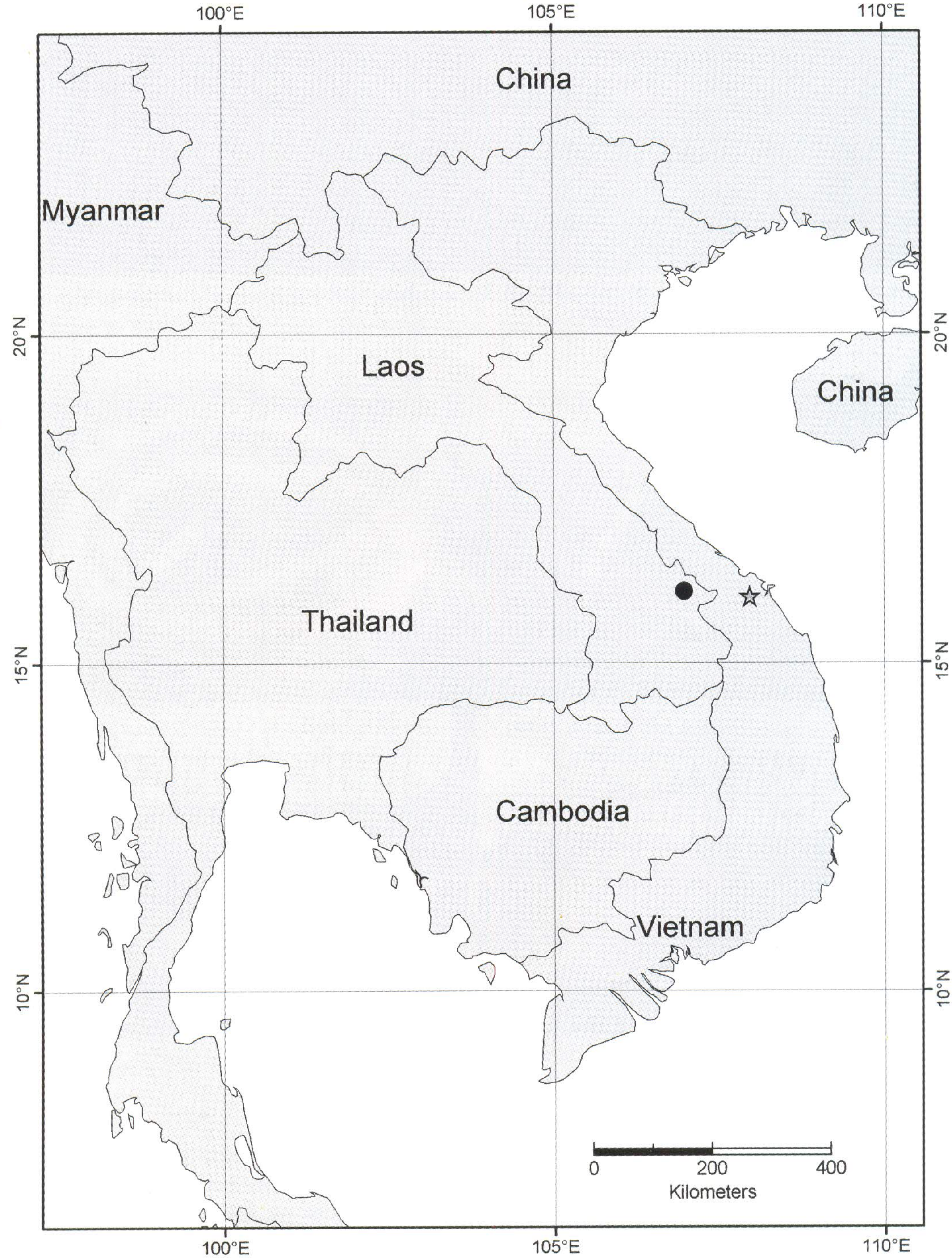

Figure 3. Map showing the type locality (indicated by a star) of *Parahelicops annamensis* at Bana, Vietnam, and the new locality (indicated by a circle) of a specimen (FMNH 258637) from Xe Kong Province, Kaleum District, Laos.

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TRANSLATION OF THE ORIGINAL DESCRIPTION OF *KALOULA AUREATA* NUTPHAND, 1989 (ANURA: MICROHYLIDAE), WITH LECTOTYPE DESIGNATION

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ABSTRACT.– *Kaloula aureata* Nutphand, 1989 was described in the Thai language in a popular journal with limited distribution. This taxon was overlooked or ignored in recent literature. The last existing specimen of the type series of *K. aureata* was recently erroneously indicated in the literature as the holotype by monotypy. In order to facilitate the establishment of the taxonomic status of this taxon, we here provide a translation into English of its original description and designate a lectotype.

KEYWORDS.– *Kaloula aureata*, *Kaloula pulchra macrocephala*, Microhylidae, Surat Thani, Nakhon Si Thammarat, Thailand, lectotype designation.

INTRODUCTION

The rich batrachofauna of the Kingdom of Thailand is still very imperfectly known, and new species for Science or for the Thai fauna are still regularly added. The exact number of taxa is difficult to assess because many genera are in critical need of revision. For instance, two recently published field guides on the amphibians of Thailand, Nutphund (2001) and Chan-ard (2003), respectively listed 112 and 141 taxa, and there was notable disagreement on the application of names among these publications. Among the discrepancies, Nutphund's opus (2001), where less than half of the photographed species were correctly identified (*fide* Ohler, 2003), gave an account for *Kaloula aureata* Nutphand, 1989. This latter taxon was not considered by Chan-ard (2003) nor by most recent checklists, even by Thai authors such as Nabhitabhata et al. (2004, who listed 132 amphibian species for Thailand). A recent comment on the taxonomic status of *K. aureata*, with questionable statements about the type-material and type-locality, leads us to make the original description in Thai available through its translation into English, and to list the currently available type-material in order to facilitate its further taxonomic evaluation.

NUTPHAND'S ORIGINAL DESCRIPTION OF *KALOULA AUREATA*

The two-page original description can be translated as follows (translators' comments are indicated between square brackets):

"*Ungthong* [Thai common name: *ung* = bullfrog, *thong* = gold]. Golden Burrowing Frog, Golden Bull Frog [originally in English]. *Kaloula aureata* Nutphand (New species) [originally in Latin/English]. [laterodorsal photograph of an adult specimen, accompanied by the caption *ungthong*]. The size is similar to that of *ungang* (*K. punchra* [sic]). The length from snout-tip to coccyx is about 6.5 centimeters. The habitus looks like that of *ungang* [*K. pulchra*] but the pattern is more beautiful. The ground color of the body is brown with irregular yellow marks, because there are many yellow marks and wide bands. There is more yellow surface than brown surface. The bright yellow color gives a golden aspect to the whole body. The median dorsal marks are bright yellow. The lateral bands along the back are yellowish orange. The belly is white. All four legs show nearly white, faded yellow markings throughout their whole length until the finger tips. The exact characteristics are difficult to adequately describe. It appears that this species of *ung* is a new species (New sp.) [the content of these latter brackets originally in English], because there has never been any report on it previously for the whole long period during which amphibians were collected. Only five specimens of this *ung* species were obtained. It can thus be regarded as a rare species. All specimens come from the South [of Thailand]. The first specimen was sent from Surat Thani Province in Buddhist year 2519 [Christian Era's year 1976]. The following specimens were obtained from Nakhon Si Thammarat Province. Through interviews and investigations in the field localities, it appears that this *ung* species has a natural history close to that of *ungang*, but that it does not live in syntopy with *ungang*. Now it is under study in order to get more data and show more specificities of this species of *ung*. Professor Wichian Jirawong, member of the Royal Institute, Science Office, gave the following name for this species, "*aureata*" [originally in Latin], which means "covered with gold"."

COMMENTS AND LECTOTYPE DESIGNATION

In the section devoted to *Kaloula pulchra* Gray, 1831, Frost (2004) listed *Kaloula aureata* as a synonym of *Kaloula pulchra macrocephala*, and *Kaloula macrocephala* as a synonym of *Kaloula pulchra*, referring in both instances only to Ohler (2003), although Ohler (2003) did not put *K. macrocephala* in synonymy with *K. pulchra*. Frost (loc. cit.) erroneously indicated "Nutphund, 2001" as author and publication date for *Kaloula aureata*, and noted "given in original publication as "Nutphand, 1989"", believing that the species' name first appeared in Nutphund (2001), and thus ignoring that the species was indeed actually described in 1989. In Frost's defense, it is true that the species account for *K. aureata* in Nutphund (2001) is misleading in that the photograph caption reads "*Kaloula* (new sp.)", while the scientific name was given as "*Kaloula aureata* Nutphand 1989".

It is important to mention here that Nutphand and Nutphund are two of several English transliterations that the late Wirot Nutphand (1932-2005) alternatively used to sign his publications. For the same reasons as those explained by Webb & van Dijk (2004: 94), the best transliteration into English of his patronym is Nutphand, a spelling that he recommended one of us (OSGP) to use (Nutphand, in litt.) and that he used in the original description of *K. aureata*.

In a book review of Nutphund's (2001) opus on Thai amphibians, Ohler (2003) wrote: "Bourret (1942) described a subspecies *Kaloula pulchra macrocephala* (syntypes, Hanoi University B.35, adult male, B.36 adult female; type-locality: Indochina) showing indistinct dorsolateral bands and mid-dorsum covered by large-sized irregular patches. The holotype by monotypy of *Kaloula aureata* Nutphand, 1989 (MNHN 1997.4923, adult male, SVL 59.9 mm after preservation, donated by Nutphund to the Paris Museum; type-locality: Thung Song District, Nakhon Si Thammarat, Thailand) is figured p. 163 (Nutphund, 2001) and shows a similar dorsal pattern as the holotype of *Kaloula pulchra macrocephala*. The name *Kaloula aureata* Nutphand, 1989 is here tentatively considered a subjective junior synonym of *Kaloula macrocephala* Bourret, 1942".

Wirot Nutphand had offered one of us (OSGP) the last existing specimen (Nutphand, pers. comm.) of the series on which he based the description of *Kaloula aureata*. That specimen was later deposited in the Amphibia collections of the MNHN, Paris. It was identified by Ohler (2003) as the specimen illustrated on the color photograph provided in Nutphund (2001), identical to the black and white photograph given in the original description. Nutphund (2001) gave "South" for the species' distribution in Thailand, and noted that it did not live outside Thailand. He moreover indicated: "specimens collected: Thung Song District, Nakhon Si Thammarat Province". This probably caused Ohler (2003) to indicate that Thung Song District was the type-locality (an error repeated by Frost, 2004), while the original description stated "Surat

Thani Province" and "Nakhon Si Thammarat Province".

According to the Articles 72.4.1 and 73.2 of the current International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature, 1999), simply referred to hereafter as the Code, the five specimens mentioned in the original description would constitute the syntypical series and, collectively, the name-bearing type. In 1989, i.e., the year *K. aureata* was published, the former edition of the Code (International Commission on Zoological Nomenclature, 1985) was still applicable, and there was no obligation to explicitely designate a holotype or syntypes (contrary to the current rules, through Articles 73.2.1.1 and 72.3). Nutphand was thus in agreement with the Code by not formally designating the types. As stated in the original description, the type series consisted of five specimens, so the indication of MNHN 1997.4923 by Ohler (2003) as holotype by monotypy is twice erroneous, since on the one hand no holotype had been designated (cf Article 73.1) and on the other hand the mention of five specimens in the original description excludes monotypy. The Article 74.6 of the current Code (corresponding to the Article 74(b) in the former Code), being not applicable here, Nutphand (1989) having explicitely specified the existence of several (five) specimens in the type series, Ohler's action cannot be regarded as a valid lectotype designation.

Some doubt remains about the taxonomic identity of *Kaloula aureata*, a name tentatively considered by Ohler (2003) as a subjective junior synonym of *Kaloula macrocephala* Bourret, 1942. Das et al. (2004: 106) uncritically accepted the synonymy which could however be regarded as an unavailable conditional act (see Article 15.1).

Southern Thailand is inhabited by two other *Kaloula* species: *K. baleata* (Müller, 1836), known from the provinces of Krabi, Narathiwat, Phang-Nga, Phuket, Surat Thani, Trang and Yala (see Nabhitabhata et al., 2004, Nutphund, 2001 and Pauwels et al., 1999, its northernmost localities until its recent remarkable record from southern Laos by Teynié et al., 2004), and *K. pulchra*, represented in all peninsular provinces, including Surat Thani and Nakhon Si Thamma-
rat (Nabhitabhata et al., 2004; Pauwels, pe
obs. in Surat Thani and Nakhon Si Thamma
provinces; Pauwels et al., 1999).

The type-locality of *Kaloula macroceph*
Bourret, 1942 is "Indochine", "Tonkin: ? (
de localité indiquée)" ["Indochina", "Tonkin
(no locality indicated)"], i.e. extreme north
Vietnam, cf the map provided by Bourret (194
(not simply "Indochina" as stated by Ohl
2003, which is much vaguer).

Nutphund (2001) did not provide mu
additional information on *Kaloula aureat*
morphology, only mentoning that the dor
skin is finely granulated, the fingers are sl
der, and the toes tips are sometimes broader
into small disc-shaped pads. By its dorsal p
tern, *K. aureata* seems readily distinguisha
from the above mentioned two sympatric s
cies and *K. mediolineata* Smith, 1917 fr
elsewhere in Thailand. A comparison betwe
K. aureata and the illustrations of *K. pulch*
macrocephala provided by Bourret (19
490) shows differences in pattern and he
morphology. Furthermore, given the large ge
graphical gap between the known distributio
of both taxa, situated in two distinct zoo
ographical areas (see Inger, 1999; Pauwels
al., 2003; Teynié et al., 2004), the sugges
synonymy of both taxa should be re-evaluat
To this end, we here designate the adult m
MNHN 1997.4923 as lectotype for the speci
Its collecting locality is "Nakhon Si Tham
rat Province" (Nutphand, pers. comm.), wh
hence becomes the type-locality for *K. aure*
(Article 73.2.3).

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EFFECTS OF THE SANDAPHOS (ORGANOPHASPHATE) AND b–CYPERMETHRIN (SYNTHETIC PYRETHROID) ON CHOLINESTERASE ACTIVITY IN LIVER AND KIDNEY OF *EUPHLYCTIS CYANOPHLYCTIS*

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ABSTRACT.– **In this study, skittering frogs, *Euphlyctis cyanophlyctis* were exposed to sandaphos (organophasphate) and β–cypermethrin (synthetic pyrethroid) in a laboratory experiment. Two different concentrations– 5% and 10%– were used, and cholinesterase activity was observed in the liver and kidney of *E. cyanophlyctis*. Under the effect of sandaphos, cholinesterase activity decreased to 41.28 and 51.46% in the liver and 4.43 and 22.85% in the kidney, respectively. Under the effect of β–cypermethrin, cholinesterase activity decreased to 24.46 and 26.34% in the liver and 21.46 and 26.63% in the kidney, respectively. This study shows that sandaphos and β–cypermethrin decrease the cholinesterase activity in *E. cyanophlyctis*.**

KEY WORDS.– **Cholinesterase, sandaphos, β–cypermethrin, *Euphlyctis cyanophlyctis***

INTRODUCTION

Twenty-two species of amphibians have been recorded in Pakistan (M. S. Khan, 2003). Like many other forms of wildlife, a large number of amphibian species have become threatened in recent years, and many more need some form of conservation. One reason for their population decline is exposure to pesticides, indirectly as non-target animals. Pesticide pollution is considered a major factor in the decline of amphibian populations observed in agricultural areas. In 1981–1992, between 915–6,865 million tonnes of pesticides were used in Pakistan (Baloch, 1995). A number of non-target species can be affected by pesticides as they inhibit cholinesterase activity. Cholinesterase, an enzyme essential for the functioning of the nervous system occurs in a number of species, and inhibition of its activity can result to sub-lethal toxicity and death (Cooper, 1991), usually through respiratory failure as a result of overstimulation in the synapses. Widespread use of pesticide in agriculture worldwide has affected many animals, including amphibians. Many frogs and toads grow extra legs and eyes due to toxic chemicals in the environment (Kegley et al., 1999). Effects of pesticides on amphibians have previously been reported from Pakistan by Khan et al. (2002a, b, 2003a, b).

The objective of this study was to determine the effects of two different groups of agricultural pesticides- sandaphos and β–cypermethrin on cholinesterase activity in liver and kidney of the frog, *Euphlyctis cyanophlyctis*.

MATERIALS AND METHODS

Chemicals.– Pesticides: Sandaphos and β–cypermethrin; Cholinesterase Randox Kit No. CE–190.

Animals and exposure conditions.– The experimental work was carried out on adult *Euphlyctis cyanophlyctis,* collected from Karachi and kept in glass aquarium at the Wildlife Lab, Department of Zoology, University of Karachi. Before exposure to the selected pesticide, the frogs were held for five days in the glass aquarium at room temperature and provided food. Two different exposure concentrations– 5% and 10% of sandaphos and β–cypermethrin– were selected . 0.18 ml pesticide per frog (single pesticide per animal) was injected in the abdominal region using an insulin syringe. The exposure was done for 24 h. Weight of each frog was recorded before and after 24 h treatment. Each batch of treated animals consisted of five frogs. A batch of untreated (Lab standard) was also kept for comparison. Liver and kidney were taken using the method of Shakoori and Ahmad (1973).

Cholinesterase assay.– Cholinesterase activity was estimated by Randox Kit No. CE–190. The method is based on hydrolysis of acetylcholine through the action of cholinesterase (Knedel and Boetteger, 1967). The reaction between thiocholine and Dithiobis (nitrobenzoate) gives 2–nitro–5–mercaptobenzoate, a yellow compound, which can be measured at 405 nm.

RESULTS AND DISCUSSION

In this study, experimental work was performed on adult frogs of approximately the same size and weight. Pre- and post-treatment frog body weights were recorded and 24 h after treatment, a nominal weight difference was observed. Under the effect of sandaphos, cholinesterase activity decreased up to 41.28 and 51.46% in the liver (Table 1), and 4.43 and 22.85% in the kidney (Table 2), respectively. Under the effects of β–cypermethrin, cholinesterase activity decreased up to 24.46 and 26.34% in the liver (Table 3) and 21.46 and 26.63 in the kidney (Table 4), respectively.

