

Two new species of land snails of the genus *Rahula* from Peninsular Malaysia (Gastropoda: Euconulidae)

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Abstract. Two new species of the genus *Rahula* are described from Peninsular Malaysia. *Rahula limbooliati*, new species, is distinguished from congeners by the presence of five or six distinctly raised spiral ridge striations at protoconch and widely-spaced (5–8 ribs per mm), slightly prosocline radial ribs that terminate abruptly sub-peripherally at teleoconch as well as a semi-closed umbilicus. *Rahula tonywhitteni*, new species, is distinguished from congeners by its prominent radial ribs angled towards the apex at protoconch that become slightly prosocline and densely-arranged (12–15 ribs per mm) at teleoconch as well as its open umbilicus.

Keywords. Mollusca, limestone karsts, range extension, Pahang, Perak

INTRODUCTION

The genus *Rahula* Godwin-Austen, 1907 was first erected to accommodate *Helix macroleuris* Benson, 1859 on account of its conically trochiform shell with regularly raised ribs on its spire, which differs from other small shelled pulmonates such as *Kaliella* Blanford, 1863, *Microcystina* Mörch, 1872 and *Thysanota* Albers in Albers & von Martens, 1860 (Godwin-Austen, 1907). The genus *Rahula* includes species of land snails characterised by small shells (2 to 5 mm) that are globular conical to conically trochiform with more or less distinct peripheral keel, simple peristome as well as the diagnostic regular-spaced and raised radial ribs (Godwin-Austen, 1907; Godwin-Austen, 1918; Schileyko, 2003; Vermeulen et al., 2015; Gittenberger et al., 2017a, 2017b). *Rahula* species vary in umbilicus sizes from almost closed to wide (up to one fifth of shell width) and protoconch with radial and spiral sculpture variations (Gittenberger et al., 2017a, 2017b).

The only published anatomical description for the genus *Rahula* is that in the original description of *R. koboensis* by Godwin-Austen (1918). He described *R. koboensis* as a spotted white animal with banded black visceral sac, broad peripodial margin, distinct mucous pore at extremity of short foot, tricuspid radula and a somewhat straight front jaw with slight central projection. The taxonomically informative

reproductive anatomy is unknown for *Rahula*. As such, *Rahula* remains diagnosed by conchology only.

Without reproductive anatomy and molecular data, the familial and subgeneric classifications for *Rahula* remain contentious (Gittenberger et al., 2017a). Based on conchology, *Rahula* has been placed in families Helicarionidae Bourguignat, 1877 (Zilch, 1959; Gittenberger et al., 2017a, 2017b), Ariophantidae Godwin-Austen, 1888 (Thiele, 1931; Schileyko, 2003) and Euconulidae Baker, 1928 (Vermeulen et al., 2015). In view of this, we followed the taxonomic decision of Vermeulen et al. (2015) for convenience and considered the familial assignment tentative pending further evidence.

Rahula has two subgenera: *Sinaenigma* Pilsbry, 1934 and *Rahula* sensu stricto (Pilsbry, 1934; Schileyko, 2003). *Sinaenigma* was erected to accommodate one western China species *R. (S.) chengweiensis* Pilsbry, 1934, which shares with *Rahula* sensu stricto strong radial rib sculpture but differs by being low conoidal and without peripheral keel. Pilsbry (1934) considered the subgeneric placement of *Sinaenigma* in *Rahula* as provisional pending anatomical analysis.

Rahula sensu stricto has a Tropical East Asian distribution encompassing a wide area from north-eastern India and Bhutan in the west to northern Vietnam in the east as well as Sumatra and Borneo in the south, although most of its species appear to be very range-restricted (Godwin-Austen, 1907, 1918; Schileyko, 2003; Vermeulen et al., 2015; Gittenberger et al., 2017a, 2017b). Only 19 species and one subspecies of *Rahula* are known across tropical East Asia so far, with no species reported in between these known localities, especially in central Sundaland encompassing Peninsular Malaysia (Ray & Rajagopalaiengar, 1953; Gittenberger et al., 2017a, 2017b).

