



A CONTRIBUTION TO THE KNOWLEDGE
OF A CHINESE ENDEMIC GENUS
STILPNODISCUS MÖLLENDORFF, 1899
(GASTROPODA: PULMONATA: BRADYBAENIDAE),
WITH A DESCRIPTION OF TWO NEW SPECIES

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ABSTRACT: Three species of a Chinese endemic genus *Stilpnodiscus* Möllendorff, two of them (*S. moellendorffi* and *S. yeni*) new, are conchologically and anatomically examined, based on material from Gansu and Sichuan Provinces, W China. Their genitalia are described in detail; a finger-shaped structure of unknown function, found in *S. moellendorffi* sp. n., is unique among bradybaenids. Definition of the genus is discussed. Principal component analysis of seven metric characters and two coefficients reveals a compatibility of conchological features between the two new species. Their conchological resemblance, combined with the great dissimilarity of the dart sac and sympatric distribution, suggests a particular speciation process.

KEY WORDS: Helicoidea, shell, genitalia, Bradybaenidae, *Stilpnodiscus*, new species, China

INTRODUCTION

The genus *Stilpnodiscus* includes elegant terrestrial snails, endemic to the area in W China, where Sichuan and Gansu Provinces adjoin. It was erected in 1899 by O. VON MÖLLENDORFF, diagnosed “T. discoidea, late umbilicata, oleo-nitens, peristoma haud expansum, intus fortiter limbatum”, and originally comprised three species: *S. entochilus* Möllendorff, 1899, *S. scassianus* Möllendorff, 1899 and *S. vernicinus* Möllendorff, 1899 (MÖLLENDORFF 1899), all from Gansu (= Kansu). Two years later, STURANY (1901) added a fourth species, *S. euphyes* from Southern Gansu, to the genus. In BLUME’s (1925) paper on the shells from Sichuan (= Szetschwan), two species, *S. hassi* and *S. stoetzneri*, were described, thus extending the known range of the genus from Gansu to Sichuan.

Thus, prior to this study, the genus included six species (MÖLLENDORFF 1899, WIEGMAN 1900, GUDE

1902, BLUME 1925, THIELE 1931, YEN 1939, ZILCH 1968, RICHARDSON 1983, WU 1999); more detailed data existed only with respect to the type species *S. vernicinus* Möllendorff, 1899 which was also the only member of the genus anatomically examined. The purpose of this paper was to supplement the knowledge of the genus with some anatomical data and provide a description of two more species.

All the specimens examined are deposited at the Zoological Museum, Institute of Zoology (ZMIZ), the Chinese Academy of Sciences, Beijing, China. The following abbreviations were used in the figures: AS – accessory sac, At – atrium, DS – dart sac, F – finger-like appendage, MG – mucus gland, P – penis, R – penial retractor, S – spermatheca, Va – vagina, VD – vas deferens.

GENUS AND SPECIES DESCRIPTIONS

Stilpnodiscus Möllendorff, 1899

Stilpnodiscus MÖLLENDORFF 1899: 65; type species: *Stilpnodiscus vernicinus* Möllendorff, 1899, by original designation

Diagnosis: Shell dextral, strongly shiny, semitransparent; broadly umbilicate; aperture not expanded; peristome not reflexed. Epiphallus and flagellum absent; dart sac containing only one dart.

Description: Shell dextral, disc-shaped or slightly elevated, broadly umbilicate. Spire from flat conical to completely flat. Whorls 5.25–7, slowly increasing, faintly convex; body whorl more or less obtusely angled. Aperture lunate, rhomboid or triangular, somewhat oblique, not expanded; peristome not reflexed. Shell thick, whitish to yellowish brown, banded or unbanded, semitransparent, shiny; embryonic whorls smooth or more or less granulose, on definitive whorls spiral furrows, fine growth lines and extremely fine spiral lines may occur. Diameter 16–25 mm, height 5–12 mm, height/diameter ratio 0.31–0.58, ratio umbilicus diameter/shell diameter 0.17–0.38. Epiphallus and flagellum absent. Dart sac containing one dart; at its base a finger-shaped appendage may occur. Number of mucus glands equal to or exceeding two. Diagnostic shell characters and distribution of members of *Stilpnodiscus* are summarized in Table 1.

Remarks: The above combination of shell characters (see diagnose) makes the genus easy to distinguish from all other known bradybaenid genera.

Distribution: Mountain area of NW China – Sichuan and Gansu.

Stilpnodiscus entochilus Möllendorff, 1899

Stilpnodiscus entochilus MÖLLENDORFF 1899: 67, Pl. III, Fig. 4.

Stilpnodiscus entochilus Mdf.: GUDE 1902: 10.

Stilpnodiscus entochilus Möllendorff: YEN 1939: 154, Pl. 16, Fig. 3.

Stilpnodiscus entochilus Möllendorff: ZILCH 1968: 192.

Material: Guoyuanxiang, Nanping County (33°12'N, 104°12'E), Sichuan Prov., China; 1,000 m a.s.l.; leg. CHEN DE-NIU & ZHANG GUO-QING, 18.05.1998: 17 immature and 25 mature specimens: 20 randomly selected mature specimens (ZMIZ00076: spec. 1–20) were measured and anatomically examined.

