


***Notharinia sinensis* sp. nov., first record of *Notharinia* from China,
with a preliminary geometric morphometric analysis of
the relationship of *Notharinia* and *Arinia* s. l.
(Gastropoda: Caenogastropoda: Diplommatinidae)**

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Abstract. A new species, *Notharinia sinensis* sp. nov., is described from Guangxi, China, extending the known range of the genus. Geometric morphometric analysis distinguishes *Notharinia* from *Arinia* s. l., supporting its generic validity. Two East Asian species, *Notharinia japonica* (Pilsbry & Hirase, 1903) **comb. nov.** and *N. chejuensis* (Kwon & Lee, 1991) **comb. nov.**, are reassigned to *Notharinia* based on morphological and geometric morphometric evidence. The study also reveals that several Bornean species traditionally placed in *Arinia* s. l. may be more appropriately assigned to *Arinia* (*Leucarinia*), warranting further taxonomic revision.

Key words. Micro-snails, new species, taxonomy, geometric morphometrics, Guangxi, China

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INTRODUCTION

Notharinia Vermeulen, Phung & Truong, 2007 is a genus of minute diplommatinids distributed in Vietnam, Cambodia, Malaysia, and Laos. It is only distinguished from the morphologically similar genus *Arinia* H. & A. Adams, 1856 by the absence of a circular thickening in the constriction (Maassen 2008; Marzuki & Foon 2016; Páll-Gergely & Hunyadi 2018; Vermeulen *et al.* 2019; Vermeulen & Khalik 2022). Besides the *Arinia* s. s., Möllendorff (1893) established *Arinia* (*Leucarinia*) based on the white shell, small size and sculpture of the shell, and peristome. In his catalogue, Kobelt (1902) noted that apart from *Glyptop-upoides egregius* (Hedley & Musson, 1892), which at that time was misassigned to Diplommatinidae and occurs in Australia, all *Arinia* s. s. are restricted to the Philippines, whereas *A. (Leucarinia)* occurs in the Philippines and farther south on Borneo, Sulawesi, and Flores. Since Vermeulen (1996b), the subgenus *Arinia* (*Leucarinia*) has seen limited use in the literature, with Bornean species generally treated as *Arinia* in the work. A new species of *Notharinia* was isolated from a recently collected soil sam-

ple from Guangxi, China, and is described and illustrated herein. Given the limited structural differences between *Notharinia* and *Arinia*, a geometric morphometric analysis was employed to preliminarily assess intrageneric variation within *Arinia* s. l., and its relationship with *Notharinia*. Based on both morphological and geometric morphometric evidence, two East Asian species previously assigned to *Arinia*, namely *Arinia japonica* Pilsbry & Hirase, 1903 from Japan and *Arinia chejuensis* Kwon & Lee, 1991 from the Korean Peninsula, are reassigned to *Notharinia*. This study greatly expands both the known and potential geographic distribution of *Notharinia*.

MATERIALS AND METHODS

Dry soil samples containing shells were collected directly from the type locality of the new species. The soil samples were then soaked in water to loosen the soil structure. After filtering and manually sorting, the extracted shells were identified and separately stored under a Leica MZ6 stereomicroscope. Shells are being cleaned using a soft brush and distilled water. The shells were photographed using a Canon SD Mark IV camera with a Laowa 25mm f/2.8 2.5–5× Ultra Macro lens. The final high depth-of-field images were pro-

duced by a WeMacro Rail System and stacked from 20–30 single photos using Zerene Stacker v. 1.04. The shells were measured with digital vernier callipers to the nearest 0.01 mm. Shell whorls were counted as described by Kerney & Cameron (1979).

Geometric morphometric (GM) methods were used to explore the conchological relationship among the new species described herein, *Notharinia* and *Arinia* s.l. Shell morphological variation analyses were performed in the tps series software including tpsUtil32 (Rohlf 2004) and tpsDig32 (Rohlf 2005), using the geometric morphometric methods based on the landmarks on the profile of the aperture-viewed shell (Schilthuisen *et al.* 2012; Wu *et al.* 2019; Páll-Gergely *et al.* 2023). Geometric morphometric variables of the shells were obtained with 13 landmarks representing the outline of the shell and of the aperture as shown in Figure 1A. The landmarks were treated indiscriminately. The geometric morphometric analysis employed aperture-viewed images of 91 shells including most Philippine *Arinia* s.s. species (18 specimens of 17 spp. and subspp., including

