

Three new species and one subspecies of the *Amynthas corticis*-group from Guangxi Zhuang Autonomous Region, China (Oligochaeta, Megascolecidae)

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Abstract

Three new species and one subspecies of the genus *Amynthas* are described from Guangxi Zhuang Autonomous Region, China: The new species are: *Amynthas maximus* Qiu & Dong, **sp. nov.** and *Amynthas tortuosus* Qiu & Dong, **sp. nov.**, and *Amynthas shengtangmontis* Dong & Jiang, **sp. nov.**, the subspecies is *Amynthas shengtangmontis minusculus* **subsp. nov.** All have four pairs of spermathecal pores in 5/6–8/9, which indicates that they should belong to the *corticis*-group. Their morphological characteristics are compared to other similar species in the *corticis*-group from China and other Asian countries, such as *Amynthas pulvinus* Sun & Jiang, 2013, *Amynthas homosetus* (Chen, 1938), *Amynthas corticis* (Kinberg, 1867), *Amynthas dorsualis* Sun & Qiu, 2013, and *Amynthas carnosus* (Goto & Hatai, 1899). In addition, the results presented are confirmed by the pairwise comparison of COI barcode sequences. The pairwise distances between each new species and the other eighteen *corticis*-group species are greater than 14.7% on average. Furthermore, the pairwise distance between *A. shengtangmontis shengtangmontis* and *A. shengtangmontis minusculus* is 10.7–11.4%.

Keywords

Earthworm, cytochrome c oxidase subunit I gene, new species

Introduction

The genus *Amyntas* Sims & Easton, 1972 is the dominant genus of Megascolecidae in China (Jiang 2016, Zhao 2015) and the *Amyntas corticis*-group consists of a large number of species. Before 1972, only 99 species names had been recorded in the group (Sims and Easton 1972). *Amyntas diffringens* (Baird, 1869), *Amyntas divergens divergens* (Michaelsen, 1892), *Amyntas yunnanensis* (Stephenson, 1912), and *Amyntas heterochaetus* (Michaelsen, 1891) are synonyms of *Amyntas corticis* (Kinberg, 1867) (Blakemore 2004). Since then, 22 more species were reported: two species were described from mainland China (Chen et al. 1975, Chen and Xu 1977), seven species from Hainan Island in China (Sun et al. 2012, 2013), eight species from Taiwan Island (James et al. 2005, Tsai et al. 2001, 2007, 2010, Wang and Shih 2010), and five species from Korea (Hong and James 2001, Hong and Kim 2002).

Guangxi Zhuang Autonomous Region is located in the southeast edge of Yunnan-Guizhou plateau, and west of Guangzhou-Guangxi hilly land. The landforms in Guangxi include mountains, hills and plains. Guangxi has a subtropical monsoon climate and the Pearl River, the Yangtze River, the Red River, and the coastal water systems flow through it. Guangxi has an average annual temperature between 16.5–23.1 °C, which is suited to the survival and dispersal of earthworms. In order to investigate the diversity of earthworms in China, we conducted a field survey in Guangxi Zhuang Autonomous Region in 2013 and have found both a number of described species and also species that are new to science. The previously described species are *Amyntas dissimilis* Qiu & Jiang, 2018 (Jiang et al. 2018), *Amyntas anteporus* Jiang & Dong, 2018 (Jiang et al. 2018), *Amyntas marsupiformis* Jiang & Yuan, 2018 (Jiang et al. 2018), *Amyntas crassitubus* Qiu & Dong, 2018 (Dong et al. 2018), and *Amyntas stabilis* Dong & Jiang, 2018 (Dong et al. 2018). In this paper, we describe three new species and a subspecies of *Amyntas* which were collected from the Shiwan Mountain National Nature Reserve (22.6750°–22.07167°N, 107.49972°–108.21972°E) and the Dayao Mountain National Nature Reserve (25.11667°–25.23334°N, 113.18333°–113.26667°E) in Guangxi Zhuang Autonomous Region, China. Distributions of known species in Guangxi Zhuang Autonomous Region and sampling points for this paper are shown in Figure 1.

All of the newly described species and subspecies have four pairs of spermathecal pores in 5/6–8/9; hence, they belong to the *Amyntas corticis*-group.

Materials and methods

The earthworms were collected in 2013, anaesthetized in 10% ethanol solution, and preserved in 99% ethanol solution. DNA was extracted from several specimens of *A. maximus*, *A. tortuosus*, *A. shengtangmontis shengtangmontis*, and *A. shengtangmontis minusculus* using the EZNA Mollusk DNA Kit (Omega Bio-tek, Norcross, GA, USA). The gene cytochrome oxidase subunit I (COI) was amplified. The PCR was carried out as follows:

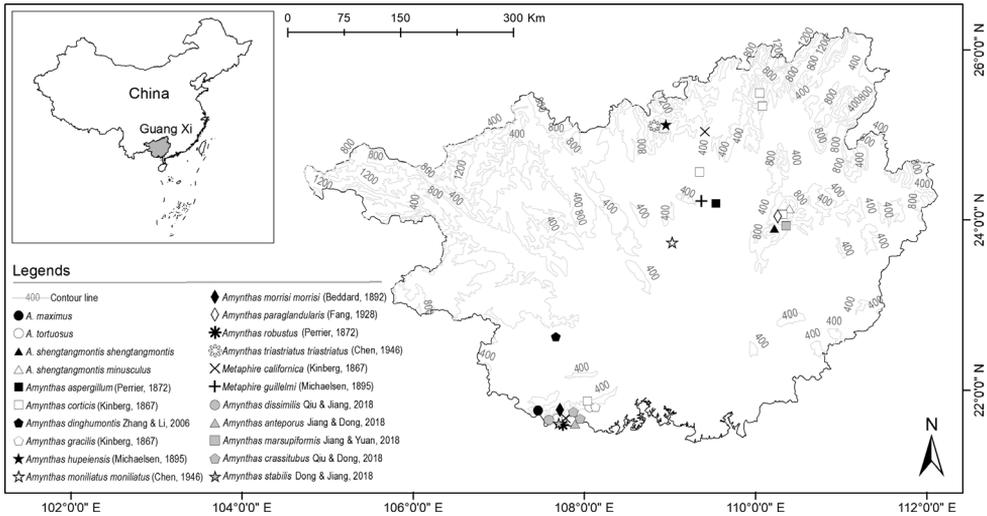


Figure 1. Distribution of known species in Guangxi Zhuang Autonomous Region and sampling points of this paper.

5 min at 94 °C followed by 32 cycles 94 °C for 30 s, 50 °C for 30 s and 72 °C for 1 min, with an extension of 10 min at 72 °C. Primers used in the research were: 5'-GGT-CAACAAATCATAAAGATATTGG-3' and 5'-TAAACTTCAGGGTGACCAAAAAAT-CA-3' (Folmer et al. 1994), or 5'-GGTCAACAAATCATAAAGATATTGG-3' and 5'-TATACTTCTGGGTGTCCGAAGAATCA-3' (Bely and Wray 2004). Sequencing was performed in the Beijing Genomics Institute (Shanghai, China). Sequencing was submitted to NCBI GenBank and accession numbers were shown in Table 1. All holotypes and paratypes are deposited in the Shanghai Natural History Museum.

Sequences were aligned with ClustalX (Thompson 1997), and then pairwise distances between these species were calculated using Kimura two-parameter model of DNA evolution with MEGA 5 (Tamura et al. 2011). Images were produced using the Affinity Photo and SketchBook software.

Taxonomy

Amyntas maximus Qiu & Dong, sp. nov.

<http://zoobank.org/E84CFBE5-4FF8-4F53-B49A-233EC5D04298>

Figure 2, Table 2

Material. Holotype: 1 clitellate (C-GX201304-01A): China, Guangxi Zhuang Autonomous Region, Shiwan Mountain Nature Reserve (21.50299°N, 107.3035°E), 449 m asl, black sandy soil under bryophytes in a subtropical evergreen forest, 12 May 2013, JP Qiu, Y Hong, JB Jiang, LL Zhang, Y Dong legit. **Paratypes:** 8 clitellates (C-GX201304-01B): same date as for holotype.