Diagnosis: Shell depressed, with 5.25–6.00 convex, peripherally rounded whorls, deep suture and vertical columella, broadly umbilicate; diameter ca. 16–20 mm, height/diameter ratio ca. 0.4–0.5. Embryonic whorls finely granulose. Aperture varying from rounded to triangular. Lip uniformly thickened within and forming a ring-like thickening. Peristome thin. Callus indistinct. Shell yellowish brown, unbanded, bottom of body whorl paler. On inner wall of penis several rows of longitudinal folds. Dart sac with one accessory sac attached to its mid part. Dart curved, basally unexpanded. Mucus glands two, as long as dart sac, inserting at the base of accessory sac.

Description: Shell (Fig. 1) depressed, thick, height 7.25–8.89 (mean 7.93) mm, diameter 16.51–20.32 (mean 18.43) mm, height/diameter ratio 0.40–0.48 (mean 0.43). Apex distinct and sharp. Number of whorls 5.25–6.00 (mean 5.64), convex and rather slowly increasing, embryonic shell of 1.88–2.25 (mean 2.08) whorls. Suture deeply impressed. Umbilicus broad, 4.07–5.06 (mean 4.99) mm wide, ratio umbilicus diameter/shell diameter 0.24–0.31 (mean 0.27). Columella quite vertical. Columellar lip never dilated, hardly covering umbilicus. Spiral furrows irregularly distributed and sparse. Embryonic shell finely granulose. Immature shells peripherally rounded. Body whorl large, not descending, unkeeled. Bottom

Table 1. Diagnostic characters and distribution of all members of *Stilpnodiscus*

| Species | number of whorls | height/diam. | umb./diam. | distribution |
|--|------------------|----------------|----------------|---|
| <i>S. entochilus</i> Möllendorff, 1899 | 5.25–6 | 0.43 | 0.24–0.31 | Gansu: Pui-ho & Shy-pu, between Yu-ling-guan and Wen County |
| <i>S. euphyes</i> Sturany, 1901 | 7 | 0.48 | 0.22 | Gansu: near Shy-pa, Pei-shui-kiang in Tsin-ling-shan-Mountains |
| <i>S. haasi</i> Blume, 1925 | 6 | 0.50–0.58 | 0.17–0.19 | Sichuan: Songpan |
| <i>S. scassianus</i> Möllendorff, 1899 | 5.5 | 0.31 | 0.38 | Sichuan: Lunganfu? Gansu: Na-ti-ha, between Wen County and Yu-ling-guan |
| <i>S. stoetzneri</i> Blume, 1925 | 6–6.5 | 0.48–0.56 | 0.29–0.35 | Sichuan: Songpan; Gansu: Omi |
| <i>S. vernicinus</i> Möllendorff, 1899 | 6.5–7 | 0.39–0.41 | 0.33 | Gansu: between Yu-ling-guan and Wen County, between Lijiapu and Xigucheng; Sichuan: Nanping |
| <i>S. moellendorffi</i> sp. n. | 6.38–6.75 | 0.38–0.42–0.46 | 0.23–0.25–0.28 | Gansu: Dangchang |
| <i>S. yeni</i> sp. n. | 5.75–6.13 | 0.39–0.42–0.45 | 0.23–0.25–0.27 | Gansu: Dangchang |

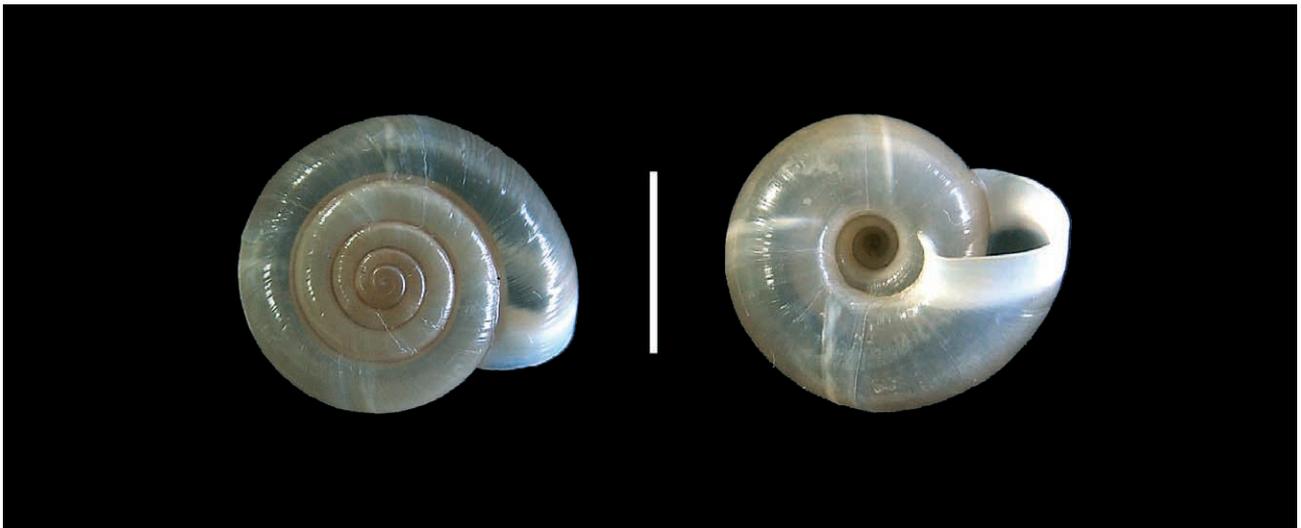


Fig. 1. Shell of *Stilpnodiscus entochilus*, ZMIZ00076 – spec. 1, top and bottom view. Scale bar 10 mm

