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A new species of the genus *Mongoloniscus* Verhoeff, 1930 (Crustacea: Isopoda: Agnaridae) from China

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Abstract

A new species of suborder Oniscidea from northeast China, *Mongoloniscus chevronus* **sp. nov.**, is described and illustrated. The new species is most related to *M. sinensis*, only can be distinguished from the latter and other congeners by all pereonites with concave-convex-concave posterior margins, pleon without any decorations. But it can be found new to science by *Cox1* gene. A key to all species of genus *Mongoloniscus* is presented herein.

Key words: *Mongoloniscus*, northeast China, new species, taxonomy, *Cox1* gene

Introduction

Oniscidea is the earliest described group of order Isopoda, and the only suborder completely adapted to terrestrial life. Up to now, 39 families, 523 genera, and more than 3700 species were described (WoRMS Editorial Board 2021). The members of family Agnaridae Schmidt, 2003 are mainly distributed in the temperate and subtropical regions of Eurasia and North Africa (Eshaghi 2015). The unique feature of Agnaridae is the single stomatal "lung" on the exopodites of the all pleopods. According to WoRMS (2021), Agnaridae includes 14 genera, of which three genera (*Mongoloniscus* Verhoeff, 1930*, Agnara* Budde-Lund, 1908*,* and *Lucasioides* Kwon, 1993) were recorded from China (Chen 2003).

According to Kwon's (1993) definition of the genus *Mongoloniscus*: cephalon with well-developed median lobes and lateral lobes. Epimera of pereonites 1–2 relatively rounded, and 3–7 gradually pointed. Noduli laterales on pereonites 1–4 farther from lateral margins than those pereonites 5–7. As for male, carpus of pereopods 7 expanded on tergal margin; exopods of all pleopods with *Protracheoniscus*-type pseudotrachea; exopod of pleopod 1 with outer margin deeply concave, and endopod of pleopod 2 with long and filiform distal part.

Mongoloniscus differs from *Lucasioides* in the former with noduli laterales on pereonites 1–4 farther from lateral margins than those pereonites 5–7; and for male, exopod of pleopod 1 with a deeply concavity at apex; carpus of pereopod 7 expanding on tergal margin. But in *Lucasioides*, the noduli laterales of pereonites 2–4 farther from lateral margin than ones on pereonites 1 and 5–7; as for male, exopod of pleopod 1 with a shallower concavity; and carpus of pereopod 7 not expanded on tergal margin (Li 2017). It can be distinguished from *Agnara* by noduli laterales, endopod and exopod of pelopod 1 of male. In *Agnara*, the noduli laterales formed into a line, almost at the same distance from lateral margins of pereonite; for male, endopod of pleopod 1 is rounded at apex, exopod without a deeply hollow (Kashani 2016).

Verhoeff (1930) supported that *Mongoloniscus* is a subgenus of *Protracheoniscus* Verhoeff, 1917. Kwon (1993) regarded *Mongoloniscus* as the genus of family Agnaridae. Schmalfuss (2003) supported Kwon's opinion, but Schmidt (2004) considered this genus as a member of the family Porcellionidae. The taxonomic rank of genus *Mongoloniscus* are doubted.

Nunomura (1999a) transferred 9 species (Table 1) from *Nagurus* Holthuis, 1949, *Protracheoniscus, Metoponorthus* Budde-Lund, 1879 and *Porcellio* Latreille, 1804 to genus *Mongoloniscus* (Kwon 1993; Nunomura 1987,

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1999a). Nunomura (2010c, d, 2013) found 6 new species of this genus from Japan. Kashani (2014) described a new species from Iran. In summary, there are 17 species in this genus *Mongoloniscus* (Boyko *et al*. 2008 onwards).

All 17 species of *Mongoloniscus* are recorded from Asia (Table 1), from which three species (*M. sinensis*; *M. koreanus* and *M. vannamei* Arcangeli, 1927) occur in China. *M. sinensis* is endemic to China while *M. koreanus* and *M. vannamei* are also distributed in Japan and Korea (Kwon 1993; Saito 2000; Chen 2003). In the process of collecting *M. sinensis*, some specimens were found with minor differences (posterior margins of pereonites, pleon without any decorations). DNA barcoding based on mitochondrial cytochrome C oxidase subunit *Cox1* gene has been successfully applied to the identification of crustaceans (Zhang 2011; Will 2005). To verify the taxonomic status of specimens collected from Benxi City, Liaoning Province at the molecular level, *Cox1* gene of this species was sequenced. Then we combined it with all species of family Agnaridae with available *Cox1* gene data from GenBank to construct BI (Bayesian Inference) tree. A key to all species of *Mongoloniscus* is presented.

