

山东寒武系馒头组等刺虫化石的发现^{*}

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提要 等刺虫(*Isoxys*)是寒武纪海洋中一类分布广泛的双瓣壳节肢动物,在北美、欧洲、澳大利亚、西伯利亚及中国均有发现,但延续时间并不长,目前已经描述了 16 个已命名的种以及一些未定种化石。等刺虫在我国扬子地台北云南滇东地区、贵州凯里、湖北长阳等地寒武系第二、第三统均有发现。文中报道的等刺虫发现于山东省临沂市刘庄镇馒头组顶部,没有保存软体部分,被命名为一个新种 *Isoxys shandongensis* Wang and Huang sp. nov.。同时,对美国寒武系 Spence 页岩保存的未定名等刺虫软体部分特征进行修订,并进行形态比较。等刺虫的新发现对探讨这类常见的寒武纪节肢动物的演化、分布和多样性均有一定意义。

关键词 等刺虫 馒头组 寒武系 山东

1 前言

等刺虫 *Isoxys* 为寒武纪海洋中一类中等大小的双瓣壳节肢动物,其壳体分为左右两瓣,单壳为次半圆形,背缘较直,前后背角分别向前后延伸形成前后基刺,一般前腹缘膨大,后腹缘相对收缩,腹边缘有或无,壳面光滑或布满壳饰。该类虫体前端具有一对较大的带柄眼,眼后具有一对发达的形态多变的前附肢,躯干多节,不分胸腹,每一体节都有一对双肢型附肢。等刺虫最早由美国古生物学家 Walcott 发现于美国田纳西州寒武系,模式种为 *I. chilhoweanus* (Walcott, 1890)。之后, Walcott 在加拿大寒武系布尔吉斯页岩 (Burgess Shale) 中描述了 *I. acutangulus* (Walcott, 1908); Simonetta 和 Delle Cave (1975) 在布尔吉斯页岩中描述了另一种等刺虫 *I. longissimus*, 它以前后基刺很长而区别于前者; Richter 和 Richter (1927) 描述了产自西班牙 Las Ermitas 地区寒武系第二统中的 *I. carbonelli*, 其壳体较小, 一个基刺长且细; 澳大利亚报道了 2 种等刺

虫, 都发现于澳大利亚南部袋鼠岛 (Kangaroo Island) 寒武系第二统顶部的 Emu Bay 页岩中: 分别是 Glaessner (1979) 报道的 *I. communis* 和最近 García Bellido 等 (2009a) 发表的 *I. glaessneri*。另外, Williams 等 (1996) 描述了英格兰 Sirius Passet 地区寒武系第二统中的 *I. volucris*, 它有很宽的腹边缘, 前后基刺很长, 有时甚至超过了壳瓣的长度。在俄罗斯的西伯利亚的 Cape Zhurinskiy 地区寒武系第二统中产有 *I. zhurensis* (Ivantson, 1990), 这个种的壳体较小, 前后基刺很短。除此之外, 还在美国宾夕法尼亚州和犹他州 (Briggs *et al.*, 2008) 以及法国等地发现了未命名的等刺虫 (Vannier *et al.*, 2005)。

等刺虫在中国发现较多, 特别是滇东地区。 *I. auritus* (Jiang, 1982) 壳型为次半圆形, 壳面布满网状的壳饰 (罗惠麟等, 1982, 1999; 侯先光, 1987; 侯先光等, 1999; 陈均远, 2004), 广泛发现于云南昆明及澄江等地, 一些标本具有软体构造 (Shu *et al.*, 1995; 陈均远等, 1996; 侯先光等, 1999; 罗惠麟等, 1999; 陈均远, 2004); 侯先光在云南澄江发现一种前

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刺短而细, 后刺很长且粗壮的等刺虫 *I. paradoxus* (侯先光, 1987); 罗惠麟和胡世学描述了昆明海口耳材村的 *I. elongates*, 它的壳瓣狭长, 壳面有网状纹饰(罗惠麟等, 1999); Vannier 和 Chen(2000) 报道了昆明海口及澄江的一种等刺虫, 前基刺弯曲, 定名为 *I. curvirostratus*; 罗惠麟等(2006, 2008) 报道了云南武定及昆明地区等刺虫的 2 个新种: *I. wudingensis*(罗惠麟等, 2006) 和 *I. minor* (罗惠麟等, 2008)。另外, 湖北长阳发现 *I. bispinatus* (Cui,

1991)(霍世诚等, 1991)。等刺虫在贵州凯里寒武系凯里生物群中也有发现(赵元龙等, 1999)。

从以上的资料可以看出, 等刺虫在寒武纪分布十分广泛, 在北美、欧洲、澳大利亚、西伯利亚及中国均有发现。但延续的时限则相对较短, 在寒武系第二统发现最多, 少量类群延续到寒武系第三统下部。目前已经描述了 16 个已命名的种以及一些未定种化石(表 I)。

