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SOME SPECIES OF *TETRAGRAPTUS* FROM THE NINGKUO SHALE (LOWER ORDOVICIAN) OF ZHEJIANG (CHEKIANG)

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The present paper describes the following 19 species and varieties of *Tetragraptus* from the Ningkuo Shale of Zhejiang, among them 8 are new to science.

1. *Tetragraptus quadribrachiatus* (Hall)
2. *Tetragraptus harti* J. S. Hall
3. *Tetragraptus* sp.
4. *Tetragraptus zhejiangensis* Geh (sp. nov.)
5. *Tetragraptus amii* Elles et Wood
6. *Tetragraptus rigidus* Geh (sp. nov.)
7. *Tetragraptus reclinator* Elles et Wood
8. *Tetragraptus lui* Geh (sp. nov.)
9. *Tetragraptus ovalis* Geh (sp. nov.)
10. *Tetragraptus bigsbyi* (Hall)
11. *Tetragraptus bigsbyi* var. *lata* Hsü
12. *Tetragraptus mobergi* Monsen
13. *Tetragraptus hemirotundus* Geh (sp. nov.)
14. *Tetragraptus hsüi* Geh (sp. nov.)
15. *Tetragraptus isograptoides* Geh (sp. nov.)
16. *Tetragraptus minutus* Geh (sp. nov.)
17. *Tetragraptus taraxacum* Ruedemann

18. *Tetragraptus* cf. *erectus* Mu, Geh et J. X. Yin

19. *Tetragraptus insuetus* Keble et Benson

These graptolite specimens were mainly collected by Prof. Y. H. Lu, A. T. Mu and others from the Lower Ordovician Ningkuo Shale of the Jiangshan (Kiangshan) and Changshan districts, western Zhejiang in 1954, 1956 and partly by the numbers of the Geological Bureau of Zhejiang and the writer from the Ningkuo Shale of many districts of Zhejiang in 1958—1962.

The genus *Tetragraptus* was established by Salter in 1863 with *Graptolithus bryonoides* Hall as the type. The later authors usually considered *Graptolithus bryonoides* to be synonymous with *Fucoides serra* Brongniart. It seems to the writer that these two are not identical. The rhabdosome of *Graptolithus bryonoides* Hall (Hall, 1865, pl. 4, fig. 1) is smaller in size and the stipes are inclined and are shorter in length and less than 4 mm in width. Further thecae are shorter and broader than those of *Fucoides serra* Brongniart. Therefore, the writer is of the opinion that it is better to regard the two species as distinct species of *Tetragraptus* and that *Graptolithus bryonoides* Hall (Hall, 1865, pl. 4, fig. 1) should be the genotype of *Tetragraptus*.

The 19 forms of *Tetragraptus* described in the present paper fall into two groups: the Horizontal and the Reclined groups. The great majority of them belong to the reclined group.

In the mode of branching and the character of thecae, the genus *Tetragraptus* agrees with *Dichograptus*, but differs from the latter in that the number of the stipes in *Tetragraptus* is more stable. Accordingly, the family Tetragraptidae may be regarded as a subfamily of the Family Dichograptidae.

The writer wishes to express his indebtedness to Prof. A. T. Mu for the instruction and critical reading of the manuscript.

Description of Species

Tetragraptus quadribrachiatum (Hall)

(Pl. I, fig. 9)

This species is represented by many specimens. The rhabdosome consists of four horizontal stipes. The "funicle" is short and rigid, measuring 1.2—1.3 mm in length and 0.7 mm in width. The four terminal stipes are more than 16 mm in length. They are about 0.6—0.65 mm wide at their proximal end to a maximum width of 1.4 mm in the distal part.

The sicula is obscure. The thecae are generally inconspicuous, with the exception of distal portion of the stipe. They are cylindrical, about 2.6 mm in length, three times as long as wide; the ventral margin is straight and the apertural margin is normal or slightly concave. They are inclined to the axis of the stipes at about 35°, and overlapped two-thirds of their length. In a length of 10 mm there are 9—10 thecae.

Comparison: The present form closely resembles *Tetragraptus decipiens* T. S. Hall of Victoria in the shape of rhabdosome and in the arrangement of thecae, but differs slightly from the Victorian species in the direction of the stipes.

