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A NEWLY DISCOVERED *CLIMACOGRAPTUS* WITH A PARTICULAR BASAL APPENDAGE

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(With 1 plate)

In 1956 Prof. Y. C. Sun and comrade Y. Z. Hung examined the graptolite fauna collected by the 435 Expedition of the Geological Bureau of Central South China, Ministry of Geology, from the Wufeng Shale (late Upper Ordovician) of Chu-Chi district, northwestern Hupeh. They handed over to me for study two particular specimens chosen from the collection. These two specimens belong to one and the same species, and are preserved as mere carbonaceous films in black shale. The thecae are evidently of the Climacograptid type, though the specimens are not so well preserved as to show all of their details. The rhabdosome is diminutive in size, but the high development and particular form of the appendage at its sicular end is very attractive. As this species is a newly discovered form, the writer designated it *Climacograptus venustus* in allusion to the beautiful appearance of its appendage.

In the following paragraphs the writer will describe in every possible detail the species, especially its appendage, and will discuss the possible evolutional path along which it has developed from certain ancestral form and the function of the appendage as a component part of the organism.

Family Diplograptidae Lapworth

Genus *Climacograptus* Hall

Climacograptus venustus, sp. nov.

(Plate I, figs. 1—7, 13)

Description: Rhabdosome very small, about 10.7 mm long; narrow (0.6 mm) at sicular end, widening distally until a maximum width of about 1.5 mm is attained at the distal end.

Sicula obscure; virgella (Plate I, fig. 5, V) short and blunt, appearing as a medial excrescence between the basal spines.

Thecae of the Climacograptid type, numbering 7—8 in a space of 5 mm in the proximal portion and 5 in the same space in the distal portion of the rhabdosome; appearing to be long and slender; free portion of ventral walls fairly long, vertical, parallel to the axis of rhabdosome; overlapped portion not clearly shown owing to ill-preservation. The overlap should be slight as the free portion is long.

The most striking object is the appendage of the sicular end. It consists of two sets of symmetrically arranged spines. The first set comprises two symmetrically disposed, long and stout basal spines (Plate I, figs. 5—6, PS). These extend from the opposite sides of the sicular end at first horizontally outward, then gradually curve downwards so as to form a broad curvature, and by their connection with the sicular end, they form together a semicircle. These two spines constitute the main structure of the appendage, and for the purpose of discrimination, they may be designated as the principal spines. From the upper side of each of the principal spines proceed three budlike accessory spines, there being thus altogether three pairs of them (Plate I, figs. 5, 6, I^1, I^2, I^3 and II^1, II^2, II^3). They are almost equally spaced, and their longer axis is perpendicular to the general trend of the principal spines. Thus the combination of the principal spines with the accessory ones gives an appearance somewhat resembling to the shape of one half of a toothed wheel.

Each of the principal spines measures about 3 mm in length, and has a maximum width of about 0.3—0.5 mm, tapering gradually towards its apex. It expands at the portions just below the bases of the accessory spines, and contracts at the points between the bases of every two adjacent spines. The alternation of expansion and contraction gives rise to a jointed appearance like that of a lotus root. The arrangement of the accessory spines is concentrated in the first half of the length of the principal spine, while the remainder of the length is bare. The principal spines appear to be hollow tubes closed at the pointed end. Inside of each of them there appears a fine line running throughout its length. It is not impossible that this line represents a thin spine enclosed in the tube.

Accessory spines are about 2 mm long and 0.2—0.4 mm wide. Width of the interspaces between bases of successive spines ranges from 0.2 to 0.4 mm. In appearance the accessory spines resemble to a great degree the thecae of certain *Rastrites*. Some of them are club-shaped, being expanded at middle and contracted towards both the apex and the base (Plate I, fig. 6, I^2); while others are almost uniform in width throughout and have a rounded apex (Plate I, fig. 5, I^2 and II^3); still there are others which are wide at base and narrow towards the apex, thus assuming the shape of an elongated triangle (Plate I, fig. 6, II^1). In each accessory spine there is usually a median line running in the direction of extension of the spine. In some of the spines this line is only dimly shown and appears discontinuous (Plate I, fig. 5, II^1, II^2, II^3); while in others it is observed that this line is continuous and wide at middle, narrowing towards both ends and eventually thinning out before it reaches the apex and base of the spine (Plate I, fig. 5, I^2 and fig. 6, II^2). This shows that the median line represents nothing but a narrow empty space in the center of the spine, that is to say, the accessory spines are also hollow inside.

