A new euarthropod from the Cambrian Stage 4 Guanshan Biota of South China

DE-GUANG JIAO and KUN-SHENG DU


A new small euarthropod *Astutuscaris bispinifer* gen. et sp. nov. is described from the early Cambrian Stage 4 Guanshan Biota in Yunnan, China. This new euarthropod possesses a wide head shield, a pair of possible eyes, paired frontalmost appendages located antero-medially, 11 imbricated tergites most of which have backward-directed tergopleura ending in almost posteriorly oriented spines, and two well-marked wide spines. The affinity of *Astutuscaris* among euarthropods is uncertain because of the undefined nature of its frontalmost appendages, the incomplete head shield, the anterior trunk tergites, and the limbs. There are about 24 species of non-trilobite euarthropods reported from the Guanshan Biota to date, the documentation of this new taxon expands the biological diversity of euarthropods from this important biota in Yunnan, China.

Key words: Arthropoda, evolution, Cambrian, Guanshan Biota.

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Introduction

The knowledge on Cambrian arthropods is essential for resolving the phylogenetic relationships and evolutionary history of extinct and extant arthropods (Yang et al. 2013; Daley et al. 2018; Giribet and Edgecombe 2019). Euarthropods are the most diverse group among the typical Burgess Shale-type Cambrian-aged Guanshan Biota (Hu et al. 2010, 2013). There are many euarthropods (e.g., trilobites, radiodonts, and bivalved euarthropods) described from this famous biota (Hu et al. 2010, 2013; Liu et al. 2012; Chen et al. 2019; Jiao et al. 2021a, b). Except the above mentioned groups there are only a few other taxa reported (Hu et al. 2010, 2013; Zhao et al. 2020; Jiao et al. 2021a, 2022), i.e., *Guangweicaris spinatus*, *Panlongia tetranodusa*, *Longguania bispinosa*, *Leanchoilia* sp., *Sinoburius* sp., the unnamed naraoiid, *Alacaris*? sp., *Lihuacaris ferox*, and *Bailongia longicaudata*. In this contribution we describe a new and rare euarthropod with an elongated exoskeleton from the Cambrian Stage 4 Guanshan Konservat-Lagerstätte.

Institutional abbreviations.—RCP, Research Center of Paleobiology, Yuxi Normal University, Yuxi, China.

Other abbreviations.—en, endopod; ex, exopod; ey, eye; fa, frontal appendage; gut, digestive tract; hs, head shield; lim, limb; p1–p5, podomeres 1–5; st, stalk; T1–T13, tergites 1–13; ts, terminal spine.

Nomenclatural acts.—This work and the nomenclatural acts it contains, have been registered in ZooBank: urn:lsid:zoobank.org:pub:7396B74C-AE35-450C-90FA-27A9A609DAAD

Material and methods

The sole and articulated specimen (RCP 0002) of *Astutuscaris bispinifer* gen. sp. nov. and two specimens (RCP 0003 and RCP 0004) belonging to *Guangweicaris spinatus* were collected from Yiliang County which already provided exquisitely preserved fossils in the past (Jiao et al. 2016, 2021b). The fossils are housed at the Research Center of Paleobiology, Yuxi Normal University.

All the specimens were photographed with a LEICA DFC 500 digital camera mounted on a Stereoscope LEICA M205 C. The single specimen of *Astutuscaris bispinifer* gen. sp. nov. was photographed with a LEICA DFC7000 T monochrome digital camera attached to a LEICA M205 FA fluo-
rescence stereomicroscope, and also scanned with a Zeiss Xradia 520 Versa X-ray Microscope.

**Systematic palaeontology**

Clade Euarthropoda Lankester, 1904  
Class, order, and family uncertain  
Genus *Astutuscaris* nov.  

*Zoobank* LCID: urn:lsid:zoobank.org:act:8B855A7C-119F-4DDC-BE27-9AECAF99CC735  

**Etymology:** From Latin *astutus*, flexible; and *caris*, shrimp; referring to its arthropod affinities.  

**Type species:** *Astutuscaris bispinifer* sp. nov. by monotypy, see below.  

**Diagnosis.**—As for the type species.  

*Astutuscaris bispinifer* sp. nov.  

Figs. 1, 2A, A₂, B₁–B₃.  

*Zoobank* LCID: urn:lsid:zoobank.org:act:D09B7A08-1422-484C-A6AD-0204E2E9F55C  

**Etymology:** From Latin *bispinifer*, two-spined; referring to its two terminal spines on the end of the body.  

**Holotype:** RCP 0002, an articulated specimen (Fig. 1).  

**Type locality:** The outcrop near Lihuazhuang village (see Jiao et al. 2021b: fig. 1), Yiliang, Kunming, Yunnan, China.  

**Type horizon:** Lower part of Wulongqing Formation, *Palaeolenus* Biozone, Cambrian Series 2, Stage 4 (Hu et al. 2010; Jiao et al. 2021b).  