Horizon and Locality: This species occurs very abundantly in the Ningkuo Shale of many districts of Zhejiang. Field Nos. CB42, CB49, GD60, GD63, GF44, 1037-A2, 1288-A4, 2652-A1, 2652-A5, Num. 14; Cat. Nos. 13959—13962 (Plesiotypes).

***Tetragraptus* sp.**

(Text-fig. 1)

There is only one incomplete specimen with its counterpart. The stipes are long and straight, measuring more than 11 cm in length. It increases slightly in width from about 3.9 mm at its proximal end to 4.5 mm in the distal extremity. The dorsal margin of the stipe is even and straight and the ventral margin is serrate due to the mucronate apertures of the thecae.

The thecae are slender tubes, measuring 5.7—7.2 mm in length, five to six times as long as wide; the apertural margins are even or slightly concave and the ventral margins are slightly concave, forming thus an apertural denticle. They are inclined to the axis of the stipe at an angle of 25°—30° and overlap nearly all of their length. There are 5—4 thecae in 10 mm.

Comparison: In the shape of the stipes and the character of the thecae, this form is similar to *Tetragraptus headi* (Hall) (J. Hall, 1865, pl. 6, fig. 8) from North America, but our specimen is incomplete.

Horizon and Locality: This species occurs in the subzone of *Didymograptus abnormalis* of the Ningkuo Shale at Yingdianjie, Zhuji in association with *Didymograptus* sp. Field Nos. GD58; Cat. Nos. 13171, 13171a.

***Tetragraptus harti* Hall**

(Pl. I, fig. 14, text-fig. 2)

This form is represented by one specimen only. The “funicle” is straight, about 2.4 mm in length. The stipes of the second order or the terminal stipes measure 22—26 mm above in length and only 0.15 mm in breadth. They bifurcate at 90° to 120°.

The sicula is conical in shape, measuring 0.85 mm in length and about 0.15 mm in breadth at the aperture.

The thecae are tubular, measuring about 1.4 mm in length, three times as long as wide; the ventral margin of the thecae is nearly straight and the apertural margin is normal. They are inclined to the axis of the stipes at 30° and overlap one-third to two-fifths of their length. There are 10 thecae in 10 mm.

Comparison: In the essential characters of the rhabdosome, our specimen is identical with the type specimens of *Tetragraptus harti* figured by T. S. Hall (Hall, 1914, p. 113, text-figs. 5—6).

Horizon and Locality: This form occurs in the Lower Ordovician, Ningkuo Shale at Zhitang, Longyou. Field No. GH53; Cat. No. 13963 (Plesiotype).

***Tetragraptus zhejiangensis* Geh sp. nov.**

(Pl. I, figs. 1—8)

The rhabdosome is fine, consisting of four main stipes expanded outward. In one specimen (pl. I, figs. 5—7), the first order stipes diverge from the sicula at an angle of about 165° and in the others at 180°. The “funicle” is rather long, measuring 3.4—2 mm in length. It is very thin, only 0.2 mm in width. The stipes are thin and slightly flexuous about more than 17 mm in length and less than 0.5—0.9 mm in width. The angle of bifurcation between the stipes of the second order is 90°—110°.

The apical portion of the sicula has been broken. The sicula is 0.2 mm wide at its aperture. The first theca originates from the apical portion of the sicula.

The thecae are slender tubes. They are slightly elaborated. Their ventral margins are slightly sigmoid nearly parallel to the axis of the stipe. The thecae are 1.6–2.7 mm in length and nine to ten times as long as wide. They overlap three-fifths to one-half of their length, numbering 7–8 in 10 mm.

Comparison: In the general aspect of the rhabdosome, this species resembles *Tetraraptus harti* Hall, but differs strikingly therefrom in the character of the thecae and in the mode of growing of the stipes as mentioned above. In the elaborated thecae, the present form resembles *Allograptus* and *Holmograptus*, but differs in the number of the stipes. The thecae of *Allograptus* and *Holmograptus* are more elaborated than those of this species.

Horizon and Locality: This new species occurs in the Ningkuo Shale at Huangnigang of Jiangshan, at Dawu of Changshan and at Zhitang and Longmenqiao of Longyou in association with *Tetraraptus bigsbyi* (Hall), *Didymograptus extensus* (Hall), *Glyptograptus* sp. etc. Field Nos. CC9, CC10, CC11, CC15, GC72, GF51, GF114, GF151, GH53, GH54; Cat. Nos. 13964 (Holotype), 13965–13969 (Paratypes).