Aquatic ecosystems are dynamic in that there is continuous interchange of pesticides between land, sediment, sediment water interface, aquatic organisms and air-water interface. Amphibians are known to be vulnerable to pesticides that are cholinesterase inhibitors (Wang and Murphy, 1982), and are potentially sensitive indicator organisms of environmental stress because of their permeable skins and biphasic life cycle. Recent reports indicate that there appears to be a decline in many amphibian populations (Blaustein and Wake, 1990; Blaustein et al., 1994). In this study, the pesticides sandaphos (organophphate) and β–cypermethrin were shown to have decreased the cholinesterase activity in the liver and kidney in the treated *Euphlyctis cyanophlyctis*. During this study, after 24 h of sandaphos and β–cypermethrin treatment, effects on cholinesterase activity in the liver and kidney were observed. Under the sandaphos treatment, cholinesterase activity decreased up to 41.28 and 51.46% in the liver and 4.43 and 22.85% in the kidney, respectively. In the case of β–cypermethrin treatment, cholinesterase activity decreased up to 24.46 and 26.34% in the liver and 21.46 and 26.63 in the kidney, respectively. Balasundaram and Selvarajan (1990) reported the inhibition of acetylcholinesterase in the central nervous system of *Hoplobatrachus tigrinus* exposed to organophosphate. Parson et al. (2000) observed the inhibition of cholinesterase activity by organophosphate and carbamate on non-target wildlife species. Khan et al. (2003a) reported the effect of biosal (neem based formulation) on cholinesterase in kidney and liver of *Calotes versicolor* (Sauria: Agamidae), wherein cholinesterase decreased up to 13.60 and 18% in the kidney and 39.52 and 52.61% in the liver, respectively. Comparing the effect of lambda cyhalothrin and permethrin on cholinesterase activity in the liver and kidney of *E. cyanophlyctis* and *H. tigrinus*, Khan et al. (2003c) reported that after the treatment of lambda cyhalothrin, cholinesterase decreased to 34.6 and 46.3% in the liver and 25.08 and 57.1% in the kidney, while under the effect of permethrin, cholinesterase decreased to 23 and 29% in the liver and 6.76 and 35% in the kidney, respectively. The anticholinesterase effects of two agropesticides, lambda cyhalothrin (pyrethroid) and monocrotophos (organophosphate) were studied in the liver, kidney and brain of *E. cyanophlyctis*. Cholinesterase decreased to 34.6 and 46.3% in the liver, 25.08 and 57.1% in the kidney and 31.64 and 50.7% in the brain under the effect of lambda cyhalothrin. In the case of monocrotophos treatment, cholinesterase decreased to 37.7 and 57.7% in the liver, 57.5 and 67.5% in the kidney and 47.6 and 65.9% in the brain, respectively (Khan et al., 2003a). In another study, cholinesterase activity in the brain of *E. cyanophlyctis* decreased to 4.10 and 13.84% under the effect of sandaphose and 5.16 and 23.28% under the effect of β–cypermethrin, respectively (Khan and Ghazala, 2005).

In the present study, sandaphos and β–cypermethrin produced an inhibitory effect in the liver

Table 1. Activity of cholinesterase in liver of *Euphlyctis cyanophlyctis* treated with sandaphos.

	time (sec.)	mean (U/l)	S.E. (±)	range at 95% confidence	inhibition %
Control	00	00	00	00	00
	30	5313.69	675.283	3990.136 – 6637.244	
	60	5341.06	684.993	3998.474 – 6683.646	
	90	5368.43	691.639	4012.818 – 6724.042	
5%	30	3131.91	399.810	2348.29 – 3915.537	
	60	3139.73	402.979	2349.891 – 3929.569	41.28
	90	3135.82	417.656	2317.213 – 3954.427	
10%	30	2561.05	160.786	2245.91 – 2876.19	
	60	2596.24	143.245	2315.4798 – 2877.00	51.46
	90	2619.70	132.578	2359.848 – 2879.552	

Table 2. Activity of cholinesterase in kidney of *Euphlyctis cyanophlyctis* treated with sandaphos.

	time (sec.)	mean (U/l)	S.E. (±)	range at 95% confidence	inhibition %
Control	00	00	00	00	00
	30	2686.17	253.334	2189.635 – 3182.705	
	60	2697.90	250.872	2206.191 – 3189.609	
	90	2705.72	251.543	2212.696 – 3198.744	
5%	30	2611.88	154.665	2308.740 – 2915.023	
	60	2564.96	173.175	2225.537 – 2904.383	4.43
	90	2553.23	157.90	2243.745 – 2862.715	
10%	30	2076.21	64.680	1949.437 – 2202.983	
	60	2080.12	71.220	1940.528 – 2219.712	22.85
	90	2084.03	61.148	1964.179 – 2203.881	

Table 3. Activity of cholinesterase in liver of *Euphlyctis cyanophlyctis* treated with β–cypermethrin.

	time (sec.)	mean (U/l)	S.E. (±)	range at 95% confidence	inhibition %
Control	00	00	00	00	00
	30	5051.72	475.414	4119.909 – 5983.531	
	60	5067.36	472.828	4140.618 – 5994.102	
	90	5079.09	466.416	4164.915 – 5993.265	
5%	30	3796.61	323.069	3163.395 – 4429.825	
	60	3823.98	322.903	3191.091 – 4456.869	24.46
	90	3859.17	325.738	3220.724 – 4497.616	
10%	30	3702.77	416.554	2886.325 – 4519.215	
	60	3734.05	410.998	2928.494 – 4539.606	26.34
	90	3757.51	402.808	2968.007 – 4547.013	

Table 4. Activity of cholinesterase in kidney of *Euphlyctis cyanophlyctis* treated with β–cypermethrin.

	time (sec.)	mean (U/l)	S.E. (±)	range at 95% confidence	inhibition %
Control	00	00	00	00	00
	30	3088.90	256.430	2586.298 – 3591.502	
	60	3096.72	260.050	2587.022 – 3606.418	
	90	3104.54	263.678	2587.732 – 3621.348	
5%	30	2420.29	129.064	2167.325 – 2673.255	
	60	2432.02	122.296	2192.320 – 2671.720	21.46
	90	2443.75	115.531	2217.31 – 2670.19	
10%	30	2256.07	274.778	1717.506 – 2794.634	
	60	2275.62	274.666	1737.275 – 2813.965	26.63
	90	2283.44	271.326	1751.64 – 2815.240	

and kidney cholinesterase activity in *Euphlyctis cyanophlyctis*. These findings are, therefore, in line with earlier reports with reference to the used pesticides. In the present investigation, sandaphos and β–cypermethrin were applied to the frog body directly, and it was observed that both pesticides reduced cholinesterase activity in the liver and kidney. These results suggest that environmentally relevant levels of contaminants could cause the decline of non-target species, such as frogs, and that contaminants believed benign in the environment may alter communities and could, potentially, contribute to reductions in biodiversity and population size over time.

In summary, this study shows that the pesticides, sandaphos and β–cypermethrin decreased the cholinesterase activity in *E. cyanophlyctis*. Results from our experiments indicate that the sandaphos is more toxic than β–cypermethrin. It also highlights that the use of pesticides do not only pollute the environment, but may also adversely affect biodiversity.

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REPTILES AND NATIONAL PARKS IN GABON, WESTERN CENTRAL AFRICA

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(with two text-figures)

ABSTRACT.– **A synthesis of the current state-of-knowledge of herpetofaunal diversity in the recently-created Gabonese national park system is provided. A provisional reptile list is currently available for only four of the 13 parks: Crystal Mountains, Loango, Lopé and Moukalaba-Doudou. Representation of endemic, near-endemic and legally-protected Gabonese reptiles in the parks is analyzed. Only one of the seven (near-)endemic species is recorded from a national park. Among non-park sites, Mount Iboundji and the Rabi oil field (including Lake Divangui) were shown to be of high herpetological interest, enough to constitute adequate biodiversity sanctuaries. Enforcement and revision of protection laws, especially regarding sea turtles, softshell turtles and crocodiles, is urgently needed.**

KEYWORDS.– **Reptiles, Cheloniidae, Trionychidae, Crocodylidae, biodiversity, conservation, national parks, Iboundji, Rabi, Gabon, Africa.**

In memory of the late Jens B. Rasmussen (University of Copenhagen), a brilliant herpetologist and a dearly missed friend

INTRODUCTION

In 2002, H. E. Omar Bongo Ondimba, President of Gabon, officially declared the establishment of 13 national parks covering 30,000 square km, i.e., 10% of the country's territory (Anonymous, 2002b:3; see Figures 1–2). The main objective of these parks is to preserve the high biodiversity of the pristine ecosystems of Gabon, and, through ecotourism, to contribute to diversification of the national economy, presently based on oil exploitation and logging. A detailed description of the parks with their geographical situation and potential ecotourist attractions has been provided by Anonymous (2002a, b). Six other sites of particular conservation interest which did not receive the status of national park are: Wonga-Wongué Reserve, the Ogooué Wetlands (just south of the latter Reserve), Mount Iboundji (Ogooué-Lolo Province), Rabi-Ndogo (Ogooué-Maritime Province), "Northeast", and Minkol-Makok (inselbergs in Woleu-Ntem Province) (Anonymous, 2002a; 2002b). The Ogooué Wetlands were proposed as a "Biosphere Reserve (UNESCO)", due to their rich aquatic fauna, including crocodiles and chelonians (Anonymous, 2002b:83). No precise geographical delimitations were specified for these six sites except for the Wonga-Wongué Reserve.

Our current state-of-knowledge validates the 13 parks as of high biodiversity value and as potential refuges for most ecological assemblages and species of Gabon, yet detailed inventories are lacking for most biological groups in most parks, including for reptiles, the least-studied vertebrates in Gabon. A comprehensive list of the reptiles of the country was indeed not available until 2004 (Frétey and Blanc, no date), and moreover that list has to be seriously revised (Pauwels, 2004a). Many old literature species records are doubtful and have to be carefully checked, due notably to the fact that what was formerly called Gabon does not necessarily correspond to today's actual borders of this country. Also in recent literature, some species records were shown to be erroneous (Pauwels and Branch, 2003).

Based on the current state-of-knowledge, Gabonese reptile endemic taxa are the worm-lizards *Cynisca bifrontalis* (Boulenger, 1906) and *C. haughi* (Mocquard, 1904) (Amphisbaenidae), the legless skink *Feylinia boulengeri* Chabanaud, 1917 (Scincidae) and the newly-described blind snake *Letheobia pauwelsi* Wallach, 2005 (Typhlopidae). Near-endemic taxa (known so far to be limited to Gabon and directly bordering countries) include the recently-discovered mud terrapin *Pelusios marani* Bour, 2000 (Pelomedusidae) and forest gecko *Hemidactylus kamdemtohami* Bauer and Pauwels, 2002 (Gekkonidae), and the aquatic snake *Hydraethiops laevis* Boulenger, 1904 (Colubridae). These near-endemic species are known only by either one or two localities outside Gabon, in Cameroon, Equatorial Guinea and/or Congo-Bra zaville.

Figure 1. Map of Africa showing the position of Gabon.

In addition to continuing taxonomic and fie research towards the establishment of a mo accurate national reptile list, a herpetologic conservation priority in Gabon is to evalua the representation of the herpetofauna in its n tional parks, especially for (near-)endemic a endangered species. A synthesis of current (M 2005) knowledge, as presented below, will he orient future efforts.

MATERIALS AND METHODS

The following compilation on the reptile fau of each park is based on a detailed study of reliable literature available on the reptiles Gabon, and on intensive field work made the first author from 2001 to 2005 in all pa of Gabon except the north-east (Minkébé are and the southeast (Franceville area, Bate Plateaux). Our field surveys were mainly spo sored by WWF-CARPO (in *Monts de Crist Massif du Chaillu* and central Gabon) and the Smithsonian Institution, Shell Found tion and Shell Gabon (in the Gamba Compl of Protected Areas, southwestern Gabon) a were documented through voucher specime deposited in museum collections in Gabon a abroad (specified in our publications, see lit ature cited). Species records not strictly ma within actual park borders are not consider for the park lists. National Park delimitatio agree with those presented by Anonymo (2002a; 2002b).

Abbreviations: N. P.: National Park; SI/MA Smithsonian Institution/Monitoring and Asses ment of Biodiversity Program.

RESULTS

Akanda National Park (540 sq. km).— In the chapt devoted to Akanda N. P., Anonymous (2002b:1 noted that "the undersea pastures of Corisco b are important feeding zones for turtles, whi come from as far afield as Brazil." Fretey a Girardin (1988) considered local accounts nesting by *Dermochelys coriacea* (Vandel 1761) in the Park near Moka doubtful since t beaches seem very muddy and thus not suitab for the turtles. Pauwels and Vande weghe (200 and Vande weghe (2005) listed *Osteolaemus*

Table 1. List of reptile species for the nine Gabonese national parks for which records are available. Only records from strictly within the park borders are taken into account. Literature and sources for species records is specified in the account for each park.

Taxa/Parks	Akanda	Crystal	Ivindo	Loango	Lopé	Mayumba	Minkebe	Moukalaba	Pongara
Chelonii									
Pelomedusidae									
Pelusios castaneus				X				X	
Pelusios marani								X	
Pelusios niger				X					
Cheloniidae									
Chelonia mydas				X		X			X
Eretmochelys imbricata									X
Lepidochelys olivacea				X		X			
Dermochelyidae									
Dermochelys coriacea				X		X			X
Testudinidae									
Kinixys erosa		X		X	X		X	X	
Trionychidae									
Cycloderma aubryi				X					
Trionyx triunguis				X				X	
Crocodylia									
Crocodylidae									
Crocodylus cataphractus			X	X				X	
Crocodylus niloticus				X				X	
Osteolaemus t. tetraspis	X			X	X		X	X	X
Lacertilia									
Agamidae									
Agama agama		X		X				X	X
Agama cf. *paragama*					X				
Chamaeleonidae									
Chamaeleo dilepis				X					
Rhampholeon s. spectrum		X						X	
Gekkonidae									
Hemidactylus fasciatus		X		X	X			X	
Hemidactylus mabouia	X	X		X	X			X	X
Hemidactylus muriceus				X				X	
Gerrhosauridae									
Gerrhosaurus nigrolineatus				X	X			X	X
Lacertidae									
Poromera fordii					X				
Scincidae									
Feylinia currori					X				

Feylinia grandisquamis				X				X	
Lygosoma fernandi				X					
Panaspis breviceps		X		X				X	
Panaspis reichenowii				X				X	
Panaspis rohdei		X							
Trachylepis affinis	X			X	X			X	X
Trachylepis albilabris		X		X				X	X
Trachylepis maculilabris					X			X	
Trachylepis polytropis				X	X			X	
Varanidae									
Varanus ornatus	X	X		X	X		X	X	
Serpentes									
Atractaspididae									
Aparallactus modestus		X			X				
Atractaspis corpulenta								X	
Boidae									
Calabaria reinhardtii					X			X	
Colubridae									
Boiga blandingii		X		X	X				
Boiga cf. *pulverulenta*					X			X	
Bothrophthalmus brunneus								X	
Crotaphopeltis hotamboeia								X	
Dasypeltis fasciata		X							
Dasypeltis scabra					X				
Dipsadoboa duchesnii				X				X	
Dipsadoboa underwoodi								X	
Dipsadoboa viridis		X						X	
Dipsadoboa weileri								X	
Gonionotophis b. brussauxi								X	
Grayia ornata					X			X	
Hapsidophrys smaragdinus		X		X	X			X	
Hydraethiops melanogaster					X				
Lamprophis olivaceus					X				
Mehelya guirali								X	
Mehelya poensis		X							
Mehelya savorgnani								X	
Mehelya stenophthalmus				X					
Natriciteres fuliginoides				X	X			X	
Philothamnus carinatus		X		X	X			X	
Philothamnus heterodermus					X				
Psammophis cf. *phillipsii*				X	X				
Rhamnophis aethiopissa				X	X			X	
Thelotornis kirtlandii		X							

Thrasops flavigularis				X					
Elapidae									
Boulengerina a. annulata		X			X				
Dendroaspis j. jamesoni					X		X	X	
Naja melanoleuca		X			X		X	X	
Pseudohaje goldii							X		
Pythonidae									
Python sebae	X	X		X	X		X		X
Typhlopidae									
Typhlops angolensis				X					
Typhlops congestus					X				
Viperidae									
Atheris squamiger		X			X		X	X	
Bitis arietans								X	
Bitis gabonica				X	X		X	X	
Bitis nasicornis	X	X							
Causus lichtensteini								X	
Causus maculatus					X				
Total: 75	6	22	1	37	34	3	9	44	10

tetraspis Cope, 1861 (Crocodylidae), *Hemidactylus mabouia* (Moreau de Jonnès, 1818) (Gekkonidae), *Trachylepis affinis* (Gray, 1838) (Scincidae), *Varanus ornatus* (Daudin, 1803) (Varanidae), *Python sebae* (Gmelin, 1789) (Pythonidae) and *Bitis nasicornis* (Shaw and Nodder, 1792) (Viperidae) from the park. No data are available for other reptiles, but, due to the homogeneity of biotopes, the total diversity is most probably low.

Bateke Plateaux National Park (2,050 sq. km).— No herpetological data are available for the Park, which harbors biotopes that are unique in Gabon. The Park could constitute a sanctuary for the uncommon terrapin *Pelusios carinatus* Laurent, 1956, known so far in Gabon from only five localities situated just north of the Park (Maran, 2002:51). Geographically-close records of other savanna-dwelling species, like *Elapsoidea semiannulata moebiusi* Werner, 1897 (Elapidae) in Franceville (Broadley, 1971), seem to indicate the local existence of a typical savanna herpetofauna. We expect that thorough surveys will bring a number of new records for the country, especially among savanna-dwelling species, since the park's savanna is a continuation of the Congolese savanna.

Crystal Mountains National Park (1,200 sq. km).— Field surveys have been conducted by Gossmann et al. (2002) and Pauwels et al. (2002b) in the Park and its immediate vicinity, providing a preliminary list of 48 species. Among them only 22 species were actually recorded strictly within the Park borders (see Table 1), but all 48 species and many others can be expected from the park, since the other records were made in the Park's immediate vicinity in similar biotopes, and the total search effort so far was limited. The herpetofauna is expected to be similar to that of Monte Alen in Equatorial Guinea. All but ten of the 48 species recorded from the Crystal Mountains, thus 79%, were indeed recorded from Monte Alen N. P. (compare with the list provided by Lasso et al., 2002), and all the remaining species of the 65 found in Monte Alen can be expected from Crystal Mountains N. P.

