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Three new species of Clausiliidae (Gastropoda: Stylommatophora) from Shaanxi Province, China

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Abstract. Shaanxi Province is divided by the transition line between the vegetation zones of subtropical evergreen and temperate deciduous broadleaf forests, which sets a limit to northward expansion for members of the clausiliid subfamily Phaedusinae. Due to this constraint and a modest interest of malacologists only eight, mostly widespread clausiliid species have been recorded reliably from this province. Here we introduce *Euphaedusa vitrea* sp. nov., *Streptodera chertoprudi* sp. nov., and *Streptodera qinlingensis* sp. nov., which were found during a 2010 trip to the Qinling Mountains in southern Shaanxi. Intriguingly, the new *Streptodera* species are sinistral members of a genus that previously was considered monotypic and dextral. The three new, apparently narrow endemic species suggest a higher-than-expected diversity of clausiliids in the forested areas of southern Shaanxi.

Key words. Phaedusinae, Qinling Mountains, endemism, habitat

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Introduction

The remarkably rich clausiliid fauna of mainland China includes more than 250 species of the subfamily Phaedusinae. Most of these occur in the southern provinces of the country which, together with northern Vietnam, constitute the eastern diversity centre of this subfamily (Nordsieck 2007). However, the number of recorded species rapidly decreases toward the central Shaanxi and Henan Provinces (Chen & Zhang 1999). In addition to the less favourable climate (Magonyi *et al.* 2024), this is also due to a relatively modest research interest in the malacofauna there. Whereas a century ago almost half of the currently known species of Chinese Phaedusinae had already been known, mainly from parts of the more southerly provinces, only few studies offered data on clausiliids of Shaanxi (Boettger 1882; Ancey 1883; Hilber 1884; Preston 1912). These, together with more recent publications (Chen *et al.* 1995; Chen & Zhang 1999; Nordsieck 2012, 2016), revealed the presence of merely eight species of Phaedusinae, and only three of these are considered endemic to Shaanxi.

Here we introduce three new species of clausiliids that were discovered during a 2010 trip by the first author and Mikhail V. Chertoprud to the Qinling Mountains, south of Xian. In addition to enriching the known clausiliid fauna of Shaanxi, the new taxa suggest that the southern mountains of this province may be home to further, yet unrecorded species of Phaedusinae.

Materials and Methods

The clausiliids used in this study were collected by hand, and live animals were preserved in 70% ethanol. Shells were photographed using a Keyence LHX5000 microscope equipped with a digital camera. For shell structures, we use the terminology of Nordsieck (2007), whereas our taxonomic nomenclature follows that proposed by Nordsieck (2007, 2021). The type material of the new species, consisting only of dry shells, is deposited in the collections of the Muséum national d'Histoire naturelle, Paris (MNHN) and Shanghai Natural History Museum, Shanghai (SNHM), as well as in the private collections of Zhongguang Chen (Chengdu,

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China; ZGCP), Jozef Grego (Banská Bystrica, Slovakia; JG), and Miklós Szekeres (Budapest, Hungary; SZ).

Systematics

Family Clausiliidae Gray, 1855

Subfamily Phaedusinae Wagner, 1922

Genus *Euphaedusa* Boettger, 1877

Type species. *Clausilia shanghiensis* Pfeiffer, 1854 [= *Euphaedusa aculus* (Benson, 1842)]; by subsequent designation (Kennard & Woodward 1923).

***Euphaedusa vitrea* sp. nov.**

Figure 1A

ZooBank identifier. urn:lsid:zoobank.org:act:A09A051A-91BF-4DEC-98D0-4372F9477CA0

Diagnosis. A small *Euphaedusa* species with finely costate, translucent shell and strongly reduced lamellae.

Type locality. China, Shaanxi Province, Xian Shi, Huyi Qu, mountain slope SE of Dasi Cun (大寺村), 33.8784° N 108.7698° E, 2,300 m a.s.l.

