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Oldest glosselline linguliform brachiopod with soft parts from the lower Cambrian of Yunnan, Southern China

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Abstract: *Lingulella chengjiangensis* Jin et al., 1993 is one of the most abundant brachiopods from the celebrated lower Cambrian Chengjiang Lagerstätte. A detailed study of abundant new well-preserved specimens clearly shows that the morphology and preserved soft anatomy differs widely from that of the linguliforms of the Subfamily Obolinae, including *Lingulella*. *Lingulella chengjiangensis* herein is re-described as the probable earliest member of the Subfamily Glossellinae, which was previously known only from the Ordovician, and it is referred to the new genus *Eoglossa*. *Eoglossa chengjiangensis* differs from species of *Lingulella* in lacking a dorsal pseudointerarea, having an elevated ventral proparea without flexure lines and in the lack of pitting on the visceral areas of both valves. The detail study of the exceptionally preserved specimens of *Eoglossa chengjiangensis* also reveals that it bears a unique musculature, which includes a single umbonal and a pair of posterolateral scars on each valve. The material of *Eoglossa chengjiangensis* also permits a more detailed study of the pedicle giving further insights into the early diversification and life habit of the linguliform brachiopods.

Key words: Brachiopoda, Lingulida, Obolidae, Glossellinae, lower Cambrian, China

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Introduction

Although the Cambrian linguliform brachiopods were remarkably successful in colonizing early marine shelly environments (Walcott 1912; Rong 1974; Holmer & Popov 1996; Popov et al. 1996; Bassett et al. 1999; Zhang et al. 2008), occurrences of their soft-bodied preservation are extremely rare and mostly restricted to a few Cambrian Konservat Lagerstätte, notably the famous Chengjiang Lagerstätte (Chen & Zhou 1997; Hou et al. 2004). During the past decades, significant progress has been made towards understanding the taxonomy of brachiopod faunas in the Chengjiang Lagerstätte (Rong 1974; Zhang et al. 2008). Numerous detailed studies of soft-bodied preserved characteristics of linguliform brachiopod faunas from the Lower Cambrian of Yunnan provide unique information that cannot be obtained by only studying structures that are preserved on the mineralized valves (Jin et al. 1993; Zhang et al. 2003, 2004a, 2004b; 2005; 2006; 2007) and some have been essential in improving our understanding the Cambrian brachiopod communities (Zhang et al. 2010, 2011; Wang et al. 2012).

Lingulella chengjiangensis Jin, Hou and Wang, 1993 is one of the most abundant brachiopods in the lower Cambrian Yu'an-shan Formation (Chengjiang muddy deposits) of eastern Yunnan. Jin et al. (1993) first described the exceptionally preserved pedicles of *Lingulella chengjiangensis* and concluded that the pedicles of the Cambrian lingulids are closely comparable in morphology and function to those found in extant lingulids, indicating that *Lingulella chengjiangensis* also had an infaunal life habit like that of living lingulids. Nevertheless, new data on the soft-tissue morphology of lingulids preserved in the Early Cambrian Chengjiang Lagerstätte has brought this interpretation into question and suggests that all known linguliform brachiopods in Chengjiang had epifaunal lifestyles (Zhang et al. 2003, 2004a, b; 2005; 2007; Wang et al. 2012). The continuing work on *Lingulella chengjiangensis* also gave

further information on its internal soft-tissue anatomy characteristics (Zhang et al. 2004a, b; 2005, 2007, 2008). However, the main features of its pseudointerarea and musculature in both valves remained unclear, leaving the systematic position of *Lingulella chengjiangensis* unsolved.