表 I 世界各地寒武纪等刺虫名录(修改自 Vannier and Chen, 2000)
A list of *Isoxys* in the world(Modified from Vannier and Chen, 2000)

种名	产地	地层
<i>Isoxys chilhoweanus</i> Walcott, 1890	美国, 田纳西 Montvale Springs	寒武系第二统 Chilhowee 群
<i>Isoxys acutangulus</i> (Walcott, 1908)	加拿大 British Columbia	寒武系第三统 Stephen 组
<i>Isoxys carbonelli</i> Richter and Richter, 1927	西班牙 Las Ermitas	寒武系第二统 Pedroche 组
<i>Isoxys longissimus</i> Simonetta and Delle Cave, 1975	加拿大 British Columbia	寒武系第二统 Stephen 组
<i>Isoxys communis</i> Glaessner, 1979	澳大利亚 Kangaroo Island	寒武系第二统 Emu Bay 页岩
<i>Isoxys auritus</i> (Jiang, 1982)	中国云南昆明、澄江	寒武系第二统 玉案山组
<i>Isoxys paradoxus</i> Hou, 1987	中国云南澄江	寒武系第二统 玉案山组
<i>Isoxys zhurensis</i> Ivantsov, 1990	西伯利亚 Cape Zhurinskiy	寒武系第二统
<i>Isoxys bispinatus</i> (Cui, 1991)	中国湖北长阳	寒武系第二统 水井沱组
<i>Isoxys volueris</i> Williams <i>et al.</i> , 1996	格陵兰 Sirius Passet	寒武系第二统 Bu en 组
<i>Isoxys elongatus</i> Luo and Hu, 1999	中国云南昆明	寒武系第二统 玉案山组
<i>Isoxys curvirostratus</i> Vannier and Chen, 2000	中国云南昆明、澄江	寒武系第二统 玉案山组
<i>Isoxys wudingensis</i> Luo and Hu, 2006	中国云南武定	寒武系第二统 乌龙箐组
<i>Isoxys minor</i> Luo and Hu, 2006	中国云南昆明、武定、宜良	寒武系第二统 乌龙箐组
<i>Isoxys glaessneri</i> Gardá & Bellido <i>et al.</i> , 2009	澳大利亚 Kangaroo Island	寒武系第二统 Emu Bay 页岩
<i>Isoxys</i> sp. Vannier <i>et al.</i> , 2005	法国 Montagne Noire	寒武系第二统 Pardailhan 组
<i>Isoxys</i> sp Briggs <i>et al.</i> , 2008	美国犹他州 Box Elder Country	寒武系第三统 Langston 组
<i>Isoxys</i> sp.	加拿大 Mackenzie Mountains	寒武系第三统 Mount Cap 组
<i>Isoxys</i> sp.	加拿大 Mt Stephen 和 Fossil Ridge	寒武系第二统 Stephen 组
<i>Isoxys</i> sp.	加拿大 British Columbia, Cranbrook	寒武系第二统 Eager 组
<i>Isoxys</i> sp.	美国, 宾夕法尼亚 Lancaster	寒武系第二统 Kinzers 组

等刺虫类由于壳体较硬, 是澄江动物群中常见化石, 已经描述了较多种类, 一些类型具有软体构造, 如分布较广泛的 *Isoxys auritus* (Shu *et al.*, 1995), *I. curvirostratus* (Vannier and Chen, 2000), *I. acutangulus* (Vannier *et al.*, 2009; Gardá & Bellido *et al.*, 2009b), *I. longissimus* (Gardá & Bellido *et al.*, 2009b), *I. communis* (Gardá & Bellido *et al.*, 2009a) 和 *I. glaessneri* (Gardá & Bellido *et al.*, 2009a)。其中, 澄江动物群

中奇异等刺虫(*I. paradoxus*) 一些标本也保存了软体构造, 但还没有详细的描述(陈均远等, 1996; 陈均远, 2004)。Vannier 和 Chen(2000) 描述的奇异等刺虫后基刺(Vannier and Chen, 2000, pl. 2, fig. 1) 为一残缺的生物构造, 并不能确认与等刺虫有关。

本文描述的新等刺虫化石发现于山东省临沂市费县刘庄镇寺口村(北纬 35°08′04.1″, 东经 118°04′15.9″)附近的寒武系第二统馒头组顶部(插图 1)。这里除保存大量完整三叶虫外(以 *Maotunia* 为