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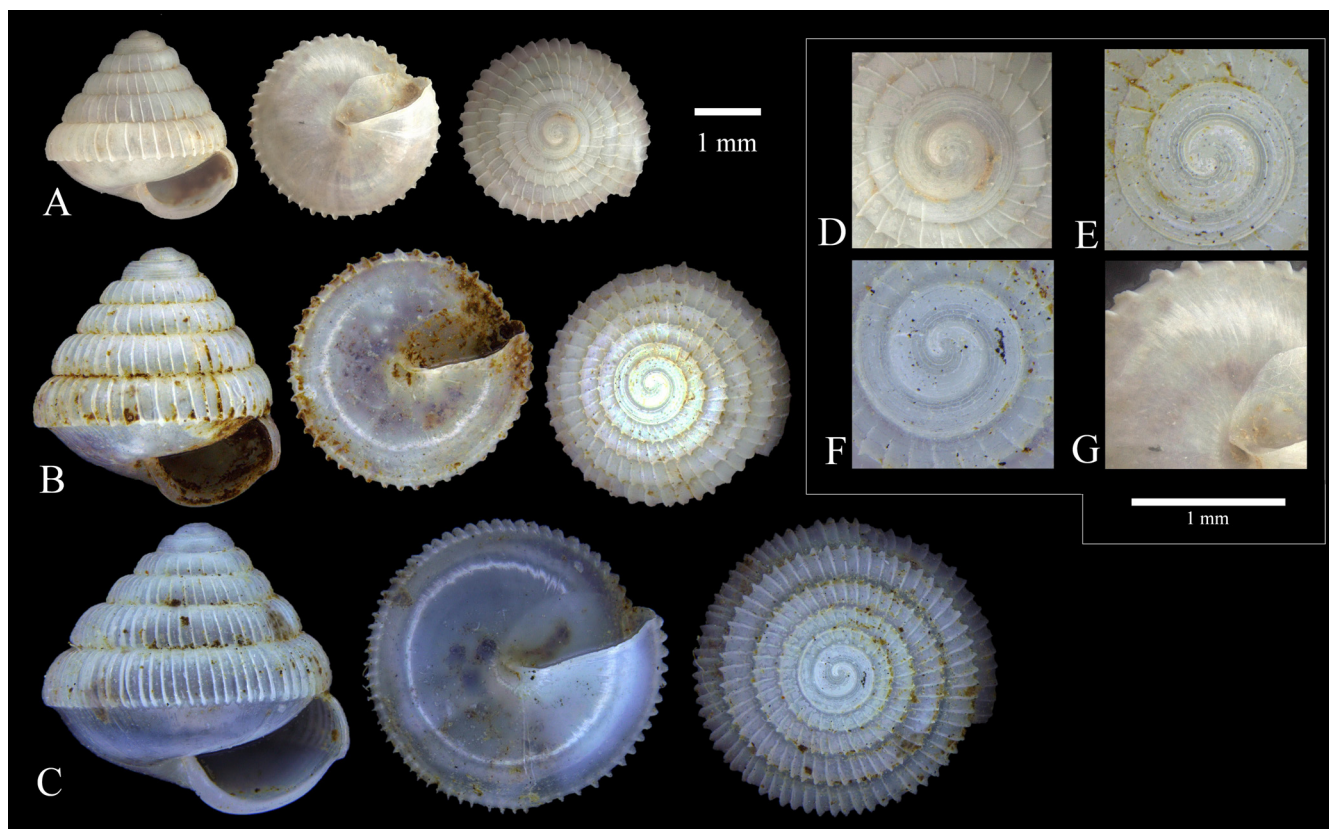


Fig. 1. *Rahula limbooliati*, new species. A, holotype, from PHG 02 Gunung Senyum, Pahang, Peninsular Malaysia (BOR/MOL 14214); B, paratype, from PHG 03 Bukit Jebak Puyuh, Pahang, Peninsular Malaysia (ME 861); C, paratype, from PHG 01 Kota Gelanggi, Pahang, Peninsular Malaysia (ME 2134); D, close-up of the apical whorls of BOR/MOL 14214; E, close-up of the apical whorls of ME 861; F, close-up of the apical whorls of ME 2134; G, close-up of the umbilical side of BOR/MOL 14214 shell showing fine sculpture.

In recent years, intensified malacofaunal surveys across Peninsular Malaysia have led to discoveries of many new species including two new *Rahula* species, which are described herein. The discovery of these two new species marks a new genus record for Peninsular Malaysia and fills a major geographical gap for *Rahula*.