**Material.**—Type material only.  

**Diagnosis.**—Small elongate euarthropod with a pair of prominent and bulb-like first appendages without sturdy spines and elbow articulations, a wide head shield potentially possessing a pair of antero-median eyes, an elongated thorax consisting of eleven imbricated and homonomous tergites, second to eighth thoracic tergites having lateral doublures of tergites, and the two terminal spines of the successive tergites, is preserved on both part and counterpart (Fig. 1A₁, A₂, B₁–B₄, B₅). Anterior margin of T3 is straight, and posterior margins of T₅–T₇ and T₁₁ are straight (Fig. 1A₁, A₂, B₁–B₄). The tergopleura of T₃–T₈ curve backwards, and their pleural spines are almost posteriorly oriented (Fig. 1A₁, A₂, B₁–B₄). The tergopleura of T₂–T₈ have narrow doublures (Fig. 1A₁, A₂, B₁–B₄). T₂–T₁₀ have similar length. T₁₁ is slightly longer than the preceding tergites and lacks pleural spines (Figs. 1A₁, A₂, B₁–B₄, B₅. A₁, A₂, B₁–B₄). One robust endopod underneath the heashield preserves at least five conical podomeres (Fig. 1A₃, A₄, A₅). Four elongate, red structures ("en" in Figs. 1A₁, A₂, B₁–B₄, B₅, A₆, A₁, A₂, B₁–B₄) represent trunk endopods, although they do not display obvious segments. These endopods, one located underneath T₁ and T₂, and two beneath T₃ (Fig. 2A₁, A₂, B₁–B₄), indicate there is one pair limb belonging to each of these three tergites. The smaller structure, relative to the endopod, of the limb beneath T₃ is tentatively interpreted as exopod (Figs. 1B₁, 2A₁, B₂, B₃), further clarification of its morphology is contingent on the discovery of additional specimens. The irregular line passing along the entire length of the body may represent the gut (Fig. 1A₁, A₂, B₁–B₄).  

**Remarks.**—The elongate exoskeleton, the possible eyes and the first pair of appendages located antero-medially on the head, and the curvature of the first appendages are also observed in the great-appendage euarthropods (Haug et al. 2012b; Aria et al. 2020; Liu et al. 2020). The morphology of the frontalmost appendages, 11 trunk tergites, the narrow doublures of tergites, and the two terminal spines of *Astutuscaris* contribute to distinguish this new euarthropod genus from *Yohoia* (Haug et al. 2012b). The morphology of the first appendage of *Astutuscaris* and the pair of posterior terminal spines differ from those of other megacheirans, e.g., leanothioids and jianfengiids (Haug et al. 2012a, b; Aria et al. 2020; Liu et al. 2020).  

*Astutuscaris* is distinguishable from *Guangweicaris* by its curving frontalmost appendages, and elongate exoskeleton without medial axial spines and distinct sections (e.g., the abruptly reduced abdomen). *Guangweicaris* possesses a wide head shield with a pair of long antennae, a thorax composed of three small tergites and five normal tergites, and an abruptly reduced abdomen (Fig. 2C, D) consisting of seven tergites all bearing a axial spine (Luo et al. 2007; Yang et al. 2008; Wu and Liu 2019; Chen et al. 2020). The curving first appendages
Fig. 1. Euarthropod *Astutuscaris bispinifer* gen. et sp. nov. from the Cambrian Stage 4 Guanshan Biota, Lihaizhuang village, Yunnan, China. A. RCP 0002a, part of the sole specimen; showing the head shield, 11 imbricated tergites most with pleural spines, and two terminal spines (A₁, A₂); possible eyes (A₃, A₅, A₆); first appendages with small spines (A₃, A₄, white arrows); endopod with at least five podomeres (A₆). B. RCP 0002b, counterpart of the sole specimen; note the 11 imbricated tergites and trunk limbs (B₁, B₃); restored specimen by digitally combining the part and counterpart, the dashed line indicating the contact (B₃); interpretive drawing of the narrow doublures of thoracic tergites marked in dark grey (B₄); T⁷–T₁₀ and pleural spines (B₅); detail of the unknown structure (B₆); the limb with an endopod and a possible exopod (B₇); single endopod under T₁ and T₂ respectively (B₈); T₁₁ and two separate spines being marked (B₉). Natural light photographs (A₁, A₃, A₄, B₁, B₇); fluorescent photographs (A₂, A₅–A₆, B₂, B₃–B₆, B₉). Abbreviations: en, endopod; ex, exopod; ey, eye; fa, frontal appendage; gut, digestive tract; hs, head shield; lim, limb; p1–p₅, podomeres 1–5; st, stalk; T₁–T₁₁, tergites 1–11; ts, terminal spine.
of *Astutuscaris* are different from the long antennae (at least 21 podomeres) of *Guangweicaris* (Yang et al. 2008; Chen et al. 2020). Unlike the trunk of *Guangweicaris* including a suddenly reduced abdomen (Yang et al. 2008; Wu and Liu 2019; Chen et al. 2020), *Astutuscaris* has a trunk gradually tapering backward. The last tergite of *Guangweicaris* bears an axial spine (Yang et al. 2008; Chen et al. 2020), while, *Astutuscaris* has no axial spines. The posterior end of *Astutuscaris* comprises of two isolated spines, and the tail of *Guangweicaris* possesses a ventral medial extension and two lateral processes (Chen et al. 2020).

