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A new species of the world's smallest cave snail of the genus *Angustopila* Jochum, Slapnik & Páll-Gergely in Jochum, et al., 2014 (Gastropoda: Hypselostomatidae) from eastern Thailand

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Abstract. This research describes a newly discovered cave-dwelling microsnail, *Angustopila pallgergelyi*, from Sa Kaeo Province, eastern Thailand. The new species' conchology is similar to the cave-dwelling snail, *A. tamlod* (Panha & Burch, 1999) but differs in shell shape and apertural teeth development. The new species represents the smallest known member of Hypselostomatidae, with an average shell height of 0.66±0.03 mm (the shell height of the holotype is 0.64 mm), which is the smallest land snail species ever reported. Finally, an identification key to species is presented.

Key words. Hypselostomatidae, *Angustopila*, cave-dwelling snail, diversity, Thailand

INTRODUCTION

Angustopila Jochum, Slapnik & Páll-Gergely in Jochum, Slapnik, Kampschulte, Martels, Heneka & Páll-Gergely, 2014, is a genus of terrestrial microsnails and was established for some species in Thailand, Laos, Malaysia, and China by Jochum et al. (2014), which were previously classified within the genus *Systenostoma* Bavay & Dautzenberg, 1909 non Marsson, 1887 but later transferred to *Angustopila* due to homonymy with a bryozoan (Jochum et al., 2014; Páll-Gergely et al., 2015). This group includes nine species, namely *Angustopila concava* (Thompson & Upatham, 1997), *A. elevata* (Thompson & Upatham, 1997), and *A. tamlod* (Panha & Burch, 1999) from Thailand, *A. huoyani* Jochum, Slapnik & Páll-Gergely in Jochum, Slapnik, Kampschulte, Martels, Heneka & Páll-Gergely, 2014, *A. dominikae* Páll-Gergely & Hunyadi in Páll-Gergely, Hunyadi, Jochum & Asami, 2015, *A. fabella* Páll-Gergely & Hunyadi in Páll-Gergely, Hunyadi, Jochum & Asami, 2015, *A. subelevata* Páll-Gergely & Hunyadi in Páll-Gergely, Hunyadi, Jochum & Asami, 2015, and *A. szekeresi* Páll-Gergely & Hunyadi in Páll-Gergely, Hunyadi, Jochum & Asami, 2015 from China, and *A. singuladentis* Inkhavilay & Panha in Inkhavilay, Sutcharit, Tongkerd & Panha, 2016 from Laos (Thompson & Upatham, 1997; Panha & Burch, 2005; Jochum et al., 2014; Páll-Gergely et al., 2015; Inkhavilay et al., 2016). The known distribution of these species in Asia is shown in Figure 1. In this work, a new, world's smallest cavernicolous snail of the genus *Angustopila* is described.

MATERIAL AND METHODS

Specimens were collected from limestone caves in Sa Kaeo Province, eastern Thailand (Fig. 1). Fifteen empty adult shells were cleaned and air-dried. Scanning electron micrographs were taken by a Scanning Electron Microscope (LEO 1450 VP) at the Microscopic Center, Faculty of Science, Burapha University. Shell measurement was undertaken for shell width (SW), shell height (SH), aperture width (AW), and aperture height (AH) using ImageJ 1.52V. The shell dimension of type specimens is described in this publication as a minimum-maximum (mean ± standard deviation). Taxonomic identification was based mainly on Panha & Burch (2005), Jochum et al. (2014), Páll-Gergely et al. (2015), and Inkhavilay et al. (2016). Type materials were deposited in the following institutions: Zoological Research Collection of Burapha University (ZRCBUU), Department of Science, Burapha University, Chon Buri Province, Thailand; Thailand Natural History Museum, National Science Museum Thailand (THNHM), Pathum Thani, Thailand; and the Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum, National University of Singapore, Singapore.