MATERIAL AND METHODS

Materials examined were extracted from leaf litter during surveys of limestone hill malacofauna in Peninsular Malaysia by Clements et al. (2008) and Foon et al. (2017). These examined materials are deposited at the BORNEENSIS collection (BOR/MOL), Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah and the collection for the second author (Abbreviation: ME). The latter will eventually be deposited in the Sarawak Museum, Kuching, Malaysia. Locations of limestone hills follow the codes in the Peninsular Malaysia limestone karst database (Liew et al., 2016).

The two new *Rahula* species are described and compared with type illustrations and descriptions of congeners listed in the *Rahula* review by Gittenberger et al. (2017a) and references therein. Our taxonomic study is based on conchological characters only. As all species of the genus *Rahula* lack a distinct lip, which could be used as a

taxonomic reference point, the largest intact specimen among materials examined was chosen for measurements of shell height (SH), shell width (SW), aperture height (AH), aperture width (AW) and number of ribs per mm (Vermeulen et al., 2015). The diameters of the first four whorls (DA, DB, DC, DD) were also measured (Vermeulen & Whitten, 1998; Vermeulen et al., 2015). The calculation of number of whorls (NW) follows Vermeulen & Whitten (1998). In addition, some larger paratype shells were also measured.

TAXONOMY

Family Euconulidae Baker, 1928

Rahula Godwin-Austen, 1907

Type species. *Helix macroleporeis* Benson, 1859

Rahula limbooliati, new species

(Fig. 1A–G)

Type specimens. Holotype: (BOR/MOL 14214), PHG 02 Gunung Senyum, Pahang, Peninsular Malaysia (3.7038°N 102.4356°E), coll. G. R. Clements, 2006. Paratypes: 26 ex. (7 shells measured) (BOR/MOL 14215), same data as holotype; 1 ex. (ME 861), PHG 03 Bukit Jebak Puyuh, Pahang, Peninsular Malaysia (3.6945°N 102.4482°E), coll.

