A NEW HETERACTINELLID CALCAREOUS SPONGE FROM THE LOWERMOST ORDOVICIAN OF NEVADA AND A DISCUSSION OF THE SUBORDER HETERACTINELLIDAE

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With 1 figure, 1 table and 3 plates

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Abstract

A new heteractinellid calcareous sponge, *Contignatiospongia* n. gen. n. sp. is described from the upper part of the Windfall Formation (lowermost Ordovician) in Nevada, USA. The stratigraphic ranges of all heteractinellid genera are shown. In this connection an additional new (Lower Cambrian) genus, *Conwaymorrisispongia* n. gen., and 3 new species are described herein: The Devonian *Ensiferites langeri* n. sp., and the lower Cambrian *Conwaymorrisispongia bengtsoni* n. sp. and *C. ornata* n. sp. The Heteractinellidae are restricted to the Paleozoic and occur from the Lower Cambrian up to the Permian; they died out within the Lower Permian.

Zusammenfassung

Ein neuer heteractinellider Kalkschwamm, *Contignatiospongia* n. gen. n. sp., wird aus der oberen Windfall-Formation (basales Ordovizium) von Nevada beschrieben. Die stratigraphische Reichweite aller Heteractinelliden-Gattungen wird diskutiert. In diesem Zusammenhang werden eine weitere neue Gattung, die unterkambrische *Conwaymorrisispongia* n. gen., and 3 neue Arten, eine devonische (*Ensiferites langeri* n. sp.) und zwei unterkambrische (*Conwaymorrisispongia bengtsoni* n. sp. und *C. ornata* n. sp.), beschrieben. Die Heteractinellidae sind auf das Paläozoikum beschränkt und reichen vom Unterkambrium bis in das Perm; sie sterben noch im Unterperm aus.

1. Introduction

Rich and well preserved conodont, radiolarian, and sponge spicule faunas were found by one of the authors (JER) in the upper part of the lowermost Ordovician Windfall Formation in a section in the Antelope Range, Eureka County, Nevada, USA. Besides radiolarians and siliceous sponges (Hexactinellida and Demospongiae), described by the present authors recently (Kozur et al., 1996a, b), a very characteristic spicule type is common that must be assigned to the Heteractinellidae. These originally calcareous spicules are all silicified.

The heteractinellid sponges, a Paleozoic group of calcareous sponges, were described comprehensively by Rigby (1983, 1991). Reitner & Mehl (1996) regarded the Heteractinellidae as a basic group of the calcareous sponges. Their spicules are either regular oxactines, octactine-based spicules, or irregular polyactines and triactines. Despite the fact that the Heteractinellidae are a small group of calcareous sponges their spicules are common, above all in shallow water carbonates, but rarely in deep water sediments.

The spicules with their characteristic triactine symmetry were originally described by Rigby & Toomey (1978) and assigned to the heteractinellid Calcarea.

Mostler (1985) established the family Polyactinellidae Mostler for this group of Calcarea and Mostler (1996) discussed in detail the independence of the Polyactinellidae (with 9 genera) from other

Calcarea, and therefore also from the Heteractinellidae, which are considered to be a polyphyletic group as already pointed out by Finks and Rigby (2004).

Previously, 14 heteractinellid genera were known; these were assigned to 3 families (sensu Rigby, 1983). For our fauna, the Astraeospongiidae Miller, 1889 are important. Previously, the following 6 genera (in alphabetical order) were assigned to this family:

Asteriospongia Rigby, 1977
Astraeoconus Rietschel, 1968
Astraeospongium Roemer, 1854
Constellatospongia Rigby, 1977
Ensiferites Reimann, 1945
Stellarispongia Rigby, 1976

To these we now add herein the new genera *Contignatiospongia* n. gen. and *Conwaymorrisispongia* n.gen.

There are only a few publications concerning new heteractinellid sponges. As mentioned above, the most recent comprehensive paper about "Heteractinida" was published by Rigby (1991). In the same year, Langer (1991) figured several spicules of calcareous sponges, octactine spicules and derived forms, from the Devonian of the Rheinisches Schiefergebirge (Germany). He did not assign these spicules taxonomically. We will discuss them later.