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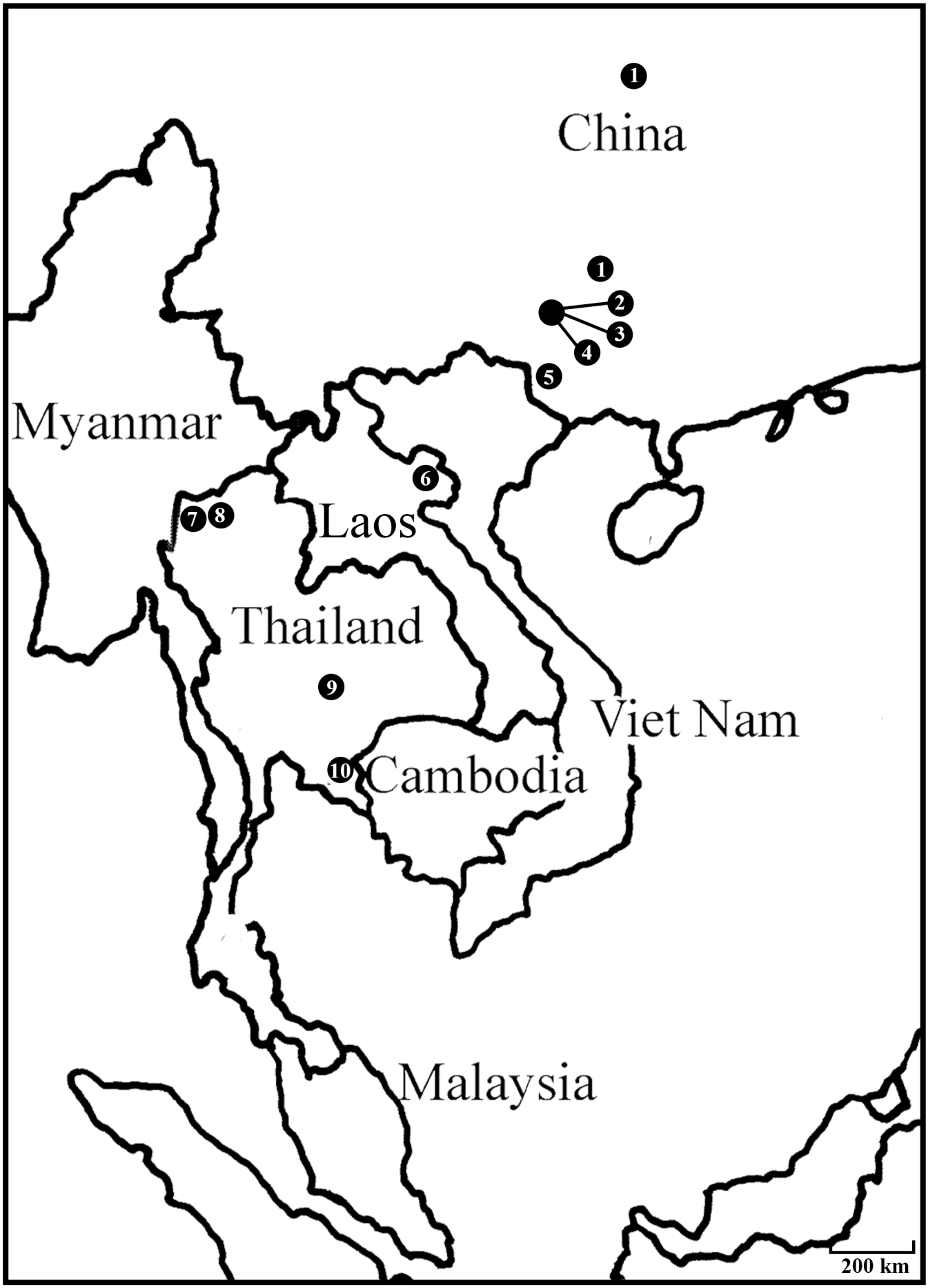

Fig. 1. Distribution map of Angustopila species. 1, *A. huoyani*; 2, *A. dominikae*; 3, *A. subelevata*; 4, *A. szekeresi*; 5, *A. fabella*; 6, *A. singuladentis*; 7, *A. tamlod*; 8, *A. elevata*; 9, *A. concava*; 10, *Angustopila pallgergelyi*, new species.