Table 1. Species with molecular data used in this study. Abbreviations: HT holotype, PT paratype.

| Species | Species No. | Locality | Reference | GenBank Acc. No |
|--|----------------|------------------|--|-----------------|
| <i>Amyntas maximus</i> sp. n. (HT) | C-GX201304-01A | China: Guangxi | This paper | MG450707 |
| <i>Amyntas tortuosus</i> sp. n. (HT) | C-GX201306-06A | China: Guangxi | This paper | MG450708 |
| <i>Amyntas tortuosus</i> sp. n. (PT) | C-GX201301-09 | China: Guangxi | This paper | MK606425 |
| <i>Amyntas tortuosus</i> sp. n. (PT) | C-GX201305-07 | China: Guangxi | This paper | MK606426 |
| <i>Amyntas shengtangmontis shengtangmontis</i> sp. n. (HT) | C-GX201312-03A | China: Guangxi | This paper | MG450709 |
| <i>Amyntas shengtangmontis minusculus</i> subsp. n. (HT) | C-GX201316-02A | China: Guangxi | This paper | MG450710 |
| <i>Amyntas shengtangmontis minusculus</i> subsp. n. (PT) | C-GX201316-02B | China: Guangxi | This paper | MK606427 |
| <i>Amyntas fuscatus</i> (Goto & Hatai, 1898) | | Japan: Tokyo | Minamiya, submitted to GenBank in 2010 | AB542475 |
| <i>Amyntas pulvinus</i> Sun & Jiang, 2013 | C-HN201115-08 | China: Hainan | Sun et al. 2014 | JQ905266 |
| <i>Amyntas robustus</i> (Chen, 1936) | C-SC201009-01 | China: Sichuan | Sun 2013, in Chinese | KF179573 |
| <i>Amyntas corticis</i> (Kingberg, 1867) | C-HN201035-02 | China: Hainan | Sun 2013, in Chinese | KF205966 |
| <i>Amyntas carnosus</i> (Goto & Hatai, 1899) | C-HN201002-01 | China: Hainan | Sun 2013, in Chinese | KF205962 |
| <i>Amyntas mirifigus</i> Sun & Zhao, 2013 | C-HN201103-02 | China: Hainan | Sun et al. 2013 | JQ905265 |
| <i>Amyntas micronarius</i> (Goto & Hatai, 1898) | | Japan: Tokyo | Minamiya, submitted to GenBank in 2010 | AB542498 |
| <i>Amyntas alexandri</i> (Beddard, 1900) | | Thailand | Jeratthitikul et al. 2017 | KU565178 |
| <i>Amyntas andersoni</i> (Michaelsen, 1907) | | Thailand | Jeratthitikul et al. 2017 | KU565179 |
| <i>Amyntas comptus</i> (Gates, 1932) | | Thailand | Jeratthitikul et al. 2017 | KU565187 |
| <i>Amyntas exiguus</i> (Gates, 1930) | | Thailand | Jeratthitikul et al. 2017 | KU565189 |
| <i>Amyntas formosae</i> (Michaelsen, 1922) | | India | Farooqui, submitted to GenBank in 2019 | LC458750 |
| <i>Amyntas longicauliculatus</i> (Gates, 1931) | | Thailand | Jeratthitikul et al. 2017 | KU565195 |
| <i>Amyntas szechuanensis vallatus</i> (Chen, 1946) | C-SC201102-05 | China: Sichuan | Sun 2013, in Chinese | KF205477 |
| <i>Amyntas mediocus</i> (Chen et al., 1975) | C-GD201108-02 | China: Guangdong | Sun 2013, in Chinese | KF205405 |
| <i>Amyntas wulinensis</i> Tsai et al., 2001 | | Taiwan island | Chang et al. 2007 | DQ224182 |
| <i>Amyntas yunlongensis</i> (Chen, 1977) | C-GZ201101-06 | China: Guizhou | Sun 2013, in Chinese | KF179581 |
| <i>Amyntas stricosus</i> Qiu & Sun, 2012 | C-HN201104-04 | China: Sichuan | Sun 2013, in Chinese | JX315345 |

Diagnosis. Dimensions 145–170 mm by 5.8–6.2 mm at clitellum, clitellum taupe in 2/5 XIV–XVI, 78–101 segments. First dorsal pore in 13/14. Setae numbering 33–38 at III, 32–36 at V, 29–33 at VIII, 18–22 at XX, 50–65 at XXV; 9–13 between male pores; setae between spermathecal pores numbering 14–16 at VI, 10–14 at VII, and 18–22 at VIII. Four pairs of spermathecal pores ventrally in 5/6–8/9. Seven or eight (three specimens have seven papillae, and four specimens have eight papillae) postsetal genital papillae arranged in two rows in VI–IX, 0.33 circumference ventrally apart from each other. One pair of male pores in XVIII, each on the top of a central, round porophore surrounded by three or four circular ridges, with one presetal indented-topped genital papilla medial of each porophore. Ampulla elongate oval, stout duct as

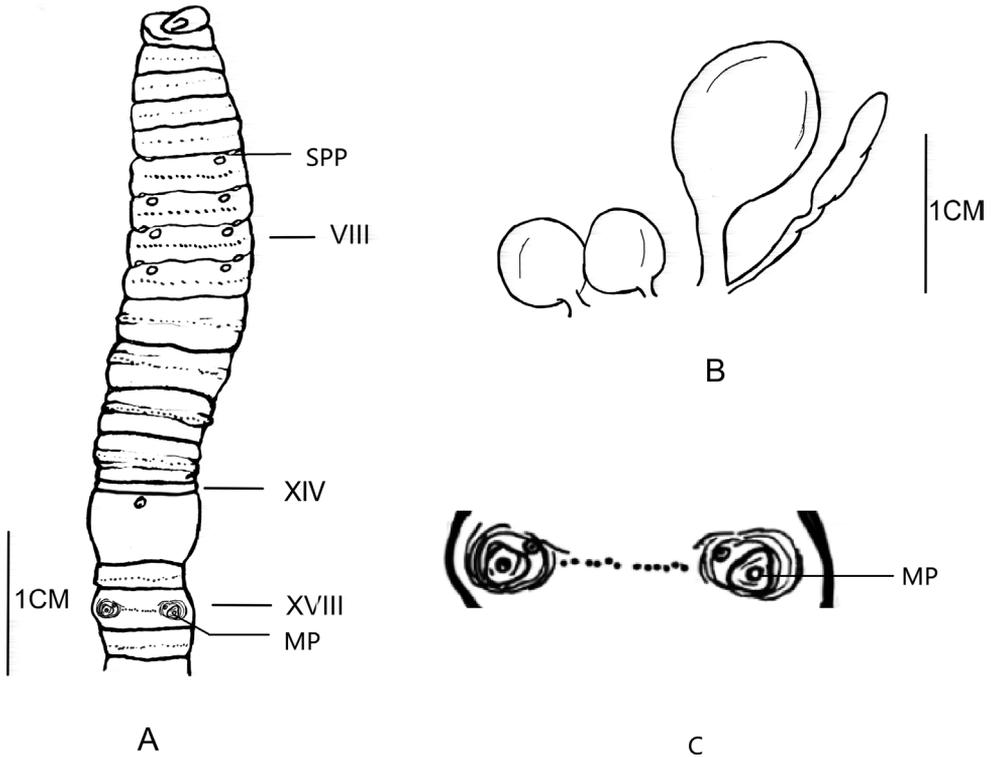


Figure 2. **A** Ventral view showing spermathecal pores, female pores and male pores of *Amyntas maximus* sp. nov. **B** spermathecae of *Amyntas maximus* sp. nov. **C** illustration of the details of the male pore region.

long as $3/5$ ampulla. Diverticulum slightly shorter than main pouch, a little twist in the middle, terminal $2/5$ dilated into a swollen, club-shaped seminal chamber. Prostate glands well developed.

