

NEW AND LITTLE-KNOWN CLAUSILIIDAE OF CONTINENTAL SOUTHEAST ASIA (GASTROPODA: PULMONATA)

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Abstract Recent field trips yielded valuable new information on the Clausiliidae of some little-researched regions of Myanmar, Thailand and central Vietnam. *Indonena admirabilis* Grego & Szekeres sp. nov., *Margaritiphaedusa grata* Hunyadi & Szekeres sp. nov. and *Phaedusa kazueae* Hunyadi & Szekeres sp. nov. are introduced as new taxa, and occurrence records are provided for some species that were described with only vaguely defined locality data. The presence of *Phaedusa lypra* (Mabille, 1887) in Myanmar and Thailand is reported and the taxonomic status of *Phaedusa lucens* Loosjes, 1953 is discussed.

Key words *Garnieriinae*, *Phaedusinae*, new taxa, Southeast Asia, zoogeography

INTRODUCTION

For historical reasons the Clausiliidae fauna in the western parts of mainland Southeast Asia received less attention than that of the eastern and southern regions. Only few publications have provided data or assessments on members of this family in Myanmar (Gude, 1914; Nordsieck, 1974, 2002a, 2002b) and Thailand (Loosjes, 1948, 1950, 1953; Hemmen & Hemmen, 2001; Nordsieck, 2002b; Nordsieck & Rähle, 2013). A few species from these countries were described with only region level locality data, have not been found since the end of the 19th century, or photo images of them have not yet been published. Based on recently collected material from Myanmar, Thailand and Vietnam we provide locality data and images of some little-known clausiliids of these countries, together with the descriptions of three newly discovered species.

MATERIALS AND METHODS

The studied material was collected by Jozef Grego during the 2019 expedition of the Myanmar Cave Documentation Project (<http://www.myanmarcaves.com/>), as well as field trips by András Hunyadi, Kanji Okubo and Jamen Uiriamu Otani to Myanmar, Thailand and Vietnam during a period from 2009 to 2019. The



Figure 1 Map showing mentioned localities of *Indonena excellens* (1), *Indonena admirabilis* sp. nov. (2), *Margaritiphaedusa grata* sp. nov. (3), *Phaedusa kazueae* sp. nov. (4), *Phaedusa lypra* (5), *Phaedusa theobaldi* (6), *Phaedusa burmanica* (7), *Phaedusa shanica* (8), and *Phaedusa cochinchinensis* (9).

localities of the collected samples are shown in the map of Fig. 1.

The type material of the new taxa has been deposited in the collections of the American Museum of Natural History, New York (AMNH), Field Museum of Natural History, Chicago (FMNH), Florida Museum of Natural History, Gainesville (UF), Hungarian Natural History Museum, Budapest (HNHM), Museu de Zoologia da Universidade de São Paulo (MZUSP), Muséum National d'Histoire Naturelle, Paris (MNHN), Natural History Museum, London (NHMUK), Naturalis Biodiversity Centre, Leiden (RMNH), Naturhistorisches Museum, Vienna (NHMW), Naturhistorisches Museum Bern (NMBE), Naturmuseum Senckenberg, Frankfurt am Main (SMF), Santa Barbara Museum of Natural History, Santa Barbara (SBMNH), Zoological Institute of the Russian Academy of Sciences, Sankt-Peterburg (ZIN), Zoological Museum of the University of Hamburg (ZMH), Jozef Grego, Banská Bystrica (GR), András Hunyadi, Budapest (HU), Kanji Okubo, Tokyo (OK), Jamen Uiriamu Otani, Koka (OT), and Miklós Szekeres, Budapest (SZ).

SYSTEMATICS

CLAUSILIIDAE

GARNIERIINAE

Indonenia Ehrmann, 1927

Type species: *Clausilia masoni* Theobald, 1864;
OD.

The latest assessment of the Garnieriinae considered *I. masoni*, *I. excellens* (Nordsieck, 2002) and *I. tuba* (Hanley, 1848) belong in this endemic genus from Myanmar (Nordsieck, 2007a). Of all three species only the type series were known, which had been collected in the second half of the 19th century. For each of them only region level localities information has been available.