Table 1. Shell measurements (mm) for *Angustopila pallgergelyi*, new species, from the type locality.

Specimen	SH	SW	SW/SH	AH	AW	AW/AH
Holotype	0.64	0.76	1.19	0.27	0.27	1.01
Paratype 01	0.66	0.82	1.24	0.31	0.29	0.93
Paratype 02	0.68	0.81	1.20	0.27	0.29	1.07
Paratype 03	0.68	0.82	1.21	0.29	0.29	0.99
Paratype 04	0.70	0.84	1.20	0.28	0.29	1.05
Paratype 05	0.59	0.78	1.33	0.27	0.25	0.95
Paratype 06	0.65	0.78	1.19	0.28	0.27	0.94
Paratype 07	0.64	0.85	1.32	0.29	0.28	0.96
Paratype 08	0.69	0.83	1.21	0.24	0.26	1.08
Paratype 09	0.68	0.84	1.25	0.29	0.28	0.94
Paratype 10	0.66	0.85	1.27	0.28	0.27	0.97
Paratype 11	0.65	0.83	1.28	0.27	0.28	1.02
Paratype 12	0.60	0.81	1.35	0.28	0.25	0.90
Paratype 13	0.62	0.82	1.33	0.28	0.29	1.02
Paratype 14	0.71	0.85	1.19	0.34	0.31	0.91

TAXONOMY

Family Hypselostomatidae Zilch, 1959

Angustopila Jochum, Slapnik & Páll-Gergely in Jochum, Slapnik, Kampschulte, Martels, Heneka & Páll-Gergely, 2014

Angustopila Jochum, Slapnik & Páll-Gergely in Jochum et al., 2014: Zookeys, 410: 26.

Type species. *Systenostoma tamlod* Panha & Burch, 1999, by original designation.

Diagnosis. Shell extremely small, conical-shaped; whorls smooth, regular, moderately growing; protoconch recessed slightly into second whorl, sculptured with spiral and radial lines, surface powdery and reticulated; body whorl sometimes continues in profile past penultimate whorl; peristome slightly reflexed; aperture slight or non-adnate, usually one or two denticles.

Angustopila pallgergelyi Dumrongrojwattana, Chuenit & Wongkamhaeng, new species
(Figs. 2, 3A, B)

Type material. Holotype. 1 shell (ZRCBUU 0699), THAILAND, Sa Kaeo Province, Klong Haad District, Tham Phet Pho Thong (Cave), an isolated limestone hill; 13°24′49.4″N 102°19′38.0″E; 280 m a.s.l., coll. S. Chuenit, 5 July 2018. Paratypes. 3 shells (ZRCBUU 0700) and 2 shells (ZRC.MOL.020945) same collecting data as holotype, coll. P. Dumrongrojwattana, 15 September 2019; 7 shells (ZRCBUU 0730) and 2 shells (THNHM-Iv-17645), same collecting data as holotype, coll. P. Dumrongrojwattana, 12 December 2020.

Measurements. Holotype. SH = 0.64 mm, SW = 0.76 mm, AH = 0.27 mm, AW = 0.27, SW/SH = 1.19, and AW/AH = 1.01. Paratypes. SH = 0.59–0.71 mm (0.66±0.03 mm), SW = 0.76–0.82 mm (1.25±0.03 mm), AH = 0.26–0.31 mm (0.28±0.02 mm), AW = 0.25–0.31 mm (0.28±0.02 mm), SW/SH = 1.19–1.35 (1.25±0.08), and AW/AH = 0.90–1.08 (0.98±0.06). See Tables 1 and 2.

Type locality. Thailand, Sa Kaeo Province, Klong Haad District, Tham Phet Pho Thong (Cave), an isolated limestone hill; 13°24′49.4″N 102°19′38.0″E; 280 m a.s.l. (locality no. 10 in Fig. 1).

Etymology. This new species is named in honour of Dr. Barna Páll-Gergely, the Hungarian malacologist, in appreciation of his significant contributions to the study of microsnails.