Description. External characters: Light purple-brown pigment on pre-clitellum dorsum, no pigment on ventrum. Pigment from light purple-brown to brown on post-clitellum dorsum, light yellowish on ventrum. Clitellum taupe in $2/5$ XIV–XVI. Dimensions 160 mm by 6.0 mm at clitellum, 92 segments. Prostomium $1/2$ epilobous. First dorsal pore in $13/14$. Setae numbering 36 at III, 34 at V, 31 at VIII, 20 at XX, 60 at XXV; 12 between male pores; Setae numbering 15 at VI, 12 at VII, 20 at VIII between spermathecal pores. Setae formula: AA = 1.1-1.4AB, ZZ = 1.2-2.0ZY. Clitellum annular, yellowish, in $2/5$ XIV–XVI, setae not visible externally. Four pairs of spermathecal pores in $5/6$ – $8/9$, ventral, eye-like, 0.4 circumference ventrally apart from each other. Seven or eight (three specimens have seven papillae, and four specimens have eight papillae) postsetal genital papillae arranged in two rows in VI–X, 0.33 circumference ventrally apart from each other. One pair of male pores in XVIII, 0.4 circumference apart ventrally, each on the top of a central, round porophore surrounded by three or four circular ridges, with one presetal indented-topped genital papilla medial of each porophore (Figure 1A). Single female pore in XIV, ovoid.

Internal characters. Septa 5/6–7/8, 10/11–13/14 thick and muscular, 8/9–9/10 absent. Gizzard bucket-shaped, in VIII–X. Intestine enlarged distinctly from XV onwards. Intestinal caeca paired in XXVII, extending anteriorly to XXII, transition state, ventral margin smooth, four pointed sacculi in dorsal margin. Four pairs of esophageal hearts in X–XIII, developed. Ovaries in XIII. Four pairs of spermathecae in VI–IX, short, approx. 1.6 mm long, ampulla elongate-oval; duct as long as 3/5 ampulla. Diverticulum slightly shorter than main pouch (ampulla and duct), a little twist in middle, terminal 2/5 dilated into a swollen, club-shaped seminal chamber (Figure 1B). One or two stalked accessory glands observed near ventral median line in VI–IX. Holandric: two pairs of testis sacs in X and XI, separated from each other, well developed. Two pairs of seminal vesicles in XI and XII, developed. Prostate glands undeveloped, inserting in XVIII and extending from XVII–XIX, coarsely lobate, prostatic duct I-shaped, of uniform thickness. No accessory glands observed in male pore region.

Etymology. The species is named after its large accessory glands observed in the spermathecal area.

Remarks. *Amyntas maximus* sp. nov. keys to the *corticis*-group in Sims and Easton (1972) with four pairs of spermathecal pores intersegmentally in 5/6–8/9. *Amyntas maximus* sp. nov. is similar to *Amyntas carnosus* (Goto & Hatai, 1899) as re-described by Chang et al. (2016) with respect to body size, the distance between spermathecal pores and male pores, shorter diverticulum than main spermathecal axis, and no accessory glands near prostates. In contrast, the pigment on its ventrum is lighter than *A. carnosus* and other differences include the first dorsal pore, clitellum location, spermathecal pores, and male pores characters. The first dorsal pore in *A. maximus* sp. nov. is located in 13/14, versus 12/13 in *A. carnosus*; the clitellum occupies less than three segments; four pairs of spermathecal pores while sometimes three pairs in *A. carnosus*; the porophore is surrounded by three or four circular ridges, but no ridges are present in *A. carnosus*; several accessory glands observed in the spermathecal region in the new species but none in *A. carnosus*.

We also compare the new species with *Amyntas corticis* (Kinberg, 1867) which has been recognized as the typical species in the *corticis*-group. They share several common characters such as body size, pigment, clitellum extent, setal number, and both have stalked accessory glands. Other than that, the first dorsal pore in the new species is in 13/14, but in 10/11 or 12/13, usually in 11/12 in *A. corticis*. The diverticulum of *A. maximus* sp. nov. has a small twist in the middle compared with *A. corticis*, which has a long stalk. Moreover, *A. maximus* sp. nov. always exhibits genital markings in the male pore region, whereas in *A. corticis*, these markings are occasionally absent.

We further compare the new species with another species *Amyntas dorsualis* Sun & Qiu, 2013 described from Hainan, China, and its clitellum also occupies fewer than three segments. In our results, we find the two species share several common characters, including the first dorsal pore location, setal formula, male pore characters, and in the diverticulum being shorter than the main pouch. However, the morphological dissimilarity of the two species is substantial. For instance, the locations of spermathecal pores are different between *A. dorsualis* and *A. maximus* sp. nov. In *A. dorsualis*, the spermathecal pores are located on the dorsum, while the pores are located on the ven-

Table 2. A comparison of characters of *A. maximus* sp. nov., *A. dorsualis*, 2013, *A. carnosus*, *A. corticis* and *A. wulinensis*.

| Characteristics | <i>A. maximus</i> sp. nov. | <i>A. dorsualis</i> | <i>A. carnosus</i> | <i>A. corticis</i> | <i>A. wulinensis</i> |
|------------------------|--|--|---|--|--|
| Body length (mm) | 145–170 | 121–? | 110–340 | 45–170 | 128–174 |
| Body width (mm) | 5.8–6.2 | 2.7–? | 4.0–9.0 | 3.0–6.0 | 5.6–6.1 |
| Pigment | | | | | |
| dorsum | Light purple brown before clitellum, from light purple brown to brown after | Dark grey before clitellum, dark brown after | Dark brown or purple | Greenish brown | Whitish purple |
| ventrum | No pigment before clitellum, yellowish after | Light grey before VII, no pigment after | Dark brown or purple | No | Whitish gray |
| First dorsal pore | 13/14 | 13/14 | 12/13 | 10/11 or 12/13, usually at 11/12 | 11/12 |
| Clitellum locality | 2/5XIV–XVI | 1/10XIV-7/10XVI | XIV–XVI | XIV–XVI, occasionally shorter | XIV–XVI |
| Spermathecal pores | 4 pairs, in 5/6–8/9, 0.33C | 4 pairs, in 5/6–8/9, dorsally, 0.6C | 4 pairs in 5/6–8/9 or 3 pairs in 6/7–8/9, 0.33C | 4 pairs, 5/6–8/9, 0.33C | 4 pairs, 5/6–8/9, ventral, 0.29C |
| Male pores | Middle, round, surrounded by 3–4 circular ridges, 0.4C | Slightly raised, glandular, surrounded by 5–6 elliptic circular folds, 0.33C | Round or elliptic | Small, circular to transverse elliptical disc, 0.24–0.30C | Round or oval-shaped on setal line with depressed center, 2–3 circular folds, 0.24–0.28C |
| Papillae preclitellum | 7–8 post-setal indented-topped genital papillae arranged in two rows in VI–IX | Invisible | 8 papillae just overhead 8 spermathecal pores, 2 pairs preclitellar arranged on VIII and IX | Paired presetal and/or postsetal in some or all, near spermathecal pores | Absent |
| Papillae postclitellum | 2 presetal indented-topped genital papillae medial of porophore | Invisible | 2 paired presetal genital on XVIII and IX, 1 pair postsetal genital on XVIII | Present or absent, occasionally one or more near male pore | Oval-shaped, medial to male pore in each of XVII and XIX, occasionally XX |
| Prostate glands | XVII–XIX | XVI–XX | Well developed | XVII–XX, rudimentary or absent | XV–XX, racemose, follicular |
| Spermathecae | About 1.6 mm long, ampulla long-oval; duct as long as 3/5 ampulla | About 2.2 mm long, ampulla heart-shaped; duct as long as 2/5 ampulla | Ampulla oval or pear-shaped, duct equal to or slightly shorter than ampulla | Ampulla ovoid | Very short and stout stalk |
| Diverticulum | Shorter, lightly twist in middle, terminal 2/5, swollen, club-shaped seminal chamber | Shorter, terminal 1/5, ovoid plump seminal chamber | One-third to half of ampulla, slender stalk and a wider seminal chamber | Blunt ovoid, straight stalk | Oval, shining white seminal chamber, a slender and straight stalk |
| Accessory glands | 1 or 2 stalked accessory glands observed near ventral median line in VI, VII, VIII, IX | Invisible | – | Stalked, coelomic, bound down to parietes or retained within body wall | Paired in XVII and XIX, sessile, flowery |

trum in *A. maximus* sp. nov. The distance between male pore is shorter on the ventral side in *A. dorsualis* than *Amyntas maximus* sp. nov. In addition, *A. dorsualis* has no genital markings and no accessory glands, whereas *A. maximus* sp. nov. exhibits genital markings near the spermathecal pores and the male pores region, and stalked accessory glands are present in spermathecal pores region.