Indonenia excellens (Nordsieck, 2002) (Fig. 2a)

The type material of *I. excellens* was collected in the Karen Hills of Myanmar by Leonardo Fea (Nordsieck, 2002a) during his journey from Taungoo (Myanmar, Bago Region, 18°56' N 96°26' E) to around Loikaw (Myanmar, Kayah State, 19°40' N 97°13' E) (Fea, 1897). Recently

the species has been found by J. Grego at two sites along the road from Taungoo to Demoso (Kayah State) road, namely at km marks 169.5 (Kayah State, 19°34'39.6" N 96°59'50.7" E, 1220m) and 124.5 (Shan State, 19°24'3.4" N 96°49'43.4" E, 970m). Both new localities are close to the route travelled by Fea (see map in Fea, 1897).

Indonenia admirabilis Grego & Szekeres sp. nov. (Fig. 2b)

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Diagnosis Small and slender *Indonenia* with dorsal crest and in front view hidden lamella subcolumellaris.

Type material Holotype: Myanmar, Kayah State, Hpruso District, Maw Ti Do, entrance of the Phruno River Cave (19°22'44.6" N 97°02'34.2" E, 1230m), leg. J. Grego 12.02.2019 (NHMUK 20200185). Paratypes: same locality and data (AMNH-IZC 00331518/3, FMNH 390513/2, HNHM 105101/2, MNHN IM-2012-25493/2, MZUSP 152141/2, NHMUK 20200191/3, NHMW-MO-113272/2, NMBE 564611/2, RMNH MOL.347620/2, SBMNH 632732/2, SMF 359902/2, UF 529137/2, ZIN 1-515-2020/3, ZMH 136982/2, GR/31, HU/2, SZ/5.

Description The greyish-brown, relatively small and slender shell with elongate apical part consists of 10.5 to 11.5 whorls. The whorls have widely spaced, wrinkle-like ribs, most of which are sharp near the suture but become indistinct or dissolved downward. The neck with a narrow basal and a wider dorsal crest is strongly and irregularly costate. The projected, circular aperture has a whitish, trumpet-like peristome with non-reflexed margin. The lamella superior is continuous with the laterally initiating lamella spiralis. The lamella inferior starts from the ventral side, runs parallel to the lamellae spiralis and superior, and terminates near the latter on the upper side of the aperture. The lamella subcolumellaris descends almost vertically. Its end at the columellar side of the aperture is not visible in front view. The half-whorl-long plica principalis starts laterally. The lateral, moderately arched lunella is fused to a strong anterior lower plica, which runs along the groove formed by the basal crest. The narrow, tongue-shaped clausilium



Figure 2 *Indonemia excellens* (Nordsieck, 2002), Myanmar, Taungoo to Demoso road at km 124.5 (a); *Indonemia admirabilis* sp. nov., holotype, NHMUK 20200185 (b). Scale bars: 5mm.

