



江西上三叠统安源组叶肢介一新属*

沈炎彬**

中国科学院南京地质古生物研究所, 南京 210008

提要 香溪叶肢介亚科(Xiangxiellinae)以壳瓣胎壳较大、壳上具有一条或两条短脊为特征, 包括两个属: 原单脊叶肢介属(*Protomonocarina* Tasch, 1962)和香溪叶肢介属(*Xiangxiella* Shen, 1976)。该亚科化石广布于世界各地, 最早出现于我国晚石炭世, 三叠纪末消失。本文建立的新属叉脊叶肢介(*Dicerestheria* gen. nov.), 以胎壳上具有两条呈“人”字形向前后分叉的、粗壮的短脊为特征, 与香溪叶肢介的构造特征最为接近。推测新属壳瓣胎壳脊的形成与闭壳肌附着引起的壳瓣变异或与生态环境变化有关。化石产于江西抚州崇礼县礼陂煤矿, 上三叠统安源组徐坊段。湘赣一带安源组为一套含煤地层, 属于滨海、近海、沼泽沉积区, 产半咸水类型的双壳类, 时代认为卡尼及早诺利期。植物化石*Ptiozamites*–*Anthrophyopsis*组合是诺利期的代表, 适宜于热带、亚热带气候, 滨海环境生长的群落。因此推测新属是一个生活在炎热、潮湿, 热带-亚热带气候近海沼泽环境的类型。

关键词 叉脊叶肢介 新属 香溪叶肢介亚科 叶肢介 晚三叠世 安源组 江西

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A new genus of clam shrimp from the Upper Triassic Anyuan Formation of Jiangxi, China

SHEN Yan-bin

Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

Abstract The clam shrimp Xiangxiellinae (Spinicaudata), characterized by one or two short ribs on the large larval valve, is comprised of two genera: *Xiangxiella* Shen, 1976 and *Protomonocarina* Tasch, 1962. The members of this subfamily are widely distributed in the Upper Carboniferous to the Triassic strata in the world. The new genus *Dicerestheria* gen. nov. is established based upon specimens from the Upper Triassic Xufang Member of the Anyuan Formation in Wuzhou City, Jiangxi Province. Its large larval valve bears two bifurcate, short, and stout ribs. It is very similar to *Xiangxiella* in that they both have two ribs on the larval valve, but the ribs of the new genus are much stronger than those of the latter. The growth bands of the new genus are ornamented with medium reticulate sculpture. It is speculated that the larval valve ribs might be caused by variation of attachments of the adductor muscles, or by changes of their habitat and living environments. The Anyuan Formation consists of a set of coal-measure sediments, yielding brackish bivalves and abundant Norian plants represented by the *Ptiozamites*–*Anthrophyopsis* flora, reflecting an environment in humid tropical-subtropical climate. Therefore, the new genus may have lived adjacent to nearshore marsh environments in warm and humid tropical-subtropical climate.

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** 通讯作者: 沈炎彬, 研究员, e-mail: ybshen123@163.com

Key words *Dicerestheria*, new genus, Xiangxiellinae, clam shrimp, Late Triassic, Anyuan Formation, Jiangxi Province

The clam shrimp ("Conchostraca") family Lioestheriidae (Spinicaudata) is characterized by the large larval valve with a node and tubercular spine or rib, and consists of two subfamilies: Vertaxiinae Kobayashi, 1954 and Xiangxiellinae Shen, 1976 (Zhang *et al.*, 1976). This extinct family ranges from the Early Devonian to the Cretaceous.

The subfamily Xiangxiellinae possesses one or two short ribs on the large larval valve and consists of two genera: *Xiangxiella* with two bifurcated ribs (Shen, 1976 in Zhang *et al.*, 1976) and *Protomonocarina* with a single rib (Tasch, 1962). The two genera are distributed in the Upper Carboniferous to the Triassic strata in China, North America, Central Asia and India. The new genus described in the present paper is the third member of the Xiangxiellinae. Specimens assigned to the new genus were collected from the Upper Triassic Xufang Member of the Anyuan Formation in Wuzhou City, Jiangxi Province. Members of the new genus bear two bifurcated, short and stout ribs on their large larval valves. The new genus is very similar to *Xiangxiella* in that they both have two ribs on their larval valves. However, the new genus has much stronger ribs and its growth bands are ornamented with medium-sized reticulations.