Reexamination of *Lingulella chengjiangensis* in the Early Life Institute, Northwest University, Xi'an, clearly reveals that *Lingulella chengjiangensis* differs widely from that of members of the Subfamily Obolinae, including *Lingulella* (Lochman 1940; Bassett 1982; Holmer 1989; Roberts & Jell 1990; Brock & Cooper 1993; Holmer & Popov 2000; Sutton et al. 2000; Holmer & Biernat 2002; Popov et al. 2002a; Brock & Holmer 2004; Li & Holmer 2004; Mergl 2008; Mergl & Kordule 2008; Hansen & Holmer 2011). The new data on the pseudointerarea indicate that it can be referred to the Subfamily Glossellinae (Havlicek & Massa 1973; Holmer 1989; Havlicek 1998; Holmer & Popov 2000; Popov 2000) and *Lingulella chengjiangensis* is here referred to the new genus *Eoglossa*. The Glossellinae was previously known only from the Ordovician (Havlicek & Massa 1973; Percival 1978; Holmer 1989; Havlicek 1998; Popov 2000; Popov et al. 2000, 2002b, 2007; Holmer et al. 2005; Mergl 2008; Hansen & Holmer 2011), and *Eoglossa* is to date the oldest Glosselline linguliform brachiopods. The new data on the soft anatomy of also provides some new information about the life habit of *Eoglossa*.

Geological setting, Material and Methods

The lower Cambrian stratigraphic successions are well developed and widely exposed in eastern Yunnan, South China. Scientists from the Northwest University (China) have for the past 20 years systematically investigated the celebrated Chengjiang Lagerstätte in East-Central Yunnan leading to the discovery on many new fossil localities (Zhang et al. 2001, 2004b; Shu et al. 2003). This work has resulted in 426 new specimens of *Eoglossa chengjiangensis* in the Early Life Institute (prefixed ELI),

Northwest University, China. 251 specimens from Jianshan section, 55 specimens from Yunlongsi, 57 specimens from Mafang and 54 specimens from Erjie. These four localities are located in the Jinning-Anning and Chenggong-Yiliang areas (Fig.1). The majority of the specimens were recovered from the Jianshan section in Haikou County. The thickness of the Yu'anshan Formation is about 41 meters in this area. The lowermost beds of the Yu'anshan Formation consist of black shales and laminated dark grey siltstones that are abundant in high organic carbon possibly corresponding to a shallow marine anoxic event (Luo et al. 1994, 1997, 1999; Steiner et al. 2001; Zhu et al. 2001). The upper layers, in which soft-bodied *Eoglossa chengjiangensis* are common (Zhang et al. 2004b), are considered to represent a shallow shore to proximal offshore environment. These layers consist of 'siltstone-clay' couplets, which might have formed as distal storm sediments and fine weather mud deposition (Luo et al. 1994, 1997, 1999; Steiner et al. 2001; Zhu et al. 2001). These couplets can be divided into two different types: greenish-yellow mudstones and dark-gray siltstones. The well preserved soft body fossils generally appear in the greenish-yellow mudstones. These parts of the layers lack evidence of algae, and have low levels of bioturbation as well as a high depositional rate that benefited from frequent inputs of fresh-water conditions (Luo et al. 1994, 1997, 1999; Steiner et al. 2001; Zhu et al. 2001). In Malong-Qujing areas of Yunnan, the uppermost beds of Yu'anshan Formation are generally formed by bioturbated siltstones which are accompanied by little mud composition. But these parts of layers are obviously not presented in Jianshan Section, Haikou Town in Kunming (Wang et al. 1012). In the Jianshan Section, the overlying quartz sandstones from the Devonian Haikou Formation have directly disconformable contact with the Yu'anshan Formation 'siltstone-clay' couplets in Jianshan Section.

Most specimens are preserved as flattened reddish-brown impressions of conjoined valves, but in

many just the ventral valve can be observed. Meanwhile, nearly all the specimens are exceptionally preserved with soft-part anatomy, including mantle canals, muscle scars, digestive system and lophophore. One specimen has an exquisitely preserved 3-dimensional pedicle in and two muddy slabs illustrate an in situ community of *Eoglossa chengjiangensis*. In the laboratory, limited preparation with needle and dental micro drill was used to remove the overlying sediment in a few cases. Specimens were examined both under the Olympus Zoom Stereo Microscope at Northwest University (China) and in scanning electron microscopes at Northwest University (China) and Cardiff University. The photography was carried by SEM and Canon 5D Mark II with a macro lens. Software Image J was employed to measure the length of different shell and soft-bodied characteristics.