Tetraraptus amii Elles et Wood

(Pl. I, figs. 10–13)

The rhabdosome is large, consisting of four slightly reclined stipes, which are about 38 mm or more in length. The stipes are thin at origin, where the width is about 0.5 mm, but widen more or less rapidly to a width of 2.5 mm within the first 7 mm of the length and gradually to attain the maximum width of 3 mm in the distal portion.

The sicula is inconspicuous, only a conic aperture about 0.95 mm in diameter has been observed in the center of the “funicle”.

The thecae are simple tubes, 3.6 mm in length, two times as long as wide; the ventral margin is nearly straight or slightly concave, expanding slightly toward their apertures. The apertural margin is somewhat concave. The angle of inclination varies from about 30° in the initial region of each thecae to 45°–50° near the aperture. They overlap three-fifths of their length and number 8–7 in 10 mm.

Comparison: In the shape of the rhabdosome, in the character of the thecae and in the branching of the stipes, our specimens closely agree with *Tetraraptus amii* Elles et Wood. One of the specimens figured by Törnquist from North Europe (Törnquist, 1904, pl. 1, fig. 18) closely agrees with our specimens in the character of the rhabdosome, whereas some specimens described by Monson as *Tetraraptus amii* Elles et Wood from Norway, in the writer's opinion, is not identical with this species.

Horizon and Locality: The present form occurs in the Ningkuo Shale at Dawu of Changshan and at Zhuge of Longyou in association with *Tetraraptus* sp., *Didymograptus extensus* (Hall), *Glyptograptus dentatus* (Brongniart) etc. Field Nos. CB47, Zhuge II-1; Cat. Nos. 13970, 13971a–b (Plesiotypes).

Tetraraptus rigidus Geh (sp. nov.)

(Pl. II, figs. 10–16, text-figs. 3a–c)

The rhabdosome is very large, consisting of four conspicuous reclined stipes. The

stipes are more than 21 mm in length. They are narrow at their initial ends, where the width is about 2.1 mm, widening gradually to a maximum width of 4.3 mm in the distal part. But at the extreme end, the width of the stipes decreases to be 2.8 mm. In one specimen (pl. II, fig. 10) the stipes are slightly narrow in width only 1.9 mm at the initial end and 3.2 mm in the maximum width. The "funicle" is short and straight, measuring 1.9—2.2 mm in length and 1 mm in width.

The sicula is generally concealed by the funicle. In one specimen (pl. II, figs. 11—12), the sicula appears to be a cone, measuring 2.25 mm in height and 0.4 mm in breadth.

The thecae are cylindrical, expanding toward their apertures. Their ventral margin is nearly straight, but they are usually slightly concave in the apertural portion. The apertural margin of the thecae is normal or slightly concave. Both the apertural and the ventral margins are expanded, forming a spine. In the proximal portion of the stipes, the thecae measure 2.5 mm in length and 0.7—0.8 mm in width; whereas in the distal portion the length of the thecae is 4.5 mm and the breadth is 1.25 mm. The average angle of inclination of the thecae is 40°—60°. The proximal portion of the thecae is inclined at a greater angle than the distal portion. The thecae are closer in arrangement, overlapping almost throughout their length. The number of thecae in a space of 10 mm is 7—8, but in the distal portion the thecae are slightly removed in arrangement, the number in the space of same unit being 6.

Comparison: This species has been considered to be synonymous with *Tetragraptus serra* (Brongniart) by Elles and Wood and many others. After a careful comparison of *Graptolithus bryonoides* Hall with *Fucoides serra* Brongniart, the writer found that these two forms are not identical in the size of the rhabdosome, in the shape of the stipes and in the character of the thecae, and they seem to be two species.

In the outline of the rhabdosome this form closely resembles *Tetragraptus bigsbyi* var. *divergens* Mosen of North Europe, but differs slightly from the latter in the shape of the stipes and in the number of the thecae. This species has rigid stipes and less number of thecae.

Horizon and Locality: This form occurs in the Lower Ordovician Ningkuo Shale at Huangnigang of Jiangshan, at Dawu of Changshan and at Longmenqiao of Lonyou in association with *Didymograptus abnormis* Hsü, *Didymograptus* sp., *Trigonograptus ensiformis* (Hall), *Trigonograptus ensiformis* var. *minor* Mu et Lee, *Cardiograptus* sp. etc. Field Nos. CB48, CB51, CB59, CB59b, CB59c, CC14, GO6, GD8, GD9, GD49, GF42, GF49, GF147, 3021; Cat. Nos. 13972 (Holotype), 13973—13975 (Paratypes).