主), 还发现了海绵、开腔骨、软舌螺、腕足类、其它非三叶虫节肢动物等, 代表了寒武纪中期华北地台的

一个新的特异埋藏动物群。

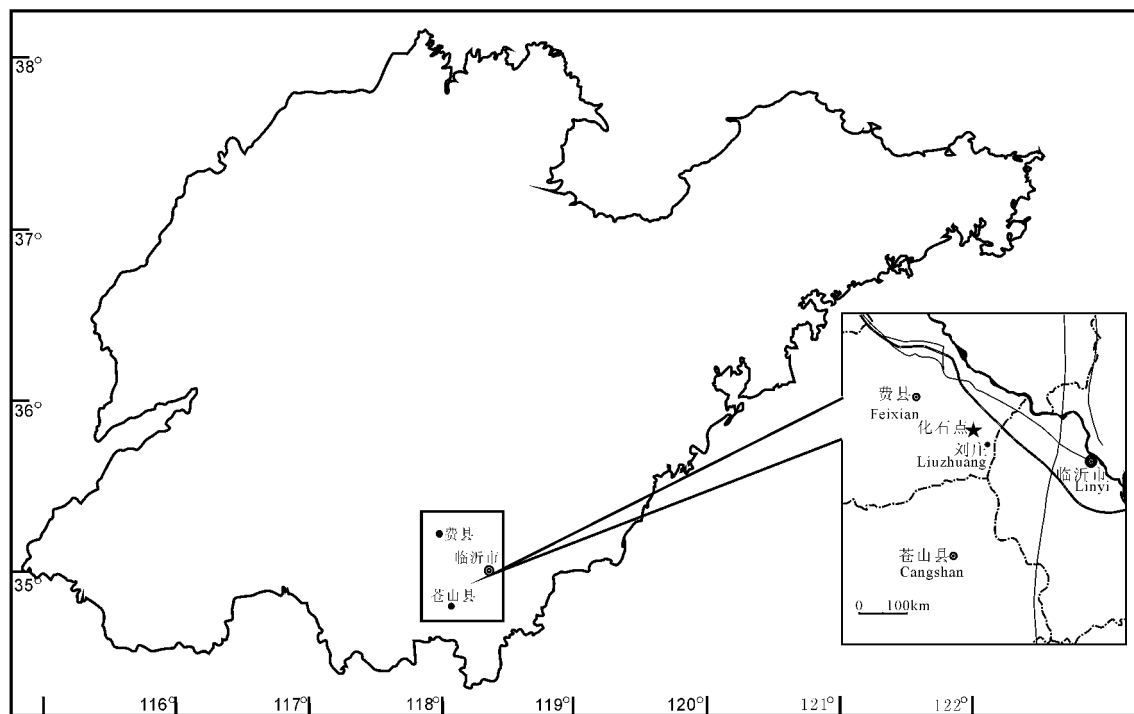


插图 1 化石产地位置图

The map of fossil locality

2 系统描述

节肢动物门 *Phylum Arthropoda* Siebold and Stannius, 1845

未定纲 *Class uncertain*

等刺虫目 *Order Isoxyida* Simoneta and Delle Carve, 1975

等刺虫科 *Family Isoxyidae* Vogdes, 1893

等刺虫属 *Genus Isoxys* Walcott, 1890

山东等刺虫(新种) *Isoxys shandongensis* Wang and Huang sp. nov.

(插图 2, 3)

词源 *Shandong*, 汉语拼音, 表示化石产地为山东省。

材料 化石保存在较强烈风化的灰绿色页岩中, 同层保存了大量毛屯虫、腕足类及海绵骨针等。目前共发现 10 块标本, 包括 7 个完整个体, 其中有 4 个等刺虫保存在一块岩石上(插图 2-c)。壳瓣呈棕灰色的印膜保存, 大部分标本侧压, 少量斜侧压, 仅有一块背压标本。仅有一块发现可能的软体部分(插图 4-5)。所有化石保存在中国科学院南京地质

古生物研究所。登记号: NIGP 151869, NIGP 151870—151874, 152315。

正模 NIGP 151869, 为一块完整的侧压标本。

特征 壳瓣较小, 前腹缘明显膨大于后腹缘; 背缘在前部略超过 1/3 处微上拱; 前后基刺均较短而直, 前基刺长于后基刺, 在后部有斜脊; 壳面光滑, 无壳饰; 有宽的腹边缘。

描述 壳体较小, 近半圆形。瓣壳长 16—19 mm (不包括基刺), 高 6—8 mm。长度与高度之比在一般标本中(可能是成年个体)约为 2.3—2.4 (插图 2-a, d), 在较小个体中约为 2.0 (插图 2-b); 从背压标本看(插图 2-e), 壳体长度与壳宽之比约为 3.2。前后基刺短而尖, 前基刺长度大约为后基刺的 2 倍。壳体具有完整的腹边缘, 在后部具有一条细而较直的斜脊, 由后基刺到达壳体后部 1/3 处。

比较 目前, 与新种最相似的种是在澳大利亚发现的 *I. glaessneri* (García Bellido et al., 2009a), 如两个种壳型相似, 壳面光滑无壳饰, 有腹边缘。两者的区别在于的新种的后基刺下部有斜脊, 而 *I. glaessneri* 没有。*I. glaessneri* 壳长高比较小, 在较大个体中约为 2.1, 但新种的长高之比在较大个体中为 2.3—2.4, 这种差异在较小的个体中