Key to the known species of genus *Mongoloniscus* Verhoeff, 1930

1	epimera of pereonites 2–7 with white extending margin	*M. vannamei*
-	epimera of pereonites 2–7 without white extending margin	2
2	epimera of pereonites 1–7 with noduli laterales	3
-	epimera of pereonites 1–7 without noduli laterales	6
3	noduli laterales on pereonites 1–7 arranged in a line	*M. koreanus*
-	noduli laterales on epimera of pereonites 1–7 not arranged in a line	4
4	noduli laterales on pereonites 1, 2–4 not arranged in a line	*M. persicus*
-	noduli laterales on pereonites 1, 2–4 arranged in a line	5
5	all pereonites posterior margin with "Wave type"	*M. chevronus* **sp. nov**.
-	all pereonites posterior margin with "Straight curve"	*M. sinensis*
6	cephalon with less-developed lateral lobes	7
-	cephalon with developed lateral lobes	9
7	cephalon markedly rectangular	*M. ishikawai*
-	cephalon markedly not rectangular	8
8	cephalon distinctly semicircle	*M. nankaiensis*
-	cephalon distinctly not semicircle	*M. hokurikuensis*
9	exopod of pleopod 1 without long hind lobe bearing a deep hollow	*M. amabilis*
-	exopod of pleopod 1 with long hind lobe bearing a deep hollow	10
10	middle of pereon and pleon with a longitudinal pattern	11
-	middle of pereon and pleon without a longitudinal pattern	13
11	middle of pereon and pleon with a longitudinal paler pattern	*M. satsumaensis*
-	middle of pereon and pleon with a longitudinal dark pattern	12
12	cephalon with pointed lateral lobes	*M. odamiyamaensis*
-	cephalon with rounded lateral lobes	*M. oumiensis*
13	both sides of pereonite tergite without paler longitudinal pattern	*M. circacaudatus*
-	both sides of pereonite tergite with paler longitudinal pattern	14
14	telson triangular with concave sides	*M. katakurai*
-	telson triangular with linear sides	15
15	eyes large, almost as long as the cephalon	*M. tangoensis*
-	eyes small, far less than the length of the cephalon	16
16	middle of pleon without paler pattern	*M. arvus*
-	middle of pleon with paler pattern	17
17	pleon tergite 3–5 with rounded posterolateral margin	*M. maculatus*
-	pleon tergite 3–5 with pointed posterolateral margin	*M. masahitoi*

Material and methods

Specimens were collected from Benxi City, Liaoning Province (41˚13'51"N, 125˚18'57"E), and all specimens were fixed in ethanol (>99.7%). Specimens were viewed and drawn using a Nikon SMZ 1500 dissecting microscope, images were scanned using Canon Scan 4400F and ArcSoft PhotoStudio, and edited using Adobe Photoshop CS6. Final line drawings were created by tracing with a drawing tablet using Adobe Illustrator CC2017. All specimens examined in this study have been deposited in College of Life Science, Shanxi Normal University, China. Terminology follows Schmidt (1997, 1998, 2000a, b, 2001).

TABLE 1. Type locality, track changes between genera and references to all species of *Mongoloniscus*.

Species	Type locality	Track changes between genera	References
M. amabilis Nunomura, 2013	Japan	*Mongoloniscus*	Nunomura 2013
M. odamiyamaensis Nunomura, 2013	Japan	*Mongoloniscus*	Nunomura 2013
M. nankaiensis Nunomura, 2013	Japan	*Mongoloniscus*	Nunomura 2013
M. ishikawai Nunomura, 2013	Japan	*Mongoloniscus*	Nunomura 2013
M. arvus Nunomura, 2010	Japan	*Mongoloniscus*	Nunomura 2010c
M. oumiensis Nunomura, 2010	Japan	*Mongoloniscus*	Nunomura 2010d
M. persicus Kashani, 2014	Iran	*Mongoloniscus*	Kashani 2014
***M. chevronus* sp. nov.**	**China**	***Mongoloniscus***	**This study**
M. circacaudatus Nunomura, 1987	Japan	*Protracheoniscus-Mongoloniscus*	Nunomura 1987, 1999a
M. hokurikuensis Nunomura, 1987	Japan	*Protracheoniscus-Mongoloniscus*	Nunomura 1987, 1999a
M. masahitoi Nunomura, 1987	Japan	*Protracheoniscus-Mongoloniscus*	Nunomura 1987, 1999a
M. satsumaensis Nunomura, 1987	Japan	*Protracheoniscus-Mongoloniscus*	Nunomura 1987, 1999a
M. tangoensis Nunomura, 1987	Japan	*Protracheoniscus-Mongoloniscus*	Nunomura 1987, 1999a
M. katakurai Nunomura, 1987	Japan	*Nagurus-Mongoloniscus*	Nunomura 1987, 1999a
M. koreanus Verhoeff, 1930	Korea	*Protracheoniscus-Nagurus-Mongoloniscus*	Kwon 1993, 1999a
M. vannamei Arcangeli, 1927	China	*Porcellio-Nagurus-Mongoloniscus*	Nunomura 1987, 1999a; Chen 2003
M. maculatus Iwamoto, 1943	Japan	*Porcellio-Nagurus-Mongoloniscus*	Nunomura 1980, 1999a
M. sinensis Dollfus, 1901	China	*Metoponorthus-Mongoloniscus*	Boyko et al., 2008 onwards