The body size of *A. maximus* sp. nov. is similar to *A. wulinensis* described from Taiwan Island. But the other characters of *A. maximus* sp. nov. differ from *A. wulinensis*. *Amynthas maximus* sp. nov. has no pigment before clitellum, yellowish after clitellum on dorsum, first dorsal pore in 13/14, 0.33C between spermathecal pores, seven or eight indented-topped genital papillae in VI–IX and accessory glands in spermathecal pores region. In contrast, *A. wulinensis* has whitish gray on dorsum, first dorsal pore in 11/12, 0.29C between spermathecal pores, no genital papillae observed in spermathecal pores region, and accessory glands observed in male pores region. Table 2 shows the comparison of characters of *A. maximus* sp. nov. with *A. dorsualis*, *A. carnosus*, *A. corticis* and *A. wulinensis*.

***Amynthas tortuosus* Qiu & Dong, sp. nov.**

<http://zoobank.org/898F2A2C-68E7-415D-B5BE-95876D8C672E>

Figure 3, Table 3

Material. Holotype: 1 clitellate (C-GX201306-06A): China, Guangxi Zhuang Autonomous Region, Shiwan Mountain Nature Reserve (21.84739°N, 107.88989°E), 553 m asl, black soil besides road, 13 May 2013, JP Qiu, Y Hong, JB Jiang, LL Zhang, Y Dong legit. **Paratypes:** 7 clitellates: 2 clitellates (C-GX201306-06B): same data as for holotype. 1 clitellate (C-GX201301-09): China, Guangxi Zhuang Autonomous Region, Shiwan Mountain Nature Reserve (21.48588°N, 107.57018°E), 130 m asl, black sandy soil at riverside, 11 May 2013, JP Qiu, Y Hong, JB Jiang, LL Zhang, Y Dong legit. 4 clitellates (C-GX201305-07): China, Guangxi Zhuang Autonomous Region, Shiwan Mountain Nature Reserve (21.50396°N, 107.53350°E), 494 m asl, black sandy soil besides road, 13 May 2013, JP Qiu, Y Hong, JB Jiang, LL Zhang, Y Dong legit.

Diagnosis. Dimensions 55–86 mm by 2.5–2.8 mm at clitellum, 55–83 segments. First dorsal pore in 13/14. Setae numbering 24–26 at III, 34–36 at V, 34–36 at VIII, 32–36 at XX, 36–40 at XXV; 8–9 between male pores; setae between spermathecal pores numbering 9–12 at VI, 10–12 at VII, 12–13 at VIII. Four pairs of spermathecal pores in 5/6–8/9, eye-like. Four pairs of postsetal genital papillae in VI–IX, 0.20 circumference ventrally apart from each other. One pair of male pores in XVIII, each on the top of a central, round porophore surrounded by three or four rhombic ridges, with one presetal crescent indented-topped genital papilla medial of each male pore. Ampulla slender, heart-shaped; duct short. Diverticulum shorter than main pouch, terminal 4/5 slightly dilated into a swollen, S-shaped twisted seminal chamber. Prostate glands well developed.

Description. External characters: Pre-clitellum, purple-brown pigment on dorsum, light purple-brown on ventrum. Post-clitellum, light purple-brown on dorsum, no pigment on ventrum. Clitellum taupe. Dimensions 76 mm by 27 mm at clitellum. 75 segments. Prostomium ½ epilobous. First dorsal pore in 13/14. Setae numbering 24 at III, 34 at V, 36 at VIII, 36 at XX, 40 at XXV; 8 between male pores; Setae between spermathecal pores numbering 11 at VI, 10 at VII, 13 at VIII. Setae formula AA = 1.2-2.0AB,

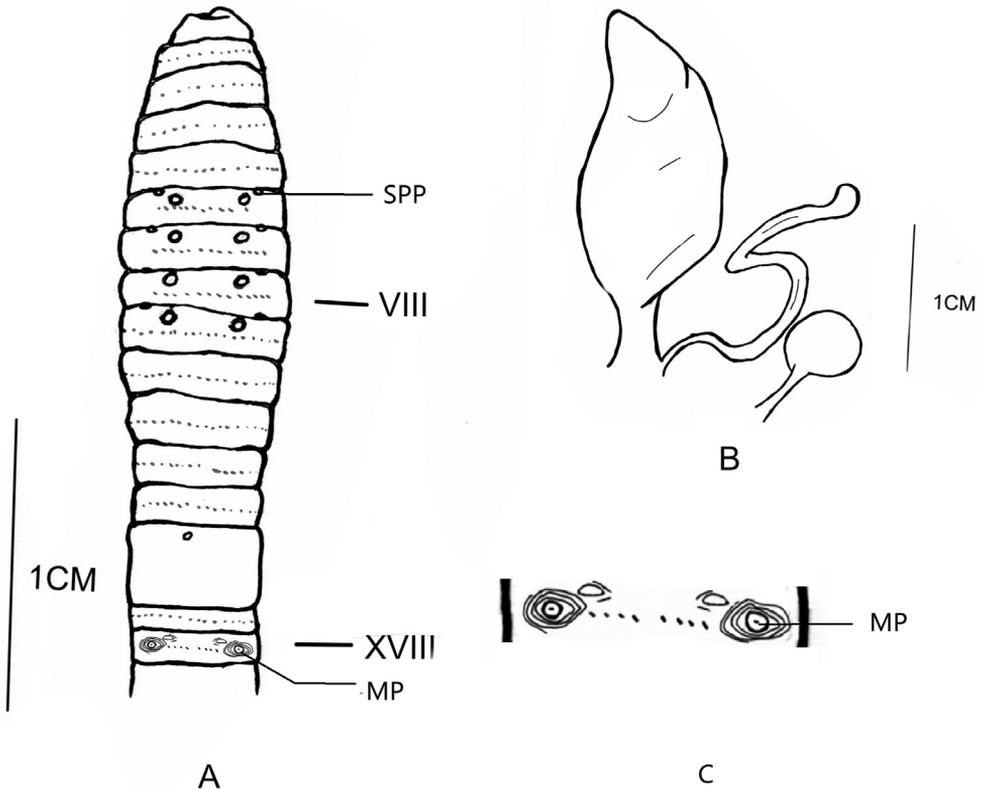


Figure 3. **A** Ventral view showing spermathecal pores, female pores and male pores of *Amyntas tortuosus* sp. nov. **B** spermathecae of *Amyntas tortuosus* sp. nov. **C** illustration of the details of the male pore region.

ZZ = 1.4-2.0ZY. Clitellum annular, pale taupe, in XIV–XVI, setae not visible externally. Four pairs of spermathecal pores in 5/6–8/9, eye-like, 0.25 circumference ventrally apart from each other. Four pairs of postsetal genital papillae in VI–IX, 0.20 circumference ventrally apart from each other. One pair of male pores in XVIII, 0.25 circumference apart ventrally, each on the top of a central, round porophore surrounded by three or four rhombic ridges, with one presetal crescent indented-topped genital papilla in the center of each male pore region (Figure 2A). Single female pore in XIV.

Internal characters. Septa 5/6–7/8 thick and muscular, 10/11–12/13 slightly thickened, 8/9–9/10 absent. Gizzard ball-shaped, in VIII–X. Intestine enlarged distinctly from XVI onwards. Intestinal caeca paired in XXVII, simple, smooth, extending anteriorly to XXIV. Four pairs of esophageal hearts in X–XIII, the first pair very thin, the last three pairs developed. Ovaries in XIII. Four pairs of spermathecae in VI–IX, small, 2.4 mm long. Ampulla slender, heart-shaped; duct short. Diverticulum 2.0 mm long, slightly shorter than main pouch, terminal 4/5 slightly dilated into a swollen, S-shaped twisted seminal chamber (Figure 2B). One stalked accessory gland observed medial to each spermathecal duct. Holandric: two pairs of testis sacs in X–XI, separated from each other, developed. Two pairs of seminal vesicles in XI–XII, well developed. Prostate

Table 3. A comparison of characters of *A. tortuosus* sp. nov., *A. carnosus*, *A. corticis*, *A. homosetus*, *A. exiguus aquilonius*, and *A. stricosus*.