Systematic Palaeontology

Terminology. Abbreviations of measurements (Table 1, in millimeters) are as follows: W, L = width, length of shells; Iw, Il = width, length of pseudointerarea; Vl=length of visceral area; N = number of measurements; S = standard deviation; MAX = maximum value, MIN = minimum value.

Repositories. Figured specimens are deposited in the Early Life Institute, State Key Laboratory of Continental Dynamics, Northwest University, China. The holotype and paratypes of *Eoglossa chengjiangensis* consisted of 7 specimens are deposited in the Nanjing Institute of Geology and Palaeontology, China.

ORDER LINGULIDA WAAGEN, 1885

SUPERFAMILY LINGULOIDEA MENKE, 1828

FAMILY OBOLIDAE KING, 1846

SUBFAMILY GLOSSELLINAE COOPER, 1956

Genus *Eoglossa* gen. nov.

Type and only species. *Lingulella chengjiangensis* Jin, 1993

Etymology. Eo (Latin), early, “an early type” of the Glossellinae.

Diagnosis. Shell elongate oval, thin, weakly biconvex, subequivalved, ventral valve typically subacuminate; external shell with growth lines only; ventral pseudointerarea with narrow subtriangular groove, propareas without flexure lines; dorsal posterior margin weakly thickened, but lacking pseudointerarea; visceral area of both valves slightly thickened; ventral visceral area not extending to mid-valve; dorsal visceral area with anterior tongue projection extending to mid-valve; lophophore simple spiral; one pair of posterolateral muscles, one umbonal muscle in both valves; ventral and dorsal *vascula lateralia* placed peripherally, slightly converging; dorsal *vascula media* short, bifurcate, located at the anterior of tongue; pedicle robust with a coelomic cavity, annulations on the exterior surface.

Discussion. In previous literatures, *Eoglossa chengjiangensis* was previously referred to the waste basket genus *Lingulella* due to the poor preservation of the pseudointerarea in previously described material (Jin et al. 1993, Zhang et al. 2004a, 2004b). As shown in Fig.1A-D, *Eoglossa chengjiangensis* has an elongate oval shell which differs from all other well-known species of *Lingulella* (including the type species *Lingulella davisii*), which are nearly subtriangular to subquadrate in outlines (Holmer & Popov 2000; Sutton et al. 2000). The shell of *Eoglossa chengjiangensis* also differs from all known species of the Obolinae in that the ventral propareas do not appear to have any traces of flexure lines (Holmer & Popov 2000; Sutton et al. 2000). Another key difference between *Eoglossa* and all members of the Obolinae is that the dorsal pseudointerarea is vestigial and represented by a slightly thickened

rim. In *Lingulella*, the dorsal valve contains a well-developed pseudointerarea. But all the dorsal valves of the specimens, for example in Fig.1B, C, clearly lack a well-developed pseudointerarea, and the dorsal posterior margin is only weakly thickened (Fig1A-F,). Meanwhile, this characteristic is one of the most important different feature between Obolinae and Glossellinae (Brock & Cooper 1993; Popov & Holmer 1994; Holmer & Popov 2000; Sutton et al. 2000). In addition, the visceral areas in both valves of *Eoglossa* clearly lack pitting, whilst the visceral areas in both valves of type species *L. davisii* are pitted (Sutton et al. 2000). *Eoglossa* and *Lingulella* also differ in the disposition of the muscle scars. Although the musculature of *Eoglossa* is not completely understood, it clearly differs from that of all known members of *Lingulella*, in having scars of an undivided umbonal muscle and a single pair of posterolateral muscle. The anterior lateral muscle scars and central muscle scars cannot be observed in *Eoglossa*. This type of umbonal muscle is unknown in all other members of both the Glossellinae and the Obolinae, but remarkably present in the living lingulids (Jin et al. 1993; Popov & Holmer 1994).

