

云南早泥盆世西山村组华南 鱼类的首次发现¹⁾

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摘要:记述了云南曲靖地区早泥盆世洛霍考夫期华南鱼类一新属——王冠鱼(*Stephaspis* gen. nov.)。新属发现于西山村组下部致密坚硬的石英砂岩中,其主要特征是:个体较大的华南鱼类,头甲呈长盾形,后缘向后凸出;角发育,侧向延伸,末端向头甲后侧方自然倾斜,内角不发育;具吻突,但不甚发育;中背孔较大,呈纵向椭圆形,前端稍尖,后端圆钝;眶孔较小,圆形,背位;头甲背面具一对背窗,呈狭长椭圆形,靠近头甲侧缘;感觉管系统不甚发育,仅见后眶上管、侧背管、侧横管及背联络管,后眶上管呈V字形;纹饰为细小的粒状瘤点。新属不仅是华南鱼类在西山村组的首次发现,也指示了目前华南鱼类出现的最低层位,为探讨华南鱼类的起源与早期辐射提供了重要资料。

关键词:云南曲靖,西山村组,洛霍考夫期,华南鱼类,新属

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1 前言

云南曲靖地区发育一套基本连续沉积的泥盆纪地层,自下而上可划分为西山村组、西屯组、桂家屯组、徐家冲组、穿洞组、上双河组、海口组和宰格组,是中国泥盆纪非海相地层的经典地区(刘玉海、王俊卿,1973;王成源,2000)。最底部的西山村组厚约224 m,沉积时代大致为早泥盆世早洛霍考夫期(early Lochkovian),岩性以坚硬致密的石英砂岩为主,夹黄绿色及黑色页岩,底部以一层灰黄色的细粒砂岩与志留系的玉龙寺组呈整合接触(林宝玉等,1998)。目前在该组中已发现大量无颌类、盾皮鱼类和肉鳍鱼类化石,它们组成了一个重要的早期脊椎动物群化石组合(朱敏,1992)。其中无颌类化石最为丰富,包括真盔甲鱼类 *Yunnanogaleaspis major* (潘江、王士涛,1980), *Nochelaspis maeandrina* (朱敏,1992) 和多鳃鱼类 *Polybranchiaspis liaojiaoshanensis*, *P. minor*, *Laxaspis* (“*Polybranchiaspis*”) *yulongssus*, *Diandongaspis xishancunensis*, *Laxaspis qujingensis*, “*Laxaspis rostrata*” (刘玉海,

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1965, 1975), “*Dongfangaspis qujingensis*” (潘江、王士涛, 1981), 该无颌类化石组合被称为 *Polybranchiaspis-Laxaspis* 组合 (王俊卿, 1984)。不过在西山村组中一直未发现具吻突和侧向延伸角的华南鱼类。华南鱼类是盔甲鱼类中出现较晚的一个类群, 化石层位包括徐家冲组、坡松冲组、平驿铺组和那高岭组等。朱敏等 (1994)、刘玉海 (2002) 据此认为, 华南鱼类的出现与辐射大致是在早泥盆世布拉格期 (Pragian), 时限较短, 对含鱼层的时代确定和对比有着重要的意义。

2004 年 7 月, 中科院古脊椎所早期脊椎动物课题组再次对云南曲靖地区的志留—泥盆纪地层开展野外调查, 于西山水库上游西山村组下部致密坚硬的石英砂岩中采获 2 件具吻突和背窗的华南鱼类化石, 经鉴定为华南鱼科一新属。新的系统学研究结果 (朱敏、盖志琨, 2006), 将发现于西屯组的 *Nanpanaspis* (晚洛霍考夫期) 归到华南鱼科, 代表了原先华南鱼类出现的最低层位, 而新属的层位为其下的西山村组底部, 时代为早洛霍考夫期, 所以新属不仅是华南鱼类在西山村组的首次发现, 也指示了目前华南鱼类出现的最低层位。新属的发现, 为我们重新认识华南鱼类的分异时间提供了重要资料, 现将标本记述如下。

2 标本记述

盔甲鱼亚纲 *Galeaspida* Tarlo, 1967

多鳃鱼超目 *Polybranchiaspidida* Janvier, 1996

华南鱼目 *Huananaspidae* Janvier, 1975

华南鱼科 *Family Huananaspidae* Liu, 1973

王冠鱼 (新属) *Stephaspis* gen. nov.