| Characteristics | <i>A. tortuosus</i> sp. nov. | <i>A. carnosus</i> | <i>A. corticis</i> | <i>A. homosetus</i> | <i>A. exiguus aquilonius</i> | <i>A. stricosus</i> |
|------------------------|--|---|--|---|---|---|
| Body length (mm) | 55–86 | 110–340 | 45–170 | 116 | 39–63 | 72–97 |
| Body width (mm) | 2.5–2.8 | 4.0–9.0 | 3.0–6.0 | 5.2 | 1.9–2.6 | 2–2.8 |
| Pigment | | | | | | |
| dorsum | Purple brown before clitellum, light purple brown after | Dark brown or purple | Greenish brown | Dark chocolate on anterior, grey on other parts | Dark reddish brown | No pigment |
| ventrum | Light purple brown before clitellum, no after | Dark brown or purple | No | Grey | Light gray on ventrum | No pigment |
| First dorsal pore | 13/14 | 12/13 | 10/11 or 12/13, usually at 11/12 | 12/13 | 6/7 | 11/12 or 12/13 |
| Clitellum locality | XIV–XVI | XIV–XVI | XIV–XVI, occasionally shorter | XIV–XVI | XIV–XVI | XIV–XVI |
| Setal formula | AA=1.2-2.0AB, ZZ=1.4-2.0ZY | | – | | | |
| Spermathecal pores | 4 pairs, in 5/6–8/9, 0.25C | 4 pairs in 5/6–8/9 or 3 pairs in 6/7–8/9, 0.33C | 4 pairs, 5/6–8/9, 0.33C | 4 pairs, in 5/6–8/9, 0.25C | 4 pairs, 5/6–8/9, 0.45C | 4 pairs, 5/6–8/9, 0.40C |
| Male pores | Middle, round, surrounded by 3–4 rhombic ridges, 0.25C | Round or elliptic | Small, circular to transverse elliptical disc, 0.24–0.30C | Roundish glandular area, about 1.5mm in diameter, 0.25C | Round, smooth, slightly elevated with a male aperture inconspicuous on lateral concave area, 0.23–0.30C | on a coniform glandular disc surrounded by a round pad, 0.33C |
| Papillae preclitellum | Four pairs of postsetal genital papillae in VI–IX | 8 papillae just overhead 8 spermathecal pores, 2 pairs preclitellar arranged on VIII and IX | Paired presetal and/or postsetal in some or all, near spermathecal pores | Invisible | presetal and postsetal, widely paired in 7, 8 and 9, number highly variable | Invisible |
| Papillae postclitellum | 2 presetal crescent indented-topped genital papilla medial of male pores | 2 paired presetal genital on XVIII and IX, 1 pair postsetal genital on XVIII | Present or absent, occasionally one or more near male pore | Invisible | presetal and postsetal, widely paired in XVII, XVIII and XIX, number highly variable | postsetal, single or paired in XVII, XIX and XX |
| Prostate glands | XVII–XXII | Well developed | XVII–XX, rudimentary or absent | XVI–XXI | XVI–XX, wrinkled | XVI–XX, coarsely lobate |
| Spermathecae | About 2.4mm long, ampulla slender heart-shaped; duct short | Ampulla oval or pear-shaped, duct equal to or slightly shorter than ampulla | Ampulla ovoid | – | Ampulla peach-shaped, stalk straight, much shorter than ampulla | About 1.6mm long; ampulla heart-shaped, gradually slender duct as long as ampulla |
| Diverticulum | About 2.0mm long, terminal 4/5, swollen, S-shaped twisted seminal chamber | One-third to half of ampulla, slender stalk and a wider seminal chamber | Blunt ovoid, straight stalk | Shorter, seminal chamber ovoid and whitish | Shorter, seminal chamber rudimentary or absent, straight or slightly bent | As long as main spermathecal axis, slender, terminal 0.4 dilated into a band shaped chamber |
| Accessory glands | 1 stalked accessory gland observed near the ental part of each spermatheca | – | Stalked, coelomic, bound down to parietes or retained within body wall | Invisible | round, stalked observed in spermathecal pores and male pores region | Invisible |

glands well developed, inserting in XVIII and extending from XVII–XXII, coarsely lobate, prostatic duct C-shaped, uniform thickness. No accessory glands observed.

Etymology. The species is named after the crooked shape of its diverticulum.

Remarks. *Amyntas tortuosus* sp. nov. is a comparatively small earthworm and shares some similarities to *A. carnosus* and *A. corticis*. All of them have genital markings both on the spermathecal and the male pore regions and share similar setal numbers. However, the body size of *A. tortuosus* sp. nov. is very distinct from others. The new species has roughly half the body size of *A. carnosus* and *A. corticis*, both in length and width. The first dorsal pore is in 13/14 and the distance between the spermathecal pores and male pores is less than those of *A. carnosus* and *A. corticis*. Moreover, *A. tortuosus* sp. nov. has long diverticulum with an S-shaped twisted seminal chamber and eight stalked accessory glands observed near the spermathecal duct, rather than a straight or slender stalk and an absence of accessory glands in *A. carnosus*.

We also compare the new species with *Amyntas homosetus* (Chen 1938) described from Hainan Island, which has a very similar distance between the male pores and spermathecal pores, and similar setal numbers. The differences between the two species are as follows: the body size of *A. tortuosus* is much smaller than *A. homosetus*; the size of prostate glands is larger in *A. tortuosus*; the shape of the seminal chamber is S-shaped twisted in *A. tortuosus*, while it is ovoid in *A. homosetus*; and several genital markings are present in the spermathecal pore region and male pore region in *A. tortuosus* sp. nov., while these markings are absent in *A. homosetus*.

The body size of *A. tortuosus* sp. nov. is similar to *Amyntas exiguus aquilonius* Tsai et al., 2001 described from Taiwan Island and *Amyntas stricosus* Qiu & Sun, 2012 described from Hainan Island. The first dorsal pore of the new species is in 13/14, but in 6/7 in *A. exiguus aquilonius*, and in 11/12 or 12/13 in *A. stricosus*. The new species has more closely spaced spermathecal pores than *A. exiguus aquilonius* and *A. stricosus*. Additionally, *A. exiguus aquilonius* has more genital papillae observed in spermathecal pores and male pores region than the new species. Accessory glands are observed in spermathecal pores and male pores region in *A. exiguus aquilonius*, but in the new species, accessory glands are only observed in spermathecal pores region. Furthermore, *A. stricosus* has a band shaped chamber, no genital papillae near spermathecal pores region, no accessory glands, and papillae observed in XVII, XIX and XX, but the new species has a S-shaped twisted seminal chamber, four pairs of genital papillae in spermathecal pores region, accessory glands near spermathecal duct, and no genital papillae observed in XVII, XIX and XX. Details of the comparison are showed in table 3.

***Amyntas shengtangmontis* Dong & Jiang, sp. nov.**

<http://zoobank.org/6831C1EE-6B6B-4B4C-8C9F-4A9B903EBCB6>

Figure 4, Table 4

Material. Holotype: 1 clitellate (C-GX201312-03A): China, Guangxi Zhuang Autonomous Region, Dayao Mountain National Nature Reserve (23.97299°N, 110.11106°E), 1210 m asl, black sandy soil in bamboo forest, 15 May 2013, JP Qiu,

Y Hong, JB Jiang, LL Zhang, Y Dong legit. **Paratypes:** 4 clitellates (C-GX201312-03A): same data as for holotype.

Diagnosis. Dimension 100–134 mm by 4.2–5.1 mm at clitellum, 116–138 segments. First dorsal pore in 12/13. Setae numbering 26–28 at III, 24–32 at V, 26–32 at VIII, 33–40 at XX, 35–42 at XXV; 8–11 between male pores. Setae between spermathecal pores numbering 11–15 at VI, 10–13 at VII, 12–16 at VIII. Four pairs of spermathecal pores in 5/6–8/9. Four pairs of postsetal genital papillae arranged in VI–IX, 0.25 circumference ventrally apart from each other. One pair of male pores in XVIII, each on the top of a large raised, round porophore, surrounded by two circular ridges, with one presetal indented-topped genital papilla medial of each porophore. First ampulla of the three pairs is heart-shaped, duct stalked, diverticulum as long as main chain, U-shaped twist in the middle, terminal 4/5 dilated into a club-shaped seminal chamber. Ampulla of the fourth pair elongate-oval, duct as long as 1/6 ampulla, diverticulum as long as main chain, U-shaped twist in the middle, terminal 1/3 dilated into a chili-shaped seminal chamber. One round, semitransparent accessory gland presents near the medial area of each spermatheca. The prostate glands are developed.