The ventral pseudointerarea of *Eoglossa* is well developed with a broad triangle groove and smooth propareas, whilst the dorsal valve of *Eoglossa* only shows a thickened posterior margin, like that of the Glossellinae. *Eoglossa* is similar to *Fezzanoglossa* in the general shape shell outline shape, but they differ in ornamentations (Havlicek & Massa 1973; Sepkoski et al. 2002). *Eoglossa* is characterised by only having growth lines across the whole shell. This simple ornamentation is rarely seen in other glossellinids (Havlicek & Massa 1973; Percival 1978; Holmer 1989; Havlicek 1998; Popov 2000; Popov et al. 2000, 2002b, 2007; Holmer et al. 2005; Mergl 2008; Hansen & Holmer 2011). In this aspect, *Eoglossa* is closer to *Rafanoglossa* which shares the same primitive ornamentations (Havliček 1980; Holmer & Popov 2000). However, the dorsal visceral area of *Rafanoglossa* is completely

bisected by well-developed median ridge, whilst the dorsal visceral area of *Eoglossa* remains undivided.

Eoglossa chengjiangensis sp. nov., Figs. 1,2,3,4

- 1912 *Obolus* cf. *chinensis* Walcott and Mansuy, p.20, Pl.1, fig.4
- 1993 *Lingulella chengjiangensis*, Jin; Hou and Wang, p.792, figs 3-4.
- 2003 *Lingulella chengjiangensis*, Zhang; Hou and Emig, p. s66, fig 1.
- 2004 *Lingulella chengjiangensis*, Zhang; Han, Zhang, Liu and Shu, p. 263, fig 4C, D.
- 2004 *Lingulella chengjiangensis*, Zhang; Shu, Han and Liu, p. 2-5, figs, 1F-H, 2A-D.
- 2005 *Lingulella chengjiangensis*, Zhang; Shu, Han and Liu, p. 278-280, figs 1A-E, 2D-E, H, K.
- 2008 *Lingulella chengjiangensis*, Zhang; Robson, Emig and Shu, p.246-251, figs 4G-I, 5D-F, 6B-D.
- 2010 *Lingulella chengjiangensis*, Zhang; Han, Wang, Emig and Shu, p.176, fig 1A-B.

Holotype. NIGP (Nanjing Institute of Geology and Palaeontology) 101597, 113919.

Paratypes. NIGP 101598, 113918, 113920, 113921, 113926.

Diagnosis. As for Genus.

Description. The ventral valve is on average 128% as long as wide, with maximum width somewhat anterior to about two-thirds of the total length from the posterior margin (Table. 1). The ventral pseudointerarea has a triangular pedicle groove (Fig.2A-C, E, F; Fig.4D, E), on average 16% of valve length, 42% of valve width (Table.1). The ventral propareas are elevated and lacks flexure lines (Fig.2A-F; Fig.4 D, E). The dorsal valve is on average 116% as long as wide and lacks a well-defined

pseudointerarea, but is provided with a more or less thickened posterior margin (Table.2; Fig.2A-F; Fig.4D, E). The shell surface has two types of concentric growth lines: fine and broad (Fig.2C, D; Fig.4C). The external shell was divided into several concentric bands by broad growth lines (Fig.2C, D; 4C). Each band contains several fine growth lines. The spaces within each band are from 0.6 to 0.8 mm. No other type of ornamentation could be observed.

The ventral visceral area of *Eoglossa chengjiangensis* is pear-shaped and occupies the posterior 33% of the shell (Table 1; Fig.2B, Fig.5). The dorsal visceral area has another tongue-shaped area extended from the anterior of pear-shaped area and forwards to the nearly half part of the shell (Fig.2D; Fig.5). The lophophore of *Eoglossa chengjiangensis* have trocholophe pattern and simple spiral patterns (Fig. 2G, H).