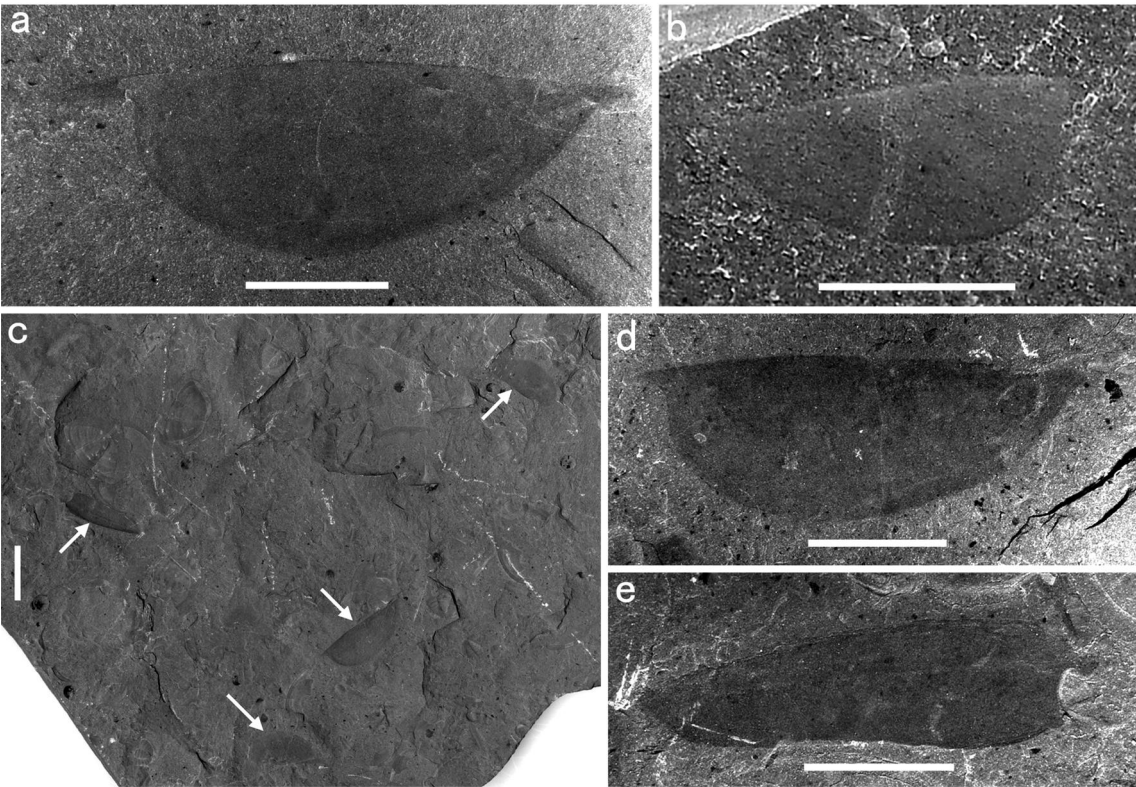


插图 2 山东省费县刘庄馒头组等刺虫新种 *Isoxys shandongensis* Wang and Huang sp. nov.

Isoxys shandongensis Wang and Huang sp. nov. from the Mantou Formation at Liuzhuang Township of Feixian County, Shandong Province
a. 模式标本 NIGP 151869, 显示一个完整壳体; b. 一个较小的等刺虫个体 NIGP 151870; c. 一块化石上保存了 4 个等刺虫个体(NIGP 151871—151874) 及毛屯虫(*Maotunia*) 碎片; d. c 中一个较完整等刺虫(NIGP 151873) 的放大; e. c 中一个背压等刺虫(NIGP 151871) 的放大。比例尺在 a, b, d, e 中代表 5 mm, 在 c 中代表 1 cm。

a. The holotype (NIGP 151869), a complete specimen; b. A rather small individual (NIGP 151870); c. 4 individuals of *Isoxys shandongensis* Wang and Huang sp. nov. preserved in one specimen; d. Enlargement from c showing a rather complete individual; e. Enlargement from c showing a specimen with dorsal compression.

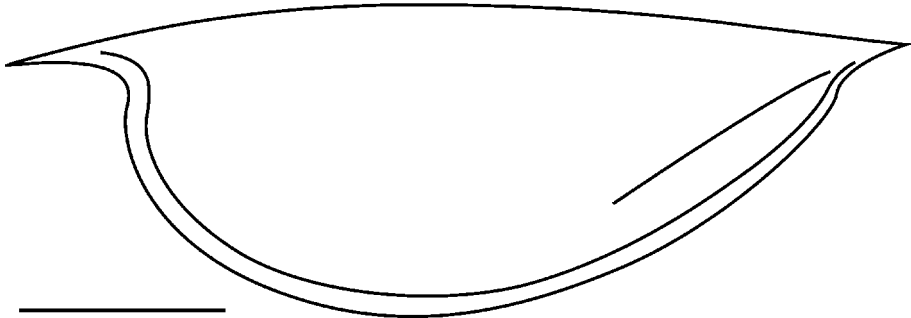


插图 3 等刺虫新种 *Isoxys shandongensis* Wang and Huang sp. nov. 的壳体复原图, 比例尺 5 mm。
Reconstruction of *Isoxys shandongensis* Wang and Huang sp. nov. Scale bar represents 5 mm.