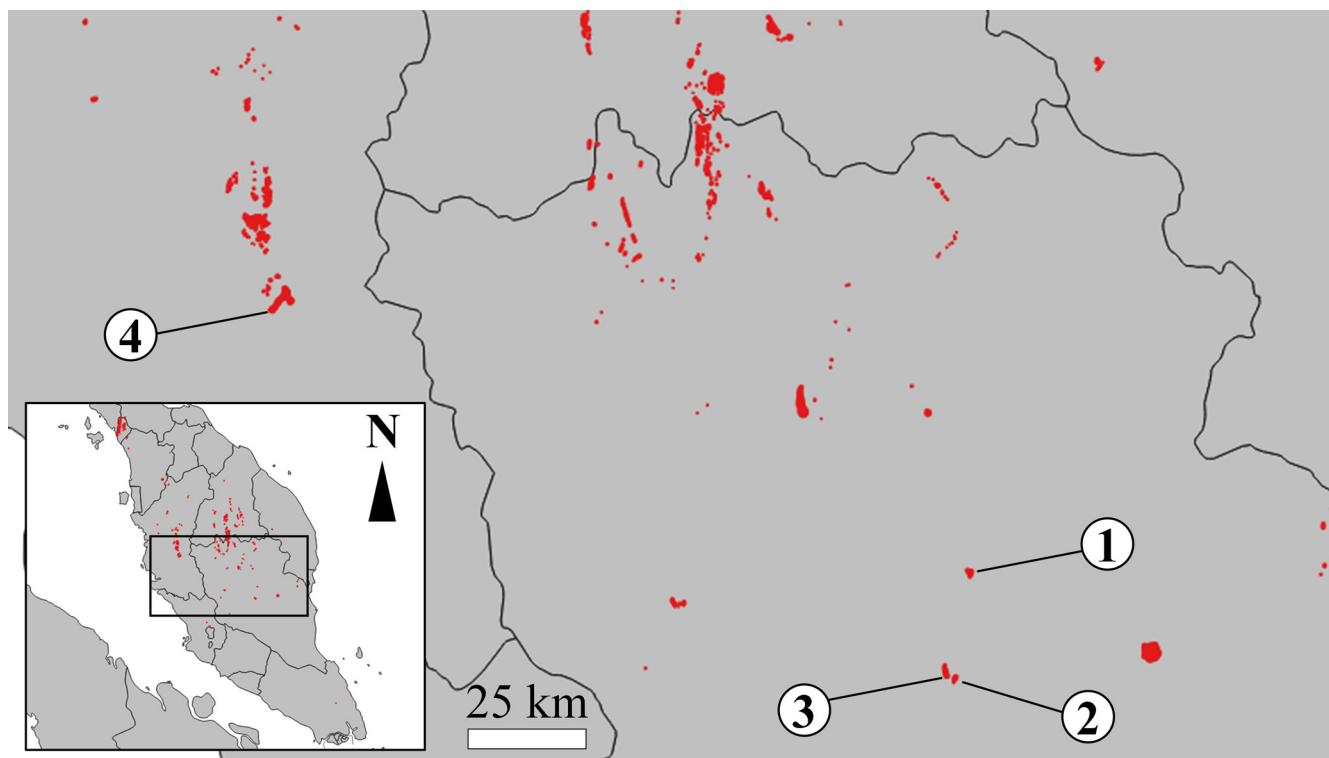


Fig. 2. Map of Peninsular Malaysia (insert) with a close-up of central Peninsular Malaysia showing the limestone hill localities of *Rahula* spp. mentioned in this paper. *Rahula limbooliati* localities: (1) PHG 01 Kota Gelanggi, Pahang; (2) PHG 03 Bukit Jebak Puyuh, Pahang; (3) PHG 02 Gunung Senyum, Pahang. *Rahula tonywhitteni* locality: (4) PRK 01 Gunung Tempurung, Perak. Red areas are limestone hills, derived from Liew et al. (2016).

M. E. Marzuki, 2009; 1 ex. (ME 2134), PHG 01 Kota Gelanggi, Pahang, Peninsular Malaysia (3.8922°N 102.4736°E), coll. M. E. Marzuki, 2010.

Etymology. *Rahula limbooliati* is named in honour of Dr. Lim Boo Liat, a Malaysian zoologist whose work has been an inspiration for many scientists in Malaysia and Southeast Asia including the authors.

Diagnosis. *Rahula limbooliati* differs from all known congeners by its conical shell with rounded periphery and sharp sub-peripheral keel without a prominent spiral ridge, 5 or 6 distinctly raised spiral ridge striations at protoconch, widely-spaced (5 to 8 ribs per mm), slightly prosocline radial ribs which terminate abruptly slightly below the periphery at teleoconch and semi-closed umbilicus.

Description. Shell small (SH up to 4.39 mm; SW up to 4.62 mm; DA 0.64–1.16 mm, DB 0.97–1.77 mm, DC 1.47–2.52 mm, DD 1.96–3.49 mm; NW up to 6½; AH up to 1.77 mm; AW up to 2.52 mm; Table 1), solid, opaque, off-white, conical, periphery rounded, sub-peripheral keel sharp. Apex rounded. Surface slightly shiny to dull. Whorls convex, rounded, suture slightly impressed. Protoconch whorls convex, radial striation absent, five or six distinctly raised spiral ridge striations from apex to first prominent radial rib at around 2¼ whorls. Teleoconch whorls convex. Dorsal whorls radial ribs regular, wide-spaced (5 to 8 ribs per mm), slightly prosocline, prominent, thin but solid. Ribs terminate abruptly slightly below periphery, sub-peripheral keel sharp,

no spiral ridge. Ventral whorls radial growth lines very fine, dense. Dorsal whorl interstices striations very fine, dense, inconspicuous. Ventral whorls spiral striations very fine, dense, inconspicuous. Umbilicus semi-closed, partially obstructed by expanded peristome columellar section.

Distribution. *Rahula limbooliati* is known from three limestone hills in central Pahang, Peninsular Malaysia: PHG 01 Kota Gelanggi, PHG 02 Gunung Senyum and PHG 03 Bukit Jebak Puyuh (Fig. 2).