Material and methods The specimens studied in this paper were collected by the 912th geological team of Shangduntu, Linchuan, Jiangxi Province in 1972 from the Xufang Member of the Anyuan Formation of Lipi Coal-mine, Chongli County, Wuzhou City, Jiangxi Province. About 70 individuals preserved in light grey platy mudstones were collected. Specimens studied in the present paper are housed in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences. Specimens are numbered as NIGP 374348–374353 with field numbers Xu7, Xu9, Xu10, Xu17, Xu30, respectively.

Photomicrography was obtained using a Zeiss Discovery V16 microscope. A LEO 1530 VP scanning electron microscope (SEM) was used in observation. However, no valuable SEM photos were taken on the carapace surface.

SYSTEMATIC PALAEONTOLOGY

Recent classification of spinicaudatans by Martin and Davis (2001) is adopted with reference to the fossil classification by Chen and Shen, 1985, and in consideration of the proper terms and suggestions of Scholze and Schneider (2015) and Shen and Wu (2022).

Class Branchiopoda Latreille, 1817

Order Diplostraca Gerstaecker, 1866

Suborder Spinicaudata Linder, 1945

Superfamily Lioestherioidea Raymond, 1946, emend

Holub and Kozure, 1981

Family Vertaxiidae Kobayashi, 1954

Subfamily Xiangxiellinae Shen (in Zhang *et al.*, 1976)

Genus *Dicerestheria* gen. nov.

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Type species *Dicerestheria jiangxiensis* gen. et sp. nov.

Etymology Derived from the large larval valve bearing two bifurcated ribs.

Diagnosis Carapace moderate in size, elliptical in outline; large larval valve bearing two bifurcated, short, and stout ribs, extending from dorsal part of umbo to anteroventral and posteroventral forwards respectively; no cross-growth lines; 8–10 growth bands ornamented with medium-sized reticulations arranged in transitional linear direction on posteroventral region of carapace.

Remarks The new genus has close affinities to *Xiangxiella* Shen (in Zhang *et al.*, 1976) in their large larval valves bearing two bifurcated ribs, but it differs from the latter in its stronger and stout ribs on the larval valves and its growth bands ornamented with medium reticulations.

Dicerestheria is easily distinguished from *Protomonocarina* reported from the Permian Wellington Formation (Tasch, 1962), which only possesses one rib on the larval valve. *Protomonocarina huixianensis* (Wang, 1987) reported from the Upper Carboniferous Tenyuan Formation of Henan, China is the earliest representative of the genus. *Protomonocarina* was also found in the Late Permian strata in Inner Mongolia (Wang, 1984) and the Triassic Panchet Formation in India (Ghosh, 2011).

Curvacornutus (Tasch, 1961), bearing one looped spine on its initial valves, was placed in the Xiangxiellinae (in Zhang *et al.*, 1976; Chen and Shen, 1985). However, the looped spine structure is much similar to those nodes, tubercular and spines of the vertaxiids. Therefore, this genus is reassigned to the Subfamily Vertaxiinae.

Both *Protomonocarina* and *Xiangxiella* were found in the Anisian Badong Formation of Hubei, China, in association with brachiopod *Lingula* sp. (Zhang *et al.*, 1976). *Xiangxiella* has a wide distribution in the Anisian strata of China, as an index fossil for stratigraphic correlation and geological age determination. *Bicornia* from the Middle Triassic Huangmaqing Formation in Nanjing, China shows two nodes on the larval valve (Bi and Xie, 1982). Therefore, this genus should be attributed to the Vertaxiinae rather than Xiangxiellinae.

Palaeolimnadiopsis vilujensis (Varentsov, 1955) from the Early Triassic Calvörde Formation in Thuringia, Germany (Scholze and Schneider, 2015, fig. 2) shows two bifurcate ribs on the larval valve, which are very similar to those of the new genus, but its postero-dorsal margin recurves.