更为明显。也就是说, 新种的壳体相对长而扁。另外, *I. glaessneri* 的前后基刺比新种稍长。

新种与 *I. communis* 比较, 两者的壳型相似, 长高之比接近, 表面都无壳饰, 背缘均微微上拱(Glaessner, 1979; Garc a Bellido et al., 2009a)。但 *I. communis* 的前后基刺明显长于新种, 体型远大于新种。另外, 它的后腹缘相对较平直。

新种与 *I. chilhoweanus* 和 *I. auritus* 也较为相似, 如壳形和微微上拱的背缘等。但后二者壳体上布满壳饰(罗惠麟等, 1982, 1999, 2006; 侯先光, 1987; Shu et al., 1995; Williams et al., 1996; 陈均远等, 1996; 侯先光等, 1999; 陈均远, 2004; Garc a Bellido et al., 2009a), 而新种的壳体光滑。另外, 新种壳体明显偏小。

产地层位 山东省临沂市费县; 寒武系第三统馒头组顶部。

讨论 不同种类的等刺虫在外形上存在显著差异。根据 García Bellido 等最近的研究表明, 不同种类的等刺虫前附肢类型也是多变的。但目前由于缺乏足够的软体构造支持, 关于等刺虫的分类仍并未系统化, 现行的系统并不能揭示不同类型间的演化与亲缘关系。通过对更多软体构造的比较研究, 完善的等刺虫新分类系统是值得期待的。新种仅一块标本保存了可能的软体印痕, 显示可能的躯干和附

肢构造, 但特征保存不清, 进一步比较研究需要更好的标本(插图 4, 5)。

Briggs 等(2008)报道了美国犹他州 Langston 组中的 1 个等刺虫未定种。该种壳体较小, 长约 15 mm, 壳高约为 6.8 mm, 长和高之比约为 2.2, 壳型接近半圆形, 前腹缘明显膨大于后腹缘; 背缘几乎是直的, 在前 1/3 处略突出; 前基刺和后基刺的长度分别为 6.4 mm 和 3.0 mm, 前基刺长度超过后基刺 2 倍, 壳面无明显的壳饰(插图 6, 7)。

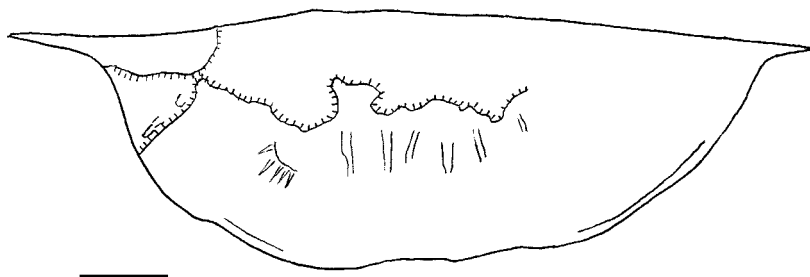


插图 4 一块可能保存软体印痕的 *Isoxys shandongensis* Wang and Huang sp. nov. 的解释图, 比例尺为 2 mm。

The interpretation of a specimen of *Isoxys shandongensis* Wang and Huang sp. nov. with possible soft parts preserved. Scale bar represents 2 mm.

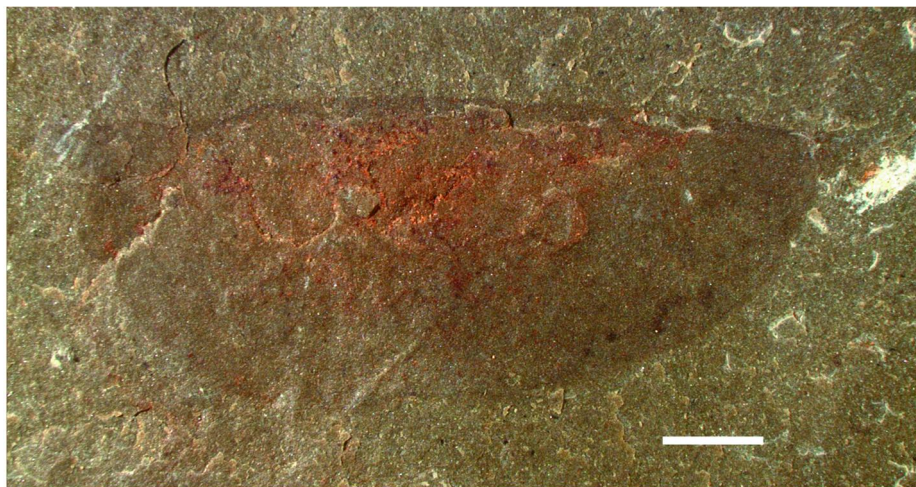


插图 5 一块可能保存软体的 *Isoxys shandongensis* Wang and Huang sp. nov. (NIGP 152315), 比例尺为 2 mm。

A specimen (NIGP 152315) of *Isoxys shandongensis* Wang and Huang sp. nov. with possible soft parts preserved. Scale bar represents 2 mm.



