A new land snail, Arinia (Notharinia) micro (Caenogastropoda: Cyclophoroidea: Diplommatinidae), from a limestone karst in Perak, Peninsular Malaysia

Mohammad Effendi bin Marzuki1 & Junn Kitt Foon2, 3

Abstract. A new snail species of the family Diplommatinidae is described from Perak, western Peninsular Malaysia. Arinia (Notharinia) micro, new species, differs from known congeners by its remarkably smaller shell. It is among the smallest land snails in the world with a mean shell height of 0.85 mm and mean shell width of 0.35 mm. The shell has tight radial ribbed whorls (except for the smooth protoconch), pronounced fine spiral ridges, and a semi-detached body whorl. The new species is known only from Gunung Rapat limestone karst complex, parts of which are subjected to rapid, destructive limestone quarrying. The reassignment of Arinia (Notharinia) from family Pupinidae to Diplommatinidae is based mainly on the oblique apex, which is not known in other members of the Pupinidae, and other shell characters.

Key words. Gastropoda, land snail, Malaysia, Diplommatinidae, Pupinidae, karst conservation, new taxon

INTRODUCTION

The genus Arinia (Notharinia) Vermeulen, Phung & Truong, 2007, is currently comprised of four nominal species. Arinia (Notharinia) attenuata Vermeulen, Phung & Truong, 2007, Arinia (Notharinia) brevior Vermeulen, Phung & Truong, 2007, and Arinia (Notharinia) crassilabris Vermeulen, Phung & Truong, 2007, inhabit a cluster of limestone karsts in south-western Vietnam while one species, Arinia (Notharinia) linnei Maassen, 2008, is known only from one isolated limestone karst on the east coast of Peninsular Malaysia. Arinia (Notharinia) species are presumed to be calcicolic endemics as they are thus far known only from limestone karst forests (Vermeulen et al., 2007; Maassen, 2008). All species have shells that are minute (< 2.05 mm), rather cylindrical in shape, white, delicate, and heavily ornamented with radial ribs on all whorls except the smooth, rounded protoconch (Vermeulen et al., 2007). Shells of Arinia (Notharinia) species are also characterised by their slightly oblique protoconch (Vermeulen et al., 2007).

Here, we describe the second species of Arinia (Notharinia) in Peninsular Malaysia. Reassignment of Arinia (Notharinia) to the family Diplommatinidae Benson, 1849, by Egorov (2013) is justified and elaborated. The new species brings the total number of known Arinia (Notharinia) species to five, and represents a 230 km range extension eastwards for the subgenus. Prior to this study, three diplommatinid genera comprising a total of 70 species occur in Peninsular Malaysia: 19 species of Diplommatina Benson, 1849, 24 species of Opisthostoma Blandford & Blanford, 1860, 26 species of Plectostoma Adams, 1865 and 1 species of Arinia (Notharinia) (Laidlaw, 1949; Benthem-Jutting, 1952, 1961; Maassen, 2001, 2008; Clements et al., 2008; Vermeulen & Clements, 2008; Egorov, 2013; Liew et al., 2014). The description of Arinia (Notharinia) micro new species, brings the number of diplommatinid species in Peninsular Malaysia to 71.

MATERIAL AND METHODS

Descriptions of Arinia (Notharinia) micro, new species, are based on conchological characteristics. Shell terminology follows Vermeulen et al. (2007), Maassen (2008) and Panha & Burch (2005). The holotype and two paratypes of Arinia (Notharinia) micro new species were photographed and measured with a Leica DFC495 Digital Microscope Camera mounted on a Leica M205C microscope. Shell height was measured from the highest part of the shell to the lowest part of the peristome parallel to the dominant coiling axis. Shell width was measured at the widest section perpendicular to the dominant coiling axis. Aperture height was measured at the widest section of the aperture parallel to the dominant coiling axis. The number of whorls including the protoconch was counted (after Kerney & Cameron, 1979). All measurements were measured to the nearest 0.01 mm. The holotype was subsequently sputter coated with gold and viewed under high vacuum with a Scanning Electron Microscope (JEOL JSM-5610LV, JEOL Ltd., Tokyo) to
further discern minute shell sculpture. Specimens were deposited in the BORNEENSIS collection, Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia (Abbreviation: BOR/MOL), and the collection of the first author (Abbreviation: ME). The latter will eventually be deposited in the Sarawak Museum, Kuching, Malaysia.