Description. External characters: Pigment from brown to no pigment on dorsum, from light brown to no pigment on ventrum. Dimensions 102 mm by 4.5 mm at clitellum, 117 segments. Prostomium $\frac{1}{2}$ epilobous. First dorsal pore in segments 12/13. Setae numbering 26 at III, 26 at V, 29 at VIII, 36 at XX, 37 at XXV; 9 between male pores. Setae between spermathecal pores numbering 13 at VI, 12 at VII, 14 at VIII. Setal formula: AA = 1.0-1.4AB, ZZ = 2.0-2.2ZY. Clitellum annular, in XIV–XVI, setae not visible externally. Four pairs of spermathecal pores in 5/6–8/9, 0.40 circumference apart ventrally. Four pairs of genital papillae on VI–IX, 0.25 circumference ventrally apart from each other. One pair of male pores in XVIII, 0.40 circumference ventrally apart from each other, each on the top of a larger raised, round porophore, surrounded by two circular ridges, with one presetal indented-topped genital papilla medial of each porophore (Figure 3A). Singled female pore in XIV, pale grey.

Internal characters. Septa 5/6–7/8 thick and muscular, 10/11–11/12 slightly thickened, 8/9–9/10 absent. Gizzard bucket-shaped, wider below than above, in VIII–X. Intestine enlarged distinctly from XV. Intestinal caeca paired in XXVII, simple, smooth, extending anteriorly to XXI. Esophageal hearts in X–XIII. Ovaries in XIII, four pairs of spermathecae in VI–IX, 2.2–3.0 mm long. Spermathecae of two shapes: ampulla of the first three pairs heart-shaped, duct stalked, diverticulum as long as main chain, U-shaped twist in the middle, terminal 4/5 dilated into a club-shaped seminal chamber. The ampulla of the fourth pair elongate-oval, duct as long as 1/6 ampulla (Figure 3C), and diverticulum as long as main chain, U-shaped twisted in the middle, terminal 1/3 dilated into a chili-shaped seminal chamber (Figure 3B). One round semitransparent accessory gland presents near the medial area of each spermatheca. Holandric: two pairs of testis sacs in X–XI, separated from each other, well developed. Two pairs of seminal vesicles, in XI–XII, well developed. Prostate glands developed, thick, inserting in XVIII and extending from XV to XXII, coarsely lobate, prostatic

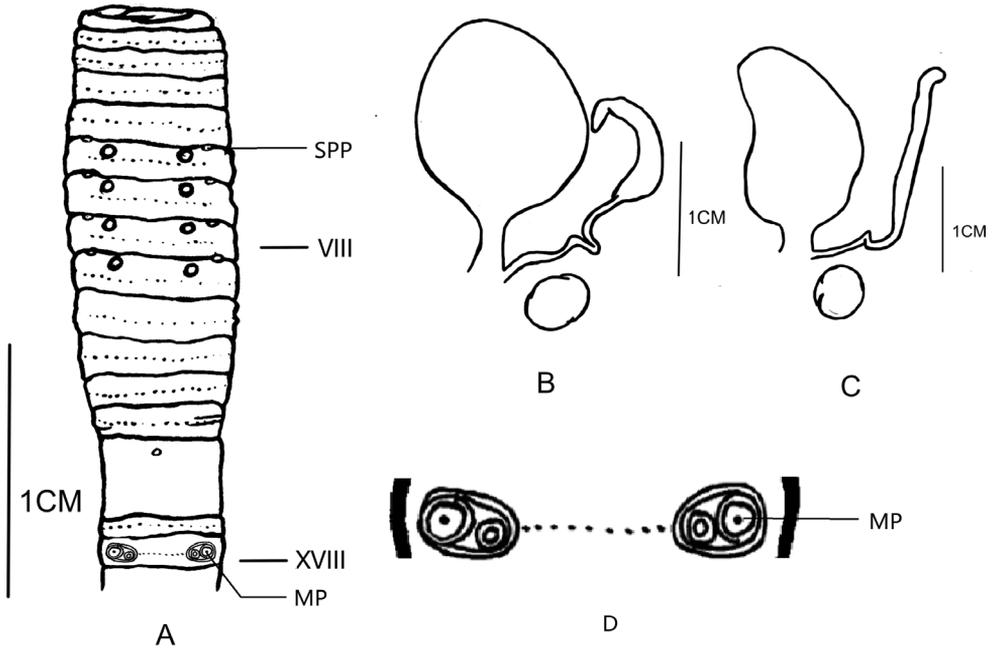


Figure 4. **A** Ventral view showing spermathecal pores, female pores and male pores of *Amyntas shengtangmontis* sp. nov. **B, C** spermathecae of *Amyntas shengtangmontis* sp. nov. **D** illustration of the details of the male pore region.

duct U-curved, slightly thicker at the ental part. Two stalked accessory glands near the medial area of the distal part of the prostatic duct.

Etymology. The species is named after the name of the collection site Shengtang Mountain, a famous peak of the Dayao Mountain National Nature Reserve.

Remarks. *Amyntas shengtangmontis* sp. nov. keys to the *corticis*-group in Sims and Easton (1972). In terms of morphology, it is closely related to *A. carnosus*, *A. corticis*, and *Amyntas pulvinus* Sun & Jiang, 2013 (described from Hainan Island). Body size, body pigment, setal numbers, the first dorsal pore location, and simple intestinal caeca are similar among the four species.

In contrast, distance between the spermathecal pores and the male pores of the new species is $0.40C$ body circumference compared with $0.33C$ in *A. carnosus*, *A. corticis*, and *A. pulvinus*. In addition, there are eight postsetal genital markings on VI–IX in the new species, but the markings are present on V–VIII in *A. carnosus*, and there are more than two pairs of markings on VIII and IX in *A. carnosus*. The porophore of the new species is large, raised, round, and surrounded by two circular ridges, whereas the porophore is small in *A. corticis* and no genital markings apparent on the spermathecal pore region in *A. pulvinus*. Moreover, the new species has two different shapes of spermathecae, heart-shaped ampulla and diverticulum with club-shaped seminal chamber; and long-oval ampulla and diverticulum with chili-shaped seminal chamber, which are very different from those in the other species (Table 4).

Table 4. A comparison of characters of *A. shengtangmontis shengtangmontis*, *A. shengtangmontis minusculus*, *A. carnosus*, *A. corticis*, and *A. pulvinus*.

| Characteristics | <i>A. shengtangmontis shengtangmontis</i> | <i>A. shengtangmontis minusculus</i> | <i>A. carnosus</i> (Goto & Hatai, 1899) | <i>A. corticis</i> (Kinberg, 1867) | <i>A. pulvinus</i> Sun & Qiu, 2013 |
|------------------------|---|--|---|--|--|
| Body length (mm) | 100–134 | 75–83 | 110–340 | 45–170 | 93.5 |
| Body width (mm) | 4.2–5.1 | 3.0–3.2 | 4.0–9.0 | 3.0–6.0 | 3.4 |
| Pigment dorsum | From brown to no | Purple brown | Dark brown or purple | Greenish brown | Buff |
| ventrum | From brown to no | No | Dark brown or purple | No | No |
| First dorsal pore | 12/13 | 11/12 | 12/13 | 10/11 or 12/13, usually at 11/12 | 12/13 |
| Clitellum locality | XIV–XVI | XIV–XVI | XIV–XVI | XIV–XVI, occasionally shorter | XIV–XVI |
| Spermathecal pores | 4 pairs, in 5/6–8/9, 0.40C | 4 pairs, in 5/6–8/9, 0.40C | 4 pairs in 5/6–8/9 or 3 pairs in 6/7–8/9, 0.33C | 4 pairs, 5/6–8/9, 0.33C | 4 pairs, in 5/6–8/9, 0.33C |
| Male pores | Large raised, round, surrounded by 2 circular ridges, 0.44C | Raised, elliptic, surrounded by 6 circular ridges, 0.40C | Round or elliptic | Small, circular to transverse elliptical disc, 0.24–0.30C | Slightly elevated round, 0.33C |
| Papillae preclitellum | Four pairs of postsetal genital papillae arranged in VI–IX | Three pairs of postsetal genital papillae arranged in VI–VIII | 8 papillae just overhead 8 spermathecal pores, 2 pairs preclitellar arranged on VIII and IX | Paired presetal and/or postsetal in some or all, near spermathecal pores | Invisible |
| Papillae postclitellum | 2 presetal indented-topped genital medial of porophore | 2 small indented-topped genital papillae medial of male pore | 2 paired presetal genital on XVIII and IX, 1 pair postsetal genital on XVIII | Present or absent, occasionally one or more near male pore | Rectangle-shaped, on 17/18–18/19 |
| Prostate glands | XV–XXII | XVI–XXI | Well developed | XVII–XX, rudimentary or absent | XVII–XX |
| Spermathecae | About 2.2–3.0mm long, ampulla of the first three pairs heart-shaped, duct stalk. Ampulla of the forth pair long-oval, duct as long as 1/6 ampulla | About 2.2–2.7mm long, duct as long as 1/2 ampulla | Ampulla oval or pear-shaped, duct equal to or slightly shorter than ampulla | Ampulla ovoid | About 2.4mm long, ampulla slender heart-shaped; duct short |
| Diverticulum | As long as main chain, U-shaped twisted in middle, terminal 4/5, club-shaped seminal chamber of the first three pairs and terminal 1/3 dilated into a chilli-shaped seminal chamber of the forth pair | As long as main chain, terminal 1/2, long club-shaped seminal chamber | One-third to half of ampulla, slender stalk and a wider seminal chamber | Blunt ovoid, straight stalk | Shorter, terminal 1/5, small ovoid plump seminal chamber |
| Accessory glands | 1 round semitransparent accessory gland present near the medial area of each spermatheca, 2 stalk accessory glands observed near the medial of the distal part of the prostatic duct | 6 semitransparent elliptic accessory glands observed near the distal part of the last three pairs spermathecae | – | Stalked, coelomic, bound down to parietes or retained within body wall | A pair, cling to body wall, irregular in shape, and extended from XVII–XIX |