(图 1-3)

词源 *stephos* (Gr.), 王冠, 从头甲形状似古代王冠, *aspis* (Gr.) 盾甲。

属型种 双翼王冠鱼 (新属、新种) *Stephaspis dipteriga* gen. et sp. nov.。

属征 个体较大的华南鱼类。头甲呈长盾形, 后缘向后凸出; 角发育, 侧向延伸, 末端向头甲后侧方自然倾斜, 内角不发育; 具吻突, 但不甚发育; 中背孔较大, 呈纵向椭圆形, 前端稍尖, 后端圆钝; 眶孔较小, 圆形, 背位; 头甲背面具一对背窗, 呈狭长椭圆形, 靠近头甲侧缘; 感觉管系统不甚发育, 仅见后眶上管、侧背管、侧横管及背联络管, 后眶上管呈 V 字形; 纹饰为细小的粒状瘤点。

比较与讨论 新属中背孔呈椭圆形, 眶孔较小, 具纤细的吻突及一对侧向延伸的角, 依据朱敏、盖志琨 (2006) 对整个盔甲鱼亚纲系统发育分析的结果, 应归到华南鱼科 (*Huananaspidae*)。华南鱼科目前共有 7 属, 分别为亚洲鱼 (*Asiaspis*)、南盘鱼 (*Nanpanaspis*)、华南鱼 (*Huananaspis*)、龙门山鱼 (*Lungmenshanaspis*)、箴门鱼 (*Qingmenaspis*)、中华四川鱼 (*Sinoszechuanaspis*) 和大窗鱼 (*Macrothyraspis*)。在现有各属中, 就中背孔形状及眶孔位置而言, 新属与南盘鱼最为相似, 两者中背孔均呈纵向椭圆形, 且前端稍尖, 后端圆钝, 眶孔背位, 而且比较靠近头甲中线的位置。其他各属的中背孔呈横向椭圆形或心形, 眶孔比较靠近头甲侧缘或位于头甲侧位。另外, 两者头甲在角的后方均存在较

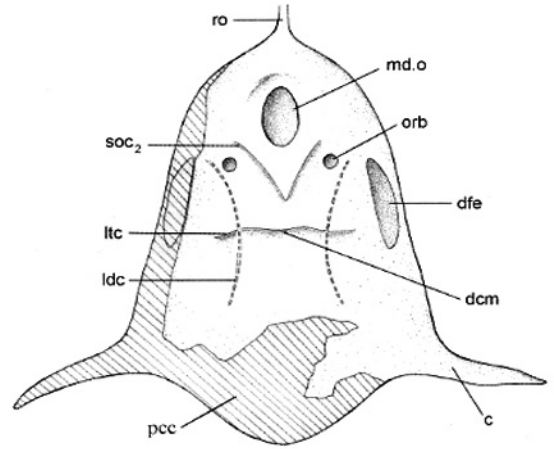


图 1 双翼王冠鱼(新属、新种)头甲(V 14333. 1A, 正型标本), 比例尺 = 1 cm

Fig. 1 External mould of an incomplete headshield of *Stephaspis dipteriga* gen. et sp. nov. (V 14333. 1A, Holotype), scale bar = 1 cm

简字说明 Abbreviations; c. corner 角; dcm. dorsal commissure 背联络管; dfe. dorsal fenestra 背窗; ldc. lateral dorsal canal 侧背管; ltc. lateral transverse canal 侧横管; md. o. median dorsal opening 中背孔; orb. orbital opening 眶孔; pcc. portion of headshield caudal to the base of corner 角后区; ro. rostral process 吻突; soc₂. posterior supraorbital canal 后眶上管

大的角后区。朱敏、盖志琨(2006)根据角伸出的位置,将盔甲鱼类的侧向延伸角区分出两种类型:一种是角从头甲后缘的位置伸出,如 *Qingmenaspis* 和 *Lungmenshanaspis*;另一种是角从远离头甲后缘的头甲侧部伸出,如 *Sinoszechuanaspis* 和 *Zhaotongaspis*。这样,在后一种类型中,角的基部与头甲后缘之间就形成了一段较长的区域——角后区。这一区域在新属和南盘鱼中较其他盔甲鱼类来说(如 *Sinoszechuanaspis*)要长。但是,新属与南盘鱼在以下方面却存在明显差异:1)两者虽然都具侧向延伸的角,但南盘鱼的角为两对,平行向头甲侧方伸出,且不甚发育,相对短宽,而新属的角只有一对,且很发育,相对细长,末端向头甲后方自然倾斜;2)新属头甲背面靠近侧缘的位置具有一对狭长椭圆形的背窗,该对构造在大窗鱼亚科的各属中广泛存在,而南盘鱼则不具有这样的构造;3)两者虽然均存在较长的角后区,但新属的相对较短,呈近半圆形,而南盘鱼的相对较长,呈梯形。