17 from Zilch (1953: figs 13–29) and one from NHMUK 19601553, *Arinia minor* (G.B. Sowerby I, 1843), type species of *Arinia*, Philippine *Arinia* (*Leucarinia*) species (13 specimens of 13 spp. and subspp., all from Zilch (1953: figs 30–34, 37–44)), Bornean *Arinia* s.l. species (39 specimens of 29 spp. and subspp., all from Vermeulen (1996b: figs 2–30)), all known species of *Notharinia* (20 specimens of 16 spp., 10 from Vermeulen *et al.* (2019), 2 from Páll-Gergely & Hunyadi (2018), 2 from Marzuki & Foon (2016), 2 from Maassen (2008)), the new *Notharinia* species described in this study (2 specimens—the holotype and paratype) and two East Asian species previously assigned to *Arinia* (1 from Min *et al.* (2004: fig. 178), 1 from ANSP 84413). Besides, *Niahia oberon* Vermeulen, 1996 (1 specimen from Vermeulen (1996b: fig. 1)) is also included in the analysis as the original description suggested its possible relationship with *Arinia* (Vermeulen 1996a). Full Procrustes fitting, covariance matrix generation, and subsequent canonical variate analysis (CVA) were performed using Past 5 v. 5.2 (Hammer *et al.* 2001).