Remarks. *Rahula limbooliati* varies in shell size with locality, whereby shells from PHG 02 Gunung Senyum are smaller than those from PHG 03 Gunung Jebak Puyuh and PHG 01 Kota Gelanggi (Table 1). *Rahula limbooliati* is somewhat similar to *R. raricostulata* Smith, 1893, from Sarawak in having widely-spaced radial ribs but differs in its white shell, less pronounced radial ribs, tall conical spire and absence of a prominent sub-peripheral spiral ridge (Smith, 1893). *Rahula limbooliati* also resembles *R. jucunda* Bavay & Dautzenberg, 1912, from northern Vietnam, in shell shape but differs in the lack of a prominent sub-peripheral spiral ridge and the presence of prominent radial ribs at the protoconch (Bavay & Dautzenberg, 1912).

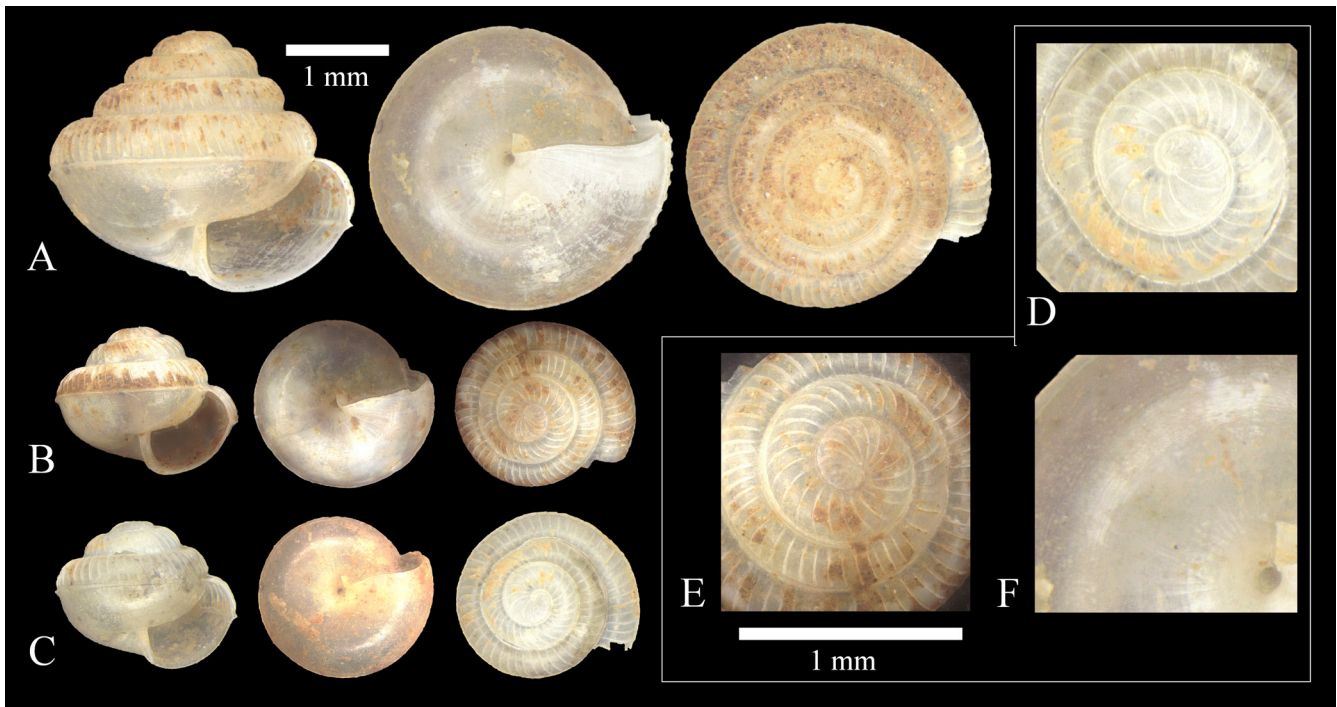


Fig. 3. *Rahula tonywhitteni*, new species. A, holotype (BOR/MOL 11422); B, paratype (BOR/MOL 12536); C, paratype (BOR/MOL 11207); D, close-up of the apical whorls of BOR/MOL 11207; E, close-up of the apical whorls of BOR/MOL 12536; F, close-up of the umbilical side of BOR/MOL 11422. All specimens from PRK 01 Gunung Tempurung, Perak, Peninsular Malaysia.

***Rahula tonywhitteni*, new species**

(Fig. 3A–F)

Rahula ‘tempurung 1’ – Foon et al., 2017: 71, fig. 27C.