***Tetragraptus reclinatus* Elles et Wood**

(Pl. II, figs. 1—6)

The rhabdosome consists of four reclined and nearly parallel stipes. The stipes are slender and straight, about 13 mm or more in length. They are narrow at their initial ends, widening rapidly to a width of 1.5—1.6 mm. This width remains unchanged to the distal end.

The sicula is a long cone, measuring 2.2 mm in length and 0.6 mm in width. At its top, there is a flaccid ting nema extended outward, measuring 1 mm in length. The apertural margin of the sicula is even and slightly concave. The virgella is about 0.8 mm in length.

The thecae are tubular, measuring 2—2.2 mm in length, four times as long as wide, expanding toward their apertures and forming a denticle. The ventral margins are nearly straight and their apertural margins are straight or slightly concave. They overlap almost throughout their length. The inclination varies from 30° to 60° owing to curvature. In 10 mm there are 10—9 thecae.

Comparison: In the general form and in the size of the stipes, the present form closely agrees with *Tetraraptus reclinatus* Elles et Wood. The difference is that the thecae of the present form have a distinct apertural denticle and are looser in arrangement. In the character of the thecae, this form bears some resemblance to *Tetraraptus rigidus* Geh (sp. nov.), but evidently differs from them in the width of the stipes. The stipes of the latter are not less than 3 mm in width.

Horizon and Locality: This form occurs in the Lower Ordovician Ningkuo Shale at Huangnigang of Jiangshan, at Dawu of Changshan, at Longmenqiao of Longyou and at Shilingshang of Changhua in association with *Cardiograptus* sp. etc. Field Nos. CB42, CB47, CB50, GD6, GD59, GF51, GF134, GF149; Cat. Nos. 13976—13977 (Plesiotypes).

Tetraraptus lui Geh (sp. nov.)

(Pl. IV, figs. 1—5)

There are many specimens of this form in the writer's material. The initial end of the rhabdosome is even and straight, consisting of four main stipes. The "funicle" consists of two initial thecae, measuring 2—2.5 mm in length and only 1.35 mm in width. The stipes diverge from both ends of the "funicle", and are curved upwards rapidly. Sometimes they are slightly inclined outward in their distal part. The length of the stipes is about 16.6 mm. These stipes are narrow at their initial ends, where the width is 1.8 mm, widening very gradually to a maximum breadth of 3.4 mm. This breadth is then maintained distally, but there is usually a decrease in width near the distal extremity owing to the imperfect growth of the last thecae.

The sicula is a long cone, measuring 3.9 mm high and 0.6 mm wide, its top diminishes abruptly, forming a long nema about 0.9 mm in length.

The thecae are cylindrical, They are 2.5 mm long in the proximal part of the stipes and are 3.5 mm in the distal. They are three or four times as long as wide. The ventral margin of the thecae are slightly concave and the apertural margin is straight, forming an angle of 120° with general direction of the stipes. The angle of inclination varies in different portions of the stipe. The thecae in the immediate proximal region are nearly inclined at a right angle, while those in the distal portion are gradually at 65° to 70°. They overlap three-fifths to three-fourths their length. The thecae are close in arrangement, numbering 12 in a space of 10 mm when mature. The growth of the thecae closely agrees with *Tetraraptus bigsbyi* (Hall), but differs therefrom in the development of the first two thecae, in this form each of which is 50° or 45° with the sicula in its both sides.

Comparison: The nearly erected stipes serve to distinguish this species from all other known forms of *Tetraraptus*. In the shape of the rhabdosome, this form resembles *Tetraraptus rigidus* Geh (sp. nov.), but differs from the latter in the smaller thickness of the stipes, in the greater number of the thecae in a given unit and in the trian-

gular apertural portion of the thecae. The present form resembles *Tetraraptus woodi* Ruedemann, but differs from the American species in the greater size and in the smaller number of thecae in a given unit.

Horizon and Locality: *Tetraraptus lui* Geh (sp. nov.) occurs in the Lower Ordovician Ningkuo Shale of Huangnigang of Jianshan. Field Nos. CB47, CB49, CB59c; Cat. Nos. 19009 (Holotype), 14010—14013 (paratypes).