Type material. Holotype: leg. M.V. Chertoprud and D.M. Palatov, 06.VII.2010, MNHN-IM-2018-1808.

Description. Shell sinistral, very small, almost colourless, slightly fusiform with relatively thick apex. Whorls 8, glossy and bulging, with fine and densely spaced blunt ribs that become wider-spaced and sharper on last quarter whorl. Base rounded. Aperture pear-shaped; peristome with detached, slightly thickened margin. Superior lamella weak, highest at its centre, widely separate from spiral lamella. Inferior lamella reaches columella in an arch, remains invisible in apertural view. Subcolumellar lamella retracted, not visible through the aperture. Half-whorl-long principal plica spans from lateral to left-lateral side. Upper plica dorsolateral, short, parallel to principal plica. Clausilium plate partly visible within aperture.

Measurements: holotype: shell height 8.2 mm, spire width 1.9 mm, aperture height 1.5 mm, aperture width 1.1 mm.

Habitat. The holotype of *E. vitrea* sp. nov. was collected from decaying wood in humid deciduous broadleaf forest (Fig. 2A), together with specimens of *Dentiphaedusa spinula* (Heude, 1882) and *Formosanella bensoni* (Adams, 1870).

Etymology. The specific epithet *vitrea*, feminine of the Latin adjective *vitreus*, meaning "glassy", refers to the translucent shell of the new species.

Remarks. The new species possesses all diagnostic shell characters of the genus *Euphaedusa*. Namely, the mostly separate spiral lamella, spirally descending and high-positioned inferior lamella, immersed subcolumellar lamella, broad, lateral clausilium plate, and weakened middle palatal plicae (Nordsieck 2001, 2021). *Euphaedusa vitrea* sp. nov. differs from *E. anceyi* (Boettger, 1882) by its smaller size, from *E. loczyi* (Boettger, 1884) by its light colouration, from *E. costifera* Nordsieck, 2001 by its much weaker ribs, and from all these by its thin peristome and weak lamellae. *Euphaedusa minatoi* Nordsieck, 2002 is smaller, markedly ventricose, and has a pointed apex.

Genus *Streptodera* Lindholm, 1925

Type species. *Clausilia* (*Garnieria*) *trachelostropha* Möllendorff, 1885; by monotypy.

***Streptodera chertoprudi* sp. nov.**

Figures 1B, 3A, 4A

ZooBank identifier. urn:lsid:zoobank.org:act:D5A37B4C-77ED-48F4-9F08-A75C44441285

Diagnosis. Sinistral *Streptodera* with slender, light-brownish shell, rounded base, and non-marginal inferior lamella.

Type locality. China, Shaanxi Province, Xian Shi, Huyi Qu, valley of the Xilao River (西涝河) 1 km upstream of Dongyue Temple (东岳庙), 33.8460° N 108.4618° E, 1,230 m a.s.l.

Type material. Holotype: leg. M.V. Chertoprud and D.M. Palatov, 26.VII.2010, MNHN-IM-2018-1806. Paratypes: same collection data as holotype, SNHM 17583/1, JG C3147/1, SZ 22092205/1; Shaanxi Province, Xian Shi, Zhuozhi Xian, valley of the Hongshui (红水河) WNW of Damanghe Cun (大蟒河村), 33.9016° N 107.8456° E, 1,440 m, leg. M.V. Chertoprud and D.M. Palatov, 12.VII.2010, JG C3172/1, SZ 22092206/1, ZGCP 26001/1.