Van Hinte et al. (1995) investigated Upper Ordovician, Lower Silurian, and Devonian sediments from the northwestern part of the Atlantic Ocean. They also described and figured spicules of heteractinellid sponges and tried to assign these forms to *Asteractinella* Hinde 1887 and *Ensiferites* Reimann 1945.

Bengtson et al. (1990) recognised that *Lenastella araniformis* (Missarzhevsky) belongs to the genus *Eiffelia* ("Heteractinida"). They figured numerous spicules of *E. araniformis* in two plates (their Fig. 12 and 13) and described them as six rayed and, less commonly, seven rayed forms with a central ray, unusually short and sometimes inclined relative to the plane of six rays.

They also noticed that the central part of the convex side of some spicules has more or less regular nodes (see Bengtson et al. 1990, Fig.12 A, B and C), contrary to the other eiffeliids. This nodose central surface recalls some other heteractinellids, such as *Zangerlispongia* and *Tholiasterella*. *Eiffelia araniformis* is distributed world-wide in the Lower Cambrian (Atdabanian): Siberian Platform, Mongolia, China, Europe, and Australia.

Bengtson et al. (1990) also figured other spicules of *Heterostella* Federov, 1987. These are typical octactine spicules of Heteractinellidae. Bengtson et al. (1990) left the systematic position of this genus open because of the siliceous preservation of the spicules.

Mehl-Janussen (1999) distinguished two groups of Heteractinellidae; the Octinellidae Hinde 1887 (= Astraeospongiidae Miller 1889), comprising mainly Early Palaeozoic sponges, and the Late Palaeozoic Wewokellidae King 1943.

The Astraeospongiidae are characterized by octactines, which are bilaterally symmetrical, with a central, vertical ray and 6 tangential rays equally distributed in one plane. Only the central rays may be partly atrophied.

The skeleton of Wewokellidae is made chiefly of polyactines; most of the spicules are developed as irregular polyactines.

As shown in Mehl-Janussen (1999: Fig. 7), the Middle Cambrian heteractinellid genus *Jawonya* also has irregular polyactines similar to the spicules of *Asteractinella*.

Further, Mehl-Janussen (1999: 54) called into question the wewokellid genera *Regispongia* and *Talpospongia*. In this case the Wewokellidae would be reduced to the genera *Astraeactinella*, *Tholiasterella* and *Wewokella*.

Mehl & Lehnert (1997) described heteractinellid spicules from the Arenigian San Juan Formation from the Precordillera of Argentina; they assigned these to *Eiffelia* sp. Beresi & Heredia (2000) disputed the generic assignment of the spicules of Mehl & Lehnert, but proposed instead that these were derived from another eiffellid genus or genera, perhaps *Chilcaia*. Beresi & Heredia (2000) further reported several types of heteractinellid spicules from Lower Ordovician (Arenigian) allochthonous olistostromal blocks and Middle Ordovician (Llanvirnian) authochthonous beds of the Ponón Trehué Formation in southern Mendoza Province, Argentina.

Culver et al. (1988) reported calcareous six- and seven-rayed spicules of probable Early Cambrian age from the southwestern part of the Taoudeni Basin, Senegal and Guinea, West Africa. They tentatively assigned these spicules to "*Lenastella*" Missarzhevsky. Subsequently, based on additional