of shell well convex. Aperture varying from rounded to triangular, more or less oblique, 6.52–8.29 (mean 7.41) mm high, 5.72–7.32 (mean 6.55) mm wide. Lip toothless, uniformly thickened within to form a ring-like thickening. Aperture seldom expanded. Peristome thin. Callus indistinct. Shell strongly shiny, transparent, yellowish brown, unbanded; bottom of body whorl paler.

Body pale brown. Jaw arcuate with ca. 8 ribs dentating the concave margin. Penis short, slender or moderately thick, without papilla. On inner wall of penis several rows of longitudinal folds. Penial retrac-

tor thick and short. Dart sac relatively large, rather elongated, with one accessory sac attached to its mid part. Dart about 9.0 mm in length, curved, basally unexpanded, its apical part two-bladed, ratio of bladed part to the whole length of dart 0.33. Mucus glands two, terminally branched, with distinct peduncles inserted at the base of accessory sac. Each gland as long as dart sac, its apical part adhering tightly to the dart sac. Mucus gland lobules radially arranged, simply branched, not expanded terminally. Spermatheca oval and well delimited from its moderately long duct. Measurements of genitalia of ZMIZ00076 – spec. 1:

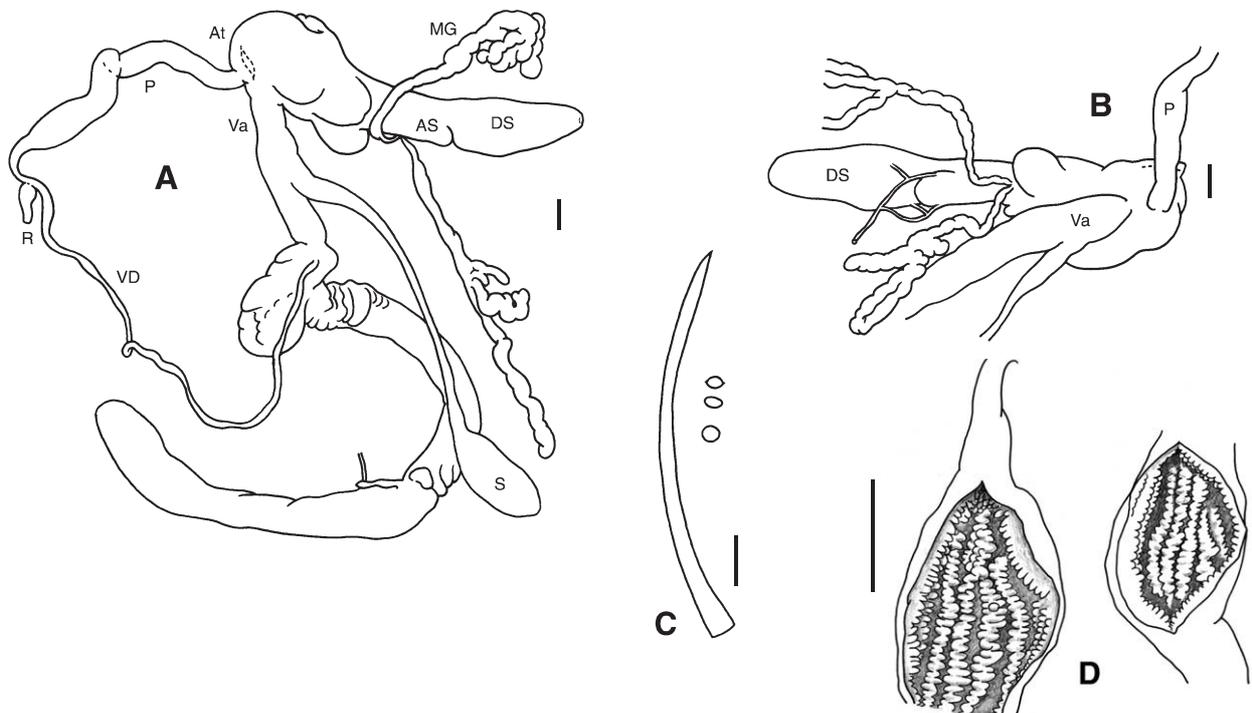


Fig. 2. Genitalia of *Stilpnodiscus entochilus*: A. general view of genitalia; B. detailed terminal part of genitalia; C. dart, with cross sections at various levels. ZMIZ00076 – spec. 2; D. penis interior with longitudinal folds; A, B. & D. ZMIZ00076 – spec. 1. Scale bars 1 mm

dart sac 11.9 mm long, 1.9 mm wide, mucus glands 12.2 mm, vagina 4.4 mm, spermatheca duct plus spermatheca 13.8 mm, vas deferens 18.4 mm, penis 11.3 mm, penial retractor 1.6 mm (Fig. 2).