***Tetraraptus ovalis* Geh (sp. nov.)**

(Pl. IV, figs. 8—9)

There is only one specimen in well preservation. The rhabdosome with four reclined stipes is ovate in outline, about 24.5 mm in length. The maximum width is attained 21 mm at the middle portion of the rhabdosome. The stipes are above 22 mm in length and narrow at origin, widening very gradually to a maximum width 3.9 mm. This width is maintained distally, but there is usually decrease in width near the distal extremity (about 0.7—1.3 mm in width).

The sicula is inconspicuous. The thecae are tubular. Their ventral margins are slightly concave expanding toward their apertures, and forming a conspicuous denticle. The thecae are 2.5—4 mm in length and are three times as long as wide. The thecae overlap almost throughout their length and inclined at 45° to 30°—25°. They number 12—11 in 10 mm.

Comparison: The character of the rhabdosome serves to distinguish this species from all other known species of the genus *Tetraraptus*. In the outline of the rhabdosome, the present form resembles *Tetraraptus inosculans* Nicholson et Marr, but differs therefrom in the greater size of the rhabdosome and in the smaller number of the thecae.

Horizon and Locality: This new species occurs in the Lower Ordovician Ningkuo Shale at Huangnigang of Jianshan. Field No. CB48; Cat. No. 14014 (Holotype).

***Tetraraptus bigsbyi* (Hall)**

(Pl. II, fig. 7; pl. III, figs. 16—18)

There are many specimens preserved as films. The rhabdosome consisting of four reclined stipes is spheriform in outline, less than 14 mm in diameter. The stipes are 7—14 mm in length and 2.7—3.7 mm in the maximum width in the middle part.

The sicula is conspicuous. The “funicle” is short and straight, measuring 1.7—2.7 mm in length. The thecae are long tubes with concave ventral margins, expanding toward their apertures. The angle of inclination varies in different portion of the stipe. The thecae in the proximal portion are nearly inclined at right angle, while those in the mature portion are inclined at their bases at 40°—50°, but then curve downward so that near their aperture the angle of inclination increases to about 60°—70° and only 30°—40° in the distal. The length of the thecae varies in different portion of the stipes and is about 4 mm in maximum. The thecae number 11—10 in 10 mm.

Comparison: The size of the rhabdosome and the shape of the stipes serve to distinguish this species from all other known species of the genus *Tetraraptus*. The specimens described as *Graptolithus bigsbyi* by Hall (Hall, 1865, p. 86) seem to represent two forms: one is spheriform with directly upward stipes, and another is smaller ovate form with stipes nearly connected at their extremity. The former is identical with

Tetraraptus bigsbyi, and the latter is here named *Tetraraptus bigsbyi* var. *similis*.

Horizon and Locality: This form occurs in the Lower Ordovician Ningkuo Shale of the many districts of Zhejiang. Field Nos. CB44, CB47, CB48, CB49, CB203, CC13, CC14, CC15, GD10, GD12, GD49, GD65, GF34, GF37, GF39, GF54, GF59, GF60, GF65, GF66, GF114, GF139, GF141, GH12, 2072A1, 2072A2, 2072A6, 2072A10, 3007, 3023 etc.; Cat. Nos. 13982—13985 (Plesiotypes).

Tetraraptus bigsbyi var. *lata* Hsü

(Pl. III, figs. 19—22)

There are many specimens. One of them is well-preserved in relief. The rhabdosome is oval in shape, measuring 17.7 mm in length and 14—16.3 mm in width. The stipes are reclined. They are wide and straight with semicircular ventral wall. They are narrow at their origin where the width is about 2 mm, but widen to a maximum of 4.9 mm in the middle portion.

The sicula is inconspicuous. The thecae are long tubes, expanding toward their apertures. The inclination varies in different portions of the stipe owing to the curvature of the thecae. The thecae in the proximal region are about 30°, while those in the mature portion are inclined at their bases at about 20°, but then curve outward so that near their apertures, the angle of inclination increases to about 90° or 50°—60°. When fully developed, the length of the thecae are about 4—4.5 mm. and five to six times as long as wide, overlapping almost throughout their length. The number of thecae in the proximal portion is 4—5 in a space of 5 mm, but in the distal portion, only three in the same unit.