Description. Shell minute, lenticular, white, apex blunt, spire lenticular with deep sutures (Figs. 2A, 3A, B); protoconch about one whorl, surface finely reticulate (Fig. 2B, C); teleoconch 4–4¼ rounded whorls, irregularly spaced growth lines crossed by rows of fine spiral threads forming fine reticulate sculpture (Fig. 2D); aperture broadly kidney-shaped, peristome slightly thickened, slightly expanded, slightly prosocline, detached from the body whorl; apertural teeth well developed, one parietal and one palatal directly opposite (Fig. 2E); umbilicus deep, relatively narrow.

Differential diagnosis. *Angustopila pallgergelyi* is similar to *A. singuladentis* by having a white shell, nearly smooth protoconch sculpture, and the teleoconch sculpture having irregular growth lines crossed with fine spiral threads, peristome slightly thickened and slightly expanded. The new species differs from *A. singuladentis* in some significant ways. The aperture is kidney-shaped (vs. circular in *A. singuladentis*); apertural teeth consist of parietal and palatal

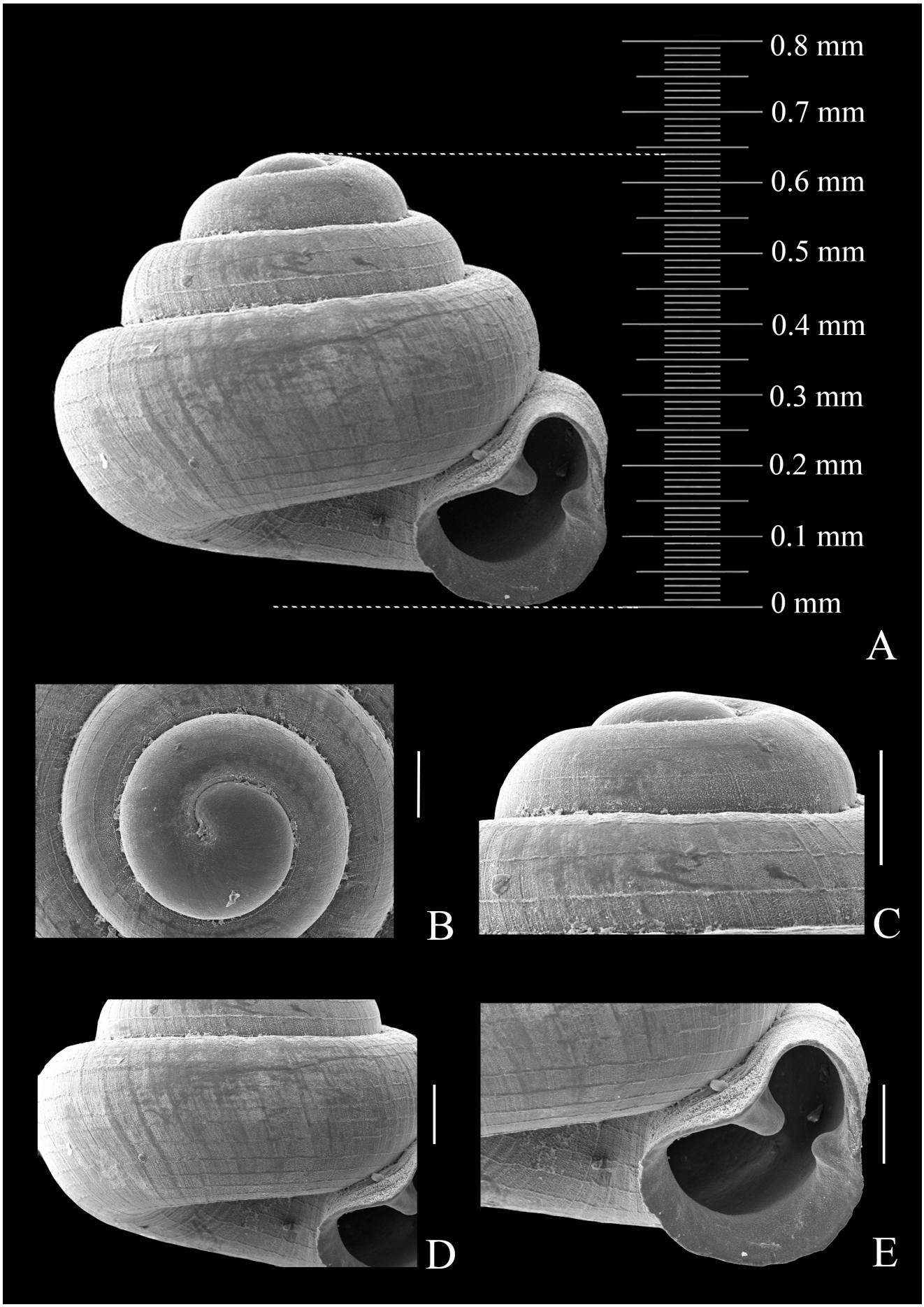

Fig. 2. Holotype of *Angustopila pallgergelyi* Dumrongrojwattana, Chuenit & Wongkamhaeng, new species (ZRCBUU 0699). A, front view with scale; B, C, protoconch; D, teleoconch sculpture; E, apertural teeth. Scale bar = 100 µm.

Table 2. The average, minimum value (min), a maximum value (max), a standard deviation of a set of values (stdev) for *Angustopila pallgergelyi*, new species (n = 15).

Specimen	SH	SW	SW/SH	AH	AW	AW/AH
Min	0.59	0.76	1.19	0.26	0.25	0.90
Max	0.71	0.85	1.35	0.31	0.31	1.08
Average	0.66	0.82	1.25	0.28	0.28	0.98
SD	0.03	0.03	0.06	0.02	0.02	0.06