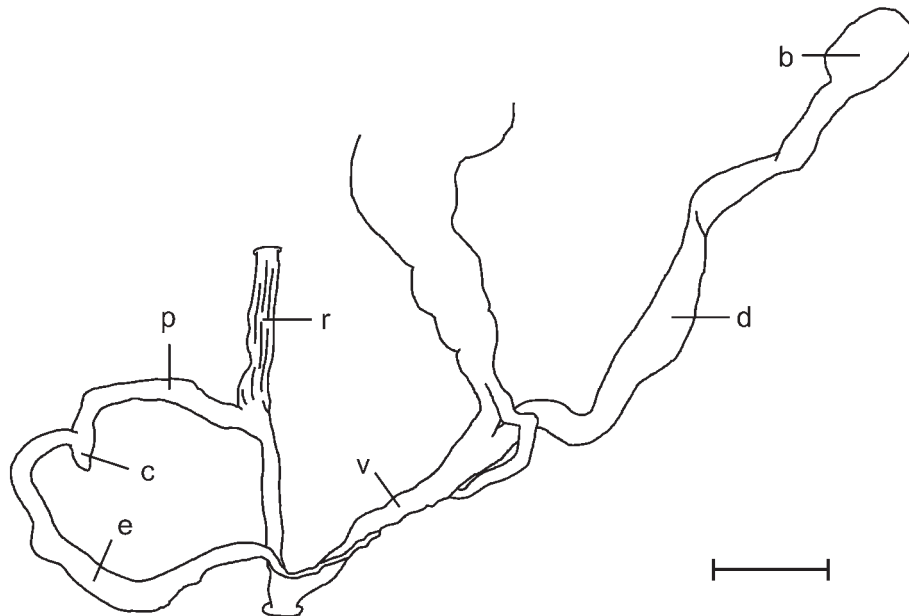


Figure 3 Reproductive organs of *Indonemia admirabilis* sp. nov. Abbreviations correspond to penis (p), epiphallus (e), caecum (c), retractor muscle (r), vagina (v), bursa (b), and pedunculus (d). Scale bar: 2mm.

plate tapers off to a pointed apex, which is visible through the aperture.

A single live-collected specimen allowed examination of the reproductive organs (Fig. 3). The penis is roughly of the same length as that of the wider epiphallus. Its lumen is partitioned by six weak longitudinal folds (Fig. 4a). The retractor muscle is attached at about half of

the penis length. The epiphallus is widest at its central part. Its inner wall is divided by three very strong longitudinal folds (Fig. 4c), which thicken as ending abruptly at a small caecum formed at the epiphallus-penis junction (Fig. 4b). The vagina is much shorter than the penis. The pedunculus of the bursa copulatrix, lacking a diverticulum, is twice longer than the vagina.