Distribution: Gansu Prov.: Pui-ho, Shy-pu, between Yulingguan and Wenxian; Sichuan Prov.: Nanping County.

***Stilpnodiscus moellendorffi* sp. n.**

Type locality: Shanggou, Shawanxiang, Dangchang County (34°00'N, 104°18'E), Gansu Province, China.

Type material: 23 specimens from Shanggou, Shawanxiang, Dangchang County (34°00'N, 104°03'E), Gansu Prov.; 1,100 m a.s.l.; leg. CHEN DE-NIU & ZHANG GUO-QING, 06.05.1998. Holotype: full-grown shell with soft parts, ZMIZ00081 – spec. 1. Paratypes: 22 mature shells, ZMIZ00081 – spec. 2–23.

Etymology: This species is named after the famous malacologist, O. VON MÖLLENDORFF, who contributed a lot to the knowledge of Chinese land snails.

Diagnosis: Shell distinctly depressed, with 6.38–6.75 rather flat whorls, angulate in immature and rounded in adult shells, moderately deep suture and almost vertical columella, rather broadly umbilicate; diameter ca. 21–25 mm, height/diameter ratio ca. 0.4–0.5. Embryonic whorls smooth. Aperture obtusely rhomboid. Lip thickened basally. Peristome slightly thickened. Callus distinct. Shell two-banded, bottom of body whorl of the same colour as the shell. On inner wall of penis two large folds, each branched into ca. three finer folds. A finger-shaped appendage present on the basal part of dart sac. Dart sac with 2 accessory sacs attached at its base. Dart fairly straight, basally somewhat expanded. Mucus glands 4–6, longer than dart sac, with indistinct peduncles, inserted near the basal part of dart sac. It differs from *S. yeni* sp. n., to which it is externally much similar, in the presence of the finger-shaped appendage which is unique among Bradybaeninae. Conchologically, the

species is also very similar to *S. euphyes* Sturany, 1901, but compared to the latter species it is more flattened, more broadly umbilicate, and has fewer whorls.

Description: Medium-sized, distinctly depressed, height 8.67–10.48 (mean 9.79) mm, diameter 21.75–24.62 (mean 23.14) mm, height/diameter ratio 0.38–0.46 (mean 0.42). Shell rather solid (Fig. 3). Apex distinct and blunt. Number of whorls 5.88–6.25 (mean 6.02), embryonic shell of 1.38–1.75 (mean 1.59) whorls; whorls flattish, increasing rather slowly. Suture not markedly impressed. Umbilicus fairly broad, 5.07–6.82 (mean 5.90) mm wide, ratio umbilicus diameter/shell diameter 0.23–0.28 (mean 0.25). Columella rather short, almost vertical, columellar lip not dilated, never covering umbilicus. Spiral furrows irregularly and sparsely distributed, without ribs, growth lines not accompanied by irregular thickenings, background striations absent. Embryonic shell smooth. Immature shells bluntly angulate at the periphery. Body whorl large, rounded, not descending. Bottom of shell convex. Aperture obtusely rhomboid, more or less oblique, 8.67–10.10 (mean 9.38) mm in height, 6.41–7.63 (mean 6.99) mm in width. Lip toothless, clearly thickened basally, seldom expanded. Peristome slightly thickened. Callus distinct, thick and semitransparent. Shell strongly shiny, semitransparent, white with brown striations and two brown bands: one at the periphery and one beneath suture. Bottom of body whorl of the same colour as the remaining part of the shell.

Body rather pale. Jaw arcuate, not ribbed or ribbed, when ribbed, then with ca. 6 ribs dentating the concave margin, ribs separate and narrow. Penis short, somewhat swollen, without papilla. On inner wall of the basal part of penis two large valve-shaped folds, towards vas deferens each branched into ca. three fine folds. Penial retractor thin and long. Beside dart sac, a finger-shaped appendage present and connected to the vagina near atrium, inner wall of the fin-



Fig. 3. Shell of *Stilpnodiscus moellendorffi* sp. n., holotype, top and bottom view. Scale bar 10 mm