teeth (vs. only parietal tooth in *A. singuladentis*), and the whorl number ranges from 4–4.5 (vs. 3.5 in *A. singuladentis*) (Table 3). The apertural teeth of *A. pallgergelyi* consist of parietal and palatal teeth, and share this characteristic with only *A. dominikae*, *A. huoyani*, and *A. tamlod*. This new species can be distinguished from these three species by having teleoconch sculpture irregular growth lines crossed with fine spiral threads and the umbilicus deep and relatively narrow. In contrast, the other species have spiral threads and narrow umbilicus.

Ecology. Living snails live in the dark and moisture zone of caves, gliding on the wall or hidden among coral-like stalactite (Fig. 3A, B). All type specimens were collected from soil sampled from the dark zone of Phet Pho Thong Cave, Sa Kaeo, approximately 300 metres from the entrance at the type locality. We assume that this new species is a cave-dweller, similar to *A. tamlod*.

Distribution. The new species is only known from the type locality.

Remarks. All specimens were collected inside the cave in Sa Kaeo Province, eastern Thailand, about 300 metres from the entrance. Among the previously described species, *A. dominikae* was the smallest known land snail (Pall-Gergely et al., 2015), with the shell height of the holotype being 0.86 mm. *Angustopila pallgergelyi*, new species, is even smaller (shell height of the holotype is 0.64 mm and shell heights of the paratypes 0.59–0.71 mm), and is therefore now the world's smallest known terrestrial snail (Fig. 4).

Fig. 3. A, B, *Angustopila pallgergelyi* Dumrongrojwattana, Chuenit & Wongkamhaeng, new species, living snail at Phet Pho Thong Cave, Sa Kaeo, approximately 300 metres from the entrance. Photograph: Rattanwadee Tekavong.