新属头甲背面靠近侧缘的位置保存了一对洞穿背甲的背窗。潘江、王士涛(1981)在记述箴门鱼时首次报道了盔甲鱼类的背窗构造,但由于标本保存条件的限制,对此构造的确认有所保留。随着背窗的构造在盔甲鱼类中的逐步确认(潘江、王士涛,1981,潘江,1992,刘玉海,1993),王念忠(1991,1995)认为龙门山鱼头甲侧缘的向内凹陷区亦应该解释为背窗的构造。对于背窗的演化,目前各家争议较大。潘江(1992)认为背窗在盔甲鱼类中是一次产生,并依据该衍生特征建立了大窗鱼亚纲(Subclass Macrothyrsapida within the Class Galeaspidomorpha)。刘玉海(1993)对背窗的功能进行了初

步探讨,并认为背窗在盔甲鱼类中多次产生或消失。赵文金等(2002)赞同了这一观点,认为像吻突一样,背窗在盔甲鱼类的演化中无疑是多次发生。盔甲鱼类系统发育分析结果表明,头甲背窗的起源在盔甲鱼类的演化中至少发生了两次,一次在多鳃鱼目五窗鱼科中,另一次在华南鱼目华南鱼科中,基于背窗特征而建立的大窗鱼亚纲并不是一个单系类群(朱敏、盖志琨,2006)。在华南鱼科中,具有背窗的属共有4个,分别为龙门山鱼、箴门鱼、中华四川鱼和大窗鱼。就背窗的形状和位置来说,新属与龙门山鱼最接近,均呈狭长椭圆形,且位于头甲背面靠近侧缘的地方,而其他3属的背窗呈宽大豌豆形,位置上也比较靠近头甲中线,与新属区分明显。另外,两者在眶孔背位、内角不发育等特征上也比较相似。不过,两者在以下方面明显不同:1)新属的头甲(不考虑角)呈长盾形,头甲后缘向后凸出,而龙门山鱼头甲(不考虑角)呈近三角形,且后缘向前凹。2)前者中背孔呈纵向椭圆形,前端稍尖,后端圆钝,而后者中背孔呈心形,与新属明显不同。3)新属角的末端向后自然倾斜,而后者角的末端明显前翘。

基于以上比较与讨论,笔者认为王冠鱼的属征明显,不能归到华南鱼科已有各属,应代表华南鱼科的一新属。

双翼王冠鱼(新种) *Stephaspis dipteriga* gen. et sp. nov.

词源 *dipterigus*, 具双翼的, 表示该鱼头甲两侧具一对翼状侧向延伸的角。

正型标本 1件保存不完整的头甲内、外模。中科院古脊椎所标本登记号 IVPP V 14333.1A, B。

归入标本 1件保存近于完整的头甲内、外模, IVPP V 14333.2A, B。

产地与层位 云南曲靖, 早泥盆世早洛霍考夫期, 西山村组。

种征 同属征(惟一的种)。

描述 个体较大的华南鱼类, 头甲(不考虑角)呈长盾形, 长大于宽, 头甲后缘向后凸出。正型标本 V 14333.1A 缺失头甲的后端及左侧部分, 最大保存长度约为 50.0 mm, 最大保存宽度约为 37.6 mm。V 14333.2 完整保存了整个头甲的外轮廓, 最大长度约 58.7 mm, 最大宽度约 35.3 mm。头甲两侧具一对侧向延伸的角。V 14333.1A 缺失左侧的角, 右侧的角也不完整, 最大保存长度约 19.4 mm; V 14333.2 两侧的角均保存完整, 长约 20.0 mm, 角的末端向头甲后方自然倾斜。包含角在内的整个头甲呈古代王冠状, 估计宽度 85.0 ~ 90.0 mm(图 1, 2A; 表 1)。