Comparison: The present form is identical with Hsü's type specimens. According to Hsü's description in this species, there are 12—10 thecae in 10 mm. After a detailed examination, the writer found that in both Hsü's type specimens and ours, the number of the thecae are all 9—10 in a space of 10 mm.

Horizon and Locality: This species occurs in the Lower Ordovician Ningkuo Shale of many countries. Field Nos. CC14, CC15, CB48, CB49, GF114, GF154, GH09, GH50; Cat. Nos. 13986—13989 (Plesiotypes).

Tetraraptus mobergi Monsen

(Pl. IV, figs. 6—7, text-fig. 4)

The rhabdosome is nearly elongate-fusiform, measuring about 14 mm in length and having a maximum width of about 8 mm. This width is maintained to the distal portion. The sicula is unapparent. The "funicle" is 1.7 mm in length. The rhabdosome consists of four reclined and subparallel stipes. The width of the stipes is uniform about 2.2 mm at the central portion.

The thecae are simple tubes, measuring 3.6 mm in length and 0.7—0.8 mm in width, with slightly concave ventral margin. The proximal thecae are nearly inclined at 60°—50°, and the distal ones are inclined at 20°—30°. They overlap almost throughout their length, numbering 8 in 10 mm.

Comparison: In the character of the rhabdosome and thecae, our specimens are identical with the type specimens described by Monsen (Monsen, 1937, p. 173, pl. 13, fig. 12). The only difference is that the stipes of the present form are not in contact

at their ends as in the specimens of Norway.

Horizon and Locality: This form occurs in the lower part of the Ningkuo Shale at Yingdianjie in association with *Didymograptus* sp. etc. Field No. GD56; Cat. Nos. 13173a—b, 13174 (Plesiotypes).

***Tetragraptus hemirotundus* Geh (sp. nov.)**

(Pl. III, figs. 7—13)

There are many well preserved specimens. The rhabdosome is spherical in outline, measuring 5.8—6.5 mm in length and 5.5—6.5 mm in width. A few examples are slightly elongate. The stipes are nearly parallel. They are semicircular in shape and 4 mm in maximum breadth.

The sicula is loniconic, measuring 2.5 mm in height and 1.1 mm in width. The thecae are cylindrical, expanding toward their aperture. Their ventral margins are slightly curved. The angle of inclination varies owing to curvature. The inclination is decreased slightly in the proximal end of the stipe. When fully developed, the length of the thecae are about 3.5 mm. They are five times as long as wide, overlapping almost throughout their length and numbering 14—16 in 10 mm.

Comparison: The shape of the rhabdosome and the arrangement of the thecae serve to distinguish this species from all other known species of *Tetragraptus*.

Horizon and Locality: This species occurs in the Lower Ordovician Ningkuo Shale of Changshan, Jiangshan, Longyou and Yuqian, in association with *Didymograptus* sp., *Trigonograptus ensiformis* (Hall), *Glyptograptus dentatus* (Brongniart), etc. Field Nos. CC13, CC14, CC15, CB40, CB43, CB48, CB49, CB59a—c, CB203, GD49, GD58, GD59, GF34, GF37, GF57, GF64, GF114, GF115, GF130, GF134; Cat. Nos. 13990 (Holotype), 13991—13996 (paratypes).

***Tetragraptus hsüi* Geh (sp. nov.)**

(Pl. III, figs. 1—4, text-figs. 5a—b)

This form is represented by four specimens. The rhabdosome is very small and circular in shape about 10 mm in diameter. Each of the main stipes is about 5.7 mm in length. They are very narrow at their origin and increase rapidly to a maximum width of 1.6—1.8 mm at the second or third theca, this breadth is maintained distally.

The sicula is longiconic, measuring 2.1 mm in height and about 0.6 mm in width, having a nema about 0.75 mm in length. The primary stipes are thin and straight. They attain together a length of about 1.5—1.7 mm and 0.4 mm in width. The first theca appears to originate from the upper portion of sicula and grows downward parallel to sides of the sicula, then twisted outward, forming an angle of 50° with the sicula. The second theca grows from initial portion of the first theca across the sicula.

The ventral margin of thecae is nearly straight and the apertural margin is slightly convex, forming a projecting mucronate denticle. The angle of inclination varies in different portion of the stipe. The average angle of inclination of the thecae is at 35°—45° to the general direction of the stipe; in fact, the thecae in the distal portion are inclined at a fairly small angle, those in different portions of the stipe are first inclined at their bases at a small angle, then bend outward, forming with the axis of the stipe a larger angle. The thecae are about 1.8 mm in length, about three times as long as wide. They

overlap nearly throughout their length. In 10 mm, there are 10—8 thecae.