Ivindo National Park (3,000 sq. km).— Steel (1994:4) recorded *Crocodylus cataphractus* Cuvier, 1825 and *C. niloticus* Laurenti, 1768 from the "Réserve d'Ipassa" and mentioned that 65 reptile species were recorded from the same part of the Park (including *Crocodylus cataphractus*, *Osteolaemus tetraspis* and *Varanus niloticus* (Linnaeus, 1766) [probably *V. ornatus*]

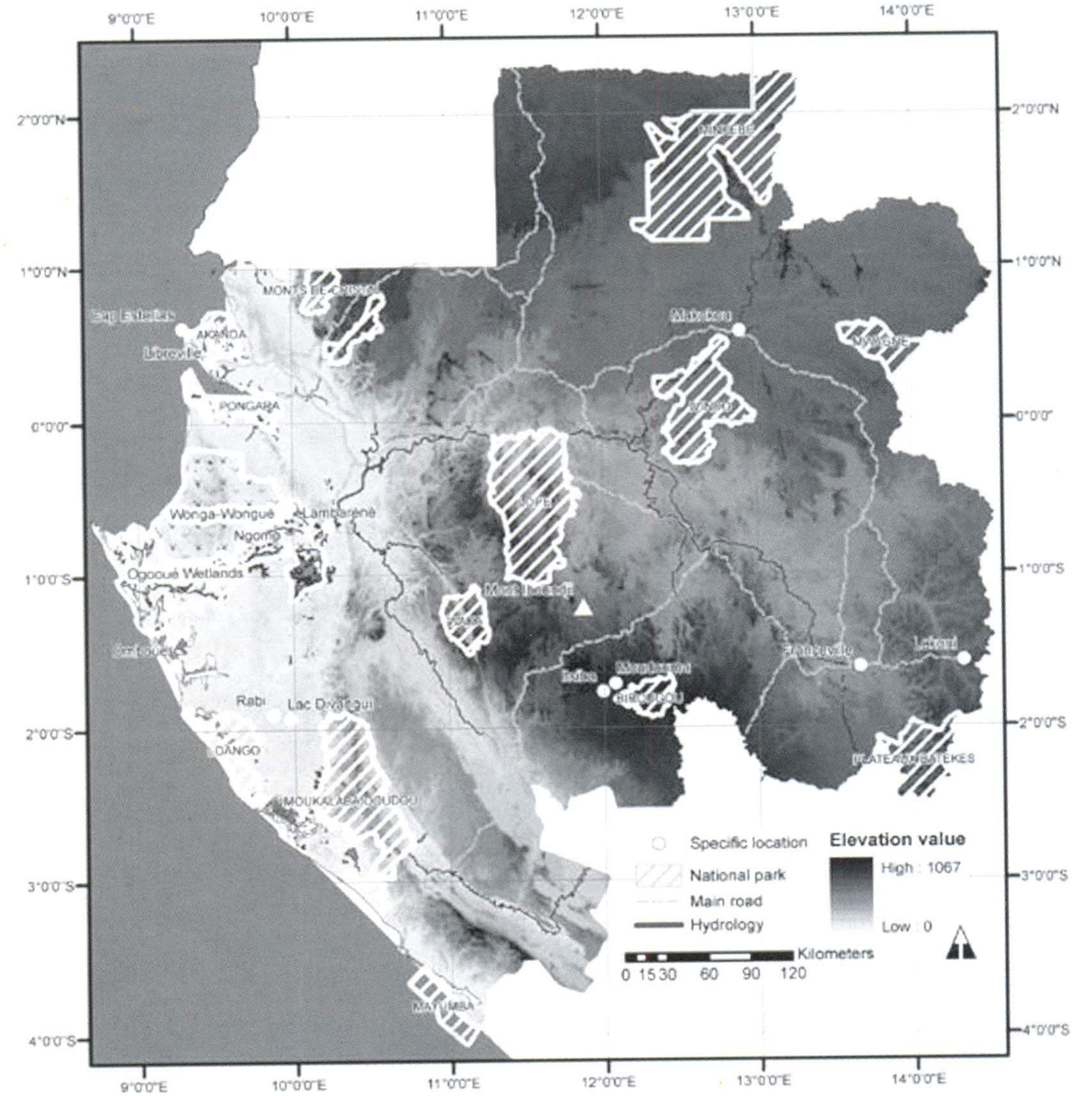

Figure 2. Map of Gabon, showing the relief and hydrography, and the national parks and other sites and localities mentioned in the text.

according to Anonymous, 1994:9). It is likely that Steel (1994) was referring to the unpublished report by Anonymous (no date - b) who listed 65 reptile species from the Ivindo Basin (see also Blanc and Frétey, 2000:289); however this latter anonymous report does not give any precise indication on the localities, nor any reference to preserved museum material. Steel's (1994) record of *Crocodylus niloticus* requires confirmation. A number of the species recorded by Knoepffler (1966, 1974) at and around Makokou must be present in the park, including the regional endemic snakes *Gonionotophis b. brussauxi* (Mocquard, 1889) (Colubridae) and *Paranaja multifasciata* (Werner, 1902) (Elapidae). Knoepffler's records from Loa-Loa (13 species) and his record of *Cycloderma aubryi* (Duméril, 1856) from "en aval des chutes de Mingouli" ("downstream Mingouli waterfalls") might actually have been made within the parks borders. In conclusion, the only reptile record unambiguously made within the Park limits to date is that of *Crocodylus cataphractus* by Steel (1994). Within the park, Mont Kinguié (749 m asl) is possibly home to high altitude taxa and would deserve dedicated herpetological surveys.

Loango National Park (1,550 sq. km).– On the entire West African coast, Loango N. P. may be the most beautiful, ecologically-intact example of the juxtaposition of lowland forest, savanna, swamp, lagoon and marine ecosystems (Anonymous, 2002b:31; Lee et al., 2005). A two-month herpetological survey of the Park was conducted in 2002, recording 37 species (Pauwels et al., 2004a; see Table 1). Among others, evidence of the nesting of *Chelonia mydas* (Linnaeus, 1758), *Lepidochelys olivacea* (Eschscholtz, 1829) and *Dermochelys coriacea* was found, although Anonymous (2002b) did not mention sea turtles in the brief description and highlights for Loango N. P. The occurrence and seasonal abundance of sea turtles might, however, become a popular attraction for ecotourism in the Park. Pauwels et al. (2004a) provided a list of species that could be expected from the Park, and predicted a total of about 50 species.

Lopé National Park (4,970 sq. km).– This was the first protected area of the country, declared as such in 1946 (Anonymous, 2002b:7). This is also the first Gabonese protected area to have benefitted from a herpetological survey: a list of 38 species was established by Blanc and Frétey (2000). It includes two crocodile and other protected species, and an *Agama* population referred as to *A. paragama* Grandison, 1968 by these authors and as *A.* cf. *paragama* by Pauwels et al. (2002a); the status of this population requires further study. Blanc and Frétey (2000) included records that were actually made just outside the park; moreover, the Park delimitations were partly modified after their work. If one considers today's delimitations (according to Anonymous, 2002a; 2002b), only 34 records were made within the Park (see Table 1). The remaining four species recorded by Blanc and Frétey (2000) might, however, be expected from the Park, as they were recorded from biotopes represented within the park next to the Park borders. Christy and Wilmé (2003) mentioned the "crocodile à museau court" (*Osteolaemus tetraspis tetraspis*), "varan" (*Varanus ornatus*; with picture in loc. cit.:91) and "python" (*Python sebae*) from Offoué River near Ololo Camp. Many additional species should be added to the Park herpetofauna, notably through surveys in the hilly southern part of the park which belongs to the *Massif du Chaillu*.

Mayumba National Park (80 sq. km).– Fretey and Girardin (1988) considered the park the most important nesting site for *Dermochelys coriacea* in Gabon. The Park was, moreover, qualified as the "most important nesting site for leatherback turtles on Earth," and proposed as a World Heritage Site (Anonymous, 2002b:11, 41, 43). Billes (2003) provided data on the locally-nesting population of *Dermochelys*, and stressed important conservation problems, including local human predation on *Dermochelys*, *Chelonia mydas* and *Lepidochelys olivacea*. Data on other reptile species are totally lacking for the park, but its small land surface and high homogeneity in biotopes suggests that herpetofaunal diversity must be low, i.e., probably even lower than those of Akanda and Pongara Parks.

Minkebe National Park (7,570 sq. km).– Nearly no herpetological data are available for the park, which is, nonetheless, by far the largest in Gabon. Anonymous (no date - a:9) mentioned that Sally Lahm recorded eight reptile species from the Minkébé area. Steel (1992) mentioned the 11 reptile species listed by Lahm (1991) from Minkebe forest: *Kinixys erosa* (Schweigger, 1912), *Osteolaemus t. tetraspis*, *Varanus niloticus* (probably *V. ornatus*), *Thrasops* sp., *Dendroaspis jamesoni* (Traill, 1843), *Naja melanoleuca* Hallowell, 1857, *Pseudohaje goldii* (Boulenger, 1895), *Python sebae*, *Typhlops* sp., *Atheris chloroechis* (sic; probably *A. squamiger* [Hallowell, 1854]) and *Bitis gabonica* (Duméril, Bibron and Duméril, 1854). These records of *Thrasops* sp. and *Typhlops* sp. require vouchers and confirmation, since they might concern other genera as well (respectively *Rhamnophis* Günther, 1862 and *Leptotyphlops* Fitzinger, 1843 or *Ramphotyphlops* Fitzinger, 1843 – this latter genus having recently been added in Gabon by Pauwels et al., 2004b). With its large surface of pristine forest, its high peaks (particularly those above 650 m asl) and inselbergs, Minkebe N. P. undoubtedly harbors a rich herpetofauna, among them probably a number of species yet-unrecorded from Gabon, but known from southern Cameroon, or even new taxa.

Mount Birougou National Park (690 sq. km).– No herpetological collection has been done within the park, but survey work has taken place in its immediate vicinity in the Itsiba and Moudouma areas by Pauwels et al. (2002a, c). The altitude of Mount Birougou is 975 m (Anonymous, 2002b:21). With one of the highest peaks of Gabon, a largely-intact forest, and its remote situation in the heart of the *Massif du Chaillu*, this park is a very promising research field site for herpetologists.

Moukalaba-Doudou National Park (4,500 sq. km).– *Crocodylus cataphractus* was mentioned from Lake Kivoro by Dijkstra (1993:259). Obame Ondo (2000:8) reported that about 16 reptile species were listed from the *Monts Doudou*, without specifying which, but more information on this inventory was available in the report of Bagafou et al. (2000) where some taxa are identified down to the specific level. The detailed results of this first survey were eventually provided by Burger et al. (2004), who produced the first documented reptile list for the park. A more recent second survey brought in a number of new records, giving a current total list of 42 species (Pauwels et al., 2005; see Table 1). Minko Ekomo (no date:11) listed *Crocodylus niloticus* from the *Monts Doudou* (see also Burger et al., 2004:175). On 30 April 2005, we (OSGP) observed two subadult *C. niloticus* basking on partly-immersed logs in the Nyanga River within the Park, and examined a large skull in Igotchi (Nyanga Province, Basse-Banio Dept.), which is said to have been caught in the Nyanga in front of the village. A specimen of *Bitis arietans* (Merrem, 1820) was observed in 1987 in the park near Mourindi (PC, unpubl. data). Although this viper species was not listed for Gabon by Frétey and Blanc (no date), it might be found in the savanna areas of Gabon (another specimen caught in the savanna along Road 16 between Udéac and Lékoni, just north of Bateke Plateaux N. P., was examined by J. Maran, pers. comm.). Field surveys in the highest peaks of the park will certainly add new records, and possibly new taxa.

Mwagne National Park (1,160 sq. km).– No herpetological data are available for the park. Due to its relatively small size and mainly low relief, we do not expect it to house an especially rich nor unique herpetofauna.

Pongara National Park (870 sq. km).– *Dermochelys coriacea* was mentioned from the park by Fretey and Girardin (1988) and Vande weghe (2005). Pauwels and Vande weghe (2005) and Vande weghe (2005) also listed *Chelonia mydas* and *Eretmochelys imbricata* (Linnaeus, 1766) (Cheloniidae), *Osteolaemus t. tetraspis* (Crocodylidae), *Hemidactylus mabouia* (Gekkonidae), *Gerrhosaurus nigrolineatus* Hallowell, 1857 (Gerrhosauridae) and *Python sebae* (Pythonidae). On 12 Sept. 2004, we (OSGP and J. P. Vande weghe) caught, identified and released specimens of *Agama agama* (Linnaeus, 1758) (Agamidae), *Gerrhosaurus nigrolineatus* (Gerrhosauridae), *Mabuya affinis* and *M. albolabris* (Scincidae), all locally abundant. Vande weghe (2005) mentioned that *Crocodylus niloticus* was probably once present, but is surely absent today from the park. The whole herpetofauna is probably not very diverse, and identical to that of Akanda N. P.

Waka National Park (1,070 sq. km).– No herpetological information is available for the park, which is probably home to the species recorded from low and middle altitude by Pauwels et al. (2002a) in other parts of the *Massif du Chaillu*. The highest summits might harbour *Hemidactylus kamdemtohami* or *Letheobia pauwelsi*, both known from Mount Iboundji situated at less than 70 km.

DISCUSSION

General representation of reptiles in Gabon's national parks.– Seventy-five reptile species are so far known to be represented in the national parks of Gabon (Table 1). The total number of reptiles currently recorded from the whole country is still a matter of discussion, since a number of historical and non-documented records have to be re-evaluated. Lötters et al. (2000) and Pauwels (2004) estimated a total number of 95 and 140 reptile species for Gabon (respectively). The longest list currently available is that of Frétey and Blanc (no date) who mentioned 160 species. These latter authors did not include *Hemidactylus kamdemtohami*, *Letheobia pauwelsi*, *Ramphotyphlops braminus*, *Hydraethiops laevis* nor *Bitis arietans*, added to the Gabonese herpetofauna after submission of their manuscript (see Pauwels, 2004a; Pauwels et al., 2002a, 2004b; Wallach, 2005; and the present work). A number of species should also probably be withdrawn from their list (see Pauwels, 2004a).

If one considers the highest figure of 160 species and 76 genera by Frétey and Blanc without corrections, 47% of the species, 66% of the genera, and all families (22) except Amphisbaenidae and Leptotyphlopidae are currently recorded from the parks. In view of the early stage of herpetological inventory of the parks of Gabon, a representation of nearly half of all species, and all families but two (moreover discreet fossorial taxa that can be easily overlooked) is satisfying. Future surveys will undoubtedly increase the present figures, and we strongly encourage a focused effort on research in national parks, both to increase their scientific and ecotouristic value and to ensure that listed species are effectively protected. We also encourage inventories in geographically-exceptional sites outside parks, like mountain tops, inselbergs, caves, waterfalls, isolated lakes, etc., to increase their state of biological knowledge and possible justification as biodiversity sanctuaries.

Representation of endemics and near-endemics.— Endemics: *Cynisca bifrontalis* was only known by its holotype from Omboué (Ogooué-Maritime Province, Etimboué Dept.) until our recent discovery of five additional specimens in Rabi/Toucan oilfields, ca. 90 km south-east of the type locality (Branch et al., 2003). The presence of *C. bifrontalis* in Loango N. P. is very probable, and it might also be expected from Moukalaba-Doudou N. P., since Rabi is situated between both parks. The other Gabonese endemic amphisbaenian *Cynisca haughi* is still known only by its holotype from "Gabon, à environ 50 km au sud-ouest de Lambaréné" (Gabon, about 50 km SW of Lambaréné), along the Ogooué wetlands which was proposed as a Biosphere Reserve (Anonymous, 2002b). Additional specimens of *C. haughi* should be collected in order to confirm it is not conspecific with *C. bifrontalis*, since the female holotype is in poor condition and does not allow the examination of some important diagnostic characters (Branch et al., 2003)– in the case of synonymy the name *C. haughi* would have priority.

Feylinia boulengeri, regarded by some authors (e.g., Frétey and Blanc, no date) as belonging to the monotypic Feyliniine genus *Chabanaudia* de Witte and Laurent, 1943, is known from only two localities and two specimens: "N'Gomo, Ogooué, Gabon" (MNHN 1917.120; holotype) and "Riv. Bilogone, Gabon" (MNHN 1969.105) (Brygoo and Roux-Estève, 1983). N'Gomo (= Ngomo; see Figure 2) is situated in Moyen-Ogooué Province, Dept. de l'Ogooué et des Lacs. Bilogone (= Mbilagone) River flows from Wonga-Wongué Reserve to Pongara N. P.

Mount Iboundji's blind snake *Letheobia pauwelsi* is still known by a single specimen that was caught on the flank of Mount Iboundji (Pauwels et al., 2002a). Due to its obvious fossorial habits, the species could be more common than it seems; it could be searched for in the southern, hilly, part of Lopé N. P., and in Mount Birougou N. P.

Near-endemics: Since its discovery, *Pelusios marani* has been found in a dozen localities in Gabon, and in a single locality, "environs de Brazzaville" ("surroundings of Brazzaville"), in Congo-Brazzaville (Bour et al., 2001; Maran, 2002; Pauwels et al., 2002d). Its recent record from Moukalaba-Doudou N. P. (Pauwels et al., 2005) represented its first mention from a protected area. In view of the high predation pressure by humans, *P. marani* will soon be under threat, and this Moukalaba-Doudou record is thus very important.

Kamdem Toham's gecko *Hemidactylus kamdemtohami* was first collected on the flank of Mount Iboundji in the *Massif du Chaillu*, and observed in Monte Alen N. P. in Equatorial Guinea (Pauwels et al., 2002a). It was then later reported from southern Cameroon (Pauwels, 2004b) and will probably be found on more mountains in the region.

Pauwels et al. (2002a) rediscovered in Moudouma (660 m asl) the aquatic snake *Hydraethiops laevis*, which was formerly only known from its two syntypes from Efulen (670 m asl) in Cameroon. Since Moudouma village is situated less than 10 km from Mount Birougou N. P., this rare snake most likely occurs in the park.