中背孔呈纵向椭圆形, 前端稍尖, 后端圆钝, 长约 8.2 mm, 宽约 4.7 mm, 长宽比率约为 1.7。中背孔前端距离头甲吻缘较远, 之间距离约为 7 mm, 后端位于两眶孔的前缘连线之前, 距离较短(图 1, 3; 表 1)。

眶孔圆形, 背位, 且较靠近头甲中线。与华南鱼科的其他成员一样, 新属的眶孔也较小, 直径仅 2 mm 左右, 约占头甲中长的 1/30, 眶孔内间距约为 10.5 mm, 眶孔前缘距头甲吻缘约 17.6 mm。松果孔保存不清楚(图 1, 3; 表 1)。

在头甲背面靠近头甲侧缘的地方, 保存了一对背窗。该构造在 V 14333.1B(图 2B)上保存得尤为清楚, 洞穿背甲, 呈狭长椭圆形, 长约 13.5 mm, 宽约 2.9 mm, 背窗中心距头

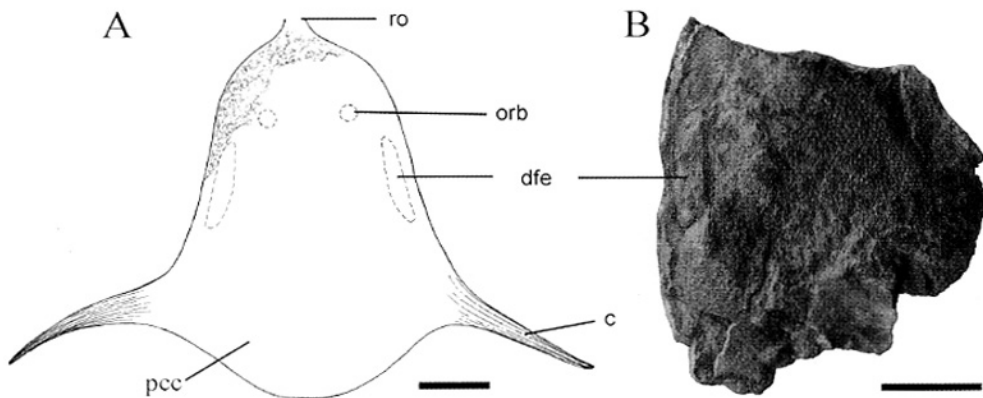


图2 双翼王冠鱼(新属、新种)的头甲,比例尺=1 cm

Fig. 2 The headshield of *Stephaspis dipteriga* gen. et sp. nov., scale bar = 1 cm

A. 一不完整头甲外模的素描 sketch of external mould of an incomplete headshield (V 14333. 2A);

B. 一不完整头甲的内模 internal mould of an incomplete headshield (V 14333. 1B, Holotype);

简字说明见图1 Abbreviations see Fig. 1

甲前、后缘的距离大致相等,前端与眶孔中心大致在同一水平线上,并且略向头甲内侧弯曲,后端则略向头甲外侧弯曲(图1, 3;表1)。

感觉管系统保存不甚清楚,仅见后眶上管、侧背管、侧横管及背联络管。后眶上管呈V字形,相对排列在两眶孔的正前方。侧背管不甚清晰,在镜下隐约可见,侧横管仅见1条,其余的并未保存。背联络管1条,较长,连接两侧的侧背管及仅有的侧横管(图1, 3)。

鳃囊数目不详,纹饰为细小的粒状突起(图2B)。

测量 见表1。

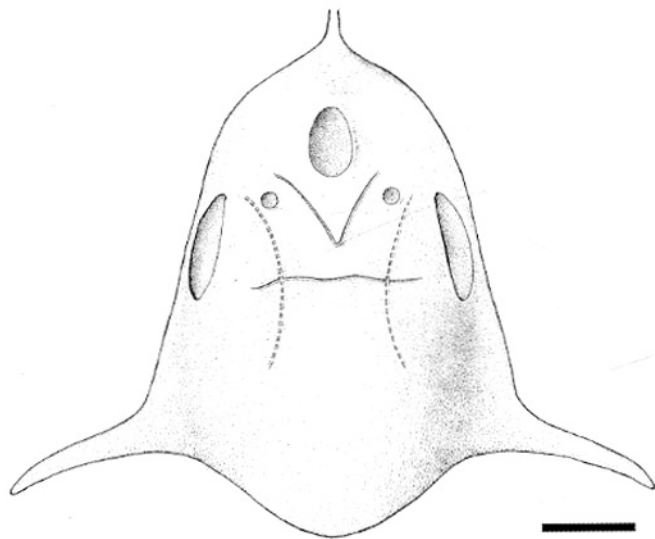


图3 双翼王冠鱼(新属、新种)头甲复原,背视,比例尺=1 cm

Fig. 3 Restoration of the headshield of *Stephaspis dipteriga* gen.