SYSTEMATICS

Family Diplommatinidae Benson, 1849

Genus *Arinia* Adams & Adams, 1856

Subgenus *Notharinia* Vermeulen, Phung & Truong, 2007

**Type species.** *Arinia (Notharinia) attenuata* Vermeulen, Phung & Truong, 2007

*Arinia (Notharinia) micro* Marzuki & Foon, new species

Figs. 1, 2

**Type material.** Holotype (BOR/MOL 6227) and paratypes (BOR/MOL 6228/2; ME0000883/10): Malaysia, Perak, central Gunung [=Mountain] Rapat, limestone outcrops in Kek Lok Tong, approximately 6.9 kilometres south of Ipoh, 4°33′13.45″N, 101°7′50.34″E, coll. M.E. Marzuki, 26 May 2011.

**Diagnosis.** Shell minute, cylindrical, translucent. Whorls 4.5. All whorls except the protoconch sculptured with dense, prominent, thin radial ribs. Spiral ridges very fine, evenly spaced and distinct. Last part of body whorl detached,
peristome not touching the ultimate whorl. Umbilicus deep. Peristome simple, reflected at the parietal area but not the palatal and basal areas.

Description. Shell minute, delicate, dextral. Color dull white, translucent. Suture deeply impressed. Whorls 4.5, convex. Apical whorl depressed conical, width of the antepenultimate, penultimate and ultimate whorl consistent, thus shell appears cylindrical. Periphery rounded for all whorls. Apex somewhat sunken, slightly depressed and concave. Protoconch rounded, smooth, distinctly oblique at 25 degrees to the teleoconch. Teleoconch commences with abruptly sculptured orthoclinic radial ribs. Radial sculpture is present on all whorls except the protoconch and is characterised by dense, straight, pronounced, sharp thin ribs. Radial ribs slightly sinuous particularly on apical and ultimate whorls. Radial rib density varies ontogenically, ribs more loosely spaced at the start of the teleoconch, denser at the apical and antepenultimate whorls (10 ribs per 0.1 mm), less dense at the penultimate and ultimate whorls (6 ribs per 0.1 mm) and very dense towards the terminal of the ultimate whorl (7 ribs in 0.04 mm before the aperture, equivalent to 17.5 ribs per 0.1 mm). Internal constriction present, but not conspicuous. Spiral ridges between radial ribs very fine, evenly-spaced, distinct and are present on all whorls except the protoconch. Shell rimately perforate, last whorl loosely-coiled, slightly detached, revealing a deep umbilicus. Aperture simple, circular, white. Peristome simple, well-rounded, thinned and reflected at the parietal area but not the palatal or basal area, not touching the ultimate whorl. Operculum not examined.

Dimensions (Table 1). Shell height 0.80–0.90 mm, mean 0.85 mm; Shell width 0.34–0.35 mm, mean 0.35 mm; Aperture height 0.24–0.42 mm, mean 0.31 mm (n=3).

Etymology. From the Greek micro, meaning small, in reference to the remarkably smaller shell of matured individuals of the species compared to its four known congeners.

Habitat and ecology. Arinia (Notharinia) micro inhabits thickly vegetated lowland rainforest on and near limestone karsts. Living individuals were observed crawling among leaf
Table 1. Shell measurements (mm) for Arinia (Notharinia) species. Measurements of Arinia (Notharinia) attenuata, Arinia (Notharinia) brevior, Arinia (Notharinia) crassilabris, and Arinia (Notharinia) linnei were sourced from Vermeulen et al. (2007) and Maassen (2008).