Representation of locally-protected species.— Decree n°32/PR/MEF of 11 January 1966 gave integral protection of the three crocodiles species, with a derogation every year for a hunting period. Commercial hunting hence, took place, especially in the area of Lambaréné, in Ogooué River and adjacent lakes. This decree was renewed every year until 1975, when intensive hunting had so depleted the natural stocks that commercial hunting became non-viable. According to the present Gabonese laws, no reptile is integrally protected, but the following six species are partly protected following decree 189/PR/MEFCR of 4 March 1987 relative to the protection of fauna: *Dermochelys coriacea* (Dermochelyidae), *Crocodylus cataphractus congicus* and *C. niloticus*, *Osteolaemus t. tetraspis* (Crocodylidae), *Varanus niloticus* (Varanidae) and *Python sebae* (Pythonidae).

Dermochelys, although suffering from human predation, is recorded from three coastal parks, among them Mayumba N. P. which is one of the most important nesting sites worldwide for the species (Billes, 2003).

The subspecies *Crocodylus cataphractus congicus* Fuchs, Mertens and Wermuth, 1974, is not universally accepted. Besides its records from three parks, *C. cataphractus* still has a wide distribution in Gabon (Waitkuwait, 1985), but is heavily hunted everywhere (Gramentz, 1999; Pauwels et al., 2003). Conservation measures are urgent.

Dupuy et al. (1998:27) indicated that *Crocodylus niloticus* was probably extinct in Gabon because of intensive hunting. Fortunately this is wrong, since *C. niloticus* is presently known with certainty from Loango and Moukalaba-Doudou parks, but it is not sure whether it occurs in other parks. The Nile crocodile was probably once more common (Anonymous, 2004), and probably present in at least Pongara N. P. (Vande weghe, 2005) and Akanda N. P. Blaney et al. (1997:67) mentioned it from "rivière Mougouambi, tronçon Mayonami-Moulondo" (Nyanga Province, Basse-Banio Dept.). Today it seems limited to the coastal areas of the Gamba Complex of Protected Areas and to the Nyanga River (Bourobou Bourobou, 1999:12; Camara Gakou, 1992:23; Dijkstra, 1993; Pauwels et al., 2005). In 1996, Gramentz (1999) however observed several dead specimens sold as food on fishermen's markets at Lambaréné, which suggests that its present distribution in Gabon might be wider. The status of this species in Gabon should be urgently evaluated.

Osteolaemus t. tetraspis was inventoried from six parks, recorded from less than 15 km from Crystal Mountains N. P. (Pauwels et al., 2002b), and found on the border area of Ivindo N. P. (Knoepffler, 1974). In Gabon this species is widespread (see also Waitkuwait, 1985) and still common (pers. obs.) and will probably be found in every park.

Varanus niloticus is recorded from Gabon without exact locality (Böhme and Ziegler, 1997). In fact the decree was published before the revision of the *Varanus niloticus* species complex by the latter authors who demonstrated that *Varanus niloticus ornatus* had to be raised to full species status. From a zoogeographical point of view, the confirmation of the presence of the savanna-dwelling *V. niloticus* in Gabon would be very interesting, since that population would be isolated (see map in Böhme and Ziegler, 1997) and efforts could be made to study its exact distribution and taxonomic status. However, at the time the decree appeared, it was probably meant to protect what was later shown to be *V. ornatus*, which is very widespread and abundant in Gabon (see also Böhme and Ziegler, 2004; Pauwels et al., 2002a; 2002b), in cities as well as in cultivated lands, primary forests, savannas and beaches, and already known to occur in six national parks.

Python sebae was already recorded from not less than six parks, and is thus very satisfactorily represented. Like *Varanus ornatus*, it is very common everywhere in Gabon and will probably be recorded soon from all parks.

Representation of internationally-protected species.— Two international conventions on fauna conservation were ratified by Gabon on the same day (laws of 29 July 1987 and decrees of 30 May 1988): the Convention of Algiers and the Convention on International Trade of Endangered Species of Wild Flora and Fauna (CITES; see Anonymous, 1987a-b). The African Convention for Nature Conservation was signed in Algiers on 15 September 1968. This convention presents two levels of protection: total (A) and partial (B). All Cheloniidae and Dermochelyidae are listed in class A, and all crocodilians in class B. The terms of the Convention of Algiers were never concretely applied in Gabon. CITES species for Gabon were listed by Anonymous (2005), with mention of IUCN categories in case of listing. In Appendix I: *Chelonia mydas* (EN – A1abd), *Eretmochelys imbricata* (CR - A1abd+2bcd) (Cheloniidae), *Dermochelys coriacea* (CR – A1abd) (Dermochelyidae), *Crocodylus cataphractus* (DD) and *C. niloticus* (Appendix I/II), *Osteolaemus tetraspis* (VU – A2cd) (Crocodylidae); and in Appendix II: *Kinixys belliana* Gray, 1831, *K. erosa* (DD), *K. homeana* Bell, 1827 (DD) (Testudinidae), *Chamaeleo africanus* Laurenti, 1768, *C. camerunensis* (Müller, 1909), *C. chapini* de Witte, 1964, *C. cristatus* (Stutchbury, 1837), *C. dilepis* (Leach, 1819), *C. gracilis* Hallowell, 1842, *C. oweni* Gray, 1831 and *C. quilensis* Bocage, 1866 (Chamaeleonidae), *Varanus niloticus* and *V. ornatus* (Varanidae), *Calabaria reinhardtii* (Schlegel, 1851) (Boidae) and *Python sebae* (Pythonidae). Although *Caretta caretta* (Linnaeus, 1758) and *Lepidochelys olivacea* are not listed for Gabon by Anonymous (2005), all Cheloniidae, thus including those two species, are listed on Appendix I on http://www.cites.org/eng/app/appendices.shtml (last visited by us on 2 April 2005). The species that are also locally protected are treated in the section above.

Chelonia mydas was recorded from three of the four Gabonese coastal national parks, so its representation is satisfying, but its conservation status is, however, alarming, due to the enormous human predation pressure. In 2004 we (OSGP and J. P. Vande weghe) observed on several occasions numerous green turtle carcasses near Cap Esterias where the species is still commonly and openly offered in restaurants. This happened just a few km from Akanda N. P. It is obvious that such an exploitation is unsustainable. Maran (2002) was even offered a carapace of *C. mydas* to buy near Makokou, about 400 km inland.

Eretmochelys imbricata and *Lepidochelys olivacea* are respectively known from one and two coastal parks in Gabon (see Table 1). They are rare and preyed upon by humans; a detailed summary of the exploitation was presented by Fretey (2001).

Although a few records of *Caretta caretta* were reported from Gabon (Dijkstra, 1993; Fretey, 2001), the current presence of the species should be evaluated.

Kinixys erosa is heavily hunted in Gabon, but is widespread and still very common (see a.o. Maran, 2002:62-63). It is already known from five national parks. The status of *Kinixys belliana* and *K. homeana* in Gabon has still to be evaluated. Neither of these two latter species was listed by Maran (2002), who restricted his list to the available museum material and personal field observations (Maran, pers. comm., Apr. 2005), and of both, only *K. homeana* was listed by Frétey and Blanc (no date). Both species might, however, be eventually documented from Gabon through additional field work, particularly in savanna (*K. belliana*) and in the forests near Equatorial Guinea (*K. homeana*) (Maran, pers. comm.).

The distribution and conservation status of *Chamaeleo* spp. in Gabon is very poorly known, and only *C. dilepis* was reported from a national park (see Table 1). Anonymous (2005) listed *C. camerunensis*, but this species was not included by Frétey and Blanc (no date).

Calabaria reinhardtii is very common in Gabon, especially in secondary forest, and is not eaten by locals (pers. obs.), nor does it seem to be under any other specific threat. It was so far recorded from three parks, but should be found in most.

Suggestions for modifications to the Gabonese protection laws on reptiles.— Due to currently available data on distributions, conservation status and human consumption of reptiles in Gabon (including Billes, 2004; Gramentz, 1999; Lahm, 1993; Mengome Ango, 1998; Steel, 1994), we suggest the following changes from the decree 189/PR/MEFCR of 4 March 1987 relative to their protection: a) *Dermochelys coriacea* and *Crocodylus cataphractus* be integrally protected; b) all Cheloniidae (including *Caretta caretta*) be partly protected; c) *Varanus niloticus* and *Python sebae* be withdrawn from the list of locally-protected species; d) *Cycloderma aubryi* be added to the partly-protected species.

Unprotected areas of demonstrated herpetological interest.— Field surveys that took place out of the established national parks showed two particular sites to be of special herpetological interest, both cited by Anonymous (2002a;

2002b): Mount Iboundji, in the middle of the *Massif du Chaillu*, and the Rabi oil field, lying between Loango and Moukalaba-Doudou national parks. Mount Iboundji is described by Anonymous (2002b:11) as a "rocky tableland overlooking forest rich in biological diversity." It is specified (loc. cit.:87) that new species of reptiles were discovered on its flanks, which are actually those found by Pauwels et al. (2002a): *Hemidactylus kamdemtohami* and *Letheobia pauwelsi*. While the former is currently recorded from three countries (Pauwels, 2004b), the *Letheobia* is still known only from a single specimen. Since two new reptile species and other uncommon taxa (such as the endemic bufonid *Werneria iboundji* Rödel, Schmitz, Pauwels and Böhme, 2004) were discovered during the short time dedicated to the herpetological study of the mountain, we can reasonably expect that intensive surveys will lead to many additional interesting findings. Mount Iboundji has been proposed as a "Sanctuary", a term that Anonymous (2002b:11) defined as: "area high in biological diversity or of special interest too small for National Park status." According to the law, the surface of a national park can not be less than 1000 hectares (Anonymous, 2002a:9; this being not specified in the English version of the book).

The Rabi oil field was intensively herpetologically explored in 2002-3, and proved to be exceptionally rich (Branch et al., 2003; Burger et al., 2002; Lavoué et al., 2003; Pauwels et al., 2005), with not less than 66 species documented, i.e., so far the longest list for any locality in Gabon. Although hunting is presently locally strictly forbidden, and access and logging controlled by the oil company Shell Gabon, the question remains of what will become of this area when declining reserves force the company to leave. Lake Divangui is situated at direct proximity to the Rabi oil field, and was shown to harbor an important population of *Crocodylus cataphractus* (Pauwels et al., 2003); it is also home to *Osteolaemus t. tetraspis* (Barr et al., unpubl. data).

Among the four other exceptional sites mentioned by Anonymous (2002a-b), i.e., Wonga-Wongué Reserve and the adjacent Ogooué Wetlands, "Northeast," and Minkol-Makok inselbergs, none has so far benefitted from a dedicated herpetological survey, and the scarce data currently available do not allow pertinent evaluation. However, one might expect inselbergs to house zoogeographically-interesting and possibly-unique taxa. One of the only two known localities for the endemic legless skink *Feylinia boulengeri* is situated in the Ogooué Wetlands which were also shown to be home for at least five terrestrial and freshwater turtles: *Pelusios castaneus* (Schweigger, 1812), *P. niger* (Duméril and Bibron, 1835), *Cycloderma aubryi*, *Trionyx triunguis* (Forsskål, 1775) and *Kinixys erosa* (see Gramentz, 2001; Maran, 2002). We suggest an evaluation of the current populations of crocodiles and freshwater turtles in this area.

CONCLUSION

Although the 13 recently established national parks seem to represent all the major biotopes of Gabon, it is not yet demonstrated that all unique reptile species of Gabon are included. None of the four endemics and only one of the three near-endemics are recorded so far from a national park in Gabon. Specific surveys should be conducted for these species in convenient biotopes of possible occurrence in the parks. Although improbable, if high search efforts seem to demonstrate that they are not present in any park, conservation measures should be taken, notably through the proposition of sanctuaries for localities where these species do occur.

The numbers of species recorded to date from the parks of Gabon vary from one to 44. These numbers reflect more the search effort than real differences in diversity. However, some parks can be expected to be home to more taxa than others on the basis of their biotope diversity and the presence of altitudinal areas, with more chances to discover taxa new to science in the latter zones. Akanda, Pongara and especially Mayumba national parks show a low diversity of biotopes, no altitudinal zones, and probably house the lowest numbers of species. Bateke Plateaux, Ivindo, Loango, Lopé, Moukalaba-Doudou, Mwagne and Waka national parks should show a higher diversity, due to their wider representation of biotopes. The most diverse and original herpetofaunas are probably to be found in Crystal Mountains, Minkebe and Mount Birougou national parks, which show peaks above 900 m asl. and particular biotopes such as inselbergs (Minkebe), caves (Birougou) or waterfalls.

All four Gabonese endemic reptiles are small-sized fossorial species known from one to six specimens, and from one to two localities. This indicates a paucity of herpetological knowledge for the country, and suggests high likelihood of discovering additional endemic taxa.

The herpetological inventory of the parks of Gabon is at its beginning and is hence, totally incomplete. In order to raise the proportion of species represented in the parks, we would encourage surveys a.o. in Bateke Plateaux N. P. to search for more savanna species, and possibly new records for the national list. All parks comprising altitudinal zones should be explored since they might reveal new taxa for science, and caves, waterfalls and inselbergs should be systematically inventoried.

In the frame of the current development of Gabon for ecotourism, several parks seem particularly well-placed because they simultaneously offer landscapes which are unique within Gabon and are logistically feasible. These are Loango, Lopé, and Crystal Mountains, three of the four parks for which preliminary reptile lists are already available. Abundances of sea turtles and Dwarf and Nile crocodiles are among the highlights of Loango N. P. Lopé offers a rich lowland and savanicolous herpetofauna, and is situated in close proximity of the exceptional site- Mount Iboundji- which we strongly suggest for protection integrally. The Crystal Mountains harbour a rich mid-altitude herpetofauna, including regional endemics. These three parks combined offer an opportunity to view a wide portion of the Gabonese herpetofauna. Among unprotected areas, Rabi offers so far the richest known assemblage of lowland forest reptile species and is situated in direct proximity to Lake Divangui, a perfect place to observe large numbers of *Crocodylus cataphractus* and a potential sanctuary for the species. Potential impacts of ecotourism on crocodiles and their nesting should of course first be evaluated. It is evident that some reptiles could play a positive role in ecotourism, in particular sea turtles and crocodiles in coastal parks, should protection laws be adequately and quickly enforced. A revision of the list of protected reptile species is also becoming a necessity.

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FIRST RECORD OF *UPERODON GLOBULOSUS* (GÜNTHER, 1864) (ANURA: MICROHYLIDAE) FROM ANDHRA PRADESH, INDIA

(with one text-figure)

Uperodon globulosus (Günther, 1864) was originally described from Russelkonda, Orissa, in eastern India. This species has been sporadically collected from isolated localities in India, including Arunachal Pradesh (Bordoloi et al. 2000; Borah and Bordoloi, 2001), Assam (Bhaduri and Saha, 1980; Chanda, 1994; Choudhury et al. 1999), Bihar (Dutta, 1997; Molur and Walker, 1998), Goa (Molur and Walker, 1998), Gujarat (Daniel and Shull, 1963), Karnataka (Daniels, 1992), Kerala (George and Leelamma, 1995), Chattisgarh (then in Madhya Pradesh, now a separate district) (Abdulali and Daniel, 1954), Maharashtra (Abdulali and Daniel, 1954; Bhaduri and Daniel, 1956; Daniel, 1963; Daniels, 1992; Padhye and Ghate, 2002; Padhye et al., 2002), Orissa (Thurston, 1888; Boulenger, 1890; Satyamurti, 1967; Dutta, 1997) and West Bengal (Bhaduri, 1945; Bhaduri and Basu, 1956; Bhaduri and Saha, 1980; Sarkar, et al., 1992; Deuti and Bharathi Goswami, 1995), and from Bangladesh (Khan, 1982).

During a faunistic survey in the Nallamala Hills (14° 26'–16° 31'N; 78° 30'–80° 10'E), Eastern Ghats, Andhra Pradesh, between 3-16 June 2003, we recorded its occurrence from two different localities. On 14 June 2003, an adult female (Fig. 1) was collected between Mannanur and Farahabad (16° 19'N; 78° 44'E) on the Amrabad Plateau, Nagarjunasagar Srisailam Tiger Reserve. This specimen was collected at ca. 2125 h while it was crossing the road during a heavy downpour. This constitutes the first record of the species from Andhra Pradesh. The voucher specimen (FBS/ZSI/N/1138) is deposited in the Freshwater Biology Station, Zoological Survey of India, Hyderabad. Subsequently on the same night, three male specimens were also encountered near Shikaram (16° 02'N; 78° 55'E), ca. 79 km s of the location from where the voucher was collected. These were not collected as they were badly damaged by vehicular traffic.

Description of voucher collected.– Abbreviations used – SVL (snout to vent length), HW (head width), HL (head length), MN (mandible to nasal opening length), MFE (mandible to front of eye length), MBE (mandible to back of eye length), SL (distance between front of the eye to tip of the snout), EL (horizontal diameter of eye), IUE (maximum distance between upper eyelids), UEW (maximum width of inter upper eyelid), IN (distance between the nasal opening), IFE (distance between front of the eyes), IBE (distance between back of the eyes), EN (distance between front of the eye and the nostril), SN (distance between tip of the snout and the nostril), FLL (forelimb length), HAL (hand length), TFL (length of the third finger), TL (length of the tibia), TW (width of the tibia), FL (femur length), FOL (foot length), IMT (length of the inner metatarsal tubercle), OMT length of the outer metatarsal tubercle), and ITL (inner toe length)]

A.] Size: Specimen of medium size (SVL 75.6 mm; males were between 55.1 – 62.0 mm), body stout and globular.

B.] Head: Head small, wider (HW 16.3 mm) than long (HL 13.7 mm; MN 9.8 mm; MFE 8.1 mm; MBE 7.9 mm), convex. Snout rounded, not protruding, its length (SL 6.5 mm) almost equal to the horizontal diameter of eye (EL 6.6 mm). Canthus rostralis distinct, loreal region obtuse. Interorbital space convex, broader (IUE 11.4 mm) than upper eyelid (UEW 4.84 mm) and internasal distance (IN 7.3 mm). Distance between the front of the eyes (IFE 12.3 mm) about three fourth the distance between the back of the eyes (IBE 16.2 mm). Nostrils round, closer to the eye (EN 3.1 mm) than to snout (SN 4.1 mm). Pupil vertical. Tympanum indistinct. Maxillary and vomerine teeth absent. Choanae large with movable integumentary flap. Tongue oval, free behind.