***Amyntas shengtangmontis minusculus* Dong & Law, subsp. nov.**

<http://zoobank.org/AE048B96-5A37-4C48-A734-22EA11119010>

Figure 5, Table 4

Material. Holotype: 1 clitellate (C-GX201316-02A): China, Guangxi Zhuang Autonomous Region, Dayao Mountain Nature Reserve (24.16658°N, 110.24313°E), 1285 m asl, black sandy soil under bryophytes beside road, 16 May 2013, JP Qiu, Y

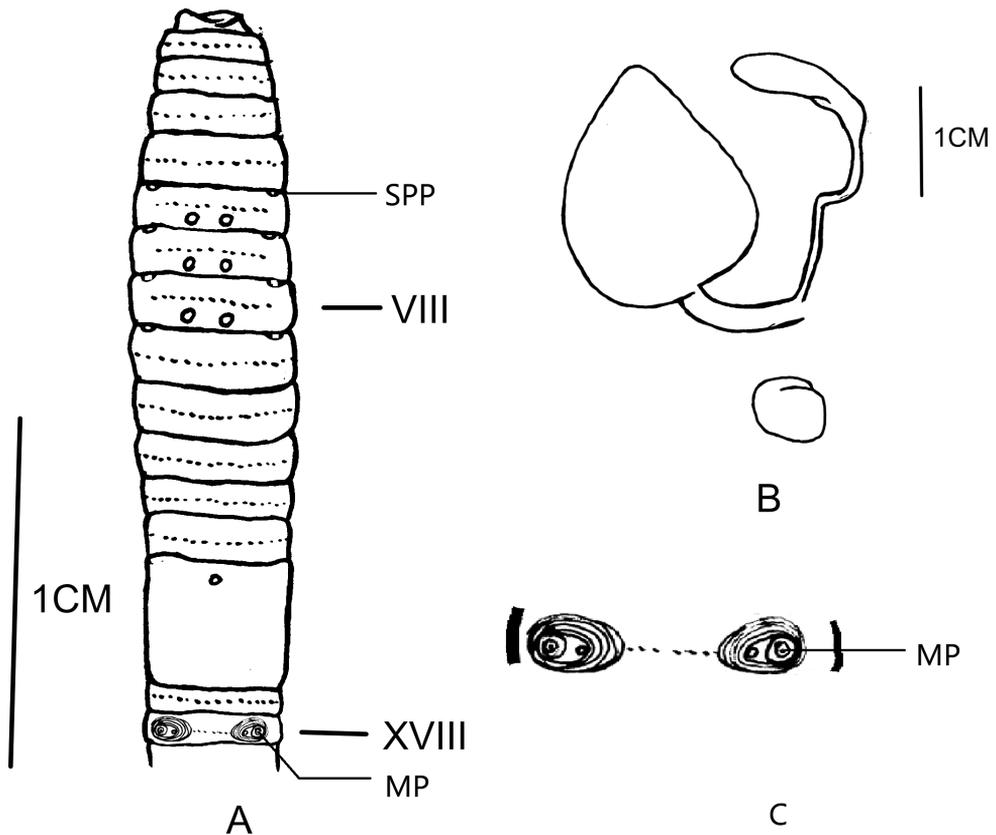


Figure 5. **A** Ventral view showing spermathecal pores, female pores and male pores of *Amyntas shengtangmontis minusculus* subsp. nov. **B** spermathecae of *Amyntas shengtangmontis minusculus* subsp. nov. **C** illustration of the details of the male pore region.

Hong, JB Jiang, LL Zhang, and Y Dong legit. **Paratypes:** 6 clitellate (C-GX201316-02B): same date as for holotype.

Diagnosis. Dimensions 75–83 mm by 3.0–3.2 mm at clitellum, 75–87 segments. First dorsal pore in 11/12. Setae numbering 21–26 at III, 18–21 at V, 27–32 at VIII, 29–34 at XX, 36–40 at XXV; 5–7 between male pores; Setae between spermathecal pores numbering 9–11 at VI, 10–12 at VII, 10–12 at VIII. Four pairs of spermathecal pores in 5/6–8/9. Three pairs of postsetal genital papillae arranged in VI–VIII, 0.13 circumference apart ventrally. One pair of male pores in XVIII, each on the top of a raised, elliptic porophore surrounded by six circular ridges, with one small indented-topped genital papilla medial of each male pore. Ampulla heart-shaped; stout duct as long as 1/2 ampulla. Diverticulum as long as main pouch, terminal 1/2 dilated into a long club-shaped seminal chamber. Prostate glands developed.

Description. External characters: Purple brown pigment on dorsum, no pigment on ventrum. Dimensions 83 mm by 3.2 mm at clitellum, 87 segments. Prostomium 1/2 epilobous. First dorsal pore in 11/12. Setae numbering 26 at III, 21 at V, 32 at VIII, 34 at XX, 38 at XXV; 6 between male pores; setae between spermathecal pores numbering

10 at VI, 11 at VII, 12 at VIII. Setal formula AA = 1.2-1.4AB, ZZ = 1.4-1.8ZY. Clitellum annular in XIV–XVI, setae not visible externally. Four pairs of spermathecal pores in 5/6–8/9, 0.40 circumference ventrally apart from each other. Three pairs of postsetal genital papillae arranged in VI–VIII. One pair of male pores in XVIII, 0.40 circumference apart ventrally, each on the top of a raised, elliptic porophore surrounded by six circular ridges, with one small indented-topped genital papilla in the center of each male pore (Figure 4A). Single female pore in XIIV.

Internal characters. Septa 5/6–7/8, thick and muscular, 10/11–11/12 slightly thickened, 8/9–9/10 absent. Gizzard bucket-shaped, wider below than above, in IX–X. Intestine enlarged distinctly from XV. Intestinal caeca paired in XXVII, simple, smooth, extending anteriorly to 1/2 XXIV. Esophageal hearts in X–XIII. Ovaries in XIII, four pairs of spermathecae in VI–IX, heart-shaped, 2.2–2.7mm long, duct as long as 1/2 ampulla. Diverticulum as long as main pouch, terminal 1/2 dilated into a long club-shaped seminal chamber. Six semitransparent elliptical accessory glands observed near the ental part of the last three pairs spermathecae (Figure 4B). Holandric: two pairs of testis sacs, separated from each other, in X–XI, oval, the first pair extremely developed. Two pairs of seminal vesicles, in XI–XII, developed. Prostate glands, thick, inserting in XVIII and extending from XVI to XXI, developed, coarsely lobate; prostatic duct U-curved, long, slightly thicker at the ental part.