Comparison: This new form resembles *Tetragraptus törnquisti* Monsen and *Tetragraptus bigsbyi* var. *askerensis* Monsen described by Monsen from Norway (Monsen, 1937). It seems to the writer that one specimen of the *Tetragraptus törnquisti* (Monsen, 1937, pl. 13, fig. 3) and some specimens of the *Tetragraptus bigsbyi* var. *askerensis* (Monsen, 1937, pl. 51, fig. 35; pl. 13, fig. 6) may belong to our new species.

Horizon and Locality: New species occurs in the Lower Ordovician Ningkuo Shale of Changshan, Jiangshan and Longyou in association with *Tetragraptus quadribra-chiatus* (Hall), *Didymograptus extensus* (Hall), *Didymograptus nitidus* (Hall), *Didymo-graptus panatulus* (Hall), *Cardiograptus amplus* Hsü etc. Field Nos. CB44, CB49, CB50, CB59c, GD13, GD65, GD69, GF124; Cat. Nos. 13997 (Holotype), 13998—14000 (paratypes).

***Tetragraptus isograptoides* Geh (sp. nov.)**

(Pl. III, figs. 5—6; pl. IV, figs. 10—11, text-fig. 6)

The rhabdosome is small, consisting of four main reclined stipes, about 5 mm in length. The initial end of the stipes is narrow, where the width is about 0.6 mm. This increases very rapidly till a maximum width of 2.6 mm is attained at the second or third pair of theca. The latter width is then usually gradual diminution, soon take place towards the distal extremity, where the width is only 1.5 mm.

The sicula is longiconic, measuring 2.8 mm in length and 0.75 mm in width. Its apertural margin is curved slightly and its apex is diminished gradually upwards. The earliest theca grows from the apex of the sicula. First it grows along the sicula downward parallel to the sicula and then turned outward, forming about an angle of 40° with the apex of the sicula. The second theca grows from near initial portion of the first theca and then across the sicula, and is together in symmetrical development.

The thecae are cylindrical. The angle of inclination varies in different portions of the stipe. The thecae in the proximal region are nearly inclined at 60°—50°, while those in the mature portion are inclined at about 20°—30°. The length of the thecae is about 2.3 mm, three times as long as wide, overlapping nearly throughout their length. In 10 mm there are 10 thecae.

Comparison: *Tetragraptus isograptoides* sp. nov. resembles *Isograptus* in general shape of the stipes, but the initial thecae of the present form appear to be inclined outward and their maximum width of stipes is in the aperture of the second or third pair of theca.

Horizon and Locality: *Tetragraptus isograptoides* sp. nov. occurs in the Lower Ordovician Ningkuo Shale of Jiangshan and Longyou in association with *Tetragraptus quadribra-chiatus* (Hall). Field Nos. CB59, GF114, GF122; Cat. Nos. 14001 (Holotype), 14002—14003 (paratypes).

***Tetragraptus minutus* Geh (sp. nov.)**

(Pl. IV, fig. 12, Text-figs. 7a—b)

This new species is represented by several specimens. The rhabdosome is small, consisting of four reclined stipes which are about 4.4 mm in length and 1.3 mm in breadth.

The sicula is inconspicuous. The "funicle" consisting of two earliest thecae (Th_1 and $th_1^?$) is tiny, about 1.4 mm in length and 0.3 mm in width.

The thecae are tubular. Their ventral margin is straight and their apertural margin is even. The proximal thecae are nearly inclined at an angle of 40° — 45° ; and the distal ones are inclined somewhat slight diminution. The thecae measure about 1.3—1.5 mm in length and 0.8 mm in width. The overlapped is only about one-half. In 5 mm there are 6.5 thecae.

Comparison: This species is characterized by its very small rhabdosome. It resembles *Tetragraptus hsüi* sp. nov. in the shape and size of the rhabdosome, but differs from the latter in the large number of the thecae and the smaller rhabdosome and having a triangular thecal mucro.

Horizon and Locality: This form occurs in the Lower Ordovician Ningkuo Shale at Huangnigang, Jiangshan and at Honxu, Longyou. Field Nos. CC15, GK03; Cat. Nos. 14004 (Holotype), 14005 (paratype).