C.] Forelimbs: Arm shorter (FLL 15.1 mm) than hand (HAL 19.3 mm), not enlarged. Fingers long (TFL 10.0 mm), stout. Relative length of fingers, shortest to longest: IV < I < II < III.

Fingers free, tips not dilated, without dermal fringe or webbing. Subarticular tubercles indistinct.

D.] Hind limbs: Shank about two times longer (TL 18.1 mm) than wide (TL 10.0 mm), smaller than thigh (FL 27.3 mm) and also smaller than the distance from the base of inner metatarsal tubercle to the tip of toe IV (FOL 29.1 mm). Relative length of toes, shortest to longest: I < II < V < III < IV. Tips of toes rounded, dermal fringe absent, webbing rudimentary. Subarticular tubercles indistinct. Inner metatarsal tubercle prominent, shovel-shaped, its length (IMT 6.3 mm) more than one and a half times in length of the outer metatarsal tubercle (OMT 4.1 mm) and the length of the toe 1 (ITL 4.0 mm). Supernumerary tubercles and tarsal tubercle absent.

E.] Skin: Dorsal skin smooth throughout excepting near vent where it is granular. Ventral surface smooth. Dorsolateral folds absent. Occipital fold rather prominent.

F.] Colouration: Dorsal parts of head and dorsum brown with olive tinge, with black on snout, between the nasal openings and between the shoulders. Upper and lower flanks on either side, dorsal and lateral parts of the limbs spotted dark brown to black. Ventral parts of head, body and limbs pale with yellowish tinge. Vocal sac subgular and black.

All four specimens encountered were from well-wooded tracts of the Reserve. Owing to their fossorial habits, these frogs are seldom encountered and have been recorded sporadically. As all the males encountered had well-developed black vocal sac, we presume that their breeding in the Nallamala Hills, Eastern Ghats also commences from June with the onset of monsoon as reported earlier (Chanda, 2002).

Figure 1. *Uperodon globulosus* (Günther, 1864) from Nagarjunasagar Srisailam Tiger Reserve, Andhra Pradesh, southern India.

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ON TWO REMARKABLE COLOUR VARIANTS IN *BOIGA DENDROPHILA MELANOTA* (BOULENGER, 1896) (SERPENTES: COLUBRIDAE)

(with five text–figures)

A multitude of articles deal with colour variants of snakes (e.g., Clark, 1997; Love, 1997, 2003; Vosjoli, 1997; Northcott, 1999), and entire books have covered this subject (e.g., Bechtel, 1995; Broghammer, 1999; Bartlett and Bartlett,

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Figure 1. *Boiga dendrophila melanota*, a nearly melanotic male from Pattalung, with white dots instead of yellow bands.

Figure 2. *Boiga dendrophila melanota*, a nearly melanotic male from Pattalung, with white dots instead of yellow bands.

Figure 3. *Boiga dendrophila melanota*, a nearly melanotic male from Pattalung, with white dots instead of yellow bands. Close up of head.

Figure 4. Female of *Boiga dendrophila melanota* from Nakhon Sri Tammarat, with stripes instead of bands.

Figure 5. Female of *Boiga dendrophila melanota* from Nakhon Sri Tammarat, with stripes instead of bands.

2002), that deal mainly with variants resulting from offspring, especially bred for this purpose, or occasionally obtained as a result of inbreeding in captivity. Most of them concern albinos, leucistic animals or other unusual developments of the chromophores. Presumably, a majority of these animals would not be able to survive for a long time in nature. On the other hand, aberrant colour varieties of snakes found in the wild are rarely reported.

Colouration is of importance for systematics within *Boiga dendrophila* (Boie, 1827). Nine subspecies are currently known (Gaulke et al., 2003 [2005]), and the differences between these depend primarily on colouration (Brongersma, 1934; Vogel, 2000). Adults are black, with yellow bands for all but two forms. The taxon from Sulawesi has silver rings for periods of its life and turns unpatterned black with maturity (Vogel, 2000; Lang and Vogel, 2005). Juvenile specimens are more vividly coloured than the adults and sometimes tend to be a shade of red in colouration. However, there appears to be no literature on abnormal colouration within a subspecies.

Boiga dendrophila melanota (Boulenger, 1896) inhabits West Malaysia and Thailand. The northern limit of its distribution is not precisely known, as there are reports from Vietnam that need to be confirmed (Campden-Main, 1970; Nguyen and Ho, 1996; Szyndlar and Nguyen, 1996). This is a common species, widely collected for the leather industry. Nevertheless, the major standard works do not mention any variations in the colouration beside the number of the rings (e.g., Tweedie, 1983; Taylor, 1965; Cox, 1991; Manthey and Grossmann, 1997). Brongersma (1934) examined 40 specimens and found a consistent pattern in all of them.

Figures 1–5 depict photos of two unpreserved specimens of *Boiga dendrophila melanota*. Both animals were collected for trade, but the animals can be traced back to their province of origin. They are both adults.

Description of specimen 1: An adult male, collected in the Province of Pattalung, Thailand, in 2001. The upper side of the body is totally black. On the lowest dorsal row, there are white dots expanding to the ventrals. These white dots replace the yellow bands of the more typical colour morph. They are also present on the tail. The head is black. The upper labials are white with black posterior margins. The underside of the head is white.

Description of specimen 2: An adult female, collected in the Province of Nakhon Sri Thammarat, Thailand, in 2000. This specimen has a striped, instead of a banded pattern. The body is black, on each side there is a bright yellow stripe dorsolaterally. This is no lateral stripe. Dorsolateral stripe about one dorsal row wide. A part of the streak is straight but a smaller part is wavy and interrupted. The tail is banded, as is usual for this subspecies. The head is black, the white upper labials have small black margins; this is also typical for the subspecies.

The first of these two remarkable specimens is a nearly melanotic animal. This is not the astonishing fact, but the remainder of the bands are white instead of yellow. This leads to the hypothetical question: whether this animal had white bands when it was a juvenile, as animals of this species tend to get darker with age and the bands tend to get reduced to dots.

There is one report of specimens of *Boiga dendrophila* with white instead of yellow bands (Vogel, 2000). These animals were members of the nominate form, supposedly originating from Java or an adjacent island, and belong to a population with the offspring being white and black, with no exception. Vogel (2000) noted that *Boiga dendrophila melanota* and *Boiga dendrophila dendrophila* (Boie, 1827) are closely related, resulting in hybridisation at Vanicek (1993) (see Vogel, 2000, for an explanation). Only from these two subspecies are white, instead of yellow, banded specimens known so far. Gaulke et al. (2003 [2005]) showed a nearly melanotic animal from Sumatra (1997), but in this specimen, the reduced bands were yellow.

We do not think that this animal is a member of a white population. A population with this colouration cannot be unnoticed by snake catchers and traders in this country. It is obviously an individual variant showing an axanthic mutation and melanistic tendencies.

The second specimen has a striped instead of a banded pattern. This is not really a rare phenomenon with banded snakes. A well known example is *Lampropeltis getula californiae* (Blainville, 1835), with a banded and a striped phase. This case has been thoroughly discussed in the past (Klauber, 1936, 1944; Smith, 1943; Mayr, 1944; Dunn, 1944). A striped pattern is also known for *Pituophis melanoleucus* (Daudin, 1803). In contrast to *Lampropeltis getula*, it is rarely found in this species, but it is also a regular component of some populations (Riemer, 1958). In *Boiga dendrophila*, this colouration was not noted before and is not a phase. There is another example of a banded snake with aberrant striped specimens. Whitaker (1968) and Kuch (1991; 1993) reported on several specimens of striped *Bungarus fasciatus* (Schneider, 1801) from two widely separated localities (India and Java). In the specimen of *B. fasciatus* reported by Whitaker (1968), there were, beside the stripes, two bands across the tail. This snake was a gravid female. All neonates had a striped pattern, similar to the female. The parallelism in colouration is obvious.

Broghammer (1999) called this pattern mutation "striped mutation" and associated it with low incubation temperatures or a dominant or recessive genetic deposition. As this animal was wild caught, a genetic defect seems to be likely.

It is a mystery that such conspicuous colour variants have remained unnoticed for such a long time in a common species such as *Boiga dendrophila*. This is another example of the limited knowledge we have of the tropical fauna.

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UROPELTIS MACROLEPIS IN THE DIET OF *CALLIOPHIS NIGRESCENS*

On 25 September 2004 at 1900 h, a specimen of *Calliophis nigrescens* (Günther, 1862) was collected from the leaf litter under a shrub on the Surla Plateau in the northern part of the Madhei Wildlife Sanctuary, Goa, India. The Sanctuary is located in the Western Ghats of north Goa and is contiguous with the Amboli forests in Maharashtra to the north, Bhimgad forests of Karnataka to the east and the Bhagwan Mahaveer (Mollem) Wildlife Sanctuary to the south. It covers an area of 208.48 km^2.

Probably due to stress of capture, handling or transport, the specimen regurgitated a freshly ingested snake. Although parts of the head of this snake were partially digested, based on other scalation data, it was identified as *Uropeltis macrolepis* (Peters, 1861). The identity was also confirmed by comparing with a live conspecific specimen captured at this locality.

Oriental coral snakes are included in three genera: *Calliophis*, *Hemibungarus* and *Sinomicrurus* by Slowinski et al. (2001). There is little information on their ecology and most published information on these species is based on anecdotal observations (e.g., Takahashi and Kawamura, 1982; Anon., 1988; Mori and Hikida, 1991; Nobusaka et al., 1995; Cox, 2000). These snakes are known to primarily prey on fossorial snakes (Smith, 1943, Mattison, 1995), and in some cases, are also known to consume skinks, lizards and amphibians (Cox, 1991). Apart from this, there is a report of captive specimens of *Calliophis melanurus* being fed on *Ramphotyphlops braminus* in captivity (Vyas and Vyas, 1981). The present observation of *Uropeltis macrolepis* in the diet of *Calliophis nigrescens* is first prey record for *Calliophis nigrescens*.

I thank D. Pandey, Chief Conservator of Forests, Goa, for supporting and encouraging my work, and my friend Ryan Meredith for drawing my attention to the snake. Special thanks are due to Varad Giri and Eric Smith for their useful comments on this note.

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TWINNING IN *PYTHON MOLURUS MOLURUS* IN CAPTIVITY

The Indian rock python, *Python molurus molurus,* is one of several reptiles to have been successfully bred at the Arignar Anna Zoological Park, Chennai, India. There are several reports on management, captive breeding, gestation, clutch size, incubation, feeding and growth rates in this species (e.g., Acharjyo and Misra, 1976; Paulraj and Thiruthalinathan, 1983; Kalaiarasan and Rathinasabapathy, 1991; Sekar and Rao, 1995; Baskar et al., 1999). The first report on twining in *Python molurus bivittatus* was reported by Clark and Tytle (1983). The present study reports observation on twinning in *Python molurus molurus* for the first time in captivity.

The animals are housed in a custom-built enclosure, measuring 6.2 x 3.3 x 1.8 m. The three side of the enclosure are concrete walls and the side of the viewing gallery is covered with 8 mm glass of dimensions 3.72 x 1.26 m above the viewing glass. Perforated aluminium sheet is provided for ventilation. The door towards the service path has perforated iron sheet for cross ventilation. A cement trough of dimensions 0.92 x 0.58 m is provided inside the enclosure at ground level to provide water, and dried leaves, few logs, stones, sands are provided to facilitate moulting and to landscape the enclosure. A total of three adult female pythons, inclusive of the incubating female, are maintained in the enclosure.

The incubating female python was continuously monitored and the hatchlings measured and weighed. The twins were isolated and maintained in separate ventilated boxes to study their growth.

Mating was not observed, but on 11 April 2001, muscular contractions of the body were noticed in the gravid female, who was found in a corner of the enclosure laying eggs in the leaf litter. The clutch was left alone for natural incubation and the eggs were not manipulated. On 23 May, the female abandoned the clutch and swallowed a 1.5 kg chicken. It then resumed the position of coiling around the clutch. During this feeding interval, 30 eggs were counted. On the afternoon of 5 June, the first hatching was observed. A total of three pipped eggs were found, including one that contained the two hatchlings with a single yolk mass. The other two eggs contained a single hatchling each. The calculated incubation period was 56 days, inclusive of the hatchling day. On 6 June 2001, the remaining 25 eggs were examined and proved to be fertile. However, there were 30 to start with and three were removed on 5 June. The remaining two infertile eggs contained well developed but dead embryos. The mother abandoned the clutch and the young ones were observed emerging from the respective eggs on the 58th day. Of 30 eggs, 29 hatchlings were produced.

The python babies were released into a ca. 1 x 0.3 m plastic tray, covered with newspaper and the twin python babies were separated from the single yolk. Later liquid Wocadine™ was

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The python babies were released into a ca. 1 x 0.3 m plastic tray, covered with newspaper and the twin python babies were separated from the single yolk. Later liquid Wocadine™ was applied on the cut portion as an antiseptic. The hatchlings were found to be active and agile.

On 15 June 2001, the twins were measured and weighed. The length and weight were 55 cm and 48 gm, respectively. The length of the other hatchlings varied from 55–70, mean 61.08 cm (n = 25), and weight 78–130, mean 111.56 gm (n = 25). The twins were marked and kept separately and are being monitored.

The two siblings born at a time for a mother (twins) are due to multiple pregnancy. There are three types of twins: identical twins, fraternal twins and Siamese twins. Identical twins are extremely similar in their characters, they are developed from a single zygote and called monozygotic twins. During clevage, the zygote divides into two blastomers, the blastomer separate and each blastomere develop into a sibling (Meyyan, 1988). Fraternal twins are like ordinary brother and sisters, they develop from two independent zygotes (dizygitic twins) or (non-identical twins). Siamese twins are similar to identical twins, they develop from a single egg (monozygotic twins) and they are joined together physically.

From the above references it indicates that the python hatchlings are identical twins. Interestingly, the length and weight were similar. The sex of the twins has not been identified. This is the first report of the twins in captivity observed in this species. The literature survey revealed the rarity of identical twins in *Python molurus molurus*, and there are no published reports.

Our earlier studies revealed that while incubating, the female never abandoned the clutch (n = 6) for feeding. In the present study we observed that on the 43rd day, the female abandoned the clutch for feeding. Murthy (1990) reported that female pythons display a remarkable maternal instinct by remaining coinled around the clutch till hatchling.

Yadav (1967) observed that incubation period was 53 days, Paulraj and Thiruthalinathan (1989) noted the incubation period of 55 days at Arignar Anna Zoological Park, and Basker et al. (1999) reported 57 days at Arignar Anna Zoological Park. In present study, the incubation period was 56 days for 25 remaining eggs closely coincide with the above findings.

The clutch size varies from 8 to 100 (Daniel, 1983), Murthy (1990) reported that clutch size of python were 100 to 107. In the present study, the clutch size was 30 eggs with hatching percentage of 93.33.

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EVIDENCE FOR THE HISTORIC OCCURRENCE OF *CROCODYLUS POROSUS* SCHNEIDER, 1801 IN TONLE SAP, CAMBODIA

(with one text-figure)

Two species of crocodiles are known from Cambodia: the Siamese crocodile (*Crocodylus siamensis*) and estuarine crocodile (*C. porosus*) (Thorbjarnarson, 1992). The Siamese crocodile formerly occurred in freshwater wetlands throughout the country (Campbell, 1860; Smith, 1931; Kimura, 1969; Thuok and Tana, 1994; Thuok, 1998; Platt et al., in press), but populations are now much reduced due to habitat destruction, unrestricted hunting, and over-collecting to stock crocodile farms (Platt et al., in press). Extant populations in Cambodia are restricted to the Cardamom Mountains (Daltry and Chheang, 2000; Barr, 2002), Sre Ambel River and floodplain wetlands (Platt et al., 2003), and parts of the Tonle Sap (Platt et al., in press). In contrast to *C. siamensis*, little is known regarding the past or present distribution of *C. porosus* in Cambodia. Tirant (1885) stated that *C. porosus* was widespread in Cambodia and responsible for more human fatalities than tigers (*Panthera tigris*), but provided little specific locality data. Kimura (1969) noted that *C. porosus* occurred in Kampong Som Bay near Sihanoukville, and according to Thuok and Tana (1994), *C. porosus* was present, albeit rare in coastal habitats of Koh Kong Province. Two large adult *C. porosus* on display in the Government-owned Siem Reap Crocodile Farm (S. Platt, pers. obs.) were reportedly captured in the latter region during the early 1980's (Nao Thuok, pers. comm.).

The situation regarding *Crocodylus porosus* in Tonle Sap is equivocal; anecdotal evidence suggests that estuarine crocodiles may have formerly occurred in the lake, but verified records are apparently lacking. A Chinese diplomat living in Angkor during the 13th century mentions exceptionally large crocodiles inhabiting Tonle Sap (Chou, 1987), and Thorbjarnarson (2001) notes that Bas-reliefs at the Angkor ruins depict crocodiles attacking and eating humans, a behaviour more likely attributable to *C. porosus* (Platt et al., 2001 and references therein) than *C. siamensis*. Indeed, confirmed reports of anthrophagy by *C. siamensis* are extremely rare (Smith, 1931; S. Platt, unpubl. data). In another likely reference to *C. porosus,* villagers living on the lake described a large, aggressive crocodile known locally as *krapear* (sea crocodile) that once occurred in Tonle Sap, but disappeared 30 to 50 years ago (Platt et al., in press). Furthermore, *C. porosus* was present in the lower Mekong River and delta until recently (Cao and Jenkins, 1998; Stuart et al., 2002), and occasional upstream dispersal to the Tonle Sap is likely, especially given that transoceanic movements of over 1000 km have been reported in this species (Allen, 1974; Bustard and Choudhury, 1980). Likewise, other estuarine reptiles, such as the river terrapin (*Batagur baska*) and file snake (*Acrochordus granulatus*) are known to have historically occurred in the Mekong River system as far upstream as Tonle Sap (Saint Girons, 1972; Platt et al., 2003). Herein we provide physical evidence for the past occurrence of *C. porosus* in Tonle Sap.