*Astutuscaris bispinifer* gen. et sp. nov. is different from the stages 8 and 9 of *Fuxianhuia protensa* Hou, 1987, by its at least 11 trunk tergites, one pair endopod under normal tergites two and three respectively, and last tergite carrying two long and separate spines. The juveniles (stages 8 and 9) of *F. protensa* are about 11 mm to 15 mm long, and consist of eight or nine trunk tergites which have a pattern of segmental mismatch in thoracic region and a terminal telson with paired caudal flukes (Fu et al. 2018).

**Fig. 2.** Euarthropods *Astutuscaris bispinifer* gen. et sp. nov. (A, B) and *Guangweicaris spinatus* Luo, Fu, and Hu, 2007 (C, D) collected from Cambrian Guanshan Biota, Lihuazhuang village, Yunnan, China. A. RCP 0002a, specimen before preparation. B. RCP 0002b, specimen before preparation (B1, B2) and after preparation (B3). C. RCP 0003, a small and incomplete specimen about 16 mm in length. D. RCP 0004, a small specimen about 17 mm in length. Natural light photographs (A1, B1, C, D); fluorescent photographs (A2, B2, B3, B4). Abbreviations: en, endopod; ex, exopod; ey, eye; fa, frontal appendage; gut, digestive tract; hs, head shield; lim, limb; p1–p5, podomeres 1–5; st, stalk; T1–T11, tergites 1–11; ts, terminal spine.

**Concluding remarks**

The curvature and insertion of first appendages, the location of the possible eyes, and the elongate body of *Astutuscaris bispinifer* gen. et sp. nov. are similar to the Cambrian megacheiran, such as species of *Fortiforceps*, *Jianfengia*, *Sklerolibyon*, and *Yohoia*. Similarities of *A. bispinifer* and *Yohoia tenuis* from the Cambrian Burgess Shale are particularly marked for the elongate exoskeleton and the tergopleura with pleural spines (Haug et al. 2012b; Aria et al. 2020). The smallest *Y. tenuis* is about 6 mm in length, and bears thirteen trunk tergites and a paddle-like telson with eight marginal spines (Haug et al. 2012b), while *A. bispinifer* is about 8.6 mm in length, possesses eleven trunk tergites and two terminal spines. The thorax with eleven tergites of *A. bispinifer* is the same as that of the leanchoilid megacheiran arthropods, like species of *Leanchoilia* and *Alalcomenaeus* (Edgecombe et al. 2011; Hu et al. 2013; Aria et al. 2020; Liu et al. 2020). Evidently, the frontalmost appendage without sturdy spines of this new taxon differs...
quite considerably from the multisegmented sub-chelate appendages of megacheirans. The pair of terminal spines are another character differentiating A. bispinifer from typical megacheirans (Edgecombe et al. 2011; Hu et al. 2013; Aria et al. 2020; Liu et al. 2020). The prominent and curving frontmost appendages are also found in some bivalved euarthropods (Fu et al. 2014; Yang et al. 2016; Hou et al. 2017; Jin et al. 2021), e.g., Pectocaris inopinata, Isoxys inopinata, and Clypecaris serrata.

The incompletely preserved walking leg with conical podomes under the head resembles the limbs of Chengjiangocaris kunmingensis from the Xiaoshiba Biota (see Yang et al. 2013: fig. 1f), but, one pair of limbs beneath each of the first three tergites and the two long terminal spines of Astutuscaris bispinifer gen. et sp. nov. support it is not a fuxianghid which have a thorax with ventral segmental mismatch and a terminal tailspine with paired caudal flukes (Fu et al. 2018).

The two sturdy separate spines of Astutuscaris bispinifer gen. et sp. nov. are possibly the modified, posteriorly directed appendages of the terminal somite that is a common character of vicissicicataudae a major clade of arthropods (Van Roy 2005; Lerosey-Aubril et al. 2017). If this interpretation is correct, then A. bispinifer might be a vicissicicataud-like euarthropod. Nevertheless, its curving frontmost appendages and possible anterior and middle eyes still separate it from the vicissicicataudes.

The nature of the first curving appendage without obvious segments of Astutuscaris bispinifer gen. et sp. nov. is contingent on the discovery of new specimens, although it’s possible to be an antenna for lacking the typical elbow joints or articulations. Together with the incomplete head, anterior trunk tergites, and limbs, the affinity of A. bispinifer among euarthropods remains unclear until new material that could provide more key taxonomic characters is found. So far, about 24 non-trilobite euarthropod species were reported from Guanshan Biota, i.e., four radiodont species (Jiao et al. 2021b), two fuxianghid species (Hu et al. 2013; Wu and Liu 2022), five non-trilobite arthropod species (Hu et al. 2013; Zhao et al. 2020; Jiao et al. 2022), Leancheolitia sp. (Hu et al. 2013), and Lihuacaris ferox (Jiao et al. 2021a). Accordingly, this new taxon increases the species diversity of the typical Burgess Shale-type Guanshan Biota, especially that of euarthropods.

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