***Dicerestheria jiangxiensis* gen. et sp. nov.**

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B4001

(Fig. 1)

Type specimens Holotype (fig. 1-B), Coll. No. Xu30, NIGP 374348; Paratype (fig. 1-A, 1-D), Coll. No. Xu10, NIGP 374349–374350.

Locality and horizon Lipi coal-mine, Chongli County, Wuzhou City, Jiangxi Province; Upper Triassic Xufang Member of Anyuan Formation.

Etymology The epithet jiangxiensis refers to Jiangxi Province.

Description Carapace elliptical in outline, moderate in size; valve length (L) 5.3–6.7 mm, height (H) 3.4–4.0 mm, H/L = 0.54–0.73; large elliptical larval valve bearing two bifurcate, short and stout ribs, extending from the top of umbo to anteroventral and posteroventral forwards respectively; no cross growth lines; height (h) 1.9–2.7 mm, h/H = 0.53–4.8; dorsal margin (d) 4.2–4.8 mm, d/L = 0.68–0.83; anterior and posterior margins curved, ventral margin gently curved; 8–10 growth bands ornamented with medium reticulations, linearly arranged on posterior-ventral region of valve.

Discussion The new genus is very similar to *Xiangxiella* in that they both have two bifurcate ribs on the larval valves, but the ribs of the new genus are much stronger than those of the latter, and the growth bands are ornamented with medium-sized reticulate sculpture. Both *Xiangxiella* and *Protomonocarina* were found from the Anisian Badong Formation in Xiangxi Town, Zigui County, Hubei Province, and co-occur with brachiopod

Lingula sp., which reflects a brackish water environment (Shen, 1976 in Zhang *et al.*, 1976).

During the Late Triassic–Early Jurassic, there was a XiangYueGan bay in Southern China. Jiangxi Province was situated on the northern coast of the bay. The Anyuan Formation consists of a set of coal-measure sediments, containing brackish bivalves such as *Jiangxiella*, *Bakevelloides* and *Waagenoperus*, which suggests a Carnian–Norian age (Chen, 1989). Abundant Norian plants represented by the *Ptiozamites-Anthropophopsis* flora were also found in the Anyuan Formation, reflecting an environment in tropical-subtropical, humid climate (Wu Shun-qing and Wu Xiang-wu, 1982; Xiong *et al.*, 2009). As a result, the clam shrimp assemblage may have survived in the warm marsh condition in an estuarine, a pool, or a swam near the coast.

The structural differences of the larval valve ribs might have been caused by the morphological modification of the carapace due to the variation of the attachment sites of the adductor muscles (Tasch, 1987, p. 94), or related to changes in habitat and environment.

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1 前言

在化石叶肢介中有一类壳瓣胎壳较大, 其上具有瘤、刺、短脊、弯钩等特殊构造的类型, 统归于光滑叶肢介科(Lioestheriidae)。其于泥盆纪早期出现, 二叠–三叠纪兴盛, 白垩纪消失(陈丕基、沈炎彬, 1985; Kobayashi, 1954; Novojilov, 1960; Tasch, 1969; Liao and Shen, 2021)。香溪叶肢介亚科(Xiangxiellinae)则以胎壳发育有一条或两条短脊为特征建立的亚科(张文堂等, 1976), 包括2个属: 具有双脊的香溪叶肢介(*Xiangxiella* Shen) (张文堂等, 1976)和一条脊的原单脊叶肢介(*Protomonocarina*) (Tasch, 1962)。该亚科曾包括弯脊叶肢介(*Curvacurnotus* Tasch, 1961) (张文堂等, 1976), 鉴于其胎壳上发育的一条脊呈卷曲的刺状构造, 本文认为置于锥顶叶肢介亚科(Vertexiinae)更合适。

香溪叶肢介亚科分布于中国、北美、中亚及印度等地, 最早见于我国河南上石炭统太原组(王德有, 1987), 三叠纪以后再无报道。

本文报道的新属叉脊叶肢介(*Dicerestheria*)具有较大的胎壳, 其上发育有两条如“人”字形分叉, 向前后延伸的粗短脊, 明显具有香溪叶肢介亚科的特征, 是该亚科的一个新成员, 也是目前分布时代最晚的一个代表。化石产于江西抚州崇礼县礼陂煤矿, 上三叠统安源组徐坊段。1975年由江西临川上顿渡912地质队采集。赋存45年后面世, 依然彰显其特有的科学蕴含。