Tonle Sap (Great Lake), located in the central plain of Cambodia, is the largest permanent freshwater lake in south-east Asia, and linked to the Mekong River system by the Tonle Sap River near Phnom Penh (Scott, 1989; Giesen, 1998). The areal extent of Tonle Sap varies widely depending on the season; during the dry months (December to mid-May) it covers 250,000 to 300,000 ha, expanding to 1.3 million ha at the height of the wet season when floodwaters from the Mekong River fill the lake (Scott, 1989; Giesen, 1998). Extensive seasonally flooded wetlands consisting of swamp forest, wet shrub lands, and open marshland surround the lake (MacDonald et al., 1997). The Tonle Sap ecosystem is described elsewhere in greater detail (Scott, 1989; MacDonald et al., 1997; Platt et al., in press).

In May 2004, we obtained the left mandible of an adult crocodile from a local villager (Fig. 1). The mandible was found by the villager during April 2004 in swamp forest near Koh Ray (ca. 13°15'N; 103° 48'W), a remote hamlet on the northern shore of Tonle Sap approximately 6 km E of Port Choeng Khneas. This specimen is currently on display in the natural history col-

Figure 1. Left crocodile mandible found by a villager in swamp forest surrounding Tonle Sap in Cambodia. The mandibular length (86.0 cm) indicates this bone is from a large, adult estuarine crocodile (*Crocodylus porosus*).

lection of the GECKO (Greater Environment of Choeng Khneas Organization) Environment Center in Choeng Khneas. Based on the weathered appearance of the bone, we estimate the mandible to be 25 to 50 years old. However, in the absence of detailed information on how taphonomic processes (Behrensmeyer, 1978) affect crocodile bone, our estimate should be regarded as wholly subjective and we lack the means to make a more accurate determination at this time.

The straight-line mandibular length (ML) of the Tonle Sap specimen measures 86.0 cm. To our knowledge, *Crocodylus porosus* and *C. siamensis* cannot be distinguished solely on the basis of mandibular characteristics, but the ML suggests this mandible is that of a large adult *C. porosus*. Regression equations that relate ML to skull length (SL), head length (HL), snout-vent length (SVL), or total length (TL) are unavailable for either *C. siamensis* or *C. porosus*. However, the ratio of SL to ML in four large *C. porosus* skulls from Australia ranged from 0.76 to 0.80 (Grahame J. W. Webb, unpubl. data). Using the median value of 0.78, the SL of the Tonle Sap specimen is estimated to be 67.0 cm. Because SL is generally 4 to 5% less than HL owing to tissue loss (Webb and Messel, 1978), the latter was calculated by adding 3.0 cm to SL, yielding a value of 70.0 cm. Webb and Messel (1978) found that HL predicted SVL of adult *C. porosus* by the equation SVL = 3.60 (HL) – 4.30; using a value of 70.0 cm for HL gives an estimated SVL of 247.7 cm. The TL of the Tonle Sap specimen can then be calculated by solving the equation SVL = 0.49 (TL) – 0.72 (Webb and Messel, 1978) yielding a value of 506 cm.

This value should be considered a conservative estimate of the TL of the Tonle Sap crocodile. The regression equations of Webb and Messel (1978) were derived from a sample of 1354 crocodiles ranging in TL from 25 to 425 cm; in larger *C. porosus*, HL is proportionally shorter in relation to TL and the equation relating HL to TL appears to considerably underestimate TL (Montague, 1983). Using these equations Montague (1983) found that a 620 cm *C. porosus* which he measured in New Guinea had a predicted TL of only 520 cm. Thus, it is likely that the actual TL of the Tonle Sap specimen was somewhat larger than indicated by our estimate.

Although *C. porosus* cannot be distinguished from *C. siamensis* on the basis of mandibular characteristics, the estimated TL of the Tonle Sap crocodile is consistent with the body size of *C. porosus* and considerably exceeds the maximum TL reported for *C. siamensis*. The former commonly attain total lengths of 3 to 4 m and specimens as long as 6 to 7 m are known (Daniel and Hussain, 1973; Greer, 1974; Webb and Messel, 1978; Montague, 1983). In contrast, while adult male *C. siamensis* occasionally reach 4 m (Brazaitis, 1973), most individuals do not exceed 3 m (Smith, 1931; Thorbjarnarson, 1992).

This report constitutes the first physical evidence that *C. porosus* formerly inhabited the Tonle Sap ecosystem in sympatry with *C. siamensis*. This is not unexpected; although the ecological relationship between *C. porosus* and *C. siamensis* is unknown, elsewhere (Australia, India, New Guinea, Philippines, Sri Lanka) in its extensive distribution, *C. porosus* inhabits inland freshwater wetlands with a congener (Thorbjarnarson, 1992). Unlike *C. siamensis*, of which small numbers persist in remote, inaccessible wetlands surrounding Tonle Sap, recent survey data indicate that *C. porosus* was extirpated from the lake 30 to 50 years ago (Platt et al., in press). We posit that large body size and aggressive behaviour rendered *C. porosus* especially vulnerable to over-hunting and hastened its local demise.

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FIRST RECORD OF *HEMIDACTYLUS PERSICUS* ANDERSON, 1872 (SQUAMATA: SAURIA: GEKKONIDAE) FROM THE REPUBLIC OF INDIA, WITH NOTES ON ITS DISTRIBUTION

The Persian gecko, *Hemidactylus persicus,* is widely distributed, from eastern Arabia to southern Iran, and in the east, it reaches Sindh and Waziristan in Pakistan (Smith, 1935; Anderson, 1999). In Pakistan, Minton (1966) did not record the species east of the Indus River. The species is a member of a chiefly arid zone clade of *Hemidactylus,* which also includes the widespread Mediterranean form *H. turicicus* (Carranza and Arnold, 2005). It prefers xeric habitats, especially rocky deserts, flood plains and thorny *Euphorbia* forests, and it is occasionally observed in edificarian situations (Smith, 1935).

During the study of the reptilian fauna of Gujarat State, one of the authors (RV) collected specimens of an unusual gecko in and around the Jassore Wildlife Sanctuary, Gujarat State, India. After examination it was identified as *Hemidactylus persicus* Anderson, 1872.

The Jassore Wildlife Sanctuary (JWS) is in Banaskantha District, Gujarat State, and is one of the prime habitats of the Sloth Bear, *Melursus ursinus*. The sanctuary lies between 24° 20' and 24° 31'N; 72° 23' and 72° 37'E, and encompasses an area 180.66 km^2. The area is in the most south-westerly part of the Aravalli Hills and the habitat continues into the adjacent portion of Rajasthan State. Champion and Seth (1968) classified the area as a dry deciduous mixed with dry arid and grasslands. The dominant tree species in the area are *Acacia catech* (Khair), *Acacia nilolica* (Baval), *Zizyphus sp.* (Bor), *Butea monosperma (*Khakharo*) Anogeissus latifolia* (Dhav), *Wrightia tinctoria* (Dudhalo*), Boswellia serrata* (Saledi) and *Prosopis juliflora*.

Recent survey results show that the sanctuary harbours 12 species of amphibians and 35 species of reptiles (Vyas, 2005). Four adult specimens of *Hemidactylus persicus* were collected in and around the JWS as vouchers. All were deposited in the museum of Bombay Natural History Society (BNHS 1710 to 1713), Mumbai. Measurements and pholidosis of these specimens are provided in Table 1.

This species is locally uncommon and found in and around areas used by humans, including under rocks and tree logs, on large boulders and in ruined houses along with two other congeners, *H. flaviviridis* and *H. brookii*. It is active from early to late evening, emerging from diurnal retreats to forage shortly after sunset. At present, the species has been recorded at three localities: Balundra village, Forest Guest House and the campus of the Kedarnath Shrine; the last two localities lie within the protected area.

If this species is naturally distributed in and around the tropical deciduous forest of Jassore, it is possible that *Hemidactylus persicus* is distributed in other parts of the state from Kachchh to northern Gujarat and most probably adjacent areas of Rajasthan State, which share similar habitats. Therefore, a survey is needed to determine the actual distributional range of the species, especially in two protected areas, namely Balaram-Ambaji Wildlife Sanctuary, Gujarat and Abu Wildlife Sanctuary, Rajasthan, that provide environments similar to that at Jassore. Further, survey in such protected areas, relatively free of human disturbance, would help to rule out the possibilities that *H. persicus* has become established in India through human agency as have several of its congeners in other parts of the world.

The present localities of JWS and its environs in the Banaskantha District of Gujarat State are east of Indus River at an approximate airline distance of 600 km from Karachi, Pakistan, previously the most south-easterly recorded locality for the species. *Hemidactylus persicus* has not previously been recorded from Gujarat (Gayen, 1999; Vyas, 2000; Sharma, 2000), nor from the Republic of India (Murthy, 1990; Tikader and Sharma, 1992; Sharma,

Table 1. Morphometrics of *Hemidactylus persicus* from Jassore Wildlife Sanctuary, Banaskatha District, Gujarat, India. Measurements in mm. Bombay Natural History Society = BNHS catalogue numbers.

	BNHS 1710	BNHS 1711	BNHS 1712	BNHS 1713
	30 Mar. 2003 Balundra	17 Oct.2003 Balundra	26 Jan. 2004 Balundra	1 Nov.2004 Kedarnath
Tip of snout to vent	52.00	48.00	54.00	54.00
Vent to tail tip	65.00	49.00	70.00	43.00
Distance between angle of jaw and snout tip	09.32	07.82	09.30	08.34
Angle of jaws	09.80	09.56	10.00	09.00
Distance between fore limb and hind limb	23.00	21.78	25.00	17.48
Greatest diameter of eyes	03.60	03.14	03.84	02.90
Distance between anterior-most point of eye and nostrils	04.78	04.28	05.00	04.46
Distance between anterior-most point of eyes and tip of snout	06.24	05.72	06.52	05.80
Anterior edge of ear opening to posterior-most point of eyes	04.70	03.82	04.60	03.50
Greatest diameter of ear opening.	01.10	01.28	01.28	01.20
Distance between nostrils	01.60	01.70	01.90	01.70
Upper labials R/L	11	11	11	10/11
Lower labials R/L	9/8	8/8	9/9	8/8
Dorsal body tubercle rows	14	14	14	14
4th digit lamellae	9	10	10	10
4th toe lamellae	14	13	13	12
Numbers of wax glands & position of preanal	8	--	--	--
Sex	M	F	F	F

2002), thus, the records presented here represent not only a significant eastern range extension for the species, but also new state and national records.

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LEPIDODACTYLUS (SQUAMATA: GEKKONIDAE) IN ISLANDS ASIA: A *L. AUREOLINEATUS* FROM SULAWESI

Lepidodactylus geckos are modestly abundant lizards in many Oceania herpetofaunas but become increasingly uncommon to rare in the faunas of the larger islands and island groups of the Pacific Rim, and even more uncommon in Islands Asia. This rarity has no current explanation, nor am I aware that anyone has attempted to explain it. Thus, a specimen of *Lepidodactylus* from Sulawesi in the Naturalis collection was unexpected.

Presently, four species of *Lepidodactylus* are reported from Islands Asia. *L. lugubris* is the most widespread of these four and occurs in Cu Lao (Vietnam), Borneo, Sulawesi, Ambon, Halmahera, Ternate, Komodo, and Lombok in this area (Ineich, 1999). Because of its occurrence also throughout the Pacific and coastally from other Asian islands and mainland (de Rooij, 1915), *L. lugubris* must be considered an exotic species, probably beginning its human-mediated dispersal within the last five centuries through European shipping. Its hybrid origin lies in east-

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Lepidodactylus geckos are modestly abundant lizards in many Oceania herpetofaunas but become increasingly uncommon to rare in the faunas of the larger islands and island groups of the Pacific Rim, and even more uncommon in Islands Asia. This rarity has no current explanation, nor am I aware that anyone has attempted to explain it. Thus, a specimen of *Lepidodactylus* from Sulawesi in the Naturalis collection was unexpected.

Presently, four species of *Lepidodactylus* are reported from Islands Asia. *L. lugubris* is the most widespread of these four and occurs in Cu Lao (Vietnam), Borneo, Sulawesi, Ambon, Halmahera, Ternate, Komodo, and Lombok in this area (Ineich, 1999). Because of its occurrence also throughout the Pacific and coastally from other Asian islands and mainland (de Rooij, 1915), *L. lugubris* must be considered an exotic species, probably beginning its human-mediated dispersal within the last five centuries through European shipping. Its hybrid origin lies in eastern Micronesia and is relatively recent (Radtkey et al., 1996). The other species are older island residents, arriving and differentiating presumably well before the arrival of humans in Asia. These species have limited distributions: *L. lombocensis*, Lombok; *L. intermedius*, Komodo and Rintja Islands.; *L. ranauensis*, Borneo (Sabah). Another species, *L. listeri*, occurs to the west on Christmas Island in the Indian Ocean.

The preceding five taxa represent the three phenetic groups (Brown and Parker, 1977) of *Lepidodactylus*. *L. lugubris* is a Group III member, *L. intermedius* and *L. lombocensis* Group II, *L. listeri* Group I, and *L. ranauensis* intermediate between Group I and II (Ota and Hikida, 1988; Bauer, 1994; Ota et al., 2000). Group III appears to be most derived "clade" of *Lepidodactylus*, and with the exception of *L. lugubris*, Group III members occur on Pacific islands with the greatest diversity in the Philippines. The Naturalis specimen (RMNH 7341, Groot Sanghis, e/o [= vicinity of] Soemalata) from the north coast of Sulawesi was hidden under the *lugubris* epithet but a close examination revealed its misidentification and dissection revealed that it was a mature male. My initial assumption was that this specimen represented a new species, but further examination revealed it to be a *L. aureolineatus* and a likely introduction from the Philippines.

Brown and Alcala (1994:78–101) provide a thorough overview of the Philippine *Lepidodactylus*. They recognize two sections of Group III *Lepidodactylus*. Section A geckos have 4ToeL (see Zug et al., 2003 for character abbreviations and definitions) greater than 12, tail only moderately depressed and no lateral skin flange, and combined femoral-precloacal pores greater than 26. RMNH 7341 has 13 4ToeLm, moderately depressed tail without flange, and 29 FemPor + PreclPor. Additionally, it has 115 Midb, which differentiates it from *L. herrei*, the other section A *Lepidodactylus*. In summary, RMNH 7341 is an adult male with large testes and epididymides, 35.7 mm SVL, 15.7 mm TrunkL, 42 mm TailL (regenerated tip), 9.4 mm HeadL, 6.5 mm HeadW, 9 Suplab, 8 Inflab, 3 CircNa, 31 IntorbS, 2 CloacS, 16 PreclP, and 8 4FingLm.

The northern peninsula of Sulawesi is ca. 400 km from southern Mindanao and linked by an arc of islands (Kepulauan Sangihe). This arc might have permitted natural dispersal; however, regular boat traffic occurs between these two coasts (C. A. Ross, pers. comm. Sept. 2005). As a regular resident of coconut palms and aerial ferns, individuals of *Lepidodactylus aureolineatus* might commonly be transported to Sulawesi. Fortuitously, a single individual was captured and preserved by a Dutch biologist in the late 1930s.

I wish to thank M. Hoogmoed and J. W. Arntzen for assisting my study of the specimens in the Netherlands' National Museum of Natural History (Naturalis, RMNH). I also appreciate H. Ota's careful reading and comments for improving this manuscript; in review, A. M. Bauer, I. Ineich and R. M. Brown further clarified my statements. My research into the biology and evolution of the Pacific and Australasian herpetofauna has been supported by the Smithsonian's Scholarly Studies Program, the Research Opportunity Fund of National Museum of Natural History and the NMNH Department of Vertebrate Zoology.

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ASIAN PITVIPERS

by Andreas Gumprecht, Frank Tillack, Nikolai Orlov,
Ashok Captain and Sergei Ryabov. 2004.
Geitje Books, Berlin. 368 pp., 1179 col. figs. ISBN 3-937975-00-4.
Email: www.geitje-books-berlin.de. Price: Euro 59.00.

At last there is a beautiful encyclopaedia of the crotaline pitvipers of Asia. This book would have been better entitled "A Photographic Atlas of Asian Pitvipers" because that more accurately describes its contents. The majority of photographs were taken by A. Captain, W. Grossmann, A. Gumprecht, N. Orlov and F. Tillack, who provided the excellent photographs in other books such as Chan-ard et al. (1999), Orlov et al. (2002) and Whitaker and Captain (2004). This hardbound book is large (29.5 x 21.0 x 3.0 cm) with 312 pages of photos printed on heavyweight, glossy paper that enhances the spectacular photography. Additionally there are 42 pages of text (including a 26 page checklist of genera and species), an eight page bibliography, a four page index and two pages of photo credits. Four pages of scale counts include summary statistics on dorsal scale rows, supralabials, ventrals and subcaudals for each taxon, the latter two separated for males and females and rare states for the former two listed parenthetically.

Included in the checklist are the original citation, designation of the type locality, listing of the type material by museum and catalog number, distributional range by country and state, a list of significant references pertaining to the taxon and systematic comments noting recent taxonomic changes or controversial opinions regarding the taxon status. Unfortunately, since a revision of Asian pitviper taxonomy (Malhotra and Thorpe, 2004) was not published early enough for Gumprecht et al. to incorporate the latest nomenclature in their book, seven current genera (three revalidated and four newly proposed) are disguised under their previous synonyms. These include *Garthius* (separated from *Ovophis*) and *Cryptelytrops*, *Himalayophis*, *Parias*, *Peltopelor*, *Popeia* and *Viridovipera* (separated from *Trimeresurus*). A conversion table on page 11 lists the 27 species and subspecies affected by the Malhotra and Thorpe (2004) paper, with their current names.

The presentation of snakes in the photographic section is in alphabetical order by genus and species exactly as in the checklist. Each page displays from one to eight photographs, artistically arranged in one or two columns. The most common page arrangement is three photos per page, followed in frequency by pages with four, five, or six photographs. A convenient feature of the book is that all of the illustrations on any given page are of a single taxon (species or subspecies). The composition of images is such that full-body shots predominate, followed in order by close-ups of the head, tail, hemipenes, egg clutches with hatching neonates and specimens in the process of feeding. The head and body photos are mainly dorsal and lateral views, less often ventral views. Adults, juveniles and neonates are figured in that order. When living material is not available, good colour photos are provided of type specimens and preserved material.