Discussion: With the exception of the appendage at the proximal end, the present species closely resembles to *Climacograptus supernus* Elles et Wood (Elles and Wood, 1906, Brit. Grapt. pp. 196—199, pl. XXVI, figs. 11a—d) in the size and form of rhabdosome and the characters of thecae. The stratigraphical position of the beds in which the present species occurs also corresponds to that in which the British form occurs. Elles and Wood pointed out that *Cl. supernus* bears obvious resemblance to *Cl. bicornis* (Hall) and, as the former occurs in a much higher horizon, it may be a dwarfed relic of the latter. The writer thinks that it is very possible that both the present species and *Cl. supernus* are descended from *Cl. bicornis* (Hall). The present species may be another relic form of Hall's species, while its rhabdosome is as dwarfed as *Cl. supernus*, its basal spines are however much further developed.

It has long been known that the appendages of the sicular end in *Cl. bicornis* and its varieties (var. *peltifer, signum* and *tridentatus*) are well developed and present a variety of forms. In 1908 Ruedemann made a systematic investigation into the development of the various forms, and successfully made out the general trend of their evolution (Ruedemann, 1908, Grapt. New York, pt. 2, pp. 80—85 and Table A). He pointed out that the simplest or the most primitive form of the appendages is composed of only two lateral spines which are thin, slightly curved and widely diverging (Plate I, fig. 7). From this all the complicate forms have evolved. The leading tendency of evolution is to develop wings at the back of the lateral spines. In most specimens these wings grow most rapidly at the base of the spines. But at the earlier stages, the wings are narrow and, as they have developed along incurved spines, their combination gives rise to a crescent form (Plate I, figs. 8—9). As a result of further development, the wings become wider and look like the caudal fins of the fish (Plate I, fig. 10). The form bearing the appendage with these fully grown wings has been designated as *Cl. bicornis* var. *peltifer* by Lapworth.

The writer thinks that the appendage in *Cl. venustus* must also have been evolved from two simple lateral spines in a way similar to that in which the appendage of *Cl. bicornis* var. *peltifer* has been developed from the simplest form of *Cl. bicornis*. The only difference is that, in *Cl. venustus* the accessory spines are developed on the back of the lateral spines instead of the development of the wings. It thus becomes apparent that there are two parallel ways of evolution, one of which leads from the simple lateral spines to the formation of wings (Plate I, figs. 7—10); the other from the same to the formation of accessory spines (Plate I, figs. 7—11—12—13). As both the accessory spines and the wings are developed on the back of the lateral spines and thereby occupy the same position, and the development of both of them obviously shows the same endeavour, an endeavour to secure a large surface for the appendages, the major tendencies of the two ways of evolution are in agreement, although they resulted in the formation of different structures, the undivided wings and the isolated accessory spines.

Ruedemann confirmed that the wings in *Cl. bicornis* and its varieties are flat bodies. He agreed with Frech's view that during the life of the organisms, these flat bodies act as a rudder aiding in a kind of vertical swimming or floating movement (Roemer and Frech, 1897, Lethaea palaeozoica, p. 533). As mentioned above, the accessory spines in *Cl. venustus* are arranged in one plane and occupy the same position as that of the wings, so that by grouping together with the principal spines they may act as a rudder as well. Besides, as they are spines, they also assume the defensive function, the thecae in the proximal portion of the rhabdosome being under their protection. The latter function is evidenced by the fact that the accessory spines always show a tendency to bend towards the proximal portion of the rhabdosome so as to cover the earlier thecae in the best possible way. The double functions of the appendage in *Cl. venustus* seem to imply that it has arrived at a still higher stage of evolution as compared with the wings in *Cl. bicornis,* var. *peltifer*.