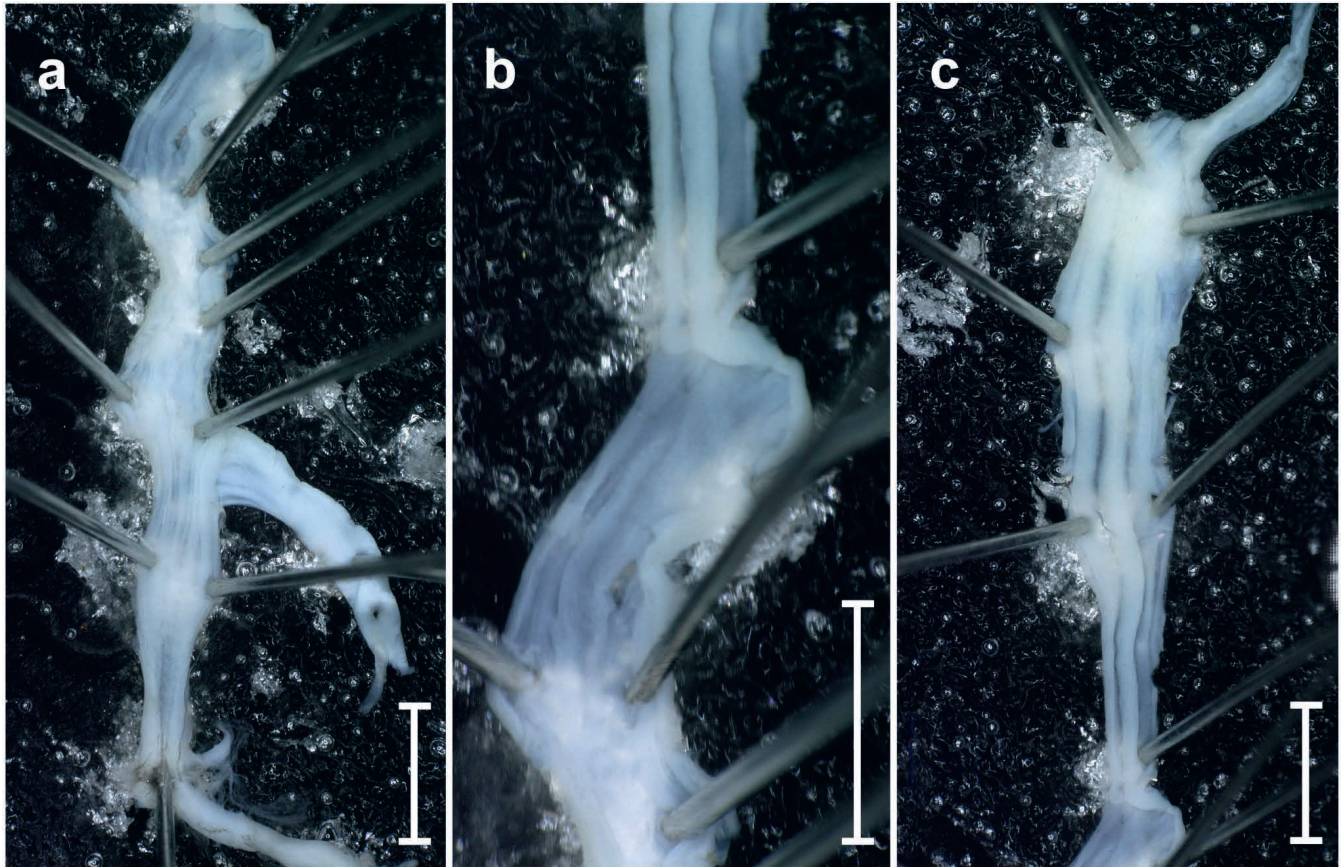


Figure 4 Internal structures of the penis (a), epiphallus-penis transition (b) and epiphallus (c) in *Indonemia admirabilis* sp. nov. Scale bars: 1mm.

The bursa is an ovoid dilatation at its distal end.

Measurements Holotype: shell height (H_s) 23.3mm, spire width (W_s) 4.0mm, aperture height (H_a) 4.4mm, aperture width (W_a) 3.9mm. Paratypes (64): H_s 23.4–28.1mm, W_s 3.9–4.5mm, H_a 4.2–5.1mm, W_a 3.8–4.4mm.

Derivation of name The Latin specific epithet *admirabilis* (meaning “admirable”) refers to the attractive-looking shell of this species.

Remarks Morphologically *I. admirabilis* sp. nov. differs from *I. masoni* and *I. excellens* by its elongate apical part, retracted, in front view invisible lamella subcolumellaris, weakly bent lunella, and narrow clausilium plate. These characters are shared with *I. tuba* (Hanley, 1868), from which the new species differs in its smaller size, stronger sculpture, narrow peristome rim, and the presence of a dorsal crest. Specimens of the type material were collected from limestone cliffs close to the entrance of the Phruno Cave, where

they were found sympatrically with *Phaedusa theobaldi* (Blanford, 1872).

PHAEDUSINAE

Margaritiphaedusa Nordsieck, 2001

Type species: *Clausilia margaritifera* Bavay & Dautzenberg, 1909; OD.

This genus with 11 recognized species occurs over large areas of southeastern China (parts of Hubei, Sichuan, Guizhou, Hunan, Jiangxi, and Guangxi Provinces), as well as in northwestern Vietnam and northeastern Laos (Bavay & Dautzenberg, 1909; Nordsieck, 2006; Páll-Gergely & Szekeres, 2017). The species described below is the southernmost member of the genus.

Margaritiphaedusa grata Hunyadi & Szekeres sp. nov.
(Fig. 5a)

urn:lsid:zoobank.org:act:4292CF24-5233-4A26-BAF3-954CCE2297CF

Diagnosis Small *Margaritiphaedusa* with marginally ending lamella subolumellaris, ventrolaterally positioned clausilium plate, and without a lunella.

Type material Holotype: Vietnam, Da Nang, Hoa Vang, Dinh Ba Na, 400m NE of Cau Vang (15°59'45.8" N 107°59'56.7" E, 1270m), leg. A. Hunyadi 13.2.2019 (NHMUK 20200186). Paratypes: same locality and data (GR/1, HU/3, SZ/1)

Description The small, tumid, light yellowish-brown shell with convex outline consists of 7.0 to 7.3 whorls. The surface is glossy with dense striate, which strengthen to regular ribs on the last half whorl. The suture is densely papillate up to the protoconch. The aperture is oval, its thickened whitish peristome with reflexed margin is attached. The lamella superior is weakly emerged, inward continuous with the even lower lamella spiralis. The lamella inferior descends steeply and reaches the margin of the peristome close to the base. Its straight end section along the columella is only barely visible in front view. The lamella subcolumellaris also terminates marginally, just below the end of the lamella inferior. The plica principalis spans from the ventral to the dorsal side. The ventrolateral upper plica runs almost parallel to it. Other plicae or a lunella are absent. The clausilium plate is not visible through the aperture.