Key to species of *Angustopila*

1. Shell without apertural teeth 2
– Shell with apertural teeth 3
2. Protoconch sculpture reticulated granules ..... *A. elevata*
– Protoconch finely pitted and granular with a powdery superficial texture ..... *A. subelevata*
3. Apertural teeth consist of only parietal tooth 4
– Apertural teeth consist of 2 or 3 teeth 6
4. Aperture heart-shaped; persistome slightly expanded; not reflected ..... *A. fabella*
– Aperture circular or rounded; peristome slightly expanded 5
5. Teleoconch sculpture irregular growth lines crossed with fine spiral threads; peristome slightly thickened ... *A. singuladentis*
– Teleoconch sculpture finely reticulate, spiral threads; peristome not thickened ..... *A. szekeresi*
6. Apertural teeth consist of weak parietal indentation; low ridge-like angular lamella and upper palatal ..... *A. concava*
– Apertural teeth consist of parietal tooth and palatal tooth 7
7. Teleoconch sculpture very fine irregular axial lamellae, reticulating micro granules ..... *A. huoyani*
– Teleconch sculpture with spiral fine reticulate spiral threads.. 8
8. Shell lenticular; teleoconch sculpture irregular growth lines crossed with fine spiral threads; umbilicus deep and relatively narrow ..... *A. pallgergelyi*, new species
– Shell conical or globular with teleoconch sculpture not as above 9
9. Shell conical; aperture semicircular; teleoconch sculpture with spiral threads ..... *A. tamlod*
– Shell globular; aperture elliptical; teleoconch sculpture finely reticulate, spiral threads ..... *A. dominikae*

Table 3. Comparison of essential morphological traits and ecological information among *Angustopila* species.

Species	Shell colour	Protoconch sculpture	Teleoconch sculpture	Aperture shape	Peristome	Apertural teeth	Umbilicus	Whorl number	Shell height (mm)	Habitat	Source
A. concava	Greyish white	Spiral/reticulated	Spiral threads; weak growth wrinkle	Kidney-shaped, oblique	Not described	Angular, upper palatal, parietal	Narrow	4.6–5.3	1.02–1.21	Leaf litter and limestone talus	1,2,3
A. dominikae	Light grey	Finely pitted and granular with a powdery superficial texture	Finely reticulate, spiral threads	Elliptical	Slightly expanded, not reflected	Parietal, palatal	Very narrow	4.75	0.86	Limestone talus	4
A. elevata	Light grey	Reticulating granules	Spiral threads; weak growth wrinkle	Ovate, oblique	Not described	Dentition lacking	Narrow	4.2–4.3	0.92–0.99	Leaf litter and limestone talus	1,2,3
A. fabella	Light grey	Finely pitted and granular with a powdery superficial texture	Finely reticulate, spiral threads	Heart-shaped	Slightly expanded, not reflexed	Parietal	Relatively narrow	4.5–4.75	0.86–1.02	Limestone talus	4
A. huoyani	Greyish white	Reticulating granules	Very fine irregular axial lamellae, reticulating micro granules	Semi-circular, oblique	Very slightly thickened and reflexed	Parietal, palatal	Very narrow	5.3	1.04–1.3	Cave	3,4
A. singuladentis	White, transparent	Nearly smooth	Irregular growth lines crossed with fine spiral threads	Circular	Slightly thickened and slightly expanded	Parietal	Narrow	3.5	0.7–1.0	Cave	5
A. subelevata	Light grey	Finely pitted and granular with a powdery superficial texture	Finely reticulate, spiral threads	Rounded or almost quadrangular, slightly oblique	Slightly expanded, not reflected	Dentition lacking	Relatively wide	4.25	0.83–0.91	Limestone talus	4
A. szekeresi	Light grey	Finely pitted and granular with a powdery superficial texture	Finely reticulate, spiral threads	Rounded	Slightly expanded, not reflected	Parietal	Relatively narrow	4–4.25	0.88–1.03	Limestone talus	4
A. tamlod	White	Not described	Spiral threads	Semi-circular	Not described	Parietal, palatal	Very narrow	4.75	0.9–1.0	Cave	1,2,3
Angustopila pallgergelyi, new species	White	Finely reticulated surface	Irregular growth lines crossed with fine spiral threads	Kidney-shaped	Slightly thickened and slightly expanded	Parietal, palatal	Deep and relatively narrow	4–4.5	0.59–0.71	Cave	This study

Source: 1 = Thompson & Upatham, 1997; 2 = Panha & Burch, 2005; 3 = Jochum et al., 2014; 4 = Páll-Gergely et al., 2015; 5 = Inkhavilay et al., 2016