Description. Shell pale brownish, slender, spindle-shaped, with gradually widening apical part. Whorls 9.3–9.5, glossy, with fine, blunt ribs that become indistinct toward base. Ribs on last half whorl with increasing sharpness and strength toward aperture. Base rounded. Aperture pear-shaped, strongly projecting forward. Peristome broad, swollen, its rim reflexed. Superior lamella highest at its centre, inwardly connected to strong, outwardly bent spiral lamella by a trough. Inferior lamella descending parallel to spiral lamella, bent toward columella (Fig. 3A), and ending at ¾ of aper-



Figure 1. Holotypes of (**A**) *Euphaedusa vitrea* sp. nov., MNHN-IM-2018-1808, (**B**) *Streptodera chertoprudi* sp. nov., MNHN-IM-2018-1806, (**C**) *Streptodera qinlingensis* sp. nov., MNHN-IM-2018-1807. Scale bar: 5 mm.



Figure 2. Habitats at the respective type localities of (**A**) *Euphaedusa vitrea* sp. nov., (**B**) *Streptodera chertoprudi* sp. nov., and (**C**) *Streptodera qinlingensis* sp. nov.

ture height behind peristome. Subcolumellar lamella barely visible within aperture. Principal plica initiating ventrolaterally and ending near aperture. Upper plica short, fused near its outer end to dorsolateral lunella. Lunella weakly bent, basally fused to residual lower plica (Fig. 4A). Clausilium plate not visible within aperture.

Measurements: holotype: shell height 12.4 mm, spire width 2.3 mm, aperture height 1.9 mm, aperture width 1.6 mm. Paratypes (n = 5): shell height 11.8–13.1 mm, spire width 2.3–3.0 mm, aperture height 1.6–2.2 mm, aperture width 1.3–1.8 mm.

Habitat. Only empty shells were found under decaying logs and in leaf litter in humid, deciduous broadleaf forest (Fig. 2B). In the valley of the Hongshui, these were accompanied by *Bathyptychia septentrionalis* Nordsieck, 2016.

Etymology. The new species is named after the late Mikhail V. Chertoprud, a dedicated zoologist and much valued colleague who accompanied the first author on several field trips.

Remarks. Until now, *Streptodera* has been regarded to be a monotypic genus that included only the dextral *S. trachelostropha*, which occurs in south-western Hubei and adjacent parts of Chongqing Municipality (Möllendorff 1885; Heude 1886). Therefore, the discovery of a very similar but sinistral species hundreds of kilometres farther north was a surprise. The semi-apostrophic aperture and very high-positioned inferior lamella (Fig. 3) are unique characters among the Phaedusinae; because of these unusual characters, *S. trachelostropha* was originally classified as a member of the Garnieriinae (Möllendorff 1885). The subfamily position of this species was clarified by Lindholm (1925) and Ehrmann (1927), who described and evaluated its apertural and clausiliar structures in detail. The shell characters of this new species are very similar to those of *S. trachelostropha*, but the shell of the new species coils in the opposite direction, is darker and more slender, has a less expanded peristome, and lacks a basal crest.

Streptodera qinlingensis sp. nov.

Figures 1C, 4B

ZooBank identifier. urn:lsid:zoobank.org:act:38E8623C-CDCB-4F84-8CAE-76B77341F676

Diagnosis. Sinistral *Streptodera* with slender, chestnut-brown shell, elongate apex, rounded base, and exposed inferior lamella that ends at the margin of the peristome.

Type locality. China, Shaanxi Province, Xian Shi, Huyi Qu, valley of the Sandao River (三道河) near Xiaogangkou (小干沟口), 33.9618° N 108.7647° E, 780 m a.s.l.

Type material. Holotype: leg. M.V. Chertoprud and D.M. Palatov 08.VII.2010, MNHN-IM-2018-1807. Para-