插图 6 美国犹他州 Spence 页岩中等刺虫未定种

Isoxys sp. from the Spence Shale, Utah, USA

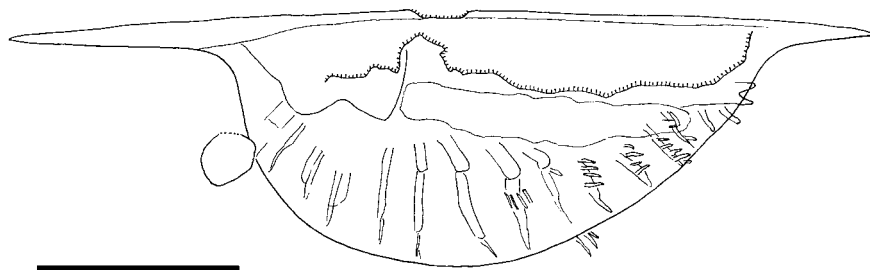


插图7 重新绘制的美国犹他州 Spence 页岩中等刺虫未定种素描图, 比例尺为 5 mm。

A new line drawing of *Isoxys* sp. from the Spence Shale, Utah, USA, scale bar represents 5 mm.

作者 2009 年访问堪萨斯大学期间, 对 Briggs 等(2008)报道的标本进行研究, 对保存的软躯体进行了详细观察, 这里补充描述(插图 6, 7)。该标本保存了眼、躯干和附肢, 为暗红色。躯干的高度不到壳高的 1/2, 前部扩大的部分可能为头部, 前方偏下可见一巨大的带柄的近圆形眼; 虫体未分化腹部, 每个体节均带有附肢, 其中头部可能具有 4 对附肢; 共可见大约 15 对附肢, 其中第 5—7 对最长, 长度向两端递减, 附肢在后部排列较密, 外肢具有明显的梳状刚毛。

犹他州发现的等刺虫未定种在形态上最接近的是 *I. communis* (Glaessner, 1979; García Bellido *et al.*, 2009a)。它们的壳型相似, 均为近半圆形, 前基刺都长于后基刺, 长高比接近。它们的不同在于犹他州所产等刺虫未定种壳体前腹缘更膨大, 背缘相对较平直。另外, 犹他州发现的等刺虫未定种壳体较小, 由于只发现一枚标本, 尚不能判断它是否成年个体。

美国犹他州发现的等刺虫未定种与新种相比, 二者壳型相似, 背缘都微微上拱, 前基刺长度都大约是后基刺的 2 倍。但前者前、后基刺明显长于新种。因此, 该等刺虫未定种可能代表了一个新种。

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参考文献 (References)

Briggs D E G, Lieberman B S, Hendricks J R, Halgedahl S L, Jar-

- rard R D, 2008. Middle Cambrian arthropods from Utah. *Journal of Paleontology*, **82**(2): 238—254.
- Chen Juiryuan(陈均远), 2004. *The Dawn of Animal World*. Nanjing: Jiangsu Science and Technology Press. 1—366 (in Chinese).
- Chen Juiryuan(陈均远), Zhou Guì qín(周桂琴), Zhu Maoyan(朱茂炎), Ye Guì yu(叶贵玉), 1996. *Chengjiang Biota—A Unique Window of the Cambrian Explosion*. Taichung: The National Museum of Natural Science. 1—222 (in Chinese).
- García Bellido D C, Paterson J R, Edgecombe G D, Jago J B, Gehring J G, Lee M S Y, 2009a. The bivalved arthropods *Isoxys* and *Tuzoia* with soft part preservation from the Lower Cambrian Emu Bay Shale Lagersätten (Kangaroo Island, Australia). *Palaeontology*, **52**(6): 1221—1241.
- García Bellido D C, Vannier J, Collins D, 2009b. Soft part preservation in two species of the arthropod *Isoxys* from the middle Cambrian Burgess Shale of British Columbia, Canada. *Acta Palaeontologica Polonica*, **54**(4): 699—712.
- Glaessner M F, 1979. Lower Cambrian Crustacea and annelid worms from Kangaroo Island, South Australia. *Alcheringa*, **3**: 21—31.
- Hou Xiangguang(侯先光), 1987. Early Cambrian large bivalved arthropods from Chengjiang, eastern Yunnan. *Acta Palaeontologica Sinica* (古生物学报), **26**(3): 286—298 (in Chinese with English summary).
- Hou Xiangguang(侯先光), Bergström J, Wang Haifeng(王海峰), Feng Xianghong(冯向红), Chen Ailin(陈爱林), 1999. *The Chengjiang Fauna—Exceptionally well preserved animals from 530 million years ago*. Kunming: Yunnan Science and Technology Press. 1—170 (in Chinese with English summary).
- Huo Shicheng(霍世诚), Shu Degang(舒德干), Cui Zhilin(崔智林), 1991. *Cambrian Bradoriida of China*. Beijing: Geological Publishing House. 1—249 (in Chinese with English summary).
- Ivantsov A I, 1990. Pervye nakhodki fillokarid v nizhnem Kembrii Iakutii. *Paleontologicheskii Zhurnal*, **1990**: 130—132 (in Russian).
- Luo Huilin(罗惠麟), Fu Xiaoping(傅晓平), Hu Shixue(胡世学), Li Yong(李勇), Chen Liangzhong(陈良忠), You Ting(尤霆), Liu Qi(刘琦), 2006. New bivalved arthropods from the Early Cambrian Guanshan Fauna in the Kunming and Wuding area. *Acta Palaeontologica Sinica* (古生物学报), **45**