In specimens ELI-E-MF313 and ELI-E-JS372B (Fig.2K, L), a pair of teardrop posterolateral muscle scars can be seen inside the ventral visceral area and arranged symmetry along the central line of shell (Fig.5). In dorsal valve, the attached places of Posterolateral muscles present at the similar locations (Fig.2M; Fig.5). Except for a pair of posterolateral muscle, the unique umbonal muscle was observed in both valves of our specimens (Fig.2I, L, M; Fig.5).

The vascular system of *Eoglossa chengjiangensis* is rarely preserved in our specimens. The ventral *vascular lateralia* can only be observed in specimen ELI-E-JS123 (fig.2N). Meanwhile only specimens ELI-E-JS394 and ELI-E-JS384 illustrate the *vascula media* and *vascula lateralia* on the dorsal valve (Fig.2O, P; Fig.5). Only *vascula lateralia* can be observed on the ventral valve (Fig.2N; Fig.5). The *vascula lateralia* of both valves stretch out from middle lateral body wall at similar place (Fig.2N-P; Fig.5). The dorsal *vascular media* extends from the middle of anterior body wall, shape as dichotomy (Fig.2O, P; Fig.5).

The pedicle varies in length to up to 60mm, generally 3-5 times to the length of shells. The width of pedicle is from 0.8 to 1.5mm, on average occupying 23% of total valve width. The pedicle of *Eoglossa chengjiangensis* has two types of wrinkles on the pedicle (Fig.3D, F; Fig.4B). The fine wrinkles along the whole pedicle and are closely spaced. The spacing between the robust wrinkles is about 0.1-0.2mm. The anterior of pedicle is wider than the pedicle groove (Fig.3C, E). The pedicle cavity stretched out of body cavity, passing through the triangular pedicle groove and extends to the posterior of pedicle (Fig.3C, E). In most of the specimens, the pedicle cavity just forms a line, but appears to be mud-filled in specimen ELI-E-JS22 (Fig.4A), and in this specimen, the diameter of the cavity can extend to 30% of the diameter of pedicle and gradually becomes narrow from anterior to posterior.

Discussion. In the middle of anterior tongue-shaped area, there is a rounded scar possible indicating the mouth of *Eoglossa chengjiangensis* (Fig.2I, J). A U-shaped digestive canal extends from the mouth and ends with a black print of anus at the left anterior body wall, as was described by Zhang et al. (2004, 2005). The exquisite preserved digestive canal structures were also observed in our specimens, but in nearly all specimens, the trace of the intestine is suddenly lost in the central of dorsal visceral areas (Fig.2H). No clear evidence of the intestine is preserved on the interior mould of ventral valve. Based on much higher frequent occurrence of the proximal digestive tract, we suggest that the anterior part of intestine, from mouth to the central of dorsal visceral area, was more robust than the posterior part of intestine and the intestine could be arched toward the dorsal side. In specimen ELI-E-85MF (Fig.2M), a pit structure near the middle of intestine could represents a possible digestive gland which was surrounded by nerve ganglion. A pair of problematic scars was presented in dorsal valve only (Fig. 2G). The 3D preserved specimen ELI-E-JS131B (Fig.3F) clearly shows that the fine wrinkles are the internal structures of the pedicle and the robust wrinkles are the external structures of the pedicle.