et sp. nov., dorsal view, scale bar = 1 cm

表 1 双翼王冠鱼(新属、新种)正型标本的测量

Table 1 Measurements of *Stephaspis dipteriga* gen. et sp. nov. (Holotype) (mm)

保存的最大长度(preserved maximum length of shield)	50.0
保存的最大宽度(preserved maximum breadth of shield)	37.6
眶孔直径(diameter of orbital opening)	2.0
眶间距(distance between orbital openings)	10.5
眶孔前缘至吻缘长(length from anterior end of orbital opening to rostral end)	17.6
中背孔长(length of median dorsal opening)	8.2
中背孔宽(breadth of median dorsal opening)	4.7
中背孔前端至吻端长(length from anterior end of median dorsal opening to rostral end)	7.0
背窗长(length of dorsal fenestra)	13.5
背窗宽(breadth of dorsal fenestra)	2.9
角长(length of corner)	19.4

3 系统学位置讨论及华南鱼类的多样性分布

为了确定新属的系统学位置,我们在朱敏、盖志琨(2006)对盔甲鱼亚纲系统发育分析的基础上,将新属的特征置于新的性状矩阵中(Appendix I)进行系统发育分析。因新属的中背孔呈前端稍尖,后端圆钝的纵向椭圆形,这一形态特征与五窗鱼属(*Pentathyraspis*)及南盘鱼属(*Nanpanaspis*)较为相似,所以在新的性状矩阵中增加一新性状。

54. 前端稍尖,后端圆钝的纵向椭圆形中背孔:0. 不存在 1. 存在。

系统学分析的数据处理采用 PAUP3. 1. 1 程序,依据最简约法在 Macintosh 上运行。计算时所有的性状均设为“无序(unordered)”和“等权(equal weight)”,用经验法(Heuristic search)搜索最简约的分支图。搜索结果共得到 3 个最简约的分支图,其树长(Tree length) = 132,一致性指数(CI) = 0.4924,保留指数(RI) = 0.7926。

在所得的 3 个最简约的分支图中,除了汉阳鱼(*Hanyangaspis*)和长兴鱼(*Changxingaspis*)的系统位置有所不同外,其他属种的系统发育关系均表现一致。这一结果与朱敏、盖志琨(2006)的分析结果相一致。新属位于华南鱼科(Node B,图 4)支系中,并与南盘鱼组成姊妹群(图 4)。定义该姊妹群的离征为前端稍尖,后端圆钝的纵向椭圆形中背孔和较长的角后区。但值得注意的是,定义该姊妹群的两个离征并非为该类群所特有,在盔甲鱼类的其他类群中也有出现,如前端稍尖,后端圆钝的中背孔在五窗鱼属(*Pentathyraspis*)中出现,较长的角后区在昭通鱼(*Zhaotongaspis*)、箭甲鱼(*Antiquisagittaspis*)和三岔鱼(*Sanchaspis*)中出现,目前只能解释为平行进化。从表面上看来,新属具有背窗,而且背窗的形状和位置与龙门山鱼有几分相近,新属似乎应归到大窗鱼亚科下,但系统发育分析结果却表明,新属头甲背面的背窗,与大窗鱼亚科的背窗并非同源关系,而是平行进化的结果。从其他性状的分布来看,定义 *Huananaspis* + *Macrothyraspininae*(大窗鱼亚科)(Node G,图 4)的离征为心形中背孔,而新属的中背孔并非心形,似乎该特征决定了把新属归到大窗鱼亚科下并非最简约性选择。总之,本次系统发育分析结果的一致性指数较低,新属的系统学位置还有待于在以后的工作中进一步确认。