2 材料及方法

本文研究的标本产于江西抚州崇礼县礼陂煤矿, 上三叠统安源组徐坊段。1975年由江西临川上

顿渡912地质队采集。标本共计70余个个体保存在浅灰色板状粉砂质泥岩中,许多个体的左右两瓣沿背缘张开,保存在一起,反映未经长距离搬运的埋藏特征。标本存放在中国科学院南京地质古生物研究所标本馆, NIGP 174348–174353。

野外采集号: 徐7, 徐9, 徐10, 徐17, 徐30。

图片采用Zeiss Discovery V16 microscope拍摄。使用LEO 1530 VP型扫描电镜观察。

3 系统古生物学

文中亚目以上的分类单元采用Martin和Davis (2001)的方案; 亚目之下的分类引用陈丕基、沈炎彬 (1985)的方案; 壳瓣度量依据Scholze and Schneider (2015), 结合沈炎彬、吴肖春(2022)的建议。

鳃足纲 **Class Branchiopoda Latreille, 1817**

双甲目 **Order Diplostraca Gerstaecker, 1866**

棘尾亚目 **Suborder Spinicaudata Linder, 1945**

光滑叶肢介科 **Family Lioestherioidea Raymond, 1946, emend Holub and Kozure, 1981**

香溪叶肢介亚科 **Subfamily Xiangxiellinae Shen (in Zhang et al., 1976)**

叉脊叶肢介属(新属) **Genus Dicerestheria gen. nov.**

模式种 **Dicerestheria jiangxiensis gen. et sp. nov.**

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产地层位 江西抚州崇礼县礼陂煤矿, 上三叠统安源组徐坊段。

词源 意即胎壳发育有两条分叉的脊。

特征 壳瓣中等大小, 椭圆形, 胎壳大, 其上有两条如“人”字形, 从背部向前、后延伸的粗而凸的短脊, 后脊比前脊粗而长, 但均未与生长线相交; 生长线较粗, 8–10条; 生长带上具有不规则小-中网状装饰, 在腹部有线状排列现象。

讨论 新属与*Xiangxiella* Shen (张文堂等, 1976)最接近, 它们的胎壳上都具有两条“人”字形分叉的短脊, 区别是新属的双脊十分粗壮高凸, 个体略大。而后的壳瓣薄、双脊细、个体小, 网状纹饰的网孔细小。新属与产于美国下二叠统Wellington组的*Protomonocarina* (Tasch, 1962)容易

区别, 后者的胎壳上只有一条向后腹方向延伸的脊。河南中石炭统太原组报道的*Protomonocarina huixianensis* (王德有, 1987)是已知该属最早的代表。在内蒙古上二叠统陶海营子组也有记录(王五力, 1984)。

印度下三叠统Panchet组报道有*Protomonocarina*的存在(Ghosh, 2011), 可见在南北两个大陆都有分布。他建立的*Indomonocarina* (Ghosh, 2011) 壳瓣前部为一条宽的壳褶, 其性质与胎壳短脊不同, 不应属于香溪叶肢介亚科的成员。

弯线叶肢介*Curvacornutus* (Tasch, 1961)曾被归入香溪叶肢介亚科(张文堂等, 1976), 考虑到其胎壳发育的是一条卷曲的刺状脊, 其形态与锥顶叶肢介亚科成员的胎壳瘤、刺构造接近, 在此将其归于该亚科。这一属还出现在哈萨克斯坦下三叠统及塔吉克斯坦的上三叠统(Novojilov, 1970)。

产于德国Thuringia下三叠统Calrörde组的*Palaeolimnadiopsis vilujensis*, 其胎壳上明显有两条粗壮的短脊(Scholze and Schneider, 2015, fig. 2), 与新属十分相似, 但其后背缘生长线向外反曲, 易于区别。这一种原先由Varentsov (1955)描述, 化石产于俄罗斯雅库提(Yakute)下石炭统。