The mitochondrial *Cox1* gene sequences of 25 species of Oniscidea in this study were obtained from the GenBank database, including 23 sequences belonging to Agnaridae family members and 2 outgroups of *Armadillidium nasatum* Budde-Lund, 1885 and *Armadillidium vulgare* Latreille, 1804.

Total genomic DNA was extracted from available specimens using a Tissue Cell Genomic DNA Rapid Extraction Kit (Aidlab Biotechnologies Co., Ltd), following the manufacturer's proposed protocol. Desired regions were successfully amplified using newly designed *Cox1* gene specific primers F (TACAGTCAATCGCTTAAAGC), R (GGAAGATAGTTCAAATCATTTC) for *Cox1*. The PCR reaction was carried out with LA Taq polymerase for 35 cycles at 94˚C for 30 s, and annealed at 50˚C for 30 s, followed by extension at 72˚C for 1 min per 1 kb. The final $MgCl_2$ concentration in the PCR reaction was 2.0 mmol/L. PCR products were cloned into pMD18-T vector (Takara, JAP) and then sequenced, or sequenced directly by the dideoxynucleotide procedure, using an ABI 3730 automatic sequencer. Sequences were assembled by software of DNAstar and adjusted manually to generate the complete sequence of mitochondrial DNA. The *Cox1* sequence data has been submitted to the GenBank databases under accession number MW792415.

The obtained sequence was aligned against other published *Cox1* gene sequences of Agnaridae using Muscle algorithms of MEGA 5. Select GTR+F+G4 models and construction of Bayesian evolutionary tree using PhyloSuite. Phylogram was visualized in iTOL, final drawing was edited by using Adobe Photoshop CS6.

Results

Taxonomy

Order ISOPODA Latreille, 1817

Suborder ONISCIDEA Latreille, 1802

Family AGNARIDAE Schmidt, 2003

Genus *Mongoloniscus* Verhoeff, 1930

Type species: *Mongoloniscus koreanus* Verhoeff, 1930, by monotypy.

Mongoloniscus chevronus sp. nov.

Figs 1−3

urn:lsid:zoobank.org:act:AC2B8A03-3DB4-4271-A953-1DD04F308BA8

Material examined. ***Holotype*** ♂ (IOA19080601), Benxi City, Liaoning Province, China, 41˚13'51" N, 125˚18'57" E, 6 August 2019, coll. Jianmei An. ***Allotype*** ♀ (IOA19080602), same data as holotype. ***Paratypes*** 3♂, 5♀ (IOA 19080603, 19080604, 19080605, 19080606, 19080607, 19080608, 19080609, 19080610), same data as holotype.

Diagnosis. Cephalon with well-developed rounded lateral lobes and triangular median lobes (Fig. 1A). Epimera of all pereonites with concave-convex-concave posterior margin (Figs 1A, 3B). Pleon without any patterns (Figs 1A, 3B). For male, carpus of pereopod 7 with convex dorsal margin (Figs 2G, 3I), exopod of pleopod 1 deep hollow at apex, endopod straight with triangular apical part slightly bent outwards (Figs 1E, F, 3D, E).

Description. ***Holotype*** ♂ (IOA19080601) length 9.60 mm, maximum width 4.41 mm. *Body* color blackish brown, surface slightly granulated (Figs 1A, 3B).

Cephalon (Fig. 1A) with well-developed triangular median process and pair of rounded lateral lobes, vertex with faint tubercles and many pale irregular patterns, posterior margin straight.

Antennula (Figs 1B, 3G) with first segment big and cylindrical, second segment rather short and square. *Antenna* (Figs 1C, 3C) surpassing posterior margin of pereonite 2 but not reaching the posterior margin of pereonite 3; first three segments square; fourth segment 1.8 times as long as third; fifth segment 1.3 times as long as fourth; fourth peduncular segment with one pale bar; fifth peduncular segment with 1–2 pale short bar pattern; flagellum somewhat shorter than fifth peduncular segment; flagellum with two articles, terminal flagellar segment 1.7 times as long as basal one.