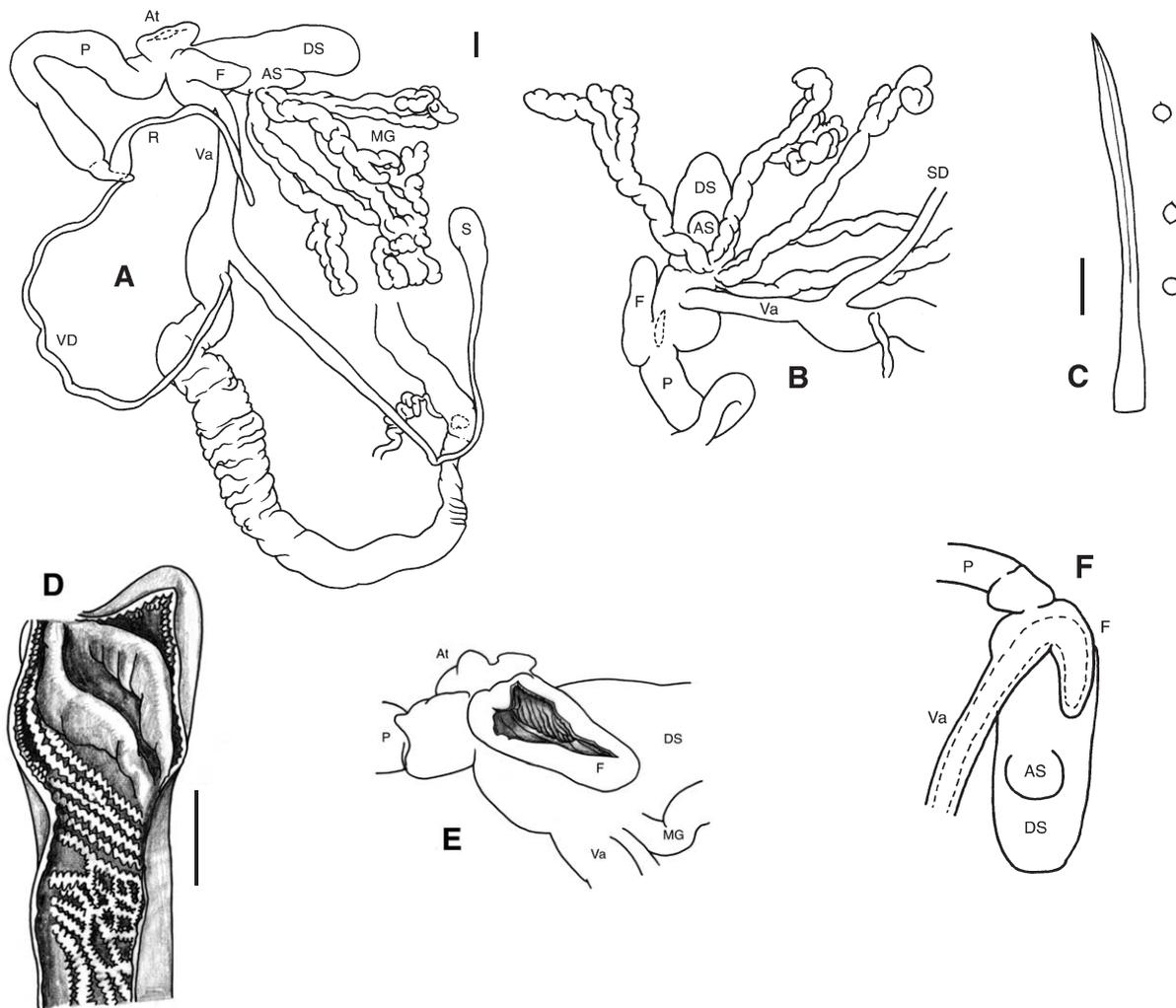


Fig. 4. Genitalia of *Stilpnodiscus moellendorffi* sp. n.: A. general view of genitalia, ZMIZ00081 – spec. 1, holotype; B. detailed terminal part of genitalia, holotype; C. dart, with cross sections at various levels. ZMIZ00081 – spec. 2, paratype; D. penis interior with folds; E. Interior of finger-shaped structure on dart sac; F. diagrammatic terminal part of genitalia, showing the internal connection between the finger-shaped structure and the vagina. Scale bars 1 mm

ger-shaped structure with fine longitudinal folds. Dart sac medium-sized, elongated, closely associated with the vagina, with two accessory sacs attached at its base. Dart ca. 6.0 mm in length, almost straight, basally slightly expanded. Cross section of apical part of dart 2-bladed, ratio of bladed part to the whole length of dart ca. 0.60. Mucus glands 4–6, longer than dart sac, with indistinct peduncles, inserting near the base of dart sac. Lobules of mucus glands radially arranged, simply branched, not expanded terminally. Spermatheca elongated, poorly delimited from its medium-length duct. Spermatheca duct joins vagina close to atrium. Vagina of medium length. Measurements of holotype genitalia: finger-shaped appendage 3.3 mm, dart sac 7.3 mm long, 2.3 mm wide, mucus glands 12.7 mm, vagina 8.3 mm, spermatheca duct plus spermatheca 21.0 mm, spermatheca duct basal width 1.0 mm, vas deferens 20.0 mm, penis 12.7 mm, penial retractor 9.0 mm (Fig. 4).

Stilpnodiscus yeni sp. n.

Type locality: Shanggou, Shawanxiang, Dangchang County (34°00'N, 104°18'E), Gansu Province, China.

Type material: 24 specimens from Shanggou, Shawanxiang, Dangchang County (34°00'N, 104°03'E), Gansu Prov.; 1,100 m a.s.l.; leg. CHEN DE-NIU & ZHANG GUO-QING, 06.05.1998. Holotype: full-grown shell with soft parts, ZMIZ00175 – spec. 2. Paratypes: 23 mature shells, ZMIZ00175 – spec. 1, & spec. 3–24.