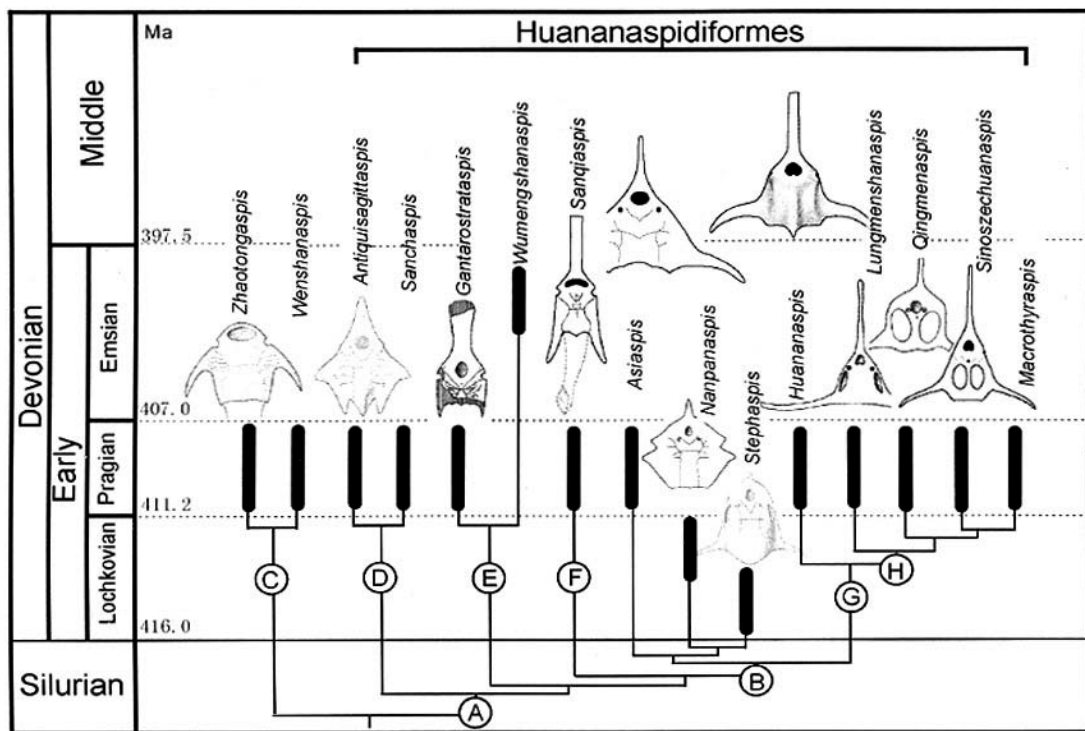


图 4 华南鱼类的年代地层学分布

Fig. 4 Chrono-stratigraphic distribution of the huananaspidoformes

The slim lines represent the relationship of huananaspidoformes; Node A: Huananaspidoformes; Node B: Huananaspidae; Node C: Zhaotongaspidae; Node D: Sanchaspidae; Node E: Gantarostrataspidae; Node F: Sanqiaspidae; Node G: *Huananaspis* + Macrothyraspinae; Node H: Macrothyraspinae

华南鱼类种类繁多,分布广泛,目前共有 13 属 16 种,与真盔甲类、多鳃鱼类共同组成了盔甲鱼亚纲的三大支系。地理分布上,在云南主要分布在曲靖地区的西山村组 (*Stephaspis*)、西屯组 (*Nanpanaspis*)、徐家冲组 (*Sanchaspis*、*Gantarostrataspis*),武定、昭通、文山等地的坡松冲组 (*Gantarostrataspis*、*Huananaspis*、*Macrothyraspis*、*Qingmenaspis*、*Sanqiaspis*、*Lungmenshanaspis*)和彝良地区的缩头山组 (*Wumengshanaspis*);在四川主要分布在江油地区的平驿铺组 (*Sanqiaspis*、*Lungmenshanaspis*、*Sinoszechuanaspis*);在广西出现于六景地区的那高岭组 (*Asiaspis*、*Antiquisagittaspis*)。上述地区在早泥盆世时均处于海盆边缘,与广海海盆相通,但又存在一定的障壁的古地理环境(王士涛等,2001)。对于几个含华南鱼类层位之间的相互对比问题,朱敏等(1994)、刘玉海(2002)、赵文金(2005)等都做过详细的讨论,本文不再赘述。这里仅结合盔甲鱼类的系统学研究结果,将坡松冲组、徐家冲组、那高岭组、平驿铺组之间华南鱼类的对比细化。坡松冲组目前发现的华南鱼类属种最多,共有 6 属,所发现的华南鱼类与其他三个组均有可直接对比的属种,如与徐家冲组可对比的属种有 *Gantarostrataspis geni* (同一种);与平驿铺组可对比的属种为: *Macrothyraspis* 与 *Sinoszechuanaspis* (姊妹群), *Lungmenshanaspis yunnanensis* 与 *L. kiangyouensis* (同一属), *San-*