记录于中国南京中三叠统黄马青组的双锥叶肢介(*Diconiastracus*) (毕德昌、谢茂辉, 1982), 其不大的胎壳上有两个圆锥形瘤状物, 不同于香溪叶肢介亚科的脊状构造, 应归于Vertexiinae。

江西安源三湾安源组曾记录有*Anyuanestheria* Zhang et Chen (张文堂等, 1976), 这种胎壳小、无脊状构造、生长带上具中网纹饰、在后腹部呈线状排列的类型与新属明显不同、分属不同的超科, 归于宽网叶肢介科(Loxomegaglyptidae)。

江西叉脊叶肢介(新属新种) **Dicerestheria jiangxiensis gen. et sp. nov.**

urn:lsid:zoobank.org:act:B88EAB44-40CC-4C4F-B29D-B07411BB4001 (图1)

模式标本 正模标本(图1-B), 野外编号徐30, 正式编号NIGP 174348; 副模标本(图1-A, 1-D), 野外编号徐10, 正式编号NIGP 174349–174350。

名称来源 标本产出地区——江西省。

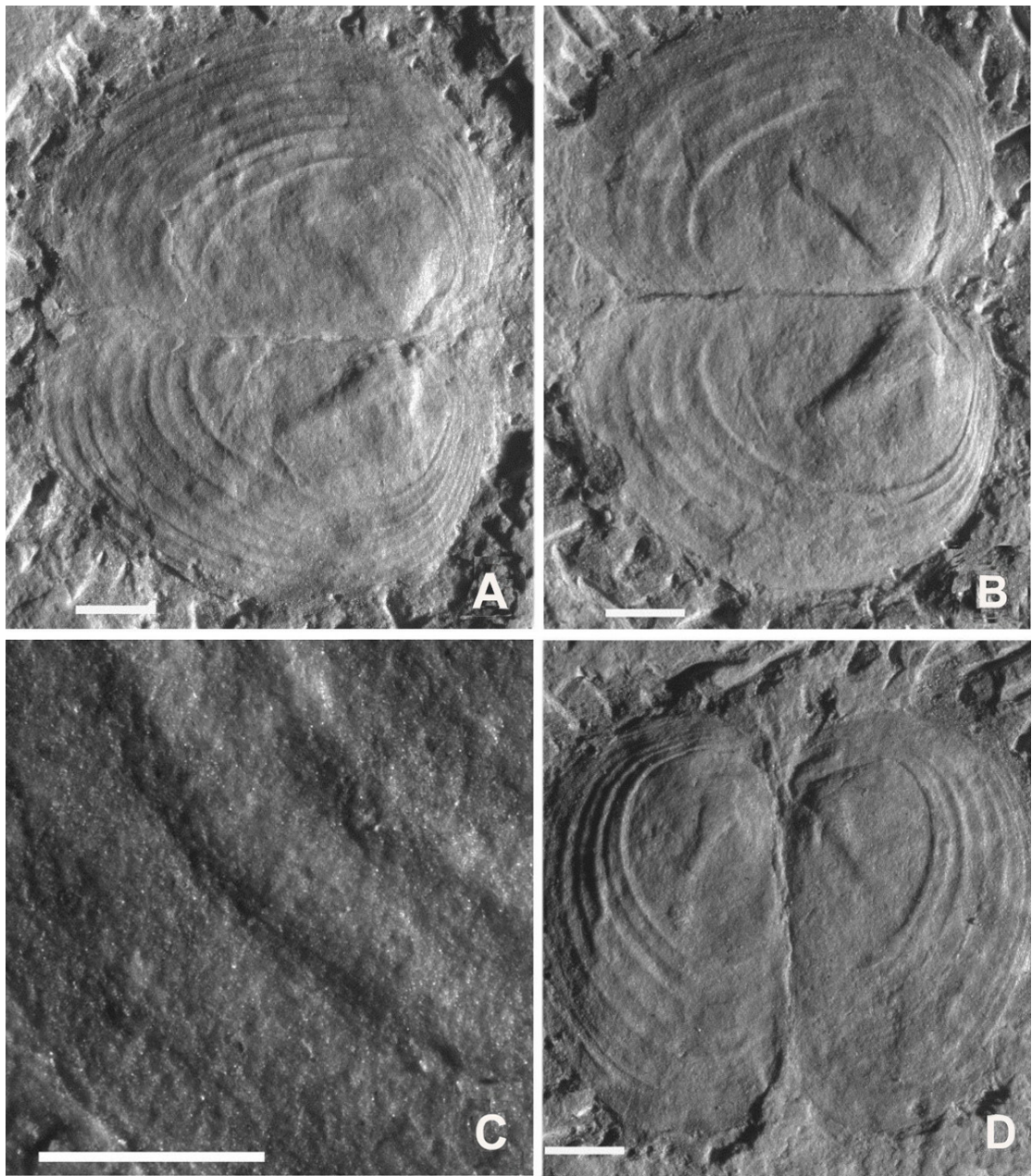


图 1 江西叉脊叶肢介(新属新种)

Fig. 1 *Dicerestheria jiangxiensis* gen. et sp. nov.

A. 沿背缘张开的双瓣, 副模, 采集号: 徐 10, NIGP 174349; B. 沿背缘张开的双瓣, 正模, 采集号: 徐 30, NIGP 174348; C. 另一壳瓣生长带上网状装饰呈线状排列, 采集号: 徐 10, NIGP 174351; D. 沿背缘张开的双瓣, paratype, 采集号: 徐 10, NIGP 174350. 除 C 比例尺=0.5 mm 外, 其余的比例尺=1 mm。

A. Left and right valves opening along the dorsal margin, paratype, coll. Xu10, NIGP 174349; B. Left and right valves opening along the dorsal margin, holotype, coll. No: Xu30, NIGP 174348; C. Showing reticulate ornamentations on the growth bands, coll. No: Xu10, NIGP 174351; D. Left and right valves opening along the dorsal margin, paratype, coll. Xu10, NIGP 174350. Scar bars = 1 mm in A, B, and D; Scar bar = 0.5 mm in C.