Type specimens. Holotype: (BOR/MOL 11422), PRK 01 Gunung Tempurung, Perak, Peninsular Malaysia (4.4182°N 101.1921°E), coll. J. K. Foon, 2016. Paratypes: 1 ex. (BOR/MOL 12536), same data as holotype; 2 ex. (1 shell measured, 1 broken shell not measured) (BOR/MOL 11207), same data as holotype; 2 ex. (juveniles, not measured) (BOR/MOL 11222), same data as holotype; 4 ex. (broken shells, not measured) (BOR/MOL 11392), same data as holotype.

Etymology. *Rahula tonywhitteni* is named in honour of the late Dr. Tony Whitten (1953–2017), a colleague and one of the world’s key advocate for limestone biodiversity conservation. He is fondly remembered for his deep appreciation of less charismatic limestone karst dwelling species especially land snails.

Diagnosis. *Rahula tonywhitteni* differs from all known congeners by its conical shell, rounded periphery, somewhat sharp sub-peripheral keel, prominent radial ribs angled towards the apex at protoconch, slightly prosocline and narrowly-spaced radial ribs (12 to 15 ribs per mm) at teleoconch and open umbilicus.

Description. Shell small (SH up to 2.14 mm; SW up to 2.34 mm; DA 0.51–0.73 mm, DB 0.98–1.23 mm, DC 1.46–1.79 mm, DD up to 2.03 mm; NW 3 to 4½; AH up to 1.09 mm; AW up to 1.24 mm; Table 1), thin, semi-translucent, off-

white, conical, sub-peripheral keel somewhat sharp. Apex rounded. Surface slightly shiny. Whorls convex, rounded, suture distinctly impressed upon spiral ridge slightly below periphery of previous whorl. Protoconch whorls convex, radial ribs prominent, thin. Apical whorl radial ribs angled towards apex. Later whorls slightly prosocline. Spiral striations very fine, dense, somewhat conspicuous. Teleoconch whorls convex. Dorsal whorls radial ribs regular, narrow spaced (12 to 15 ribs per mm), slightly prosocline, prominent, thin. Ribs terminate abruptly slightly below periphery, merged into prominent sub-peripheral spiral ridge. Ventral whorls radial growth lines very fine, irregular. Dorsal whorl interstices striations very fine, dense, regularly spaced, somewhat conspicuous. Ventral whorls spiral striations very fine, dense, regularly spaced, somewhat conspicuous. Umbilicus open, small.

Distribution. *Rahula tonywhitteni* is known only from the type locality, PRK 01 Gunung Tempurung (Fig. 2).

Remarks. *Rahula tonywhitteni* shares with *R. jucunda* from northern Vietnam and *R. manipurensis* Godwin-Austen, 1907, from north-eastern India several shell characters: prominent sub-peripheral radial ridge, convex whorls and globose shell (Godwin-Austen, 1907; Bavay & Dautzenberg, 1912). However, the aperture of *R. tonywhitteni* is more elongated than in the other two species, which possess more rounded apertures. *Rahula tonywhitteni* differs from the geographically close *R. limbooliati*, new species, in having a small but open umbilicus, somewhat sharp sub-peripheral keel and protoconch with prominent radial ribs angled towards the apex.