Tetragraptus cf. erectus Mu, Geh et Yin

(Pl. IV, fig. 13, text-figs. 8a—b)

The rhabdosome is small, about 8 mm in width. The stipes of the first order are straight. The main stipes grow outwards and then turn upward nearly parallel in the distal. Each of them is 11 mm in length and about 0.8—1.0 mm in breadth.

The sicula is longiconic, measuring 1.8 mm in length and 0.7 mm in width, having a flexible nema (0.3 mm in length) in its top. The first theca grows from nearly the middle portion of the sicula.

The thecae are simple tubular, measuring 1.3 mm in length, one-half to two-fifths as wide as long. Both the ventral and apertural margins of the thecae are nearly straight. The average angle of inclination of the thecae is 45° — 30° . They overlap only one-half to one-third of their length. In a length of 10 mm there are 11—10 thecae.

Comparison: In the general form and in the size of the stipes, the present form closely agrees with *Tetragraptus erectus* Mu, Geh et Yin, but differs in less closely arranged thecae.

Horizon and Locality: This species occurs in *Pterograptus elegans* zone of the uppermost portion of the Ningkuo Shale of Zhuji, Longyou and Jiangshan. Field Nos. CB42, GD71, GF101, GF104; Cat. Nos. 14006—14008 (plesiotypes).

Tetragraptus taraxacum Ruedemann

(Pl. II, figs. 8—9; pl. III, figs. 14—15)

The rhabdosome is small, consisting of four inclined stipes. The "funicle" is slender and straight, measuring about 2—2.5 mm in length and 0.5 mm in width. The main stipes grow from each end of the "funicle", and at once turn outwards. The stipes are short and slightly curved, measuring 6.5 mm in length. The breadth of the stipe at origin end is narrow, then increasing rapidly to 1—1.2 mm. This width is maintained distally.

The sicula is conic, measuring 1.2 mm in length and 0.4 mm in width. Its apertural margin curved slightly and the apertural mucronate is inconspicuous. The initial theca grows from the upper portion of the sicula downward and turns rapidly outward near the sicular aperture. The second theca grows from the inside of origin of the first thecae

and at once across the sicula. Both the first and the second theca formed a straight "funicle". In some specimens (pl. II, fig. 9), the "funicle" is not very straight.

The thecae are simple tubes. Its apertural margin is straight and its mucronate is conspicuous. The ventral margin of the thecae is nearly straight or slightly convex. The angle of inclination is 35° — 45° . The length of the thecae is about 1.8 mm, three times as long as wide, overlapping two-thirds their length. In a length of 5 mm there are 5 thecae.

Comparison: In the shape and the size of the rhabdosome, the present form resembles *Tetragraptus erectus* Mu, Geh et Yin, but differs in the inclination of the distal portion of the stipes and in the remote density of the thecae. In addition, the two specimens described as *Tetragraptus kindlei* by Ruedemann (Ruedemann, 1947, pl. 50, figs. 8—11) seem to be this form.

Horizon and Locality: This species occurs in the Lower Ordovician Ningkuo Shale of Changshan and Longyou in association with *Glyptograptus* sp. Field Nos. CB47, GF122; Cat. Nos. 13978—13981 (Plesiotypes).

Tetragraptus insuetus Keble et Benson

(Text-fig. 9)

The rhabdosome is small, consisting of four inclined stipes. The stipes are straight or slightly convex, measuring about 8 mm in length and 1 mm in width. The "funicle" is short and straight, measuring 2.5 mm in length and only about 0.5 mm in width. The thecae are simple tubes. The ventral margin of the thecae expands towards their aperture, forming a triangular and mucronate projecture. The thecae measure 1.4 mm in length and 1.4 mm in width. The thecae overlap each other only one-third to one-fourth their length. In a length of 5 mm there are 4—5 thecae.

Comparison: This species has been considered by Keble and Benson to be *Tetragraptus* with a query due to the incomplete specimen. According to our material this species certainly belongs to the genus *Tetragraptus*.

Horizon and Locality: The present form occurs in *Pterograptus elegans* zone of the uppermost portion of the Ningkuo Shale at Shilingshang, Changhua in association with *Glossograptus hincksii* (Hopkinson). Field No. GD38; Cat. No. 13172a—b (Plesiotype).