Measurements Holotype: H_s 8.5mm, W_s 2.3mm, H_a 2.2mm, W_a 1.7mm. Paratypes (5): H_s 8.5–8.7mm, W_s 2.2–2.3mm, H_a 2.2–2.3mm, W_a 1.7mm.

Derivation of name The Latin specific epithet *grata* (meaning “pleasing”) alludes to the graceful appearance of the new species.

Remarks The shell of the species is most similar to those of *M. margaritifera* from Vietnam’s Lao Cai Province and *M. hunyadii* Grego & Szekeres, 2017 from China’s Hunan Province. From the former it differs by the marginally ending lamellae inferior and subcolumellaris, whereas from the latter by the papillate suture. We note, however, that the new species is only tentatively classified with *Margaritiphaedusa* because its deeply positioned clausilium and lack of a lunella are unique characters within the genus. It will require molecular phylogenetic analyses to clarify whether or not

the new species represents a distinct genus. Live specimens of *M. grata* sp. nov. were found among wooden planks dumped at a forest resort.

Phaedusa Adams & Adams, 1855

Type species: *Clausilia corticina* Pfeiffer, 1842; SD Martens in Albers, 1860

Phaedusa kazueae Hunyadi & Szekeres sp. nov.
(Fig. 5b)

urn:lsid:zoobank.org:act:5306643B-6193-4717-A101-DBF9FC6D5063

Diagnosis Very small *Phaedusa* with densely costate shell and strongly reduced lamellae.

Type material Holotype: Myanmar, Shan State, at the Montawa Cave, SW of Taunggyi (20°45'16.9" N 97°01'3.4" E, 1260m), leg. A. Hunyadi, K. Okubo & J. U. Otani 05.10.2018 (NHMUK 20200187). Paratypes: same locality and data (GR/1, HU/9, OK/3, OT/3, SZ/1).

Description The very small, yellowish-brown shell consists of 8.7 to 9 whorls. The surface is densely and obliquely costate, the sharp ribs become less distinct toward the last whorl. The neck with a rounded base has strong and sharp ribs. The relatively large oval aperture is attached, the thin and narrow peristome is not reflexed. The lamella superior is absent or residual, the lamella spiralis is absent. The weak, spirally descending lamella inferior reaches the peristome. Its downward-bending terminal part is visible in front view. The deep ending lamella subcolumellaris cannot be viewed through the aperture. The plica principalis is short, spanning from the lateral to the dorsal side. There are only two further plicae, namely a short, from the principalis diverging upper plica and a very short basal plica on the dorsolateral and lateral sides, respectively. The small clausilium plate is almost entirely visible through the aperture.

Measurements Holotype: H_s 7.9mm, W_s 2.0mm, H_a 2.0mm, W_a 1.6mm. Paratypes (11): H_s 7.8–8.1mm, W_s 2.0–2.1mm, H_a 2.0–2.1mm, W_a 1.6–1.7mm.

Derivation of name The species is named, according to the wish of the late Kenji Ohara, in honour of his wife Kazue.



Figure 5 *Margaritiphaedusa grata* sp. nov., holotype, NHMUK 20200186 (a); *Phaedusa kazueae* sp. nov., holotype, NHMUK 20200187 (b); *Phaedusa lypra* (Mabille, 1887), Myanmar, Shan State, Nam Pam, War Lee Kwey Cave (c); *Phaedusa theobaldi* (Blanford, 1872), Myanmar, Kayah State, Maw Ti Do, Phruno River Cave (d); *Phaedusa coccinchenensis* (Pfeiffer, 1841), Vietnam, Da Nang, Son Tra Peninsula (e). Scale bars: 5mm.