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LITERATURE CITED

- Albers JC & von Martens E (1860) Die Heliceen nach natürlicher Verwandtschaft systematisch geordnet von Joh. Christian Albers. Zweite Ausgabe nach dem hinterlassenen Manuskript besorgt von Eduard von Martens. Engelmann, Leipzig, 359 pp.
- Baker HB (1928) Minute American Zonitidae. Proceedings of the Academy of Natural Sciences of Philadelphia, 80: 1–44.
- Bavay A & Dautzenberg P (1912) Description de coquilles nouvelles de l'Indo-Chine. Journal de Conchyliologie, 60: 1–54.
- Benson WH (1859) XXI. – Descriptions of new species of *Helix*, *Streptaxis*, and *Vitrina*, collected by Mr. W. Theobald jun., in Burmah, the Khasia Hills, and Hindustan. The Annals and Magazine of Natural History, Series 3, 3: 184–189.
- Blanford WT (1863) On Indian species of land-shells belonging to the genera *Helix*, Linn., and *Nanina*, Gray. The Annals and Magazine of Natural History, Series 3, 11: 81–86.
- Bourguignat JR (1877) Descriptions de deux nouveaux genres algériens, suivies d'une classification des familles et des genres de mollusques terrestres et fluviatiles du système européen. Bulletin de la Société des Sciences Physiques et Naturelles de Toulouse, 3(1): 49–101.
- Clements R, Ng PKL, Lu XX, Ambu S, Schilthuizen M & Bradshaw CJ (2008) Using biogeographical patterns of endemic land snails to improve conservation planning for limestone karsts. Biological Conservation, 141: 2751–2764.
- Foon JK, Clements GR & Liew T-S (2017) Diversity and biogeography of land snails (Mollusca, Gastropoda) in the limestone hills of Perak, Peninsular Malaysia. ZooKeys, 682: 1–94.
- Gittenberger E, Leda P & Sherub S (2017a) Gastropods in Bhutan, the genus *Rahula* (Pulmonata: Helicarionidae). Journal of Conchology, 42: 413–418.
- Gittenberger E, Tenzin U & Sherub S (2017b) Additional records of *Rahula* species (Pulmonata, Helicarionidae) in Bhutan. Basteria, 81: 107–110.
- Godwin-Austen HH (1888) Land and freshwater Mollusca of India, including South Arabia, Baluchistan, Afghanistan, Kashmir, Nepal, Burmah, Pegu, Tenasserim, Malay peninsula, Ceylon, and other islands of the Indian Ocean. Supplementary to Messrs. Theobald and Hanley's Conchologia Indica, 1(6): 207–257.
- Godwin-Austen HH (1907) Land and freshwater Mollusca of India, including South Arabia, Baluchistan, Afghanistan, Kashmir, Nepal, Burmah, Pegu, Tenasserim, Malay peninsula, Ceylon, and other islands of the Indian Ocean. Supplementary to Messrs. Theobald and Hanley's Conchologia Indica, 2(10): 147–238.
- Godwin-Austen HH (1918) Zoological results of the Abor expedition, 1911–12. 48, Mollusca, 8. Macroclaminae (In part). Records of the Indian Museum, 11: 581–600.
- Liew T-S, Price L & Clements GR (2016) Using Google Earth to improve the management of threatened limestone karst ecosystems in Peninsular Malaysia. Tropical Conservation Science, 9: 903–920.
- Mörch OAL (1872) Mollusques terrestres et fluviatiles des Iles Nicobar. Journal de Conchyliologie, 20: 308–327.
- Pilsbry HA (1934) Zoological results of the Dolan West China expedition of 1931. Part II. Mollusks. Proceedings of the Academy of Natural Sciences of Philadelphia, 86: 5–28.
- Ray HC & Rajagopalaiengar AS (1953) On a new variety of *Rahula munipurensis* from Teria Ghat and a new record of distribution of that species from Jaintia Hills Assam (Mollusca, Gastropoda, Pulmonata: Family Zonitidae). Records of the Indian Museum, 51: 57–59.
- Schileyko AA (2003) Treatise on Recent terrestrial pulmonate molluscs; Part 10; Ariophantidae, Ostracolethidae, Rysstotidae, Milacidae, Dyakiidae, Staffordiidae, Gastrodontidae, Zonitidae, Daudebaridiidae, Parmacellidae. Ruthenica, Supplement, 10: 1309–1466.
- Smith EA (1893) Descriptions of new species of land-shells from Borneo. Journal of the Linnean Society (Zoology), 24: 341–352.
- Thiele J (1931) Handbuch der systematischen Weichtierkunde. Band 1, Teil 2. Fischer, Jena, pp. 377–778.
- Vermeulen JJ, Liew T-S & Schilthuizen M (2015) Additions to the knowledge of the land snails of Sabah (Malaysia, Borneo), including 48 new species. ZooKeys, 531: 1–139.
- Vermeulen JJ & Whitten AJ (1998) Fauna Malesiana – Guide to the land snails of Bali. Backhuys, Leiden, 164 pp.
- Zilch A (1959) Handbuch der Paläozoologie. Band 6. Gastropoda. Teil 2 Euthyneura. Borntraeger, Berlin, xii + 834 pp.