描述 壳瓣椭圆形, 中等大小, 成年个体壳长(L) 5.5–7.3 mm, 高(H) 3.4–4.6 mm, $H/L=0.54-0.73$; 胎壳大, 椭圆形, 高(h) 1.9–2.7 mm, $h/H=0.53-0.66$, 位于背缘前部; 背缘长(i) 4.2–4.8 mm, $i/L=$

0.68–0.83 (表1); 前缘及后缘向外拱曲, 腹缘宽弧状向下突; 胎壳中前方发育有两条“人”字形分叉、粗壮的短脊, 始自胎壳背部, 两脊分别向前腹及后腹方向延伸, 但未与生长线相交, 在顶部汇合处

表 1 壳瓣数据度量
Table 1 Measurements of carapace valve (in mm)

NIGP	L	H	h	H/L	h/L	i	i/L	gl	angle
174348	5.3	3.8	2.5	0.71	0.66	4.3	0.80	6	50°
174349	5.5	4.0	2.7	0.73	0.66	4.6	0.83	8	60°
174350	5.4	3.4	1.9	0.62	0.56	4.3	0.80	9	73°
174351	6.7	3.6	1.9	0.54	0.53	4.5	0.68	8	76°
174352	5.7	3.6	2.1	0.63	0.56	4.8	0.83	9	66°
174353	5.9	3.8	2.3	0.65	0.59	4.2	0.75	9	66°

注: L=壳长(mm); H=壳高(mm); H/L=壳高/壳长; h=胎壳高(mm); h/H=胎壳高/壳高; i=背缘长(mm); i/L=背缘长/壳长; gl=生长线数目; angle=胎壳脊夹角。

Note: L = valve length (mm); H = valve height (mm); H/L = height/length; h = height of the larval valve; i = length of dorsal margin (mm); i/L = length of dorsal margin/valve length; gl = number of growth lines; angle = angle between two larval valve ribs.