It appears hardly possible that the complicate appendage consisting of the powerful principal spines with fully developed accessory ones could have developed directly from the simplest form with only two thin lateral spines. There must be some forms intermediate between them, which have not yet been discovered at present. Plate I, figs. 11 and 12 are idealized drawings illustrating the possible transitional forms.

It has long been noticed that in graptolites the high development of spinous structures is usually accompanied by the reduction of other structures or the size of the rhabdosome. This reduction may be expressed either in the form of the attenuation of the test of the rhabdosome such as occurred in *Glossograptus* and *Lasiograptus,* or in the form of the shrinkage of the whole rhabdosome such as in *Cl. venustus* and *Isograptus caduceus,* mut. *nanus* Ruedemann, etc. This is probably because of the fact that the vitality of the organism is limited, when it is spent in the overmuch development of the spinous appendage, little should be left for the development of other parts or the whole of the rhabdosome proper.

Ruedemann pointed out that dwarfed rhabdosomes with fully developed spinous structures are usually relic forms. The fact that *Isograptus caduceus* mut. *nanus* is the last survivor of the genus to which it belongs, is one of many like instances (Ruedemann, 1908, Grapt. New York, pt. 2, p. 73). In a similar manner, the present species appears to be the relic form of *Cl. bicornis,* and this may serve as a new instance in support of Ruedemann's view.

Locality and stratigraphical position: *Cl. venustus* was found from the black shale on the slope of the hill Ti'en-Chi-Pa near the village Heng-Tsao, Chu-Chi district, northwestern Hupeh, in association with *Climacograptus supernus* Elles et Wood and *Dicellograptus complanatus* var. *ornatus* Elles et Wood, etc. The fauna is evidently of a late Upper Ordovician age (Wufengian, equivalent to Ashigillian of the British succession). The specimens of *Cl. venustus* after being studied have been transferred to the Peking Geological Museum of the Ministry of Geology.

图 版 I 說 明

图 1—6 "美丽栅笔石"(新种)。

1,2. 正型标本,放大2倍及原大(号碼 519)。

3,4. 副型标本,放大2倍及原大(号碼 520)。

5,6. 图2及图4始部放大10倍,显示附連物的結构。
PS 为主干刺; I^1, I^2, I^3 及 II^1, II^2, II^3 为附生刺; V 为胎胞刺。

图 7—8—9—10. 表示"两刺栅笔石"从簡单底刺到形成翼状体的演化过程(依照路德曼, 1908, 图表 A 中的图 1,6,12 及 25)。

7,8,9. "两刺栅笔石"。

10. "两刺栅笔石,盾牌形变种"。

图 7—11—12—13. 表示"美丽栅笔石"从簡单底刺到形成附生刺的演化过程。

11,12. 为推断的可能过渡类型。

13. 为图2始部放大2倍。

Explanation of Plate I

Figs. 1—6. *Climacograptus venustus,* sp. nov.

1, 2. Holotype, enlargement (× 2) and natural size (No. 519).

3, 4. Paratype, enlargement (× 2) and natural size (No. 520).

5, 6. Enlargements (× 10) of proximal portions of Figs. 2 and 4, showing the structures of the appendage. PS, principal spines; I^1, I^2, I^3 and II^1, II^2, II^3 accessory spines; V, Virgella.

Figs. 7—8—9—10. Figures so arranged as to illustrate the evolutional path leading from the simple lateral spines to the formation of wings (after Ruedemann, 1908, table A, Figs. 1, 6, 12 and 25).

7, 8, 9. *Climacograptus bicornis* (Hall).

10. *Climacograptus bicornis*, var. peltifer Lapworth.

Figs. 7—11—12—13. Figures so arranged as to illustrate the evolutional path leading from the simple lateral spines to the formation of accessory spines.

11—12. Ideal drawings illustrate the possible transitional forms.

13. Enlargment (× 2) of proximal portion of Fig. 2.