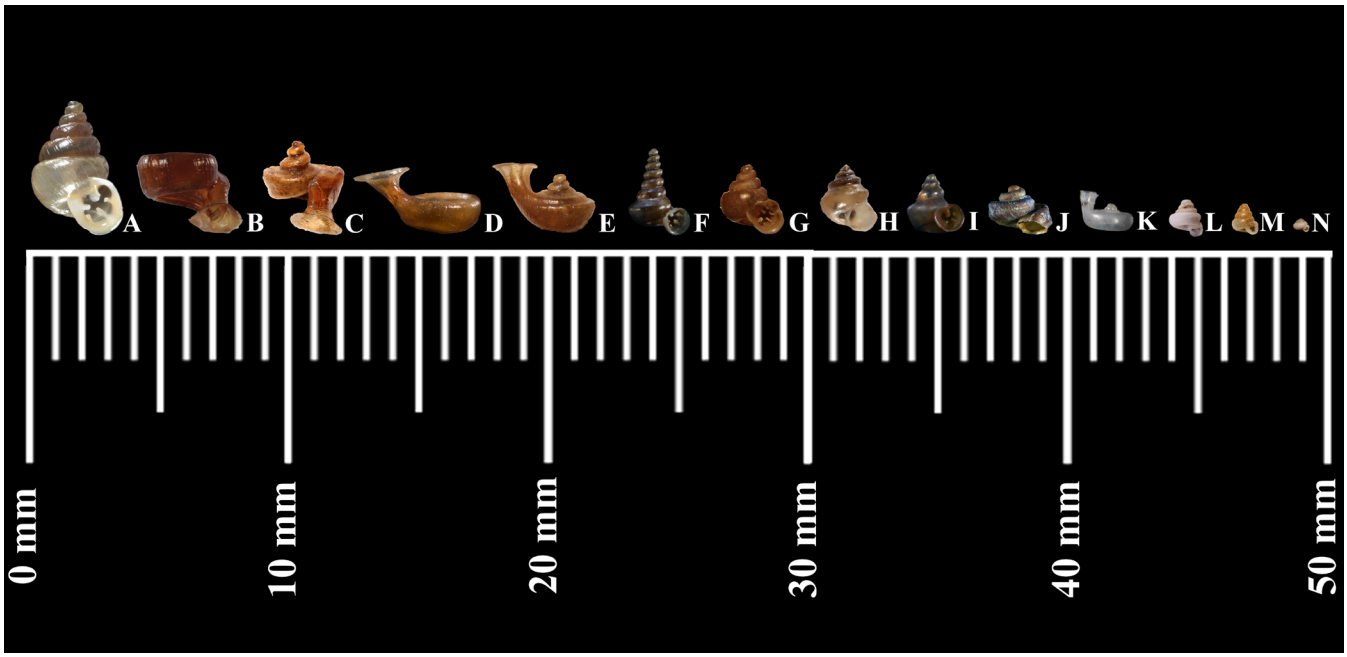

Fig. 4. Relative shell size of some Thai terrestrial microsnails. A, *Boysidia phatangensis* Dumrongrojwattana & Assawawattagee, 2018; B, *Anthroapiculus pendulus* Panha & Burch, 1999; C, *Anauchen srakeoensis* Panha & Burch, 2004; D, *Gyliotrachela tridentate* Panha & Burch, 2004; E, *Gyliotrachela diamaidi* Panha & Burch, 2002; F, *Anachen chedi* (Panha, 1997); G, *Paraboysidia tamphathai* Panha & Burch, 2000; H, *Krobylos veruwan* Panha & Burch, 2004; I, *Hypselostoma banmiensis* Panha & Burch, 2004; J, *Aulacospira khaopratun* Dumrongrojwattana & Panha, 2005; K, *Acinolaemus colpodon* Thompson & Upatham, 1997; L, *Clostophis proboscidea* (Panha & Burch, 1999); M, *Acinolaemus rhamphodon* Thompson & Upatham, 1997; N, *Angustopila pallgergelyi* Dumrongrojwattana, Chuenit & Wongkamhaeng, new species.

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