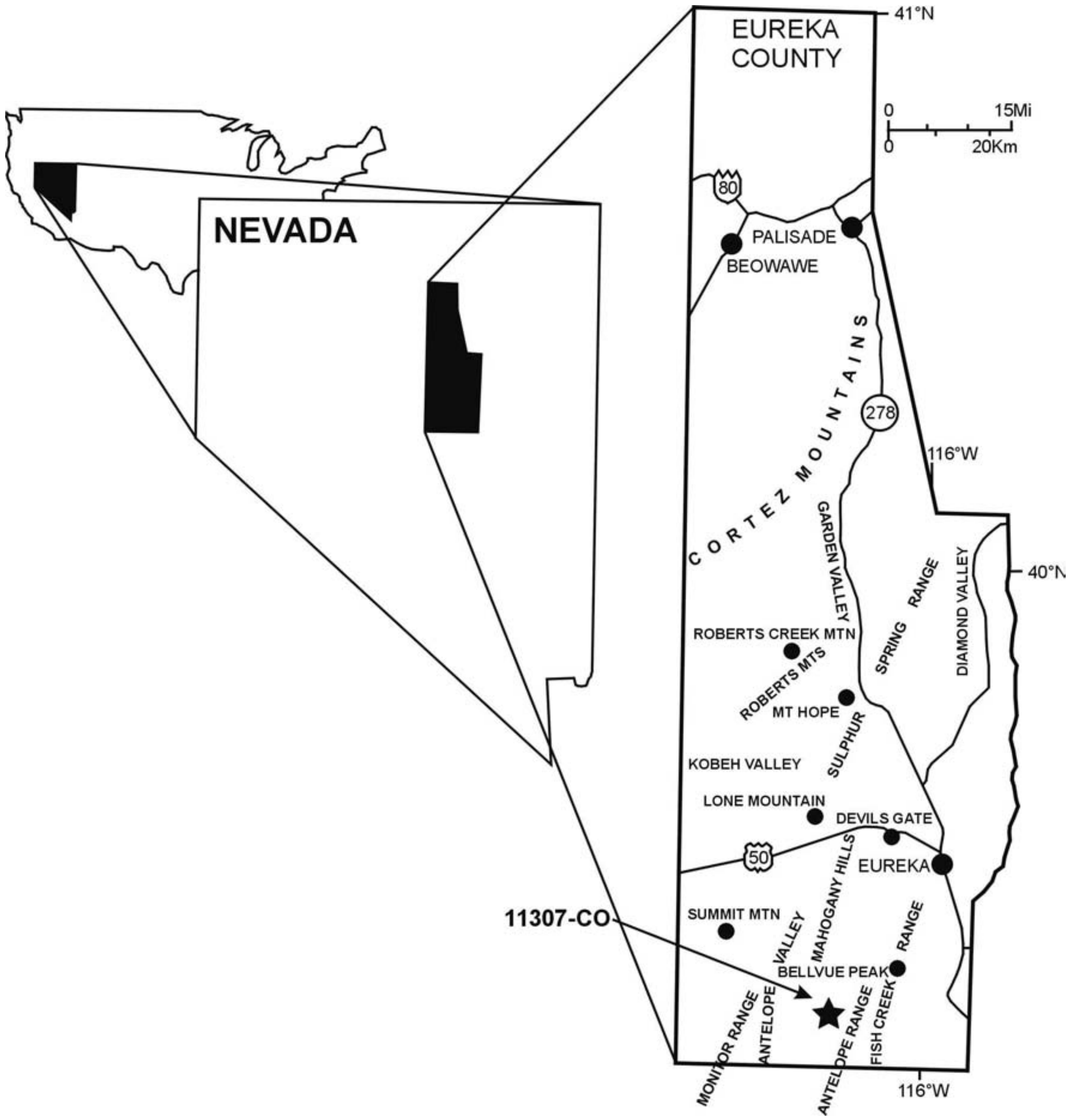

Fig 1: Location map of Ordovician sponge spicule-bearing samples in Eureka County, Nevada USA.

material, they (Culver et al., 1996) reassigned these spicules to *Eiffelia*, and at least some of them to *E. araniformis* (Missarzhevsky); they reassessed the age of the host-strata as Early to possibly Middle Cambrian.

The spicules of our Lower Ordovician material are characterised by bilaterally symmetrical polyactines, considered as modified octactines, with five to twelve tangential rays in one plane and one, mostly two-leveled distal ray. Therefore, we believe that this type of spicule belongs to the familiy Astraeospongiidae Miller 1889.

2. Locality data

The locality data were discussed in detail by the present authors in Kozur et al. (1996a). All figured forms are from sample 6-18-76 I (USGS locality number 11307-CO) collected by JER from 241 feet below the top of the Windfall Formation in a section in Ninemile Canyon, on the west side of the Antelope Range, Eureka County, Nevada (see Fig. 1).