In addition to 44 alluring habitat shots in the back of the book, the number of photos of each genus is as follows: *Calloselasma* (17), *Deinagkistrodon* (12), "*Gloydius*" (97, including 12 of *Garthius*), *Hypnale* (15), *Ovophis* (87), *Protobothrops* (123), *Triceratolepidophis* (14), "*Trimeresurus*" (686, including 234 of *Cryptelytrops*, 37 of *Himalayophis*, 80 of *Parias*, 12 of *Peltopelor*, 57 of *Popeia* and 72 of *Viridovipera*), *Tropidolaemus* (71) and *Zhaoermia* (13). A breakdown of photographs by species and type follows (B = full body, H = head, T = tail, D = dorsum, V = venter, HP = hemipenis, N = neonates, F = feeding). *Calloselasma rho-*

dostoma (17: 13B, 3H, 1V), *Deinagkistrodon acutus* (12: 8B, 3H, 1N), *Gloydius b. blomhoffii* (7: 2B, 4H, 1V), *Gloydius b. siniticus* (6: 4B, 1H, 1D), *Gloydius brevicaudus* (5: 3B, 1H, 1T), *Gloydius h. halys* (4: 3B, 1H), *Gloydius h. boehmei* (5: 1B, 2H, 1D, 1V), *Gloydius h. caraganus* (3: 1B, 2H), *Gloydius h. caucasicus* (6: 4B, 2H), *Gloydius h. cognatus* (1: 1B), *Gloydius h. stejnegeri* (1: 1B), *Gloydius himalayanus* (12: 7B, 3H, 2HP), *Gloydius intermedius* (9: 7B, 2H), *Gloydius monticola* (11: 2B, 7H, 2V), *Gloydius shedaoensis* (10: 10B), *Gloydius strauchi* (3: 3B), *Gloydius tsushimaensis* (2: 1B, 1V), *Gloydius ussuriensis* (12: 7B, 4H, 1D), *Hypnale hypnale* (3: 1B, 2H), *Hypnale nepa* (5: 1B, 3H, 1T), *Hypnale walli* (7: 3B, 4H), *Ovophis* (= *Garthius*) *chaseni* (12: 4B, 7H, 1V), *Ovophis m. monticola* (21: 13B, 4H, 1V, 1N, 2HP), *Ovophis m. convictus* (6: 6B), *Ovophis m. makazayazaya* (6: 3B, 3H), *Ovophis m. orientalis* (6: 5B, 1H), *Ovophis m. zhaokentangi* (3: 1B, 2H), *Ovophis okinavensis* (12: 10B, 2H), *Ovophis tonkinensis* (11: 8B, 3H), *Ovophis zayuensis* (4: 2B, 2H), *Protobothrops cornutus* (10: 4B, 6H), *Protobothrops elegans* (16: 14B, 2H), *Protobothrops flavoviridis* (20: 12B, 8H), *Protobothrops j. jerdonii* (10: 6B, 3H, 1V), *Protobothrops j. bourreti* (12: 10B, 1H, 1HP), *Protobothrops j. xanthomelas* (9: 7B, 2H), *Protobothrops kaulbacki* (11: 3B, 8H), *Protobothrops mucrosquamatus* (16: 11B, 4H, 1HP), *Protobothrops tokarensis* (14: 12B, 2H), *Protobothrops xiangchengensis* (5: 3B, 2H), *Triceratolepidophis sieversorum* (14: 7B, 5H, 1V, 1HP), *Trimeresurus* (= *Cryptelytrops*) *albolabris* (37: 31B, 5H, 1HP), *Trimeresurus* (= *Cryptelytrops*) *andersoni* (19: 8B, 10H, 1V), *Trimeresurus* (= *Cryptelytrops*) *cantori* (21: 10B, 9H, 2V), *Trimeresurus* (= *Cryptelytrops*) *erythrurus* (13: 7B, 4H, 1T, 1D), *Trimeresurus* (= *Cryptelytrops*) *fasciatus* (11: 8B, 2H, 1T), *Trimeresurus* (= *Cryptelytrops*) *insularis* (16: 11B, 5H), *Trimeresurus* (= *Cryptelytrops*) *kanburiensis* (24: 13B, 11H), *Trimeresurus* (= *Cryptelytrops*) *labialis* (16: 7B, 4H, 5V), *Trimeresurus* (= *Cryptelytrops*) *macrops* (31: 24B, 7H, 1T, 1V), *Trimeresurus* (= *Cryptelytrops*) *purpureomaculatus* (17: 12B, 3H, 1T, 1V), *Trimeresurus* (= *Cryptelytrops*) *septentrionalis* (13: 7B, 4H, 1T, 1V), *Trimeresurus* (= *Cryptelytrops*) *venustus* (16: 10B, 5H, 1HP), *Trimeresurus* (= *Himalayophis*) *tibetanus* (37: 22B, 12H, 1T, 2HP), *Trimeresurus* (= *Parias*) *flavomaculatus* (25: 14B, 5H, 2T, 1D, 1V, 2HP), *Trimeresurus* (= *Parias*) *hageni* (23: 16B, 5H, 1T, 1V,), *Trimeresurus* (= *Parias*) *malcolmi* (5: 5B), *Trimeresurus* (= *Parias*) *schultzei* (9: 2B, 5H, 2T), *Trimeresurus* (= *Parias*) *sumatranus* (18: 10B, 5H, 1T, 1V, 1HP), *Trimeresurus* (= *Peltopelor*) *macrolepis* (12: 4B, 8H), *Trimeresurus* (= *Popeia*) *p. popeiorum* (37: 23B, 8H, 1T, 5V), *Trimeresurus* (= *Popeia*) *p. barati* (8: 3B, 2H, 1T, 2V), *Trimeresurus* (= *Popeia*) *p. sabahi* (12: 5B, 2H, 5F), *Trimeresurus borneensis* (21: 10B, 5H, 2T, 2D, 2V), *Trimeresurus brongersmai* (6: 1B, 4H, 1D), *Trimeresurus gracilis* (6: 4B, 2H), *Trimeresurus gramineus* (29: 13B, 13H, 1T, 2V), *Trimeresurus malabaricus* (20: 8B, 9H, 1T, 2V), *Trimeresurus mcgregori* (21: 17B, 2H, 2V), *Trimeresurus puniceus* (25: 15B, 8H, 2N), *Trimeresurus strigatus* (23: 6B, 13H, 1T, 3V), *Trimeresurus trigonocephalus* (21: 16B, 3H, 1T, 1V), *Trimeresurus* sp. 1 (14: 7B, 5H, 1T, 1V), *Trimeresurus* sp. 2 (8: 4B, 2H, 2F), *Trimeresurus* (= *Viridovipera*) *gumprechti* (28: 14B, 6H, 2T, 5V, 1HP), *Trimeresurus* (= *Viridovipera*) *medoensis* (12: 3B, 2H, 5V, 2HP), *Trimeresurus* (= *Viridovipera*) *s. stejnegeri* (16: 7B, 5H, 1T, 2V, 1HP), *Trimeresurus* (= *Viridovipera*) *s. chenbihuii* (2: 2B), *Trimeresurus* (= *Viridovipera*) vogeli (11: 8B, 1H, 1D, 1V), *Trimeresurus* (= *Viridovipera*) *yunnanensis* (3: 2H, 1D), *Tropidolaemus huttoni* (6: 1B, 4H, 1D), *Tropidolaemus wagleri* (65: 40B, 22H, 1D, 2V) and *Zhaoermia mangshanensis* (13: 7B, 2H, 2T, 1D, 1N).

A major criticism of this book is the complicated method used to number the plates. The difficulty in citation is exacerbated due to the large number of photos in the book, presenting a challenge for others to cite clearly and succinctly. The authors' chose not to number each figure consecutively (and uniquely) with Arabic numerals, or each page as a plate with figures A, B, C, etc., as is typically done. Instead, they number each figure on every page starting with Roman numeral I so that every page has photos numbered from I–VIII on it. The only page reference is the page number itself, so in order to designate a photo two values are needed.

In order to cite the seventh figure on page 298 (ventral view of *Trimeresurus strigatus* syntype) one has to write something like "p. 298 no. VII," "fig. 298–VII," or "fig. 298.VII." This is surely cumbersome and fraught with potential for error.

Two minor criticisms include the lack of synonymies for all taxa and the lack of identification keys to the genera and/or species. The present authors only provide the original combination for each species or subspecies. In a work of this magnitude, as a research reference, the citation of synonymies of different names, junior synonyms, and various combinations is extremely important. Without a good synonymy it is difficult or impossible to assign names from the literature and determine which taxon is being discussed in older works. Therefore, two recent compilations are essential companions to the present atlas: David and Ineich (1999) and McDiarmid et al. (1999). Changes in the taxonomy followed by "Asian Pitvipers" from that presented in McDiarmid et al. (1999) are that the genera *Protobothrops* and *Zhaoermia* are recognized, the species *Gloydius brevicaudus*, *Ovophis tonkinensis*, *O. zayuensis*, *Trimeresurus andersoni*, *T. insularis*, *T. malcolmi*, *T. mcgregori*, *T. venustus*, and *T. yunnanensis* are recognized, the subspecies *caucasicus* and *stejnegeri* are transferred from *Gloydius intermedius* to *G. halys*, *Gloydius saxatilis* is synonymized with *G. intermedius*, *Trimeresurus karanshahi* is synonymized with *T. tibetanus*, and *Gloydius tsushimaensis*, *Trimeresurus gumprechti*, and *T. vogeli* are included.

In a monumental work such as this, which will obviously be the volume on Asian Crotalinae for years to come, it is to be expected that a key to at least the included genera and possibly also the species be included. Such keys should not have been difficult to produce considering the authors' experience and vast array of excellent photographs. Lastly, one taxon has been apparently overlooked (*Gloydius blomhoffii dubiatus* Gloyd, 1977) and several typographical errors were spotted: p. 11 *Cryptelytrops andersonii* vs. *Cryptelytrops andersoni* and p. 41 *Tropidolaemus wagleri* Boie, 1827 vs. *Tropidolaemus wagleri* (Boie, 1827).

Some of the photographs (or nearly identical photos) in this book were previously published in other works, as follows: *Calloselasma rhodostoma* – 45 IV = Chan-ard et al., 1999 (192 middle), 46 II = Chan-ard et al., 1999 (192 top), 46 I = Orlov et al., 2002 (fig. 3); *Deinagkistrodon acutus* – 49 I = Orlov et al., 2002 (fig. 4); *Ovophis monticola monticola* – 93 III = Orlov et al., 2002 (fig. 5); *Ovophis monticola convictus* – 96 I = Orlov et al., 2002 (fig. 6); *Ovophis tonkinensis* – 106 II = Orlov et al., 2002 (fig. 8); *Protobothrops elegans* – 117 V = Orlov et al., 2002 (fig. 9); *Protobothrops flavoviridis* – 119 II = Orlov et al., 2002 (cf. fig. 10); *Protobothrops jerdonii xanthomelas* – 130 III = Orlov et al., 2002 (cf. fig. 12); *Trimeresurus albolabris* – 152 II = Orlov et al., 2002 (fig. 14); *T. andersoni* 158 III = Whitaker and Captain, 2004 (458); *T. cantori* – 168 II, 169 I, 169 III, 170 I–II, 171 II, 172 III, and 173 IV = Whitaker and Captain, 2004 (449 top, 447 left, 450, 449 bottom, 453, 449 middle, 451 left, and 451 right); *T. erythrurus* – 176 I and 177 I = Whitaker and Captain, 2004 (461 top, bottom); *T. hageni* – 208 I = Orlov et al., 2002 (fig. 17); *T. labialis* – 222 I, 222 IV, 223 II, 224 I, and 225 II = Whitaker and Captain, 2004 (467 lower right, 468 left, 469, 468 left, and 467 upper left); *T. macrops* – 232 III = Orlov et al., 2002 (fig. 20); *T. malabaricus* – 243 III = Whitaker and Captain, 2004 (431 lower left); *T. medoensis* – 255 III = Whitaker and Captain, 2004 (441 left); *T. stejnegeri stejnegeri* – 293 II = Orlov et al., 2002 (fig. 22); *T. strigatus* – 298 I–II = Whitaker and Captain, 2004 (435 left and right); *T. tibetanus* – 305 III = Orlov et al., 2002 (cf. fig. 18 as *T. karanshahi*); *Tropidolaemus wagleri* – 328 III = Orlov et al., 2002 (fig. 24).

Several recent papers have relevance to this book. David et al. (2004) have supported the validity of *Cryptelytrops kanburiensis* and *C. venustus*. Orlov et al. (2004) have described a new "*Trimeresurus*" species from Vietnam: *T. truongsonensis*. Since it resembles and is presumably related to *Cryptelytrops kanburiensis* and *C. venustus*, it should be referred to that genus. Vogel et al. (2004) revised the "*Trimeresurus*" *popeiorum* complex and described two new species, "*T.*" *fucatus* and "*T.*" *nebularis*, and regarded two subspecies as good species, "*Trimeresurus*" *popeiorum barati* and "*T.*" *p. sabahi*. Following Malhotra and Thorpe (2004), they should be known as *Popeia barati*, *P. fucatus*, *P. nebularis* and *P. sabahi*.

"Asian Pitvipers" fulfills a much needed and long awaited niche, that being the dearth of good quality photographs of Asian Crotalinae. Not only is this book a superb bargain, based on the quantity and quality of the colour photographs, but it is an essential component of the library of every herpetologist, all Asian toxicologists and medical doctors, and any biologist or naturalist interested in the Eastern Hemisphere. It is an invaluable reference to the pitvipers of Asia with excellent photographs to aid in the identification of any species. I highly recommend this book for the scientist and layman alike.

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SNAKES OF INDIA: THE FIELD GUIDE

by Romulus Whitaker and Ashok Captain. 2004.
Draco Books, Chengalpattu. xiv + 479 pp., 499 col. photos.
Hardback, 15 x 22 cm, with coloured boards.
Email: draco@vsnl.com. Price: $49.95

At last there is a beautifully illustrated field guide to the snakes of India, covering 157 species in full colour, that is economically available for the lay person, hobbyist, naturalist and herpetologist alike. This is the first Indian work to provide an extensive array of high quality colour photographs of the fauna, covering nearly 60% of the known species. It is also the first original illustrated work during the past 60 years, since the publication of Smith's (1943) monumental opus. Since then there have only been a few major Indian works, none of which have good colour photographs. Daniel (1983) discusses common Indian snakes and reproduces 27 colour plates from Wall (1905–1919), Mahendra (1984) is essentially a revised form of Smith (1943), Murthy (1986) and B. Sharma (1998, 2002) contain checklists of all Indian species, and R. Sharma (2003) is a nice work with identification keys but with poor quality photos of only a few of the included species (and no close-ups showing details of head scalation).

Each species account begins with the common name and Latin name, whether it is common, uncommon or rare, and its maximum length. When known, the hatchling length and average length are also provided. The account then provides a colour description, a synopsis of scalation features, and a section on natural history and behavior. The distribution section includes a listing of each Indian province where the species is known to occur, its extralimital range, its known elevation range, and a range map. Each account is accompanied by at least one full page photo of the species in question, often with a close-up of the head. Some species have two to five pages of colour photos. Most of the venomous species are covered by three to four pages of colour photos. The snakes in all photos are indicated to be either adults or juveniles, and their origin is presented. Three colour codings are employed as borders: green for harmless snakes, orange for mildly venomous species, and red for dangerously venomous snakes.

The excellent colour photographs include 244 full body shots, 168 head close-ups, 15 ventral shots, 7 tail photos, 2 scales, and 63 miscellaneous pictures. A checklist of all 275 Indian snakes is presented in tabular form, noting their common names and (if different) previous names as used by Malcolm Smith (1943). There is one index of common names and one of Latin names. The taxonomy is up-to-date with the usage of *Grypotyphlops* for the giant blind snake, *Coelognathus*, *Euprepiophis* and *Orthriophis* for species formerly included in the composite *Elaphe*, and *Sinomicrurus* for MacClelland's coral snake.

There is hardly anything to criticize in this work. The common name for members of the Typhlopidae should be blind snakes rather than worm snakes, which is reserved for the Leptotyphlopidae (Wallach, 2003). Both *Elaphe frenata* and *E. prasina* belong in *Gonyosoma* as they exhibit the same lung structures as *G. oxycephala* (Wallach, 1998). The only thing missing from this book is an identification key to families, genera and/or species. Since most field guides do not go into such detail, one cannot justifiably criticize the authors for this omission. However, it would be fairly easy to construct keys based on the data and photos presented in the book.

This is the most valuable resource on Indian ophiology ever published. Printed on glossy, high quality paper (unlike previous Indian monographs) and well-bound with sewn signatures, this book will last many years of use and not fall apart. It is difficult to imagine how many pains-taking hours must have gone into obtaining the photographs from living subjects. They are of such quality that one can accurately count scale rows, examine the minutest details of the head shields, and note the variation in the colouration of the iris of the eyes. One cannot acclaim too much the unparalleled photography in this book as it sets a new standard in the field of herpetology. Although too small in size to be classified as a "coffee table" book, it surely fits that genre. It is not only a scientific treatise but also a genuine work of art that is an essential part of any herpetology, natural history or Indian library. Order your copy today: you will not be disappointed. And as an added bonus you will receive one free copy for every five that you purchase!

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CROCODILES: INSIDE OUT A GUIDE TO THE CROCODILIANS AND THEIR FUNCTIONAL MORPHOLOGY

by Ken C. Richardson, Grahame J. W. Webb, & Charlie S. Manolis, 2002.
Published by Surrey Beatty & Sons (Australia), Chipping Norton. 172 pp. ISBN 0 949324 90 6.
Hardcover with dusk jacket. 29.5 x 21.5 cm. Available from: Nottingham University Press, Manor Farm, Church Lane, Thrumpton, Nottingham NG11 0AX, United Kingdom,
Tel: + 44 (0) 115 9831011; Fax: + 44 (0) 115 9831003. Price: £45.00

This book is a welcome addition to the anatomy and physiology of crocodilians in general based on the saltwater crocodile (and the Aussie freshie to a lesser degree). A zoo curator, veterinarian, croc researcher, or anyone who has an interest in what makes a crocodile tick, how it functions, and why it does what it does, can literally spend hours poring through it.

The Introduction covers species specific details, illustrated with world class photographs, some of the best we've ever seen. The species descriptions are complete, with interesting tidbits on locomotion, threats, and nesting biology. The only problem we could see was concerning the mugger, where the authors note that two clutches are laid in the same season; this is possibly an artifact of captivity, having only been recorded at the Madras Crocodile Bank and not yet in any wild population.