The significance of *Eoglossa*

The detailed study of *Eoglossa chengjiangensis* from Eastern Yunnan, China shows that the first appearance of glossellinids can now be dated back to the Atdabanian, Lower Cambrian, whilst the oldest previous record of the subfamily was from the Tremadoc, Lower Ordovician (Massa et al. 1977). The earliest glossellinids appeared in the early Cambrian shows that the lingulids diversified earlier than previously thought and the lack of a dorsal pseudointerarea might possibly be a symplesiomorphy of the lingulids, rather than a synapomorphy of glossellinids. Moreover, *Eoglossa chengjiangensis* reveals the evolution of early glossellinids when compared with later Ordovician glossellinids. Unlike *Eoglossa*, most of later glossellinids have some complicate structures on the surface of shell, such as papillose, radial striation and scalloped lamellae. A possible reason for those evolvments of ornamentation is the life-critical arms race between brachiopods and durophagous predators as well as being adaptations to a burrowing life habit (Savazzi 1986, Zhang et al. 2011). As the selective pressure for evolution of morphologic characters resistant to shell breakage increased rapidly during Cambrian and Ordovician (Alexander 1986; Morris & Bengtson 1994; Ebbestad & Högström 2000; Brett & Walker 2002; Robson & Pratt 2007; Skovsted et al. 2007; Zhang et al. 2011), increasing complexity of shell ornament may be favored as it may increase the strength of shell or even the ability of disguise as well as a possible burrowing behavior as inferred by Savazzi (1986). However, some genera like *Rafanoglossa* still maintain the primitive ornamentation (Havlíček 1980; Holmer & Popov 2000), but it did have other changes based on the stem group *Eoglossa*. The convexity of ventral valve of *Rafanoglossa* is more prominent than *Eoglossa*. As *Eoglossa* has a rather narrower pedicle groove and bigger ventral propareas than the latter glossellinids, we suggest that another evolution tendency of the

glossellinids is reducing the ventral pseudointerarea, broadening the pedicle groove and expanding the body cavity by increasing the convexity of postlarval ventral valve. The reducing ventral pseudointerarea and broadening pedicle groove may be suitable for having a more efficient pedicle (Jin et al. 1993). The soft-body features of *Eoglossa chengjiangensis* also give us a lot of comparable information. The vascular system is similar between *Eoglossa* and other glossellinids (Holmer & Popov 2000), indicating that the vascular system and circulation inside the mantle canals were similar and this is supported by their similar shell shape, shell size and similar size of visceral area. Meanwhile, the similarities in vascular system between *Eoglossa* and other glossellinids can be an indirect evidence of them also having similar types of lophophore. If so, the lophophore appeared in later glossellinids could be even the same as in *Eoglossa chengjiangensis*, which go through three different stages, trocholophe, schizolophe and early spirolophe (Zhang et al. 2004b).

The new exceptionally preserved specimens of *Eoglossa chengjiangensis* also makes it possible to compare its anatomical features with that of modern lingulids. Our results suggests that the modern lingulids and *Eoglossa* are similar to each other in terms of the general pedicle anatomy, although their functions are quite difference. The pedicle of *Eoglossa*, which is preserved both as impression and three dimensionally, consists of an anterior part attached close to the umbonal muscle as well as a main trunk where the coelom can be clearly observed (Fig.2L; Fig.3C, E). The distal ends cannot be observed on the available specimens. But as shown in Fig.3A and Fig.3B, in two slabs, two small group of *E. chengjiangensis* are apparently held together by pedicles attached to same place, although the distal part of pedicles are not clearly preserved. This supports earlier suggestions that *E. chengjiangensis* was epifaunal like all other known lingulids from the Chengjiang and the Burgess Shale (Zhang et al. 2003, 2004a, b; 2005; 2007; Holmer & Caron 2006; Stolk et al. 2010; Wang et al.

2012). It is clear that just the similarities in general pedicle anatomy between the Cambrian and modern lingulids do not necessarily indicate an infaunal life habit, and no modern lingulids are found in close associations such as seen in Fig. 3A and Fig. 3B, but it is also known to occur in other epibenthic brachiopods from the Chengjiang (Zhang et al. 2007).

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Fig.1. A,B. Locations of the Mafang (1), Jianshan (2), Erjie (3) and Yunlongsi(4) outcrops where the brachiopod *Eoglossa chengjiangensis* was collected. C. Stratigraphic distribution of *Eoglossa chengjiangensis* in the Jianshan Section at Haikou Town, Kunming, China.