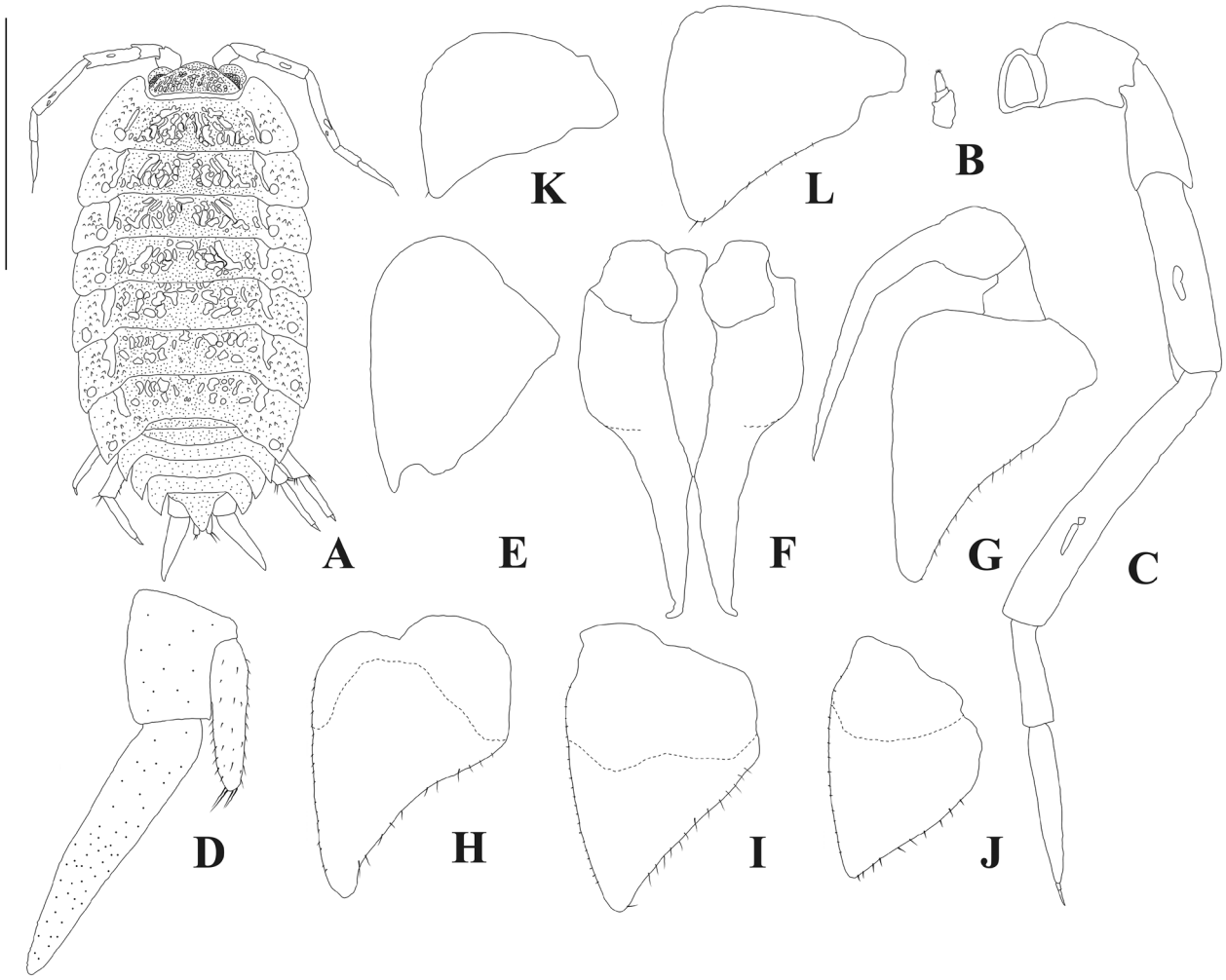

FIGURE 1. ***Mongoloniscus chevronus*** **sp. nov.**, holotype ♂ (A–J); A, Dorsal view; B, Right antenna 1; C, Right antenna 2; D, Right uropod; E, Left pleopod endopodite 1; F, Left pleopod exopodite 1; G, Left pleopod 2; H, Left pleopod 3; I, Left pleopod 4; J, Left pleopod 5. *Paratype* ♀ (K–L); K, Left pleopod exopodite 1; L, Left pleopod exopodite 2. Scale-bars: A = 0.21 mm; B = 1 mm; C–L = 0.80 mm.

Pereon (Figs 1A, 3B) covered with faint tubercles, pereonite 1–2 with relatively rounded posterolateral margin, and 3–7 with gradually pointed. Noduli Laterales on pereonites 1−4 distinctly more distant from lateral margins than ones on pereonites 5−7. Pereonite 1 with tip of anterolateral margin, reaching middle of cephalon. All pereonites with "concave-convex-concave" margin. The segments of first five pereopods with brown irregular patterns.