qiaspis zhaotongensis 与 *S. rostrata* (同一属); 与那高岭组可对比的属种为: *Huananaspis* 与 *Asiaspis* (同一科)。另外, 徐家冲组与那高岭组可对比的属种为 *Sanchaspis* 与 *Antiquisagittaspis* (姊妹群)。从系统学研究结果来看, 以上 4 个组所含的华南鱼类, 其系统发育关系均非常接近, 这几个组之间的对比应比较可靠。

在年代分布上, 除了南盘鱼、王冠鱼来自早泥盆世洛霍考夫期, 乌蒙山鱼来自埃姆斯期外, 其他属种均来自布拉格期(图 4), 说明华南鱼类的大量繁盛是在布拉格期。但值得注意的是, 虽然南盘鱼、王冠鱼是目前华南鱼类出现的最低层位, 但系统学结果却显示二者并未代表华南鱼类的最原始类型, 这说明华南鱼类的分异可能早在志留纪就已经完成, 经过漫长的演化才达到鼎盛状态。

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FIRST DISCOVERY OF HUANANASPIDAE FROM THE XISHANCUN FORMATION (LOCHKOVIAN, DEVONIAN) OF YUNNAN, CHINA

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Key words Qujing, Yunnan, Xishancun Formation, Lochkovian, huananaspids, new genus

Summary

A new genus of the family Huananaspidae (Galeaspida), *Stephaspis* is described in this paper. Fossil materials were recovered from the Xishancun Formation (early Lochkovian, Devonian) of Qujing, Yunnan Province, China. The new genus is not only the first discovery of the Huananaspidae in the Xishancun Formation but also represents the earliest occurrence of the Huananaspidae in the Devonian to date.

1 Systematic paleontology

Galeaspida Tarlo, 1967

Polybranchiaspidida Janvier, 1996

Huananaspidiformes Janvier, 1975

Family Huananaspidae Liu, 1973

Genus *Stephaspis* gen. nov.

Etymology From *stephos* (Gr.) = crown, diadem, in reference to the shape of head-shield, and *aspis* (Gr.) = shield.

Type species *Stephaspis dipteriga* gen. et sp. nov.

Diagnosis As for the type and only species, *Stephaspis dipteriga* gen. et sp. nov.

***Stephaspis dipteriga* gen. et sp. nov.**

(Figs. 1 ~ 3)

Etymology From *dipterigus* = double wings or alae, in reference to two laterally projecting corners.

Holotype An incomplete headshield (IVPP V 14333.1A, B).

Referred material An incomplete headshield (IVPP V 14333.2A, B).

Locality and horizon Qujing, Yunnan Province, southwestern China; Xishancun Formation (early Lochkovian, Devonian).

Diagnosis A large-sized huananaspidiform with a diadem-shaped headshield, longer than broad; posterior margin of headshield protruding backward; corner developed, projecting laterally and slanting backward to the caudal extremity; inner corner not developed; rostral process not very developed, slender at the base; median dorsal opening oval in outline with long axis aligned with the rostro-caudal axis and with a little pointed rostral extremity; orbital opening fairly small, round and dorsally placed on headshield, close to the mid-line of headshield; dorsal fenestra oval in outline and aligned with the rostro-caudal axis, dorsally placed and close to lateral margin of headshield; sensory canal system poorly developed, V-shaped posterior supra-orbital canal, lateral dorsal canal, lateral transverse canal and dorsal commissure present; ornament with evenly-distributed, minute round tubercles.