- (4): 460—472(in Chinese with English summary).
- Luo Huilin(罗惠麟), Hu Shixue(胡世学), Chen Liangzhong(陈良忠), Zhang Shishan(张世山), Tao Yonghe(陶永和), 1999. Early Cambrian Chengjiang Fauna from Kunming Region, China. Kunming: Yunnan Science and Technology Press. 1—129(in Chinese with English summary).
- Luo Huilin(罗惠麟), Jiang Zhizhen(蒋志文), Wu Xiche(武希彻), 1982. The Siniar Cambrian Boundary in Eastern Yunnan, China. Kunming: The People's Publishing House of Yunnan. 1—265(in Chinese with English summary).
- Luo Huilin(罗惠麟), Li Yong(李勇), Hu Shixue(胡世学), Fu Xiaoping(傅晓平), Hou Shuguang(侯蜀光), Liu Xingyao(刘兴尧), Chen Liangzhong(陈良忠), Li Fengjun(李锋军), Pang Jiyuan(庞纪院), Liu Qi(刘琦), 2008. Early Cambrian M along Fauna and Guanshan Fauna from Eastern Yunnan China. Kunming: Yunnan Science and Technology Press. 1—134 (in Chinese with English summary).
- Richter R, Richter E, 1927. Eine Crustacee (*Isoxys carbonellii* n. sp.) in den *Archaeocyathus* Bildungen der Sierra Morena und ihre stratigraphische Beurteilung. *Senckenbergiana*, **9**: 188—195(in German).
- Shu Degan, Zhang Xingliang, Geyer G, 1995. Anatomy and systematic affinities of the Lower Cambrian bivalved arthropod *Isoxys auritus*. *Alcheringa*, **19**: 333—342.
- Simonetta A M, Delle Cave L, 1975. The Cambrian non trilobite arthropods from the Burgess Shale of British Columbia. A study of their comparative morphology taxonomy and evolutionary significance. *Palaeontographica Italica*, **69**: 1—37.
- Vannier J, Chen Juyuan, 2000. The Early Cambrian colonization of pelagic niches exemplified by *Isoxys* (Arthropoda). *Lethaia*, **33**: 295—311.
- Vannier J, Gardar Bellido D C, Hu Shixue, Chen Ailin, 2009. Arthropod visual predators in the early pelagic ecosystem: Evidence from the Burgess Shale and Chengjiang biotas. *Proceedings of the Royal Society B*, **276**: 2567—2574.
- Vannier J, Williams M, Alvaro J J, Vizcaino D, Monceret S, Monceret E, 2005. New Early Cambrian bivalved arthropods from southern France. *Geological Magazine*, **142**(6): 751—763.
- Walcott C D, 1890. The fauna of the Lower Cambrian or *Olenellus* Zone. *Reports of the U. S. Geological Survey*, **10**: 509—760.
- Walcott C D, 1908. Mount Stephen rocks and fossils. *The Canadian Alpine Journal*, **1**: 232—248.
- Williams M, Siveter D J, Peel J S, 1996. *Isoxys* (Arthropoda) from the Early Cambrian Sirius Passet Lagerstätte, North Greenland. *Journal of Paleontology*, **70**(6): 947—954.
- Zhao Yuanlong(赵元龙), Yuan Jirliang(袁金良), Zhu Maoyan(朱茂炎), Yang Ruidong(杨瑞东), Guo Qingjun(郭庆军), Qian Yi(钱逸), Huang Youzhuang(黄友庄), Pan Yu(潘玉), 1999. A progress report on research on the Early Middle Cambrian Kaili Biota, Guizhou, PRC. *Acta Palaeontologica Sinica*(古生物学报), **38**(Supplement): 1—14(in Chinese with English summary).