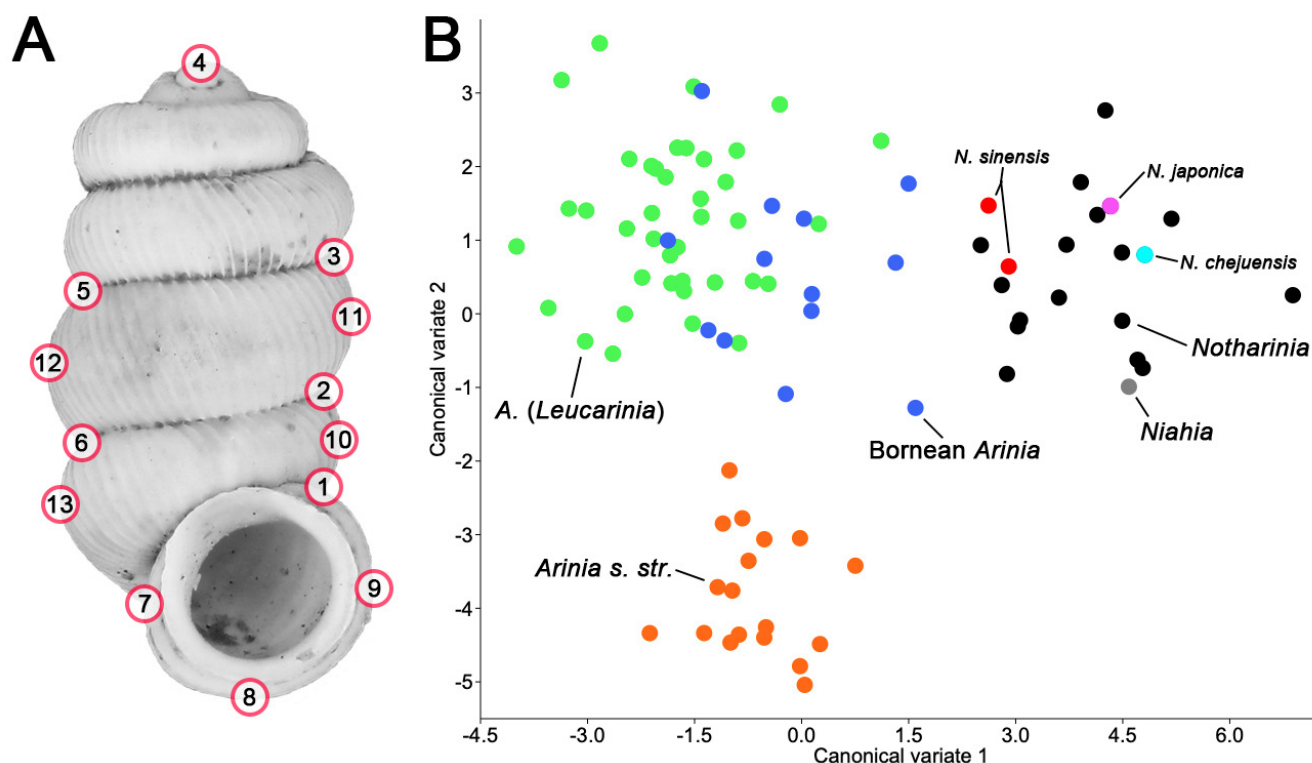


Figure 1. A, a diagram showing design of landmarks. B, scatter plot of canonical variate 1 against canonical variate 2 (Canonical Variate Analysis), showing the shell morphological relationship among Philippine *Arinia* (*Arinia*) spp. (orange dots), Philippine *Arinia* (*Leucarinia*) spp. (green dots), Bornean *Arinia* spp. (dark-blue dots), previously known *Notharinia* spp. (black dots), *N. sinensis* sp. nov. (red dots), *N. japonica* comb. nov. (purple dots), *N. chejuensis* comb. nov. (light-blue dots), and *Niahia oberon* (grey dots).

Abbreviations: ANSP = Academy of Natural Sciences of Drexel University, Philadelphia, USA; CZYC = Zhe-Yu Chen's private collection, Wuhan, China; HBUMM = Mollusks collection of Museum of Hebei University, Baoding, China; NHM / NHMUK – The Natural History Museum, London, UK; SMF = Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany.

MORPHOMETRIC RESULTS

Canonical Variates Analysis (CVA) revealed distinct separation among predefined taxonomic groups based on shape variation. The first two canonical variates explained 86.62% of the total among-group variation (CV1: 48.95%; CV2: 37.67%). *Arinia* (*Arinia*) spp. formed a compact and clearly isolated cluster along the negative end of CV2, while *Arinia* (*Leucarinia*) occupied a distinct region in the upper-left quadrant, showing moderate overlap with Bornean *Arinia* s.l. *Notharinia* is clearly separated from other groups and forms a compact cluster in the right half of the plot along the positive axis of CV1. The new species described in this study, along with two East Asian species previously assigned to *Arinia* (details see below), fall within the *Notharinia* cluster. *Niahia oberon* was also distinct but very near *Notharinia*.

SYSTEMATICS

Family Diplommatinidae

Genus *Notharinia* Vermeulen, Phuong & Troung, 2007

Notharinia Vermeulen et al. 2007: 83—Vermeulen et al. 2019: 168.

Arinia (*Notharinia*)—Egorov 2013: 24; Páll-Gergely & Hunyadi 2018: 62.

Type species. *Notharinia attenuata* Vermeulen, Phuong & Troung, 2007, by original designation.

Notharinia sinensis sp. nov.

Figure 2A–C

ZooBank identifier. urn:lsid:zoobank.org:act:26AA429C-270F-4099-9504-CE40401A14A3

Type locality. Unnamed cave, near Baitou Rock [白头岩], Luojin Town [罗锦镇], Yongfu County [永福县], Guilin City, Guangxi Zhuang Autonomous Region, China, 25°00'48"N, 110°06'19"E.

Type specimens. Holotype: HBUMM10078, collected by local people, March 2024. Paratypes: HBUMM10082 (2 shells), CZYC00161 (3 shells), same data as holotype.

Etymology. This name (Latin, meaning “Chinese”) commemorates the first discovery of this genus in China.

Diagnosis. The small size and short, stout shell form of the new species distinguish it from most congeners. Among similarly sized species, it most closely resembles *N. boucheti* (Páll-Gergely, 2018) and *N. brevior* Vermeulen, Phung & Truong, 2007. However, the new species differs from the former by its weaker and denser ribs, and from the latter by its narrower umbilicus.

Description. Shell minute, white, sinistral, cylindrical, consisting of 4–4½ convex whorls separated by impressed suture; apex truncate; three lowest whorls of equal width; no constriction observed, ventral side of body whorl flattened, as typical for the family. Protoconch oblique to shell axis, with 1–1¼ nearly smooth to somewhat pitted whorls. Teleoconch rather regularly, strongly ribbed (6 or 7 ribs per 200 µm), rib density slightly decreasing near aperture. Aperture rounded, parallel to shell axis, not oblique; peristomes double, boundary conspicuous; inner peristome protruding; parietal callus attached to penultimate whorl; outer peristome expanded but not reflected; dense lamellae present between two peristomes. Umbilicus open but very narrow. Operculum unknown.

Shell measurements. Holotype: height 1.51 mm, width 0.77 mm; paratypes ($n = 2$): height 1.42–1.45 mm, width 0.79–0.82 mm.