Fig. 2. *Eoglossa chengjiangensis* from the Lower Cambrian Yu'an-shan Formation, Yunnan, South China. Scale bars, 1mm. A, E. ELI-E-MF315A, ventral valve, interior view, showing well-preserved pseudointerarea; B. ELI-E-MF318B, a compressed specimen with interior dorsal valve imprint on top; C. ELI-E-JS288A, exterior view of dorsal valve and interior view of ventral pseudointerarea; D. ELI-E-JS112A, a highly compressed specimen showing dorsal interior imprint and fuzzy ventral pseudointerarea; F. ELI-E-JS273B, enlargement of ventral pseudointerarea; G. ELI-E-YLS141B, dorsal valve showing Trocholophe pattern lophophore and a pair of problematic scars (question mark); H. ELI-E-MF133A, dorsal valve showing free spread lophophore and part of intestine; I, J. ELI-E-EJ540A, dorsal valve showing simple spiral patterns lophophore, mouth and a possible nerve ganglion; K. ELI-E-MF313 ventral valve showing a pair of posterolateral muscle scars; L. ELI-E-JS372B, ventral valve showing a pair of posterolateral muscle scars and the connection between umbonal muscle and anterior pedicle cavity(arrow); M. ELI-E-MF85, dorsal valve showing musculature and possible intestine and stomach; N. ELI-E-JS123, ventral valve showing *vascula lateralia*; O, P. ELI-E-JS394 and ELI-E-JS384, dorsal valve showing *vascula media* and *vascula lateralia*. Vt= ventral valve, Ds=Dorsal valve, Pr=propareas(ventral), Pm=posterior margin(dorsal), Vr=visceral area, Lo=lophophore, Tp=trocholophe lophophore, Ne=nerve ganglion, In=intestine, St=stomach, Mo=mouth, Um=umbonal muscle, Pl=posterolateral muscle, Vl=*vascula lateralia*, Vm=*vascula media*.

Fig.3. *Eoglossa chengjiangensis* pedicle and community from the Lower Cambrian Yu'an-shan Formation, Yunnan, South China. Scale bars, 1mm. A, B. ELI-E-MF81 and ELI-E-JS20A showing the community of the *Eoglossa chengjiangensis*; C, E. ELI-E-JS33A and ELI-E-JS2A showing the pedicle cavity; D, F. ELI-E-JS62A and ELI-E-JS131B showing fine and robust wrinkle of *Eoglossa chengjiangensis* pedicle.

Fig.4. SEM and BSEM of *Eoglossa chengjiangensis*. Scale bars, 500um. A. ELI-E-JS22, pedicle cavity (arrow) with mud filled in; B. ELI-E-62A, pedicle showing well preserved wrinkle; C. ELI-BL-547A, External shell, arrows pointed to robust growth lines; D, ELI-BL-527B, details of pseudointerarea; E. BSEM of D. Pr=propareas(ventral), Pm=posterior margin(dorsal).

Fig. 5. Reconstruction of ventral (A) and dorsal interior (B) of *Eoglossa chengjiangensis*.

Table 1. *Eoglossa chengjiangensis*, average dimensions of ventral valves. Unit for mean, min and max is millimeter.

	L	W	II	Iw	VI	L/W	II/L	Iw/W	VI/L
n	102	102	13	13	36	102	13	13	36
mean	7,25	5,71	1,12	2,22	2,37	128%	16%	42%	33%
s	1,425	1,196	0,270	0,496	0,471	0,108	0,028	0,062	0,038
min	3,23	2,66	0,56	1,32	1,59	103%	11%	32%	21%
max	10,33	8,39	1,52	2,90	3,55	152%	27%	52%	42%

Table 2. *Eoglossa chengjiangensis*, average dimensions of dorsal valves. Unit for mean, min and max is millimeter.

	L	W	L/W
n	13	13	13
mean	6,14	5,328	116%
s	1,315	1,286	0,087
min	4,266	3,186	102%
max	8,564	7,365	134%