Remarks The new species differs from all other members of its genus by its very small size and strongly reduced lamellae. Morphologically it is closest to *Phaedusa pygmaea* Grego & Szekeres, 2011 from northern Laos which, however, is larger, has detached peristome, and all of its lamellae are present (Grego & Szekeres, 2011). Live specimens of *P. kazueae* sp. nov. were found on tree bark at 1 to 2m height from the ground, near the entrance of the Montawa Cave. At the same locality *Phaedusa lypra* (Mabille, 1887) was also collected.

Phaedusa lypra (Mabille, 1887)
(Fig. 5c)

This species has been known to occur in Vietnam (Nordsieck, 2011) and China (Nordsieck, 2012a), but not outside of these countries. Our samples reveal its presence much farther toward west and southwest with the following localities: Myanmar, Shan State, 300m NE of the Montawa Cave, (20°45'23.0" N 97°01'12.8" E, 1350m), leg. J. Grego; Montawa Cave, SW of Taunggyi (20°45'16.9" N 97°01'03.4" E, 1260m), leg. A. Hunyadi; NNE of Kalaw, 150m NW of the Osei Mountain Pagoda (20°39'19.2" N 96°34'55.6" E, 1570m), leg. A. Hunyadi; Nam Pam, War Lee Kwey Cave/Resurgence (19°58'31.7" N 96°40'14.7" E, 700m), leg. A. Hunyadi, K. Okubo & J. U. Otani (Fig. 5c); Mandalay Region, near the Maha Nandamu Peik Chin Myaung Cave and Waterfall (22°05'45.7" N 96°37'05.2" E, 740m), leg. A. Hunyadi; Thailand, Tak Province, 3.5km ENE of Ban Huai Hin Fon (16°46'47.4" N 98°39'56.2" E, 590m), leg. A. Hunyadi; Wat Who near Ban Huai Hin Fon (16°45'20" N 98°38'00" E, 360m), leg. K. Okubo; Pa Wai Waterfall of the Chi Ko Ho Sai (16°34'28" N 98°50'03" E, 780m), leg. K. Okubo.

Although these data show *P. lypra* widespread in Myanmar and Thailand, intriguingly, its presence has not yet been reported from these countries (Gude, 1914; Nordsieck, 1974; Hemmen & Hemmen, 2001). Presently there is a gap of 500km between the above localities and the closest known occurrence of the species in China (i.e., Mengla Xian in Yunnan Province, leg. Y. Nakahara, K. Ohara, K. Okubo & J. U. Otani), but the species is expected to be present in the connecting areas, too.

The shells found in Myanmar and Thailand show considerable morphological variation.

Those from the Shan State are finely and densely striate, whereas those from the Mandalay Region and Thailand's Tak Province have stronger, somewhat reticulate sculpture. In the Mandalay specimens there is a hook on the outer side of the clausilium, a character also present or absent in *P. paviei* (Morlet, 1892) (Loosjes, 1948). Morphological diversity of *P. lypra* in Vietnam and China already resulted in the description of multiple subspecific taxa with tentative acceptance (Nordsieck, 2007b, 2011, 2012b). Considering the scarcity of the knowledge available on this widespread species we rather avoid introducing additional subspecies.

Phaedusa theobaldi (Blanford, 1872)
(Fig. 5d)

This species was known only from the vicinity of Taungoo (Myanmar, Bago Region, 18°56' N 96°26' E), its type locality, and from around Mwaywa (Myanmar, Rakhine State, 19°32' N 94°01' E) (Blanford, 1872; Gude, 1914). Recently it has been found by J. Grego in Myanmar, Kayah State, Hpruso District, Maw Ti Do, entrance of the Phruno River Cave (19°22'44.6" N 97°02'34.2" E, 1230m) (together with *Indonemia admirabilis* sp. nov.), and by A. Hunyadi in Thailand, Mae Hong Son Province, 8.9km from Ban Soppong toward Mae Hong Son, left side of Road 1095 (19°33'04.5" N 98°11'55.5" E, 810m).