Remarks. Other species isolated from the same batch of soil samples include *Bensonella* sp., *Boysidia* spp., *Clostophis obliquus* Páll-Gergely & Hunyadi, 2022, *Dentisphaera zhoui* Chen, Lin & Páll-Gergely, 2025, *Metalycaeus* spp., *Sinoennea guiyangensis* Luo et al., 1998, and *Tonkinospira* spp.

Distribution. The new species is known only from the type locality in Guangxi, China.

Notharinia japonica (Pilsbry & Hirase, 1903) comb. nov. Figure 2D

Arinia japonica Pilsbry & Hirase 1903: 136—Minato 1986: 19; Azuma 1995: 14, pl. 5, fig. 45.

Type locality. “Goto, Hizen”, [Japan].

Type material. Lectotype ANSP 84413, paralectotype ANSP 359262.

Label data. “Goto, Hizen, Japan, Y. Hirase, 1903”.

Remarks. The shell size of species is significantly smaller than the range defined by the type species of *Arinia*. In addition, its minute, somewhat cylindrical shell with a truncate apex readily distinguishes it from sympatric *Diplommatina* species, all of which have a larger shell and a high-conical

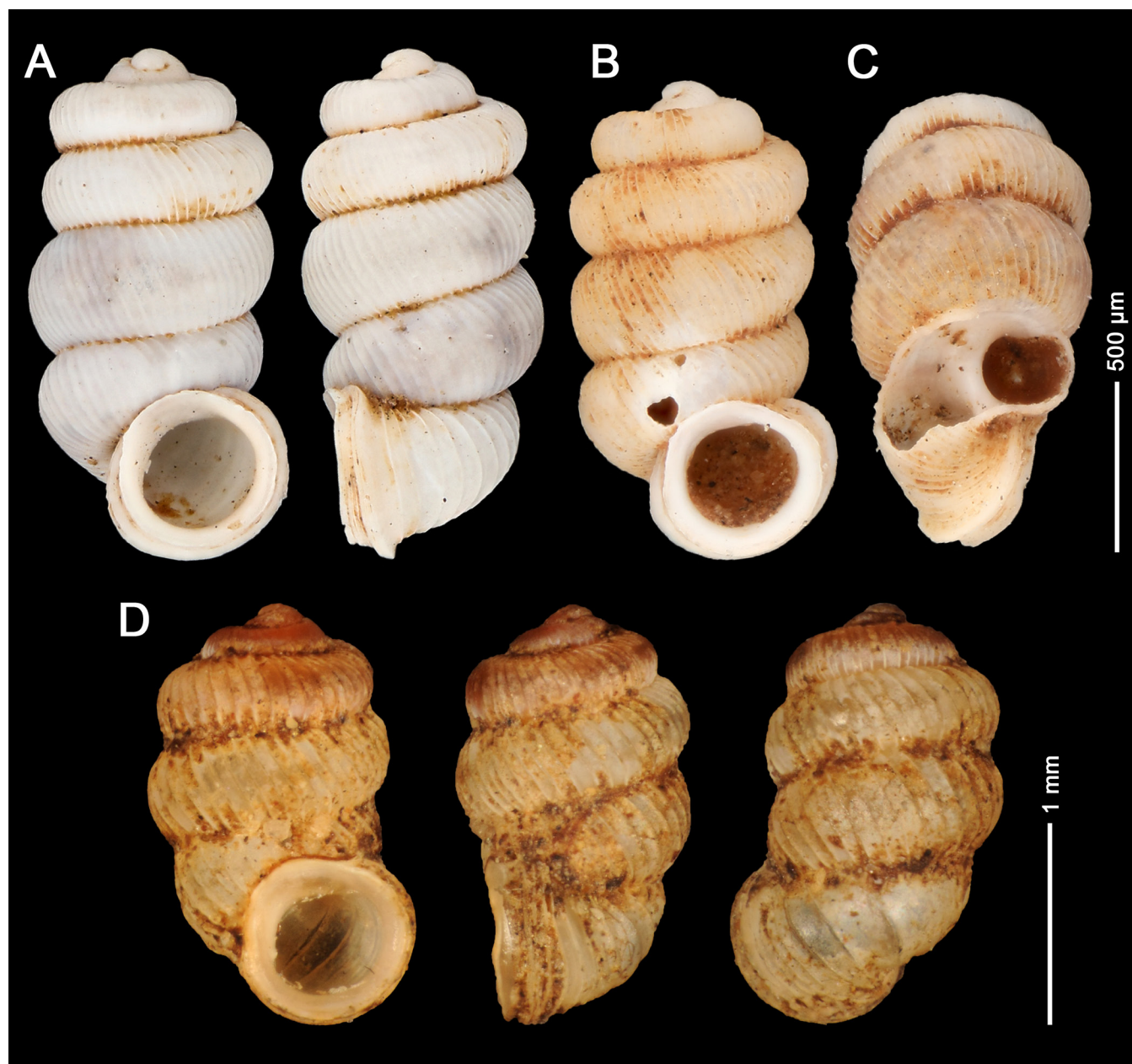


Figure 2. A–C, *Notharinia sinensis* sp. nov.: (A) HBUMM 10078, holotype; (B) CZYC 00161a, paratype; (C) CZYC 00161b, paratype, showing the internal structure. D, *Notharinia japonica* comb. nov., ANSP 84413, lectotype. Scale bars correspond to the shells on the left.

apex. Its morphological traits more closely resemble *Notharinia* and this species is therefore transferred to that genus. Geometric morphometric results also support this reassignment.

Distribution. Kyushu and Shikoku, Japan (Azuma 1995).

***Notharinia chejuensis* (Kwon & Lee, 1991) comb. nov.**

Arinia chejuensis Kwon & Lee 1991: 4, text fig. and fig. 3—Min et al. 2004: 117, fig. 178.

Type locality. “Cheju-do”, [South Korea].

Remarks. As with the preceding species, this species is also transferred to the genus *Notharinia*.