The position of the locality is: 39° 12'16" N. Lat.; 116°15'25" W. Long., on the Horse Heaven Mountain 15' quadrangle map.

Sample 6-18-76 I (11307-CO) contains the conodonts *Cordylodus angulatus* Pander, *C. intermedius* Furnish, *C. lindstromi* Druce & Jones, *C. proavus* Müller, *Iapetognathus sprakersi* Landing, aff. *Laurentoscandodus triangularis* (Furnish), *Paltodus* sp., and ?*Rossodus tenuis* (Miller). It can be assigned to the *Cordylodus angulatus* Zone of Tremadocian age (= early Ibexian age in North American/ Laurentian usage), its age being constrained by the enclosed faunas (including the index species of the *C. angulatus* Zone) and by those of underlying samples (JER; unpub. USGS collections).

The Windfall Formation at this locality comprises thin-bedded, silty, phosphatic limestones with common secondary chert. These strata represent deposition in outermost shelf or upper slope environments (Taylor & Repetski, 1985). The siliciclastic component of this succession, and likewise perhaps most or all of the sponge spicule fauna, were derived from shallower environments of the adjacent carbonate platform and deposited as constituents in grainflow and turbidite beds.

3. Systematics

The material is deposited in the collection of the Institute of Geology and Paleontology, Innsbruck University.

Class Calcarea Bowerbank, 1884
Suborder Heteractinellidae Hinde, 1887

This taxon (together with the family Octactinellidae) was originally assigned as suborder Heteractinellidae to the order Hexactinellidae (Hinde, 1887: p. 93). Laubenfels (1955) united the families Chancelloriidae, Astraeospongiidae und Asteractinellidae in the „Order Heteractinida" that is surely a polyphyletic group. Therefore, we use the original name Heteractinellidae Hinde, 1887

Family Astraeospongiidae Miller, 1889

Genus *Contignatiospongia* n. gen.

Derivatio nominis: According to the arrangement of small rays in one, or mostly two levels („stories„) on the distal ray.

Type species:
Contignatiospongia nevadensis n. gen. n. sp.
Diagnosis:
The bilaterally symmetrical spicules are modified octactines, with 5-12, mostly 8 or 10, paratangential rays. The proximal ray is very long. The distal ray has a strongly reduced length and a two-leveled structure. Distally, partly upwardly curved rays are arranged parallel to the paratangential rays in one or two separate levels („stories"). The uppermost level has mostly 6, rarely 5 or 7 rays; in the lower level the number of the small rays is dominantly 6, rarely 7-9.
Assigned species
Contignatiospongia nevadensis n. gen. n. sp.
Occurrence:
Lowermost Ordovician of Nevada.
Remarks:
The spicules of *Ensiferites* Reimann, 1945 always display 6 paratangential rays and have a local thickening, either in the proximal or in the distal ray.

Contignatiospongia nevadensis **n. gen. n. sp.**
(Plates 1 and 2)

Derivatio nominis:
Referring to its occurrence in Nevada.
Holotypus:
The specimen figured on Pl. 1, Fig. 4
Locus typicus:
USGS locality number 11307-CO, section in Ninemile Canyon, on the west side of the Antelope Range, Nevada, at 39 12'16" N. Lat.; 116 15'25" W. Long., on the Horse Heaven Mountain 15' quadrangle map.
Stratum typicum:
Limestone beds at 241 feet below the top of the Windfall Formation; *Cordylodus angulatus* Zone (Ibexian = early Tremadocian).
Diagnosis:
As for the monotypic genus.
Description:
The long proximal ray is mostly slightly curved, rarely straight, and always smooth. The paratangential rays are mostly situated in one plane. Their number is quite variable; very rarely 5, rarely 6, 7, 9, 11 and 12, and mostly 8 or 10 paratangential rays are present. Their lengths and widths are variable.

The distal ray has a strongly reduced length and also its diameter is smaller than that of the proximal ray. It always ends in a small tip. Its most outstanding feature are 1 or 2 levels of ray borders. Mostly two levels are present. The rays of the lowermost level are half the length of the paratangential rays and are always slightly curved upwards. In the upper level the upward bending of the rays becomes stronger. The number of rays is 6-9 in the first level and 5-7, mostly 6, in the second level.