Pereopod 1 (Fig. 2A) with brush of strong setae on sternal margins of merus and carpus. *Pereopods 2–6* almost with similar structure, all with more or less setae on six segments (Fig. 2B–F). *Pereopod 7* (Figs 2G, 3I), basis oblong with some small setae on inner and outer margin; ischium triangular with couple of 2 strong setae at distal outer corner and 5–6 setae on outer margin; for male, carpus of pereopod 7 rectangular with several setae on inner margin, and long setae at distal outer corner and expanded on tergal margin.

Pleon (Figs 1A, 3B, H) narrower than pereon. *Telson* (Figs 1A, 3B, H) triangular in distal part with slightly concave sides and rounded apex, surpassing protopod of uropod but not reaching middle of exopod of uropod; exopod of *uropod* (Figs 1A, 3B, H) relatively long, almost 1.5 times as long as telson; exopod of *pleopod 1* (Figs 1E, 3D) with long hind lobe bearing deep hollow and one short seta at apex, outer margin with no setae; endopod (Figs 1F, 3E) straight with triangular apical part slightly bent outwards and rather long. For male, endopod of *pleopod 2* (Figs 1G, 3F) elongated in distal part; exopod triangular with line of strong setae on outer margin. *Pleopods 3–5* (Fig. 1H–J) with line of setae on lower margin. *Uropod* (Fig. 1D) with trapezoidal basis; endopod linear and short narrow but stout with 2–3 long setae at the tip and many spines and setae around the margin; exopod 1.6 times as long as endopod.