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Shell Height</th>
<th>Shell Width</th>
<th>Aperture Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arinia (Notharinia) attenuata Vermeulen, Phung &amp; Truong, 2007</td>
<td>1.70–1.90</td>
<td>0.75–0.85</td>
<td>0.45–0.50</td>
</tr>
<tr>
<td>Arinia (Notharinia) brevior Vermeulen, Phung &amp; Truong, 2007</td>
<td>1.50–1.60</td>
<td>0.85–0.90</td>
<td>0.50–0.55</td>
</tr>
<tr>
<td>Arinia (Notharinia) crassilabris Vermeulen, Phung &amp; Truong, 2007</td>
<td>1.60–2.05</td>
<td>0.65–0.75</td>
<td>0.50–0.60</td>
</tr>
<tr>
<td>Arinia (Notharinia) linnei Maassen, 2008</td>
<td>1.58–2.16</td>
<td>0.84–0.99</td>
<td>NA</td>
</tr>
<tr>
<td>Arinia (Notharinia) micro Marzuki &amp; Foon, new species</td>
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<tr>
<td>Holotype (BOR/MOL 6227)</td>
<td>0.90</td>
<td>0.35</td>
<td>0.25</td>
</tr>
<tr>
<td>Paratype 1 (BOR/MOL 6228/1)</td>
<td>0.85</td>
<td>0.35</td>
<td>0.26</td>
</tr>
<tr>
<td>Paratype 2 (BOR/MOL 6227/2)</td>
<td>0.80</td>
<td>0.34</td>
<td>0.24</td>
</tr>
<tr>
<td>Mean (Holotype, Paratype 1 and Paratype 2)</td>
<td>0.85</td>
<td>0.35</td>
<td>0.25</td>
</tr>
</tbody>
</table>

The familial assignment of Arinia (Notharinia) has been contentious (e.g., Vermeulen et al., 2007; Maassen, 2008; Egorov, 2013). Arinia (Notharinia) was placed in the family Pupinidae by Vermeulen et al. (2007), who regarded Arinia (Notharinia) more akin to the genus Pseudopomatias Möllendorff, 1885, on the basis of shared shell characters, such as evenly-spaced radial ribs, simple or doubled and circular aperture as well as smooth protoconch transitioning to ribbed teleoconch at the apical whors (see Páll-Gergely et al., 2015a). The interspecific variability in radial rib height (pronounced or low) and the variation in radial rib density at each whorl are present in both Pseudopomatias and Arinia (Notharinia) as well (Páll-Gergely et al., 2015a). However, Arinia (Notharinia) possesses a distinctly oblique apex, which is not known in pupinids, but fairly common in diplommatinids (Webster et al., 2012; Yamazaki et al., 2013, 2015a, b; Liew et al., 2014; Neubert & Bouchet, 2015). Arinia (Notharinia) micro, new species, possesses an internal constriction unlike other known Arinia (Notharinia) species (see Vermeulen et al., 2007), which is also common in diplommatinids, but not in pupinids (Webster et al., 2012; Yamazaki et al., 2013, 2015a, b; Liew et al., 2014; Neubert & Bouchet, 2015). The sub-cylindrical to cylindrical shell, simple but distinct radial ribs and the occasionally detached last whorl of members of the diplommatinid Arinia sensu stricto, Adams & Adams, 1856, is similar to Arinia (Notharinia) (see Vermeulen, 1996; Egorov, 2013). Despite these similarities, Vermeulen et al. (2007) regards Arinia (Notharinia) a pupinid because of their lack of longitudinal teeth. However, the absence of longitudinal teeth is not a good diagnostic character for Arinia (Notharinia) because most Arinia sensu stricto species also do not possess longitudinal teeth. Thus, we concur with Maassen (2008) that the absence of longitudinal teeth alone is not a reliable familial character. Egorov (2013) placed Notharinia as a subgenus of Arinia but did not elaborate reasons for the recombination. We demonstrate above that Egorov’s (2013) decision to place Notharinia in genus Arinia and the family Diplommatinidae is justified.
Some of the smallest terrestrial snails known to science were briefly discussed by Páll-Gergely et al. (2015b). Arinia (Notharinia) micro (shell height = 0.80–0.90 mm) is one of the smallest terrestrial snails ever recorded, following closely behind Acmella nana Vermeulen, Liew & Schilthuizen, 2015 (shell height = 0.60–0.79 mm), Acmella minutissima (Maassen, 2000) (shell height = 0.8 mm), Acmella conica Vermeulen & Junau, 2007 (shell height = 0.85 mm) and Georissaiewucococa Vermeulen, Liew & Schilthuizen, 2015 (shell height = 0.70–1.05 mm). It is beyond the scope of this paper to cover the ecological and evolutionary implications of such minute snail sizes. However, such extreme body sizes in land snails is well-known and have been attributed to resource and niche partitioning among molluscan communities (McClain & Nekola, 2008; Nekola et al., 2013; Nekola, 2014). This has been alluded to in studies on the micro-snails (shell size <5 mm) of the tropics, although detailed research on such aspects remains to be done (Schilthuizen, 2011).

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