Distribution. Jeju Island, South Korea.

DISCUSSION

This study offers new insights into the redefinition of *Notharinia* and *Arinia* s. l. through geometric morphometric analysis complemented by classical morphological comparisons.

Notharinia and *Arinia* s.l. show clear separation in the geometric morphometric (GM) analysis, particularly along the CV1 axis. Therefore, the status of *Notharinia* as an independent genus appears reliable. Its distinction from *Arinia* is not limited to the absence of circular thickening in the constriction (Vermeulen *et al.* 2019), but also includes its elongate and cylindrical shell. *Notharinia sinensis* sp. nov., *N. japonica* comb. nov., and *N. chejuensis* comb. nov. were all encompassed within the morphometric space of *Notharinia* in the GM analysis, substantially extending the known geographic distribution of the genus. Although *N. linnei* Maassen, 2008 and *N. micro* (Marzuki & Foon, 2016) fell within the morphometric range of *Notharinia* in the present GM analysis, Vermeulen *et al.* (2019) noted that the presence of spiral

sculpture in these species distinguishes them from other members of *Notharinia*. The GM analysis also indicates that the monotypic genus *Niahia* more closely resembles *Notharinia* than *Arinia*. However, its strongly downward-sloping aperture and the structures near the aperture are not found in *Notharinia* (Vermeulen 1996a, b).

The currently defined *Arinia* s.l. is primarily diagnosed by its dextral, low-spired shell with a blunt apex and the absence of internal lamellae. However, the GM analysis clearly differentiates Philippine representatives of the *Arinia* s.s. from other species currently included in *Arinia* s.l. Classical morphological observations further support this distinction: species of *Arinia* s.s. (see Fig. 3a, type species of *Arinia* (*Arinia*); Zilch 1953) con-