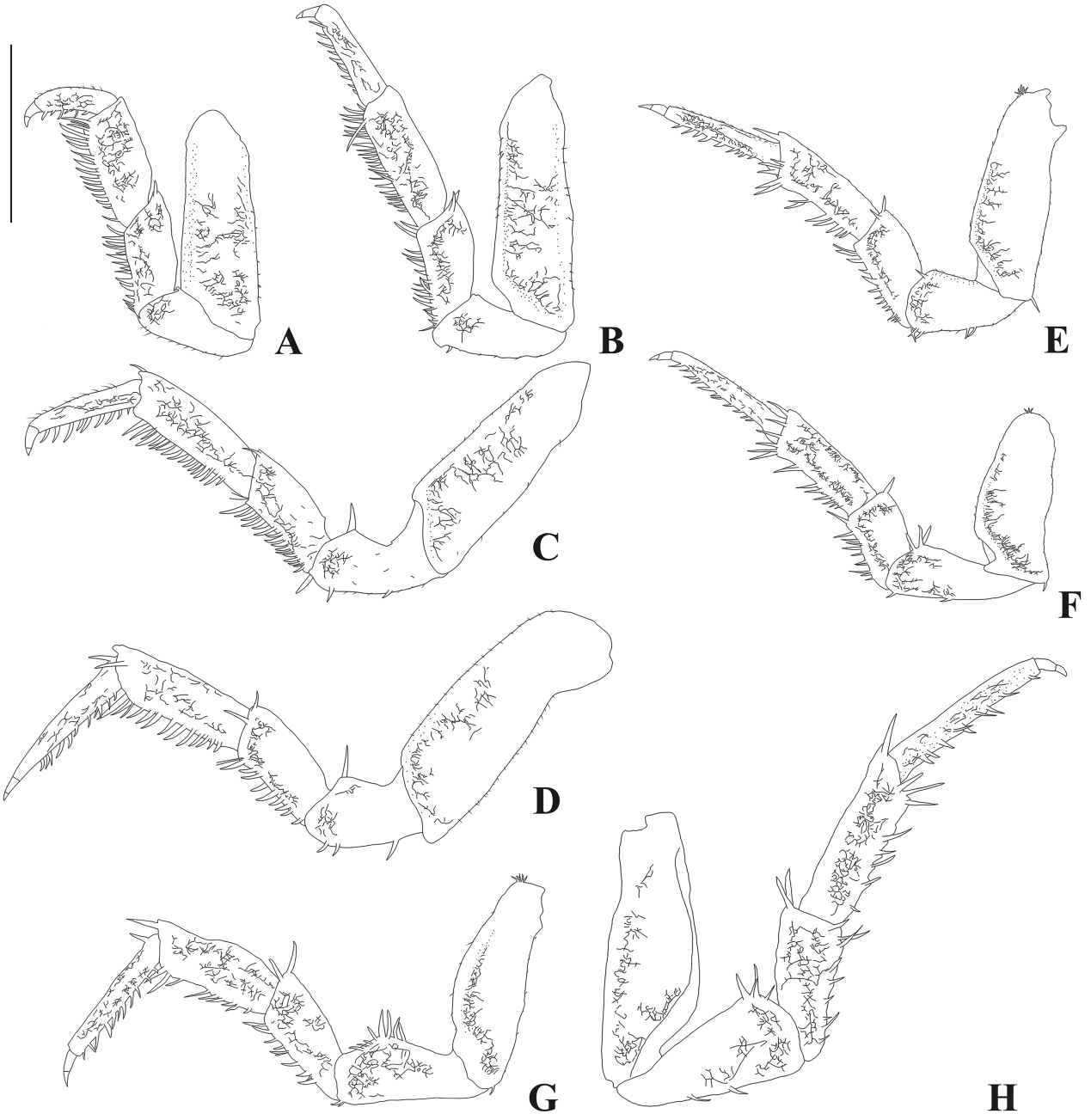

FIGURE 2. ***Mongoloniscus chevronus*** **sp. nov.**, holotype ♂ (A–G); A–G, Left pereopods. *Paratype* ♀ (H); H, Left pereopod 7. Scale-bar: A–H = 1 mm.

Allotype ♀ (IOA19080602) length 10.37 mm, maximum width 4.80 mm. Endopod of first two pleon are not specialized into genitalia (Fig. 1K, L). Carpus of female pereopod 7 smoothed on tergal margin (Figs 2H, 3J).

Distribution. China (Fig. 4).

Etymology. The specific name, *chevronus* refers to all pereonites of the new species with "wave type" posterior margin.

Remarks. According to the characteristic of *Mongoloniscus* genus, the new species should be placed in this genus. But it can distinguish from other known 17 species by all pereopods with posterior waved type margin and pleon without any pattern.

From the morphological point of view, the new species is most similar to *M. sinensis*. However, it differs from the latter in following characters: (1) all pereonites posterior margin with "wave type", concave-convex-concave (*M. sinensis* with smooth curve); (2) the middle of pleon without paler pattern (*M. sinensis* with paler longitudinal pattern); (3) telson triangular with concave sides (*M. sinensis* with linear sides).