Etymology: This species is named in honour of a Chinese malacologist, T. C. YEN, in recognition of his merits in studying Chinese malacofauna.

Diagnosis: Except for the number of whorls (5.75–6.13) the shell does not differ from that of sympatric and syntopic *S. moellendorffi* sp. n. Anatomically, *S. yeni* sp. n. differs in having only one accessory dart sac (two sacs in *S. moellendorffi* sp. n.) and in



Fig. 5. Shell of *Stilpnodiscus yeni* sp. n., holotype, top and bottom view. Scale bar 10 mm

the absence of the finger-shaped appendage (cf. diagnose of *S. moellendorffi* sp. n.).

Description: Medium-sized, distinctly depressed, height 8.71–10.95 (mean 9.82) mm, diameter 21.75–24.57 (mean 23.29) mm, height/diameter ratio 0.39–0.45 (mean 0.42). Number of whorls 5.75–6.13 (mean 6.01) whorls, embryonic shell of 1.38–1.75 (mean 1.60) whorls; whorls flattish, increasing rather slowly. Suture not markedly impressed. Umbilicus broad, 5.26–6.56 (mean 5.82) mm wide; ratio umbilicus diameter/shell diameter 0.23–0.27 (mean 0.25). Columella very short and almost vertical, columellar lip not dilated and never covering umbilicus. Weak spiral furrows irregularly and sparsely distributed, background striations absent. Embryonic shell smooth. Immature shells bluntly peripherally angulate. Body whorl large, rounded, not descending. Bottom of shell convex. Aperture obtusely rhomboid, more or less oblique, 8.71–10.33 (mean 9.45) mm in height, 6.50–7.55 (mean 7.07) mm in width. Lip seldom expanded, distinctly thickened basally and forming an indistinct flat tooth. Peristome somewhat thickened, not continuous. Callus distinct, thick and semi-transparent. Shell semitransparent, white with brown striations and two brown bands: one on the periphery and one beneath suture. Bottom of body whorl of the same colour as the remaining part of the shell (Fig. 5).

DISCUSSION

In China the region where the provinces Gansu and Sichuan adjoin has the highest malacological diversity, especially with respect to bradybaenid fauna. About 1/10 of the bradybaenid taxa, ca. 100 species and subspecies, have been recorded from this special region (WU, unpublished). *Stilpnodiscus* is a fairly unique bradybaenid group, endemic to this area (Fig. 7).

Body rather pale. Jaw arcuate, not ribbed or ribbed, if ribbed, then with up to 6 ribs dentating the concave margin, ribs separate and narrow. Penis of medium length, somewhat swollen, slightly expanded near retractor. On inner wall of the basal part of penis two large valve-shaped folds, each branching into ca. three fine folds towards vas deferens. Penial retractor thin and moderately long. Dart sac medium-sized, elongated, tightly adhering the vagina, with one accessory sac attached at its base. Dart ca. 5.5 mm in length, almost straight, basally slightly expanded. Cross section of apical part of dart hexagonal, following part 2-bladed to rounded, ratio of ridgy part to the whole length of dart ca. 0.50. Mucus glands 4–6, equal to or somewhat longer than dart sac, with indistinct peduncles, inserting near the base of dart sac. Lobules of mucus glands radially arranged, simply branched, not expanded terminally. Spermatheca elongated, poorly delimited from its duct. Spermatheca duct rather long, joining vagina close to atrium. Vagina short. Measurements of holotype genitalia: dart sac 5.3 mm long, 1.7 mm wide, mucus glands 5.3 mm, vagina 4.7 mm, spermatheca duct plus spermatheca 24.2 mm, spermatheca duct basal width 0.93 mm, vas deferens 18.9 mm, penis 11.9 mm, penial retractor 2.2 mm (Fig. 6).

Of the four members of *Stilpnodiscus* of known anatomy, only in *S. moellendorffi* sp. n., the dart sac has an obvious protuberance. It is very clear that such a structure can be distinguished from the accessory dart sac, which in the genus always attaches to the base or to the mid part of dart sac. Thus the structure mentioned in the description of *Stilpnodiscus* as “the