变得更加粗凸,两脊夹角50°–76°;生长线较粗而凸,成年个体6–9条;生长带较宽,其与胎壳都发育有不规则的小-中网状纹饰,在腹部有线状排列现象。

产地层位 江西抚州崇礼县礼陂煤矿,上三叠统安源组徐坊段。

4 讨 论

三叠纪晚期至侏罗纪早期中国南方存在湘粤赣海湾。江西处于海湾北缘,湘赣一带安源组为一套含煤地层,属于滨海、近海、沼泽沉积区。在江西萍乡安源组发育最好,自下而上划分为4段:依次紫家冲段、三家冲段、爱坡里段及三丘田段(陈文华、彭和清, 2005)。该组产半咸水双壳类,如 *Jiangxiella*、*Bakevellidoes*、*Waagenoperna*等,时代认为卡尼及早诺利期(陈金华等, 1989)。安源组丰富的植物化石,以 *Ptiozamites*–*Anthrophyopsis*组合为代表,是热带、亚热带气候,滨海环境生长的类型(吴舜卿、吴向午, 1982; 熊鑫琪等, 2009)。

殷红梅(2014)报道抚州里陂煤矿区的安源组划分为上部中华山段及下部徐坊段,彼此假整合接触。认为中华山段含介形类 *Gomphocythere yubacunensis*及香溪叶肢介亚科的分子,时代属早侏罗世,徐坊段归于晚三叠世。本文研究的材料,原始记录产于抚州崇仁县礼陂煤矿的安源组徐坊段,新属是否同时分布于上下两个不同的层位,目前难以确定。但值得注意的是,新属大的胎壳具有两条短脊的特点,与报道于四川万县长滩乡石

板坪,下侏罗统自流井组底部的瘤渔乡叶肢介(*Bulbilimnadia* Shen) (张文堂等, 1976)比较相近,后者大的胎壳上有一个粗瘤凸起。近期也报道于新疆下侏罗统三工河组(滕晓, 2020),属于早侏罗世 *Palaeolimnadia*–*Euestheria taniiformis*叶肢介动物群的成员。

香溪叶肢介亚科包括两个属: *Xiangxiella* Shen 和 *Protomonocarina* Tasch, 它们一起出现于湖北秭归香溪中三叠统安尼阶巴东组,与其伴生的还有腕足类 *Lingulla* sp., 反映了半咸水环境。*Xiangxiella*之后在南京中三叠统黄马青组底部(毕德昌、谢茂辉, 1982),山西中三叠统二马营组等相当地层也有报道(刘淑文, 1989; 乌统昱, 1991),分布时限短,具有地层划分对比意义,目前仅见于中国。

香溪叶肢介亚科(*Xiangxiellinae* Shen) (张文堂等, 1976)建立时,包括了弯线叶肢介属(*Curvacornutus*, Tasch, 1961),现在看来,其胎壳上卷曲的刺状构造,与锥顶叶肢介亚科的成员更接近,如 *Cornia* Lutkevich, 1937、*Gabonestheria* Novojilov, 1958、*Echinestheria* Marliere, 1950、*Megasitum* Novojilov, 1970等。因此,香溪叶肢介亚科由 *Xiangxiella* Shen、*Protomonocarina* Tasch 及 *Dicerestheria* gen. nov.三属组成,以有一条或两条胎壳脊为主要特征。关于胎壳脊的成因有不同的解释: 1) 脊受环境影响引起形态机能的变化; 2) 脊位于壳瓣闭壳肌附着的位置,受其影响,造成形态的变异(张文堂等, 1976; Tasch, 1987, p. 94); 3) 双脊是单脊的特化现象(张文堂等, 1976)。

5 结 论

新属以其胎壳上发育有两条“人”字形粗凸的短脊为特征,是香溪叶肢介亚科的一个新成员,与*Xiangxiella*关系最为密切。推测胎壳脊的形成与生态环境变化,或闭壳肌附着引起的壳瓣变异有关。这是一个生活在热带、亚热带,气候潮湿,滨海沼泽环境的类型。

致谢 标本由江西临川上顿渡912地质队采集。加拿大自然博物馆吴肖春博士仔细审阅、修改手稿,提出许多有益的建议。云南大学廖焕宇博士帮助标本照相,在此一并致以谢忱。

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