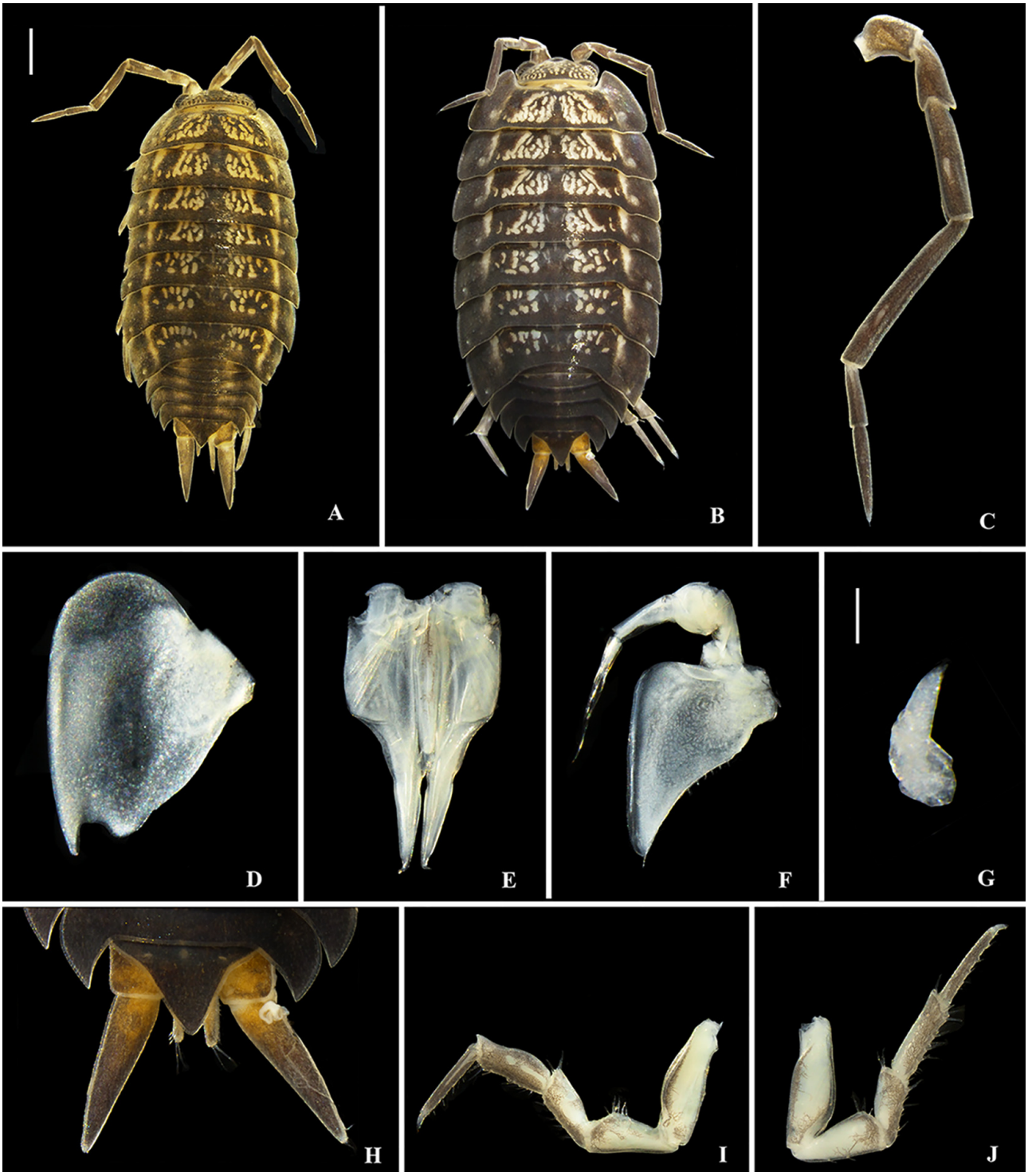

FIGURE 3. ***Mongoloniscus chevronus*** **sp. nov.**, A, *M. sinensis* dorsal view; holotype ♂ (B–I); B, Dorsal view; C, Right antenna 2; D, Left pleopod exopodite 1; E, Left pleopod endopodite 1; F, Left pleopod 2; G, Right antenna 1; H, uropod; I, Left pereopod 7. *Paratype* ♀ (J); J, Left pereopod 7. Scale-bars: A, B = 1 mm; C, I, J = 0.40 mm; D = 0.22 mm; E, F, H = 0.31 mm; G = 1 cm.

From the molecular point of view, the species described in this paper, *M. koreanus*, *M. sinensis* and *M. vannamei* clustered into a branch, belonged to the genus *Mongoloniscus*. *Mongoloniscus* and *Lucasioides-Protracheoniscus-Hemilepistus* are a sister group. The new species is found clustering together with *M. koreanus* (Fig. 5). Indeed, male of the new species and *M. koreanus* with similar exopod of pleopod 1. But the new species differs from *M. koreanus* in following characters: (1) all pereonites posterior margin with "wave type", concave-convex-concave

(*M. koreanus* with smooth curve); (2) noduli laterales of epimera of pereonites 1–7 not arranged in a line (*M. koreanus* with pale spots on a line). The striking difference between this new species and *M. vannamei* is epimera of pereonites 2–7 with a white margin (*M. vannamei* without a white margin).

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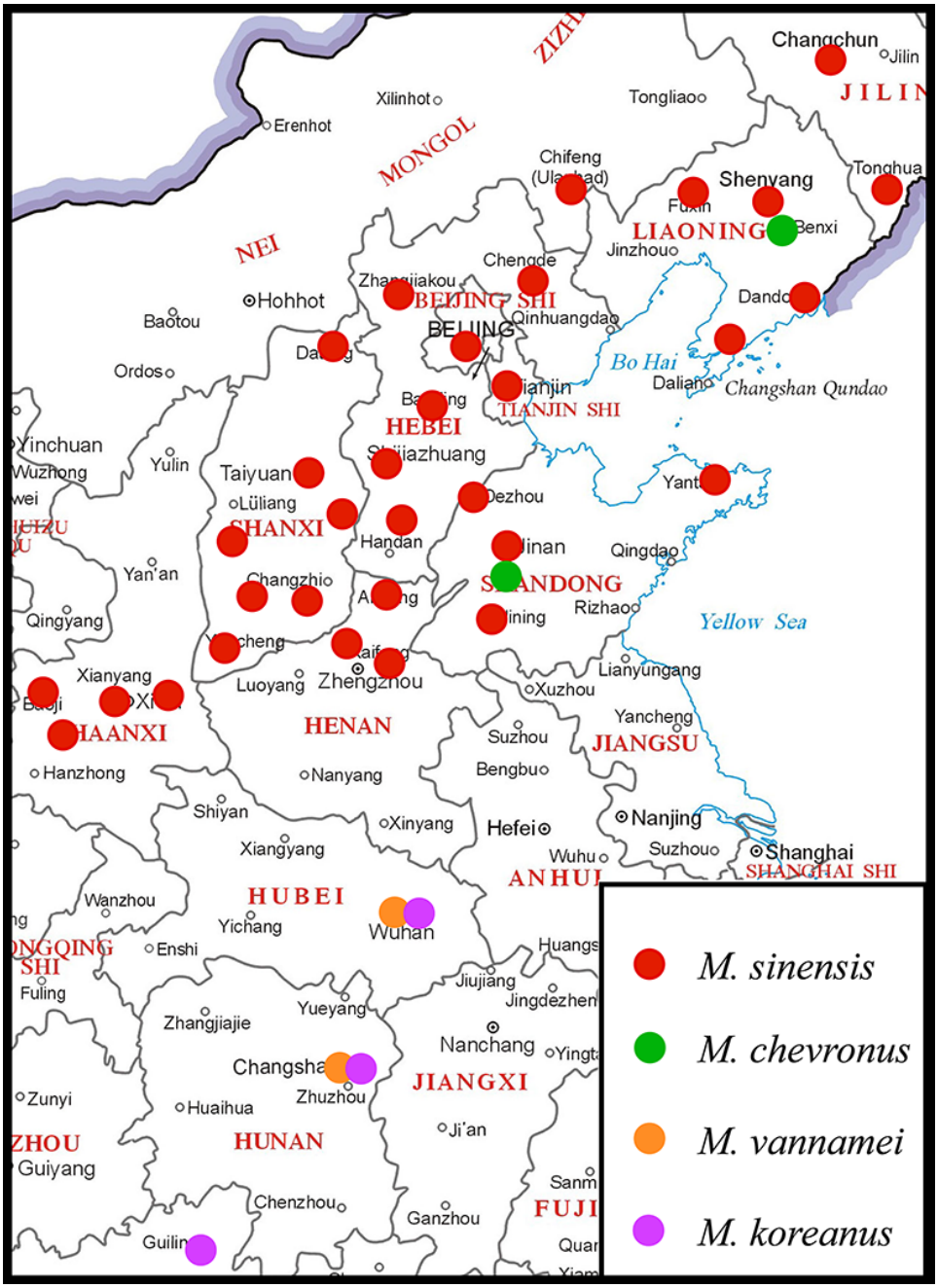