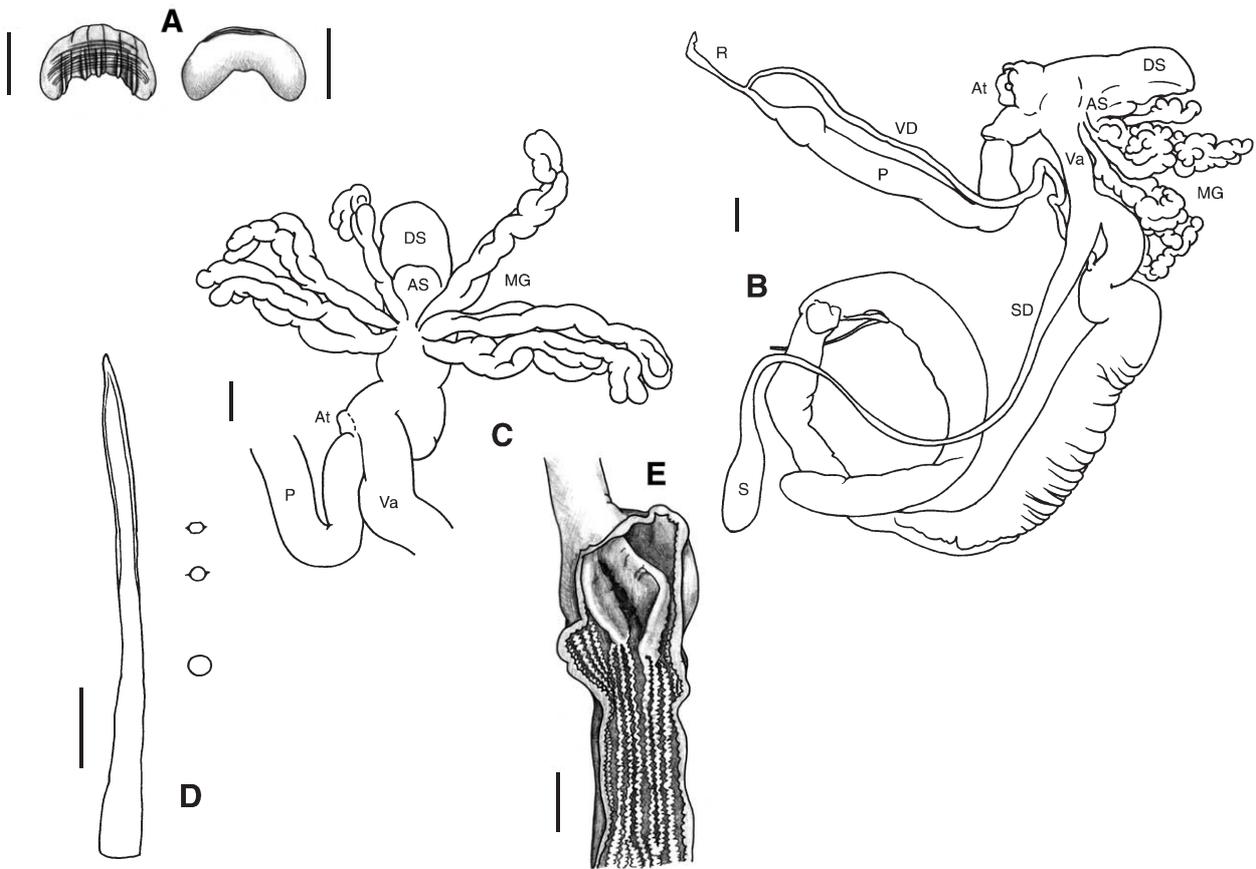


Fig. 6. Jaw and genitalia of *Stilpnodiscus yeni* sp. n.: A. ribless jaw, ZMIZ00175 – spec. 2, holotype (right); ribbed jaw, ZMIZ00175 – spec. 1, paratype (left); B. whole genitalia, holotype; C. detailed terminal part of genitalia, holotype; D. dart, ZMIZ00175 – spec. 16, paratype; E. penis interior, showing penial longitudinal folds, holotype. Scale bars 1 mm

accessory dart sac attached beside the dart sac” (THIELE 1931), should actually refer to the protuberance instead of the accessory sac. Nevertheless, in the published literature the genitalia are known only in the type species *S. vernicinus* Möllendorff, 1899 (Fig. 8). The fact that the genitalia of the type species bear no such special structure indicates that the

above-cited sentence used in the description is probably just an error in the definition of the genus.

The shells of the two new species differ only in the number of whorls but the species are readily distin-

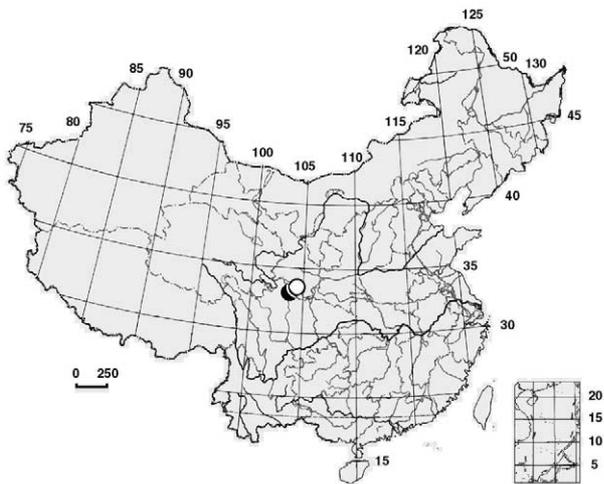


Fig. 7. Distribution map of *Stilpnodiscus entochilus* (hollow circle), *S. moellendorffi* sp. n. and *S. yeni* sp. n. (solid circle)