Next is a guide to dissection, which provides the most (and as far as we know, the only) thorough croc dissection guidelines. In combination with Huchzermeyer's (2003) book, this guide can be used to compare normal visceral anatomy, and identify organ pathology. The section on integument addresses histology of the skin at superficial and deep levels, embryonic skin development, thermoregulation, the time honored tradition of scute clipping, and integumentary sense organs. The role of the dorsal integumentary glands is of interest, a manipulation experiment at the Croc Bank involving salty eggs transplanted into a Siamese crocodile nest resulted in the female treating the salties as if they were her own. The section on skeletal elements is an expanded version of Iordansky's (1973) work, with very detailed descriptions of the axial and appendicular skeleton. Included in this chapter are sections on survival, morphological age indicators (longbone, osteoderm, and vertebral ageing), plus growth and population recovery in the Northern Territory.

Divided into axial and appendicular sections, the chapter on musculature is again dealt with in depth, and covers much of what we already know, with additional observations integrated by the authors from their own experience. The final section in this chapter on meat cuts provided mouth watering evidence that taste buds on our tongues are superior in density to that of the crocodilia. Appendices at the end of the book provide, in similar format to Chiasson (1962), details on the origin, insertion and action of the muscles. The cardiovascular system chapter is a succinct review of what is known about the anatomy and function of the crocodilian heart, with diagrams of arterial and venous distribution, essentially similar to those illustrated by Chiasson (1962). Blood sampling is dealt with briefly, and we question the effectiveness of post-occipital sinus collection. Numerous attempts at the Croc Bank (including with salties) have been disappointing, which left us wondering if crocs are able to shunt blood away from this sinus. The chapter concludes with a section on diving, describing the physiological and anatomical changes to the body, and basic descriptions of the function of the thymus and spleen.

The following chapter on the respiratory system provides a detailed analysis, from the nostrils to the lungs, with descriptions of the palate, larynx, and trachea which lie in between the two. The cilia lining the inner wall of the trachea are unmentioned here but are covered in the later chapter on histology. The chapter concludes with an excellent description of vocalization by Adam Britton, which covers sound production, purposes, and the degree to which sound is used. A chapter on the digestive system follows, with the expected information on stomach, the duodenum, and sections of the intestine. In the section on digestion, the authors discuss problems related to reduced ambient temperatures following a large meal. This has been observed first hand by us, and it's the first time we have seen it discussed in text. The schematic diagram of the viscera on page 90 places the fat body a little too anterior for a mugger; it would align itself just caudal and left to the anterior portion of the left kidney, but may well be differently placed in salties.

Next is a chapter on the urogenital system, and while the authors are careful to be concise, it combines information from many sources on crocodilian male and female reproductive cycles. The section on eggs sums up the pioneering egg research work in the classic "Wildlife Management: Crocodiles & Alligators" (1987), along with recent observations by the authors on development within the female prior to laying and the role of the extraembryonic membranes in embryo development. The section on sex determination discusses the effects temperature, gaseous exchange, and moisture levels have on embryo development, followed by a review of sex determination patterns in crocodilians. Of interest is that constant temperature experiments of Australian freshies never produce above 39% males, and production of >80 % males in natural nests is related to gradually increased temperature through development.

Next is a section on osmoregulation, and the ageing of embryos in the egg by way of the opaque band, candling (which reveals blood vessel development in the chorioallantois), morphology, and morphometrics. This final section reveals the need for embryos to be corrected to egg size at the final third of incubation, as larger hatchlings take longer to complete development and brings up the point that the use of different relationships may be needed that reflect the change in head shape; this will undoubtedly alter methodologies used in the past that were based on simple measurements not taking into account the above variables. The chapter on the nervous system and special senses begins appropriately, with functions of different parts of the brain, description, and related anatomy, complete with Romer's (1956) diagram of the crocodilian brain. This is followed by a section on peripheral nerves throughout the body. The section on special senses first covers vision, where the eyeball, eyelids, nictitating membrane, retina, iris, and retinal tapetum are described. It is noted that the nictitating membrane is an adaptation for underwater vision, and this observation is interesting as there are both arguments for and against (Fleishman & Rand 1989) this function. Next is a description of hearing, with a detailed sketch of the inner ear, and the text covers the upper ear flap to the vestibular nerve. The section on olfaction describes location of the olfactory epithelia, the role of dorsal integumentary glands in hatchlings, the chin and paracloacal glands and their role in breeding behavior and possible sibling recognition. Finally, mechanoreception is discussed, with emphasis on integumentary sense organs as detectors of vibration, movement, touch, and infrasound. The final chapter on histology by Ken Richardson and Shane Raidal is, as noted in another review of this book (Vliet 2003), the first systematic coverage of crocodilian histology. Covered are histology of the integument, musculoskeletal system, and nervous system. Of much use here is that features are described *in situ* relative to their location and structure, prior to diving into detailed descriptions of the microanatomy.

All in all, here is the companion volume to all the previous books and scattered references on crocodilians which touch upon or are confined to specific aspects of croc anatomy and physiology. No serious student of the archosaurs should be without it.

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GUIDE TO THE AMPHIBIANS AND REPTILES OF JAPAN

Richard C. Goris and Norio Maeda. 2004.
Krieger Publishing Company, Malabar, Fl, U.S.A.
viii + 285 pp. ISBN 1–57524–085–8. Hardcover.
Available from: Krieger Publishing, P. O. Box 9542, Melbourne, Florida 32902–9542, U.S.A. Email: info@krieger-publishing.com. Price: 52.95 UK Pounds or US$ 69.50.

Back in 1966 I was a U.S. Army lab tech at the 406th Medical Lab in Camp Zama, Japan and desperate to escape my dreary routine and do some field work. I had heard about herpetologist Richard Goris (then Father Goris) at Shinjuku University and got myself a weekend pass to visit him. I had been starving for the chance to see some reptiles and to just sit and talk herps with someone. The best I could elicit from my Army buddies was: “Yeah, the only good snake is a dead one” or “We learned how to kill, cook and eat snakes in survival school; they taste like chicken!”

Dick Goris had a great collection of snakes in his apartment at the University, where he was then teaching. One snake I distinctly remember was a gorgeous two meter long Sakishima Beauty Snake (*Elaphe taeniura schmackeri*). I also remember that it was late autumn and to me it felt too cold for any herps to be out. Dick just shrugged as we put our warm coats on and went tromping off through rice paddies and past tiny streams. That night I was introduced to the Japanese Fire-bellied Newt (*Cynops pyrrhogaster*) and two of the 16 salamanders found in the islands. I also learned about the Red-sided Water Snake (*Rhabdophis tigrinus*) and its toxic saliva!

At the start of the Guide, the authors describe the devastation of the Japanese countryside, especially the traditional "yato" or terraced rice fields, the main habitats of herpetofauna there. It's a bit of an eye-opener that this seemingly clued-in nation takes so little care of its unique amphibians and reptiles (though Japan is also known for its continued use of ivory, tropical hardwood and whale meat). The four pages at the start,"The Herpetological Environment in Japan", leave the reader craving for more introductory paragraphs, especially at the start of each new section. We want words of general wisdom about this little known (at least to us) geographic region.

I'd like to know things like how many species of herps there are in total and how they are distributed. Fortunately, each species description has a very clear range map showing the Japanese "mainland" (mainly temperate) and the many smaller island groups (some tropical). So it just took a few minutes to compile the following table.

	Total number	Total in Japanese mainland
Salamanders and newts	20	15
Frogs and toads	42	18
Turtles (including sea turtles)	10	5
Lizards	32	8
Snakes (including sea snakes)	43	8
Total	147	54

A table like this is revealing because it shows you just how few herps, snakes and lizards in particular, live on the Japanese Mainland and how (predictably) rich are the tropical islands.

Having dispensed with my main grouse, it is nice to be able to report that the Guide fulfils the objective of describing and illustrating all of Japan's amphibians and reptiles. The pictures by Norio Maeda are often brilliant, always adequate, with only a few being dull or lost in the noisy background.

The book layout is spot on (maps and pictures coincide with descriptions) with Krieger's usual high quality paper and tough binding.

The species description format is: Annotated scientific name; Japanese and English common names; Identification (description); Confusing Species; Distribution (extralimital would have been helpful); Reproduction; Voice (toads and frogs); Habits and finally Notes. The book ends with a useful Bibliography and Index.

Japan's herpetofauna contains surprises like the giant salamander. Imagine a five-foot long amphibian that lives for over 70 years! Japan's Turtle-headed Sea Snake (*Emydocephalus iijimae*) feeds exclusively on fish eggs and, amazingly for a sea snake, is "essentially harmless because together with the rest of its teeth, the fangs have degenerated to mere vestiges, the venom glands have shrunk and the venom has lost its potency".

Goris and Maeda's 'Guide to the Amphibians and Reptiles of Japan' is an important book for all herpetologists and naturalists in general.

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VENOMOUS SNAKES
SNAKES IN THE TERRARIUM

by Ludwig Trutnau. 2004.
Krieger Publishing Company, Malabar, Florisa, U.S.A.
xii + 340 pp. ISBN 1 – 57524 – 138 – 2. Hardcover. Price: 74.50.
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Email: info@krieger-publishing.com

Nothing is as exciting to me as seeing, for the very first time, one of the world's thanatophidia in its natural habitat. I clearly remember my first Russell's Viper, Black-tailed Rattlesnake, Papuan Taipan and King Cobra as though it were this morning. There is something awesome, beautiful, deadly and strangely unexplainable (like elusive dreams) about these creatures, that evinces the fascination many of us have for venomous snakes. I'm lucky to have worked with snakes on many continents and perhaps that's one reason why I'm not keen to keep them in captivity except perhaps for brief periods to see them eat, mate or lay their eggs.

There are thousands of other people out there with the same fascination for venomous snakes but who live in cold countries and rarely get the chance to go where their favorite snakes are found. And so the collection and international trade in snakes has grown exponentially over the past 30 years or more. The negative side of this trade is the tremendous waste of snakes' lives and the cruelty that is inherent in the business. The positive side is that responsible herpetoculturists are learning a lot about the biology of these often relatively unknown species and using the information for effective captive breeding programs.

Ludwig Trutnau has long been a familiar name as a European expert on rearing and breeding snakes in captivity and as an ace snake photographer. The first edition of "Venomous Snakes" was published in German in 1981. The present volume is a revised version of the fourth German edition published in 1998.

Following a few introductory pages, the author had a chapter titled "General Characteristics of Venomous Snakes'. This is a good general description of what differentiates a venomous from a non-venomous snake, chemistry and effects of venoms, the author's own experiences with snakebite (44 venomous bites strikes me as being a wee bit clumsy) and a fascinating discussion of immunity.

Next is a list of the 171 different species covered in the book.

The bulk of the book is the section "Species Descriptions" with the following format: Scientific Name; Identification; Length; Natural History and Habitat (which includes info on bites and venom); Husbandry and Breeding. The latter section is the main deviation from standard field guide format, the author's main focus is to familiarize the reader with facts about the snake which might help maintain it in captivity. The descriptive accounts are interesting and useful for zoo keepers and private snake breeders. There are a lot of obscure and fascinating facts, obviously gleaned from the literature, from the author's own considerable experiences as well as those of his colleagues.

Some books suffer in translation and this is one replete with little glitches from not being critically read by an independent editor during translation. For example, mambas and kraits are all referred to as "cobras" instead of elapids and the caption for the *Naja nivea* photo says that it "is a mostly bottom-dwelling snake" (underground, or farthest south?). Word choices are a bit awkward sometimes and convey a slightly different meaning. For example, *Bothrops asper* hunts at night and kills its prey "as they sleep", though we know that many rodents are nocturnal like the snake. The same snake is described as "fertile" when the word should be "fecund" or "prolific". A line on *Bungarus fasciatus* reads "Being able to feed frogs is also a rare exception". We all know what the author is trying to say, but if the translator and/or final editor could have cleaned up the text we'd be spared these irritations. There are other glitches too, like the inaccurate statement "venom of elapids causes little if any pain…even slight edema is rare". Sri Lanka is sometimes called Ceylon and so on, throughout the book. These are minor problems in what is otherwise a classic in the genre of snake husbandry books. The photographs are excellent, printing and binding of the highest standard, in general a book worth owning, especially if you are a "hot snakes" person.

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A PHOTOGRAPHIC GUIDE TO AMPHIBIANS IN THAILAND

by Tanya Chan-ard. 2003.

Darnsutha Press Co., Ltd., Bangkok. 176 pp. In Thai. ISBN 974–90930–6–2. Softcover.
Available from: Se-Education Publ. Co. Ltd., Nation Tower, 19th floor, 46/87–90 Bangna-Trat Rd., Bangna, Bangkok 10260, Thailand; http://www.se-ed.com. Price: 160 Bahts.

This nice opus is the second comprehensive illustrated book dedicated to the amphibians of the Kingdom of Thailand, after that of the late Wirot Nutphund [= Nutphand] (2001). Its pocket-sized format and good quality binding make it a very practical tool in the field. The book includes a table of contents (pp. 4–5), a brief presentation of each amphibian family in Thailand (pp. 6–7), an introductory part with details on amphibian anatomy, biology and people–amphibians relationships (pp. 9–28), identification keys to orders and families, and, within families, a key to the genera and a brief description of each genus and a list of the species it contains (pp. 29–70), species accounts (pp. 72–165), three indices (Thai common names, English common names and Latin names) and a bibliography (pp. 166–174). On the last page, a short biography of the author is given.

All 141 newt, caecilian and anuran species currently known to occur in Thailand are represented. Species are arranged at three per double page, each species account on the left facing its corresponding picture/drawing on the right page. Each species account contains the names in Thai, English and Latin, a brief text giving details on color and size, etc., and a map of Thailand showing the distribution of the species within the country. Four pictograms (explained on p. 71) are used to qualify the main biotope(s) inhabited by each taxon. Synonyms are not listed, except for *Megophrys lateralis* (still listed as such by Chan-ard et al., 1999), presented as a synonym of *M. major* (p. 84), or, erroneously, of *M. longipes* (p. 40). All species are illustrated in colour: 18 by a high-quality drawing, and all others by an outstanding picture, sometimes accompanied by a drawing or an additional picture; for 17 species, the additional illustration is that of the tadpole. Most pictures were taken by the author himself, and all pictures were taken in Thailand, except for the *Microhyla annamensis*, which was photographed in Laos (Chan-ard, pers. comm.). The outstanding drawings are all from the hand of Anantapong Poolsawasdi, who based the drawing on (pictures of) Thai specimens, except for *Leptolalax gracilis*, *Rana luctuosa*, *R. montivaga* and *Philautus petersi* (Chan-ard, pers. comm.). *Rana montivaga*, mentioned for Thailand only from Khao Soi Dao, Chanthaburi Province, was included in the guide on the basis of a personal communication from Jarujin Nabhitabhata who was himself informed by Doyle Damman (who contributed some pictures for the field guide) that the species occurs on that mountain; *Rana* *montivaga* is actually the only Thai species that was not examined by Tanya Chan-ard, and that population might in fact belong to the genus *Huia* (Chan-ard, pers. comm.). It should also be carefully compared with *Rana faber*, recently described from the Cardamom Mountains in western Cambodia and very likely to occur in hilly extreme SE Thailand (B. L. Stuart, pers. comm.).

In a recent checklist of the amphibians of Thailand, Nabhitabhata et al. (2004) based the record of *Rana montivaga* in Thailand (Khao Soi Dao), on "Nabhitabhata (per. com.)". A few comments on the differences between the present species list and the last one provided for Thailand by the author (Chan-ard et al., 1999) have to be made, in order to avoid future listings of deleted species names, since these deletions were not explicitly explained in the present opus. These changes and deletions are detailed below, and were all confirmed by personal communication from the author. What the author called *Rana chapaensis* is what was listed as *Rana adenopleaura* [sic] by Chan-ard et al. (1999). Additionally, from Chan-ard et al.'s (1999) list to the present opus, *Amolops afghanus* was replaced by *A. marmoratus*, *Rana chalconota* by *R. raniceps*, and *Rhacophorus bimaculatus* by the recently described *R. cyanopunctatus* Manthey & Steiof, 1998. The frog listed as *Rana alticola* by Chan-ard et al. (1999), was here listed as *R.* cf. *alticola*, because the Thai tadpoles are different from those of India (Chan-ard, pers. obsv. & pers. comm.). *Polypedates megacephalus*, listed in Chan-ard et al. (1999) from Thailand, is not included in the present guide, because the taxonomic status of the Thai population is currently under study. *Euphlyctis cyanophlyctis*, whose occurrence is only based on the record by Taylor (1962), for which no recent Thai record exists, suggesting that the Thai population had maybe been introduced (as suggested by Taylor, 1962) and failed to become naturalised, is provisionally withdrawn from the national list. This species' account by Nutphund (2001: 107) was wrongly illustrated by a *Limnonectes*. Besides a few species indicated as "sp." and "cf." in the genera *Megophrys*, *Chaperina*, *Amolops*, *Fejervarya*, *Limnonectes*, *Rana* and *Rhacophorus*, whose taxonomic status must be evaluated, it is to be mentioned that the Thai populations of *Ansonia* "*malayana*" were recently shown to represent a distinct species, *Ansonia kraensis* Matsui, Khonsue & Nabhitabhata, 2005. *Kaloula aureata* Nutphand, 1989, a species whose status was never clearly established (see Pauwels et al., 1999), is not included in the present guide, although a revision might prove it to be a valid species. The short bibliography includes only 40 references, all pertinent. The most recent reference dates back from 2000. Only one of those references is in Thai, and one might once more regret that not enough effort was made to present the Thai literature, which is numerous but often overlooked by foreign researchers. Since the publication of this guide, Tanya Chan-ard contributed to some additional research papers that must be mentioned here. Leong et al. (2003) published several zoogeographically interesting new anuran records from Phuket Island, and Stuart and Chan-ard (2005) described *Huia melasma*, whose name must replace *H. nasica* for the Thai populations. Besides the poor representation of Thai literature in the bibliography, we have no criticism on this outstanding opus. Even for non-Thai speaking readers, this nearly-exhaustive guide, thanks to its excellent pictures and drawings, is readily usable as an efficient identification tool in the field. Maps, maximal sizes and biotope pictograms are also universally understandable. Its very democratic price, about 4 USD, is another convincing argument. No naturalist has any excuse not to have it in his pocket while herping in Thailand.

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