Phaedusa burmanica (Gude, 1914)

The type locality of the species is the same as that of *P. theobaldi*. In Myanmar the following new localities were discovered: Shan State, Myinmati Taung, ESE of Kalaw (20°35'25.6" N 96°36'47.6" E, 1350m), leg. A. Hunyadi, K. Okubo & J. U. Otani; Hopong to Namsang road near the Hopong Spring Cave (20°49'01.7" N 97°13'28.1" E, 1110m), leg. A. Hunyadi, K. Okubo & J. U. Otani; Mandalay Region, near the Maha Nandamu Peik Chin Myaung Cave and Waterfall (22°05'45.7" N 96°37'05.2" E, 740m) (together with *P. lypra*), leg. A. Hunyadi.

Phaedusa shanica (Godwin-Austen, 1888)

So far this species was known only from its type locality, namely the Shan hills near Pingoung (Myanmar, Mandalay Region, Pyingyaung, 20°50' N 96°24' E) (Godwin-Austen, 1888).



Figure 6 *Phaedusa lucens* Loosjes, 1953 (a), and *Phaedusa filicostata* (Stoliczka, 1873) (b), both from Malaysia, Pahang State, Bukit Charas near Kuantan. Scale bar: 5mm.

Recently it has been re-discovered by A. Hunyadi near the Dee Dote Waterfall in the Mandalay Region (21°42'33.8" N 96°21'16.9" E, 190m), a locality 100km north of the type locality. Only broken shells (body whorls and apices) could be found.

Phaedusa cochinchinensis (Pfeiffer, 1841)
(Fig. 5e)

The description by Pfeiffer (1841) gave only Cochinchina as origin of the type material. More defined locality record, Touranne (Da Nang in central Vietnam), was provided by Möllendorff (1898). Since then no other occurrence data have been published. Here we report the finding of this species by A. Hunyadi near Tho Quang on the Son Tra Peninsula, NE of Da Nang (6°06'55.1" N 108°18'53.2" E, 90m). Live specimens were found on the bark of a large banyan tree (*Ficus benghalensis*).

Phaedusa lucens Loosjes, 1953
(Fig. 6a)

This species, together with *P. filicostata* (Stoliczka, 1873), was collected at its type locality: Malaysia, Pahang State, Bukit Charas, 15km WNW of Kuantan (3°54'26.2" N 103°08'49.8" E, 130m), leg. H. Hulesch & M. Szekeres. In an assessment of the Southeast Asian Phaedusinae Nordsieck

(2002b) regarded *P. lucens* as a subspecies of *P. filicostata* (Stoliczka, 1873). We point out, however, that at the type locality *P. lucens* and *P. filicostata* were found to inhabit the same cliff. Its smaller, tumid, glossy and translucent specimens are well distinguishable from those of *P. filicostata* (Fig. 6). The differences in the shell characters and size (16.0–21.0×3.5–4.5mm in *P. lucens* vs. 26.9–27.4×4.6–5.0mm in *P. filicostata* at Bukit Charas) were emphasized by Loosjes (1953), who listed the *P. filicostata* of Bukit Charas as *P. filicostata tenuicosta* (Nevill, 1878). The morphological differences and the sympatry with *P. filicostata* confirm the distinct specific status of *P. lucens*.

CONCLUDING REMARKS

The results presented above contribute important details to our knowledge of the Clausiliidae fauna in continental Southeast Asia, and particularly in Myanmar and Thailand. Well defined localities and the first anatomy information are provided for *Indonemia*, the westernmost genus of the subfamily Garnieriinae, and new occurrence data are reported for four *Phaedusa* species. Of these latter *Phaedusa lypra* was not known to be present west of China's Yunnan Province.

Currently available data already provide a sketchy zoogeographic picture of how climatic conditions influence the distribution and diversity of clausiliids in the Indochinese Peninsula.

Vietnam, which is mainly in the humid subtropical zone (Geiger, 1954) with evergreen forests, is home to five Garnieriinae and 15 Phaesusinae genera. By contrast, in the territories of Myanmar and Thailand, most of which having tropical savanna climate with some deciduous forests, the number of Garnieriinae and Phaesusinae genera is only one and four, respectively. These data highlight how the amount and yearly distribution of rainfall influences the habitats suitable for clausiliids. This is also visible in our current occurrence data, which follow the relatively humid ranges of the Karen-Kayah and Dawna Mountains (Fig. 1).

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