Comparison and discussion According to the results of a recent phylogenetic analysis of the Galeaspida (Zhu and Gai, 2006), the new genus with oval-like median dorsal opening, fairly small orbital opening, slender rostral process and laterally projecting corner can be referred to the Huananaspidae. Seven genera are referred to the Huananaspidae at present, including *Asiaspis*, *Nanpanaspis*, *Huananaspis*, *Lungmenshanaspis*, *Qingmenaspis*, *Sinoszechuanaspis* and *Macrothyraspis*. The new form resembles *Nanpanaspis* (Liu, 1965) in the shape of the median dorsal opening and the position of the orbital opening, in which the median dorsal opening is a longitudinal oval and the orbital openings are dorsally positioned close to the midline of the headshield. In addition, both are also very similar in bearing a long portion of headshield caudal to the base of the corner. However, at least three obvious differences can be seen between them. 1) Both have laterally projecting corners, but *Nanpanaspis* bears two pairs that are not very well developed, instead shorter and broader than those of *Stephaspis*. 2) The new genus bears a pair of dorsal fenestrae on the dorsal side of headshield, a feature that is found widely in Macrothyraspinae, but *Nanpanaspis* bears no such structure. 3) Both bear a long portion of headshield caudal to the base of corner, but the portion of new genus is semicircular in shape, and much shorter than in *Nanpanaspis*, in which is trapezoid.

In particular, the new genus bears a pair of dorsal fenestrae on the dorso-lateral side of headshield. Dorsal fenestra in galeaspids was first reported in *Qingmenaspis* by Pan and Wang (1981), but their described material was poorly preserved and so they only tentatively interpreted these structures as a dorsal branchial opening. The structures were subsequently confirmed in other materials (Pan and Wang, 1981; Pan, 1992; Liu, 1993). Wang (1991, 1995) thought that the embayments at the lateral margin of headshield in *Lungmenshanaspis* could also be interpreted as dorsal fenestrae. The phylogenetic analysis of galeaspids (Zhu and Gai, 2006) has shown that the dorsal fenestrae of headshield evolved twice within the Galeaspida, once in the polybranchiaspidiform lineage, and again in the huananaspidiform lineage (nested within the Huananaspidae).

Among the huananaspidiforms bearing dorsal fenestrae, the new genus resembles *Lungmenshanaspis* in the shape and position of dorsal fenestrae, in which they are slim longitudinally and oval-shaped, and dorsally placed close to lateral margin of headshield. However, it is distinguishable from *Lungmenshanaspis* in following characters. Firstly, the headshield of *Stephaspis* (excluding the corners) is diadem-shaped, and its posterior margin protrudes caudally, whereas in *Lungmenshanaspis* (excluding the corners) the caudal margin of the headshield is triangular in outline, curving rostrally. Secondly, the median dorsal opening in *Stephaspis* is oval in outline

but compressed laterally, but in *Lungmenshanaspis* the median dorsal opening is heart-shaped. Thirdly, the corner of headshield in *Stephaspis* projects laterally and slants caudally, whereas in *Lungmenshanaspis* the corner projects laterally but turns rostrally at the caudal margin.

Based on these differences, a new genus *Stephaspis* can be erected.

2 Remarks on phylogenetic relationships within the Galeaspida

To find the phylogenetic position of *Stephaspis* within the Galeaspida, we incorporated its morphological characters into the data matrix of Zhu and Gai (2006) (Appendix I). In the new genus, the median dorsal opening shows oval in outline with long axis aligned with the rostro-caudal axis and with a little pointed rostral extremity, which is very similar to *Pentathyraspis* and *Nanpanaspis*. So a new morphological character is added to the new data matrix.

54. The longitudinal-aligned, oval-shaped median dorsal opening with a little pointed rostral extremity. (0) absent, (1) present.

The phylogenetic analysis was conducted using PAUP 3.1.1, parsimony analysis package (Swofford, 1993), using the heuristic search option (10 replicates, random sequence addition), with all characters set to equal weight and unordered. This analysis yielded three equally most-parsimonious trees, with a tree length = 132, consistency index (CI) = 0.4924, retention index (RI) = 0.7926.

Among the three most parsimonious trees, the phylogenetic relationship of *Stephaspis* within the Galeaspida remains consistent, nested within the Huananaspidae (Node B, Fig. 4) and resolved as the sister to *Nanpanaspis* (Fig. 4) on the basis of such synapomorphies as the longitudinal-aligned, oval-shaped median dorsal opening with a little pointed anterior end, and the long portion of headshield caudal to the base of corner. Although the new genus bears a pair of dorsal fenestrae on the dorsal side of headshield, the phylogenetic analysis demonstrates that they are not homologous to the dorsal fenestrae of the Macrothyraspinidae, but the result of parallel evolution.

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