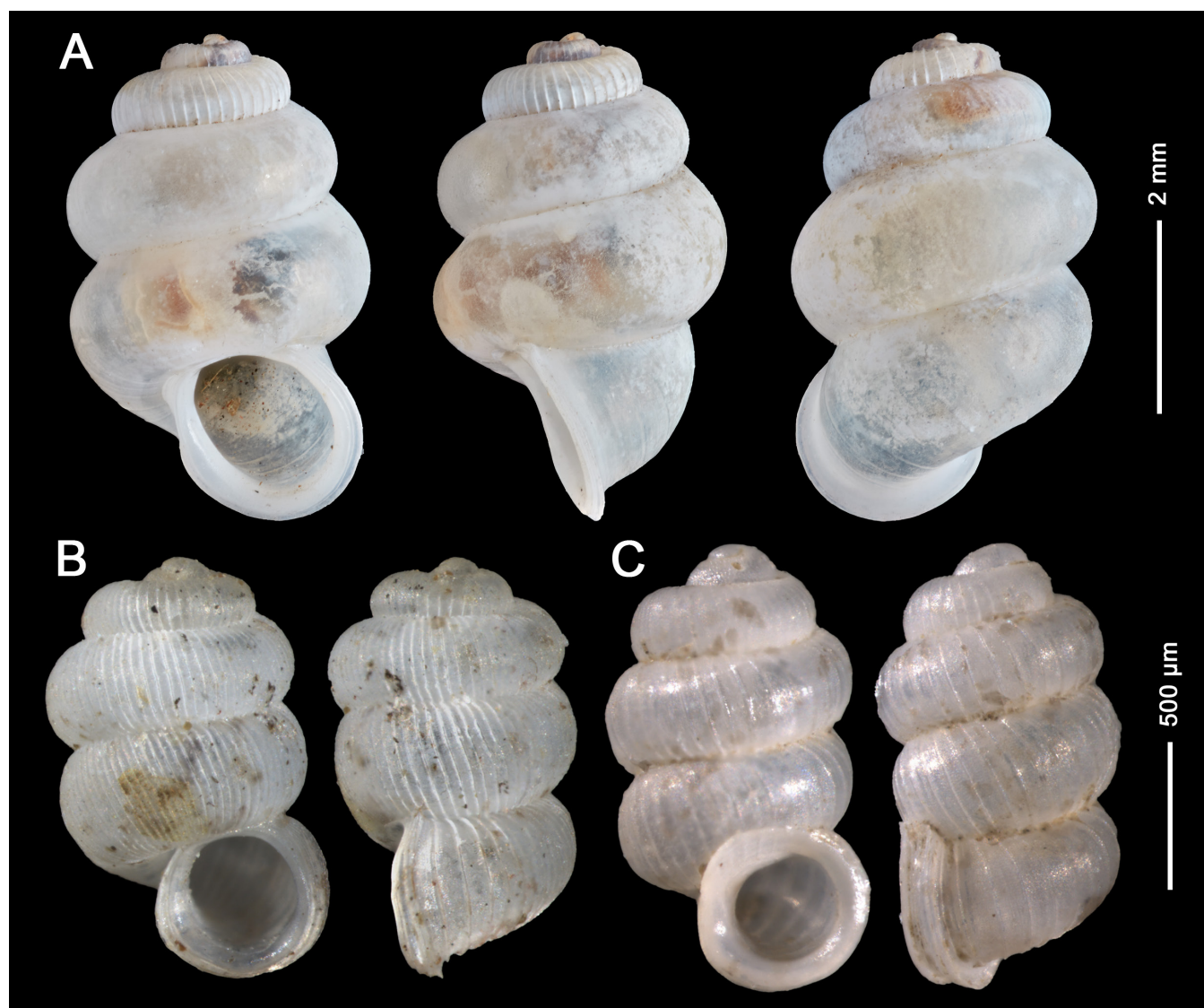


Figure 3. A. *Arinia* (*Arinia*) *minor*, NHMUK 19601553/1, syntype. B. *Arinia* (*Leucarinia*) *minutissima minutissima*, SMF 46892, lectotype. C. *Arinia* (*Leucarinia*) *minutissima latestriata*, SMF 46901, lectotype. Scale bars correspond to the shells on the left.

sistently possess larger shells (shell height >3 mm; see Kobelt 1902), a simple, rounded aperture, a parietal callus that is either absent or restricted from spreading over the body whorl, and a lack of widely spaced double peristomes.

In contrast, Bornean species currently included in *Arinia* s.l. exhibit considerable morphological overlap with Philippine *Arinia* (*Leucarinia*) in the GM analyses. These species are thus more appropriately assigned to *Arinia* (*Leucarinia*), a subgenus defined by a smaller shell size (shell height ≤ 2 mm) and more complex apertural structures (see Fig. 3b, c, *A. (L.) minutissima*, type species of *Leucarinia*¹; Möllendorff 1893; Zilch 1953; Vermeulen 1996b). It should be noted, however, that this study only included Bornean *Arinia* s.l. specimens for which image sources were consistent. Due to limited availability of images for other species, particularly those from Pacific Island populations, a comprehensive revision of *Arinia* s.l. and a robust reevaluation of the diagnostic framework for *Arinia* (*Leucarinia*) are beyond the present scope.

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