Remarks. We compare *A. shengtangmontis minusculus* subsp. nov. with *A. shengtangmontis shengtangmontis* and find that they share similar characters of spermathecal pores, male pores, intestinal caeca, and prostate glands. However, there is a level of difference between them. For instance, *A. shengtangmontis minusculus* subsp. nov. has a smaller body size, fewer and more closely spaced genital papillae, longer spermathecal duct, accessory glands only observed in the spermathecal area. On the other hand, the first dorsal pore of *A. shengtangmontis minusculus* subsp. nov. is located in 11/12 compared to in 12/13 in *A. shengtangmontis shengtangmontis*. The pairwise distance of COI between *A. shengtangmontis shengtangmontis* and *A. shengtangmontis minusculus* subsp. nov. is 10.7%–11.4%, which is acceptable to differentiate subspecies.

Etymology. The subspecies is named after its small body size, compared to the nominate species.

Molecular results

In addition to the morphological comparison between the species, we also compared the COI gene sequences of the three proposed new species and one subspecies and the results of the pairwise distances of COI, ranging from 10.7%–25.2% are shown in Table 5. Studies show that pairwise distances of COI of interspecies in the same genus are 17–23% (Sun 2013), 16–23% (Huang et al. 2007), 15–16% (Admassu et al. 2006), 16–22% (Novo et al. 2009), and 15–28% (Chang et al. 2008). In general, pairwise distances between three new species and the other eighteen *corticis*-group species are greater than 14.7%. Together with the different morpho-

Table 5. Percentage of pairwise distances obtained for the sequences of COI genes in *Amyntas* species.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|
| S1 HT | | | | | | | | | | | | | | | | | | | | | | | | | |
| S2 HT | 19.2% | | | | | | | | | | | | | | | | | | | | | | | | |
| S2 PT | 19.2% | 0.0% | | | | | | | | | | | | | | | | | | | | | | | |
| S2 PT | 19.2% | 0.0% | 0.0% | | | | | | | | | | | | | | | | | | | | | | |
| S3 HT | 16.4% | 15.7% | 15.7% | 15.7% | | | | | | | | | | | | | | | | | | | | | |
| S4 HT | 16.7% | 14.7% | 14.7% | 14.7% | 10.7% | | | | | | | | | | | | | | | | | | | | |
| S4 PT | 16.9% | 15.4% | 15.4% | 15.4% | 11.4% | 0.2% | | | | | | | | | | | | | | | | | | | |
| <i>A. fuscatus</i> | 15.9% | 17.4% | 17.4% | 17.4% | 20.4% | 17.4% | 17.0% | | | | | | | | | | | | | | | | | | |
| <i>A. pulvinus</i> | 20.0% | 18.2% | 18.2% | 18.2% | 19.7% | 18.4% | 18.8% | 18.6% | | | | | | | | | | | | | | | | | |
| <i>A. robustus</i> | 18.9% | 16.9% | 16.9% | 16.9% | 17.8% | 18.0% | 18.0% | 17.1% | 22.7% | | | | | | | | | | | | | | | | |
| <i>A. corticis</i> | 15.6% | 18.0% | 18.0% | 18.0% | 18.2% | 18.7% | 18.8% | 18.0% | 16.3% | 18.0% | | | | | | | | | | | | | | | |
| <i>A. carnosus</i> | 19.8% | 17.4% | 17.4% | 17.4% | 20.2% | 20.0% | 18.7% | 18.3% | 18.7% | 16.7% | 16.7% | | | | | | | | | | | | | | |
| <i>A. micromarius</i> | 20.7% | 19.8% | 19.8% | 19.8% | 19.9% | 19.5% | 20.1% | 21.0% | 19.1% | 20.9% | 17.5% | 21.2% | | | | | | | | | | | | | |
| <i>A. alexandri</i> | 24.3% | 21.3% | 21.3% | 21.3% | 23.7% | 22.4% | 22.0% | 21.3% | 21.5% | 20.7% | 21.5% | 20.8% | 22.6% | | | | | | | | | | | | |
| <i>A. andersoni</i> | 23.2% | 20.1% | 20.1% | 20.1% | 23.0% | 21.0% | 20.9% | 18.9% | 21.2% | 19.6% | 17.3% | 18.4% | 20.9% | 23.6% | | | | | | | | | | | |
| <i>A. comptus</i> | 21.9% | 19.2% | 19.2% | 19.2% | 20.7% | 19.4% | 20.2% | 19.1% | 21.2% | 19.6% | 18.5% | 20.0% | 20.5% | 19.2% | | | | | | | | | | | |
| <i>A. exiguus</i> | 18.2% | 18.0% | 18.0% | 18.0% | 18.1% | 18.5% | 18.7% | 18.2% | 18.6% | 18.7% | 18.5% | 19.1% | 18.3% | 24.2% | 21.3% | 22.1% | | | | | | | | | |
| <i>A.iformosae</i> | 21.4% | 21.0% | 21.0% | 21.0% | 19.3% | 21.9% | 22.0% | 23.2% | 19.8% | 22.7% | 20.3% | 22.7% | 20.8% | 20.5% | 24.4% | 24.1% | 23.5% | | | | | | | | |
| <i>A. longicaudatus</i> | 20.2% | 19.5% | 19.5% | 19.5% | 21.6% | 21.8% | 22.1% | 19.6% | 21.5% | 21.3% | 19.8% | 22.6% | 21.7% | 22.9% | 18.3% | 18.1% | 20.2% | 23.9% | | | | | | | |
| <i>A. miriflus</i> | 17.6% | 16.6% | 16.6% | 16.6% | 18.7% | 17.1% | 17.1% | 16.1% | 16.7% | 17.9% | 15.3% | 17.4% | 20.5% | 19.2% | 20.7% | 19.8% | 18.9% | 21.3% | 19.7% | | | | | | |
| <i>A. szechuanensis</i> | 22.5% | 20.4% | 20.4% | 20.4% | 22.6% | 20.4% | 20.5% | 19.3% | 22.4% | 21.8% | 18.2% | 19.8% | 21.5% | 24.7% | 19.3% | 18.9% | 20.0% | 24.0% | 18.3% | 21.4% | | | | | |
| <i>A. mediosus</i> | 19.4% | 19.4% | 19.4% | 19.4% | 19.4% | 23.8% | 23.6% | 18.0% | 19.8% | 19.1% | 18.5% | 20.5% | 21.4% | 25.2% | 22.5% | 18.7% | 18.2% | 24.2% | 20.9% | 18.8% | 22.5% | | | | |
| <i>A. vulpinus</i> | 20.2% | 18.3% | 18.3% | 18.3% | 21.8% | 18.4% | 18.4% | 19.4% | 20.9% | 20.2% | 17.8% | 19.7% | 18.2% | 25.1% | 20.7% | 21.5% | 20.4% | 23.0% | 19.9% | 19.2% | 19.7% | | | | |
| <i>A. yunnanensis</i> | 19.7% | 18.6% | 18.6% | 18.6% | 16.8% | 17.3% | 17.3% | 19.2% | 18.0% | 17.4% | 17.8% | 17.9% | 20.3% | 21.3% | 22.2% | 19.8% | 17.1% | 21.0% | 20.0% | 17.0% | 16.2% | 20.3% | 20.5% | | |
| <i>A. striosus</i> | 16.3% | 15.0% | 15.0% | 15.0% | 18.2% | 16.6% | 16.4% | 13.1% | 18.4% | 17.1% | 16.1% | 17.2% | 20.8% | 18.4% | 17.3% | 17.6% | 21.7% | 18.8% | 18.4% | 19.5% | 20.8% | 18.1% | 16.5% | 21.1% | |

Notes: S1 represent *A. maximus*, S2 represent *A. tortuosus*, S3 represent *A. shengtangmontis shengtangmontis*, S4 represent *A. shengtangmontis minusculus*

logical characters of each, we could conclude that *A. maximus*, *A. tortuosus*, *A. shengtangmontis shengtangmontis*, and *A. shengtangmontis minusculus* are different from the previously described species and each other. Since the pairwise distance between *A. shengtangmontis shengtangmontis* and *A. shengtangmontis minusculus* is 10.7%–11.4%, which is more than 1% and less than 15%, by definition we conclude that both subspecies are valid.

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