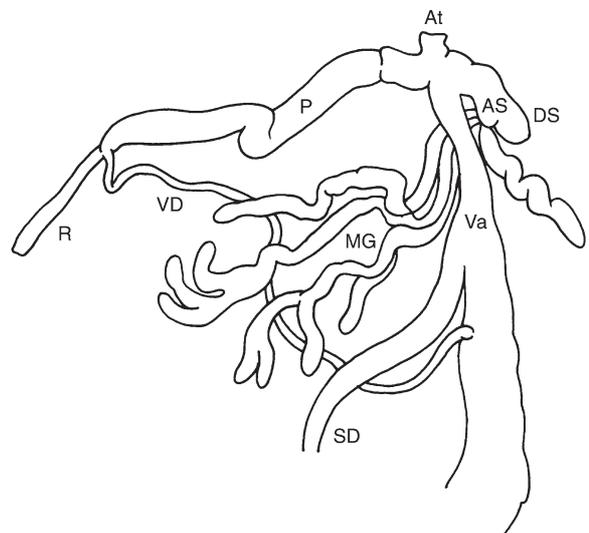


Fig. 8. Genitalia of *Stilpnodiscus vernicinus* (after WIEGMAN's 1900, Pl. II, Fig. 47, slightly modified)

guishable anatomically. Their close conchological resemblance makes them undistinguishable even by a morphometric analysis revealing very subtle differences.

The principal component analysis included seven metric characters and two coefficients (Tables 2 and 3): shell height, shell diameter, number of whorls, number of embryonic whorls, aperture height, aperture width, umbilicus diameter, shell height/diameter ratio and ratio umbilicus diameter/shell diameter. A total of 67 mature shells were measured: 20 of *S. entochilus* (ZMIZ00076: spec. 1–20), 23 of *S. moellendorffi* sp. n. (holotype and all paratypes, ZMIZ00081: spec. 1–23) and 24 of *S. yeni* sp. n. (holotype and all paratypes, ZMIZ00175: spec. 1–24).

The two eigenvalues account for more than 80% of the variance (Fig. 9). The first axis may be regarded as a size axis with some features of shape, except the degree of flattening of the shell. On the second axis, the features loading most heavily are the umbilicus diameter/shell diameter ratio and the umbilicus diameter, and thus the second axis is related to the features of umbilicus.

S. entochilus differs clearly from the group including *S. moellendorffi* and *S. yeni*. The latter two species mix very well. Based on the extreme similarity between their shells, the obvious difference of genitalia, and the sympatric distribution pattern, it is reason-

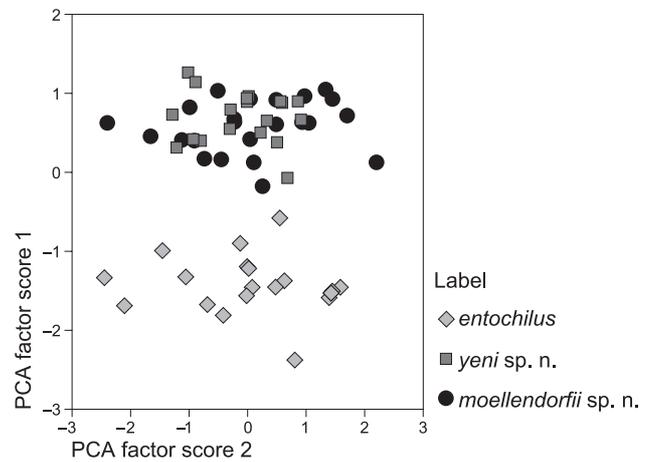


Fig. 9. Principal component analysis. The two axes explain ca. 62.4% and ca. 17.7% of the variance, respectively

Table 2. Factor loadings of shell parameters on the first two PC. Rotation Method: Quartimax with Kaiser Normalization. No missing values

| | Component | |
|----------------------------|-----------|----------|
| | 1 | 2 |
| height | 0.954 | -0.200 |
| diameter | 0.978 | 0.152 |
| number of whorls | 0.924 | 0.0159 |
| number of embryonic whorls | -0.746 | 0.140 |
| aperture height | 0.967 | 0.03617 |
| aperture width | 0.762 | 0.006226 |
| umbilicus diameter | 0.758 | 0.593 |
| shell height/diameter | -0.115 | -0.827 |
| umbilicus/shell diameter | -0.485 | 0.691 |

Table 3. Total Variance Explained. Extraction Method: PCA

| Compon. | Initial eigenvalues | | | Extraction sums of squared loadings | | | Rotation sums of squared loadings | | |
|---------|---------------------|---------------|--------------|-------------------------------------|---------------|--------------|-----------------------------------|---------------|--------------|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.620 | 62.439 | 62.439 | 5.620 | 62.439 | 62.439 | 5.616 | 62.402 | 62.402 |
| 2 | 1.594 | 17.706 | 80.146 | 1.594 | 17.706 | 80.146 | 1.597 | 17.744 | 80.146 |
| 3 | 0.719 | 7.984 | 88.130 | | | | | | |
| 4 | 0.561 | 6.234 | 94.363 | | | | | | |
| 5 | 0.346 | 3.844 | 98.208 | | | | | | |
| 6 | 0.123 | 1.361 | 99.569 | | | | | | |
| 7 | 0.034 | 0.383 | 99.952 | | | | | | |
| 8 | 0.004 | 0.043 | 99.994 | | | | | | |
| 9 | 0.001 | 0.005 | 100.000 | | | | | | |



able to suspect some particular speciation process in their common habitat, though further evidence is needed to understand the process.

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