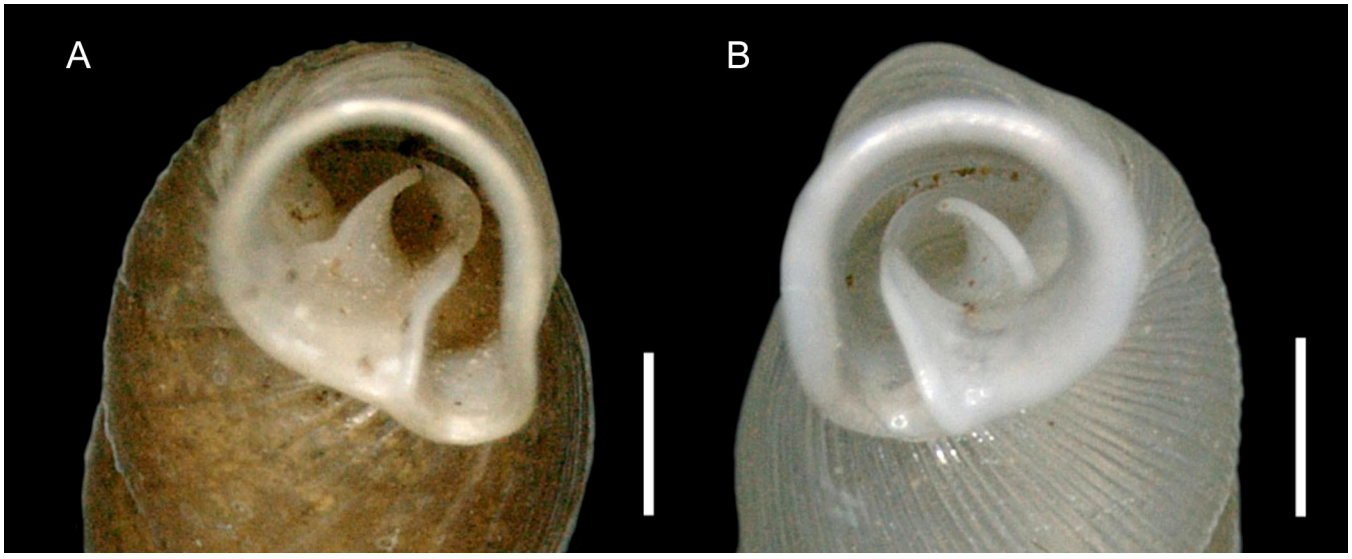


Figure 3. Lamellae in oblique view of the apertures of (**A**) *Streptodera chertoprudi* sp. nov., paratype SZ 22092205, and (**B**) *Streptodera trachelostropha*, from Badong, Enshi Zhou, Hubei Province. Scale bars: 1 mm.

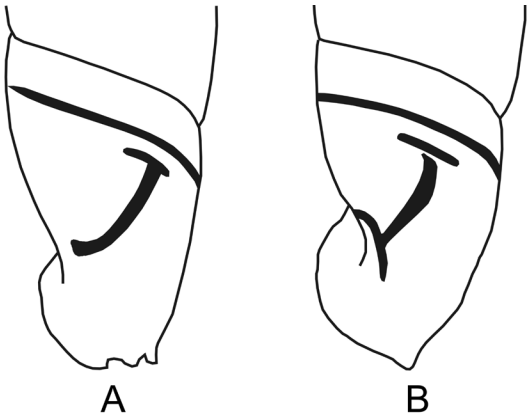


Figure 4. Palatal plicae of (**A**) *Streptodera chertoprudi* sp. nov. and (**B**) *Streptodera qinlingensis* sp. nov.

types: same collection data as holotype, JG C3173/1, SZ 22092203/1.

Description. Shell chestnut-brown, slender, spindle-shaped, sinistral, with elongate apex. Whorls 11.5 (in paratype SZ 22092203), their dense surface striae gradually strengthen to fine ribs toward base. Base rounded. Aperture pear-shaped, projecting forward. Peristome swollen, its margin strongly reflexed. Superior lamella strong, highest at its centre, connected to the much less emerged spiral lamella. Inferior lamella descending in an arch, forming a vertical plate parallel to spiral lamella, and ending marginally at ½ aperture height. Subcolumellar lamella barely visible within aperture. Principal plica initiating ventrolaterally and ending near aperture. Upper plica separate from lunella. Lunella dorsolateral, weakly bent, somewhat diffuse; basal end of lunella fused to a long lower plica with equal anterior and posterior branches (Fig. 4B). Lower edge of clausilium plate partly visible within aperture.