NEW *ISOXYS*(ARTHROPODA) FROM THE CAMBRIAN MANTOU FORMATION, SHANDONG PROVINCE

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Key words *Isoxys*, Mantou Formation, Cambrian, Shandong Province

Abstract

The bivalved arthropod *Isoxys* had a cosmopolitan distribution in Cambrian seas. They are reported from the North America, Spain, Siberia, Australia and Southwest China. All material from China occurs in a wide area of the Yangtze Plat-

form, including in the Chengjiang and Guanshan faunas from Yunnan Province, the Kaili fauna from Guizhou Province, and the Changyang district from Huibei Province. *Isoxys shandongensis* Wang and Huang sp. nov. from the Mantou Formation (Zhangxia Stage) near Sikou Village, Lizhuang Township, Feixian County, Linyi City of Shandong Province, eastern China, is described

herein. The fossils are preserved in a green gray shale from which other soft-bodied animals had also been found.

SYSTEMATIC PALAEONTOLOGY

Phylum Arthropoda Siebold and Stannius, 1845

Class uncertain

Order Isoxyida Simoneta and Delle Cave, 1975

Family Isoxyidae Vogdes, 1893

Genus *Isoxys* Walcott, 1890

Isoxys shandongensis Wang and Huang sp. nov.

(Text figs. 2, 3)

Etymology Specific name refers to the Shandong Province, where the new species was discovered.

Material The fossils are preserved in a strongly weathered green grayish shale, along with large amounts of the trilobite *Maotunia*, brachiopods and sponge spicules. There are a total of 10 specimens, including 6 complete individuals. New materials is housed in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, NIGP 151869, NIGP 151870—151874, and NIGP 152315.

Holotype NIGP 151869, a complete carapace in lateral view.

Diagnosis Carapace small, slope of the posterior margin steeper than that of the anterior margin; dorsal margin almost slightly convex in anterior third; both anterior and posterior spines short, anterior spine longer than posterior spine; an oblique ridge visible posteriorly; valve smooth; a rather broad doublure present.

Description Carapace small, valves semicircular; length 16—19 mm (excluding cardinal spines), height 6—8 mm; ratio of length to height approximately 2.3—2.4 in most specimens (probably adults), approximately 2.0 in a small individual; ratio of length to width approximately 3.2 (from a dorsally compressed specimen NIGP 151871); anterior and posterior cardinal spines short and pointed, anterior cardinal spines approximately twice as long as posterior ones; a complete

and rather broad doublure present; a thin and almost straight oblique ridge visible from posterior spines to posterior third of valve.

Comparison The new species most closely resembles *I. glaessneri* from Australia. They share many similarities such as the overall shape, the smooth valve, and the presence of a doublure. The new species differs from *I. glaessneri* in the condition of the posterior oblique ridge. Further, the ratio of length to height is smaller in *I. glaessneri* and this feature is most obvious in juveniles. In addition, the new species is smaller.

The new species resembles *I. communis* in its overall shape and in the ratio of length to height, its smooth valve, and its slightly convex dorsal line. However, both the anterior and posterior cardinal spines of *I. communis* are distinctly longer than what is found in the new species. Moreover, *I. communis* is typically larger and its posterior margin is relatively straighter.

The new species resembles *I. chilhoweanus* and *I. auritus* in its outline and slightly convex dorsal line, but they are easily distinguished by the ornamentation on the valve.

Occurrence and locality Upper part of Martou Formation at Feixian County, Linyi City, Shandong Province, Eastern China.

Discussion An indeterminate species of *Isoxys* has been described from Langston Formation Utah. It has a rather small carapace, (ca. 15 mm long, 6.8 mm wide), with a semicircular outline, a ratio of length to height approximately 2.2, the slope of the posterior margin is steeper than that of the anterior margin; the dorsal line is almost straight, but it is slightly convex in its anterior third; the anterior cardinal spine (6.4 mm long) is twice as long as the posterior spines (3.0 mm long), and the valve is smooth. This specimen has rather well preserved soft parts including eyes, trunk and limbs. The trunk is nearly half as high as the carapace, the anterior section is enlarged, and there is a large, rounded stalked eye; the abdomen lacks subdivision, and each segment appears to bear a pair of exopods and endopods; there

are around 4 pairs of appendages present in the head region; the presumptive exopods appear to be armed with comb shaped setae; there are a total of approximately 15 pairs of limbs present, and the longest are pairs 5—7; the limbs are more densely arranged posteriorly.

Isoxys sp. from Utah most closely resembles *I. communis*. They share some similarities such as the semicircular outline, the anterior cardinal spine being longer than the posterior spine, and a similar ratio of length to height. However, the anterior margin of the carapace is more rounded in *Isoxys* sp. whereas the margin is straighter in *I. communis*. By contrast, the dorsal line is straighter in

Isoxys sp. Finally, *Isoxys* sp. is smaller but this is not held to be particularly significant as thus far only one specimen is known from the Langston Formation of Utah.

Isoxys sp. from Utah and *I. shandongensis* have similar outlines and dorsal lines, and in both the anterior cardinal spine twice the length of the posterior spine. However, the cardinal spines of *Isoxys* sp. from Utah are distinct longer than *I. shandongensis*, *Isoxys* sp. from Langston Formation of Utah probably represents a new species but because it is only known from a single specimen we do not describe it at this time.