FIGURE 4. Partial map of China showing the recorded localities of the genus *Mongoloniscus*.

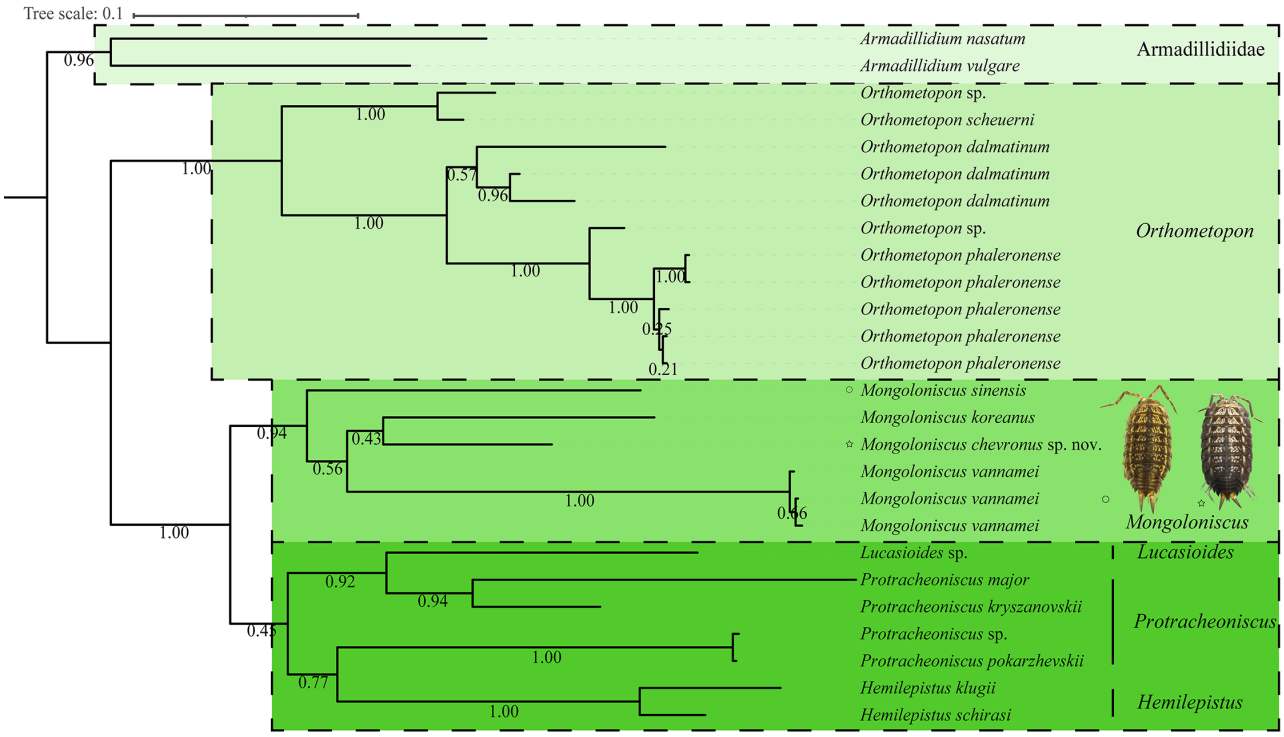

FIGURE 5. A phylogram reconstructed of the Bayesian Inference (BI) based on *Cox1* gene sequence data. Node Support Rates are given above nodes.

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