Measurements: holotype: shell height 14.6 mm (tip broken), spire width 3.1 mm, aperture height 2.6, aperture width 2.2 mm. Paratypes: SZ 22092203: shell height 15.8 mm, spire width 3.2 mm, aperture height 2.8 mm, aperture width 2.2 mm; JG C3173: shell height 13.1 mm (tip broken), spire width 3.0 mm, aperture height 2.2 mm, aperture width 1.8 mm.

Habitat. *Streptodera qinlingensis* sp. nov. was collected from leaf litter of humid, deciduous broadleaf forest (Fig. 2C).

Etymology. The name of the new species refers to the Qinling Mountains where it was discovered.

Remarks. *Streptodera qinlingensis* sp. nov. is distinguishable from both *S. chertoprudi* sp. nov. and the oppositely coiled *S. trachelostropha* by its larger, chestnut-brown shell, as well as its lower positioned, marginally ending, and (in apertural view) well-visible inferior lamella. Whereas the shared semi-apostrophic aperture and similar clausiliar structure indicate a close relationship of *S. qinlingensis* to the other two species of the genus, the markedly differing shape and position of the inferior lamella allow only its tentative allocation to *Streptodera*.

Discussion

An abrupt northward decrease in the diversity of the clausiliid fauna in mainland China shows close correlation with

changes in climate and concomitant vegetation. The northern limit of clausiliid occurrences is roughly the boundary of the subtropical evergreen broadleaf with the temperate deciduous broadleaf forests between the latitudes 34° N and 35° N (Xu *et al*. 2014). Farther north the climate is not favourable for Phaedusinae, which require year-round humid and frost-free habitats throughout their entire Eurasian distribution (Magonyi *et al*. 2024). The Phaedusinae occurring at the northern fringes of the subfamily's distribution are mainly widespread and hardy species, *Dentiphaedusa spinula*, *Euphaedusa anceyi*, *Euphaedusa loczyi*, *Formosanella bensoni*, and *Metaphaedusa pseudobensoni* (Boettger & Schmacker, 1894) in Shaanxi and Henan Provinces (Boettger 1882; Hilber 1884; Chen *et al*. 1995; Nordsieck 2012). The northernmost clausiliid records in China belong to an unspecified *Euphaedusa* species in the Taihang Mountains (35.25°N 112.15°E) of Henan Province (Chen *et al*. 2000) and the recently discovered *Formosana antilopina jianyueae* Chen, 2020 near the southern border of Yangcheng Xian (35.2441°N 112.4433°E) in Shanxi Province (Chen 2020).

Whereas the southerly provinces of China are rich in highly endemic clausiliids, so far only *Bathyptychia septentrionalis*, *Metaphaedusa hilberi* (Boettger, 1884) and *Telophaedusa meroniana* (Heude, 1888) were known to be endemic to Shaanxi (Nordsieck 2012, 2016). We do not consider *Synprosphyma cookei* (Preston, 1912) to be a Shaanxi endemic because, based on its apparently unsuitable (for congeneric species too dry) type locality and high morphological similarity, it seems to be an erroneous record and synonym of *Synprosphyma imperatrix* (Boettger & Schmacker, 1894), which is native to Sichuan Province (Preston 1912; Liu 2026; Zhongguang Chen pers. comm.). Remarkably, all three new clausiliids described in our paper add to the known endemics in Shaanxi. The discovery of two new, sinistral *Streptodera* species was fairly surprising because the genus had been considered monotypic with a dextral, much farther south occurring type species. We assume that further malacological research of the vast and yet poorly explored forestlands of southern Shaanxi could considerably increase our knowledge on the clausiliid diversity of this province.

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