Genus *Ensiferites* Reimann, 1945

Remarks:
This genus is characterized by a thin wall with several layers of octactine needles. The spicules display simple, forked or branched distal rays, and, especially in the basal region of the sponge, extremely long proximal rays that may have thickenings.

***Ensiferites langeri* n. sp.**
(Plate 3, Figs. 4–6, 9, 12–14)

1991 octactine of heteractinida – Langer, p. 41, Pl. 5, figs. 4, 8, 9, 11; Pl. 6, Fig. 4
1995 Middle-Upper Devonian Ensiferites Reimann, 1945 (Heteractinida) – van Hinte et al., p. 18, Pl. 6, Figs. 1, 1A

Derivatio nominis:
In honour of Prof. Dr. W. Langer, Bonn, who figured these forms for the first time.
Holotypus:
The specimen on Pl. 3, Figs. 5, 6
Locus typicus:
Dasberg at Gerolstein; Eifel (Germany).
Stratum typicum:
Loogh Formation, Hustley-Baley Member; Middle Devonian.
Diagnosis:
Typical *Ensiferites* spicule with long, partly thickened proximal ray, 6 paratangential rays and a trichotomous forked distal ray with zygomorphic distal ends of the branches.
Description:
The proximal ray is long, massive and its end is probably pointed (all specimens taper but are broken short of their terminus). The 6 paratangential rays have more or less the same length. They are situated in one plane. The distal ray is forked trichotomously and has, e.g. in the holotype, in every branch a zygomorphic widened distal end. In one specimen the three branches are internally subdivided (Pl. 3, Fig. 9).
Occurrence:
Devonian of the Eifel, Germany, and from Orphan Knoll (northwestern Atlantic Ocean).

Family unknown

Remarks: The spicules figured in Bengtson et al. (1990, Fig. 14) can be assigned to the Heteractinellidae and are described as a new genus, here with two new species.

Genus *Conwaymorrisispongia* n. gen.

Derivatio nominis:
In honor of Prof. Dr. Simon Conway Morris, Cambridge University.
Type species:
Conwaymorrisispongia bengtsoni n. gen. n. sp.
Diagnosis:
Spicules with moderately long or short proximal ray and 8 paratangential rays. Distal ray either missing or strongly reduced and branched in numerous partial rays.
Occurrence:
Kulpara shallow water limestone with Archaeocyatha. *Abadiella huoi* Zone (Atdabanian, Lower Cambrian). Horse Gully near Ardrossan Yorke Penninsula (W of Gulf of St. Vincent), southern Australia.
Assigned species:
Conwaymorrisispongia bengtsoni n. gen. n. sp.
Conwaymorrisispongia ornata n. gen. n. sp.
Remarks:
This spicule is derived from an octactine spicule.

***Conwaymorrisispongia bengtsoni* n. gen. n. sp.**
(Pl. 3, Fig. 3, 8, 11)

1990 Heteractinida indet. - Bengtson et al., p. 29, Figs. 14 C, E, D

Derivatio nominis:
In honour of Prof. S. Bengtson, Uppsala University.
Holotypus:
The specimen on Pl. 3, Fig. 11

Locus typicus:
Horse Gully, near Ardrossan Yorke Penninsula (W of Gulf of St. Vincent), Southern Australia.
Stratum typicum:
Kulpera Limestone, Lower Cambrian.
Diagnosis:
The proximal ray is short and massive; 8 massive paratangential rays are present. The distal ray is missing.
Description:
The proximal ray is rather short and very broad close to the paratangential rays. The 8 paratangential rays are moderately long and always massive. The distal ray is missing and in its place a shallow indentation is present.
Occurrence:
Lower Cambrian of Southern Australia.
Remarks:
Conwaymorrisispongia ornata n. sp. displays a strongly reduced, modified distal ray.

***Conwaymorrisispongia ornata* n. sp.**
(Pl. 3, Figs. 1, 2)

1990 ?Heteractinida indet. – Bengtson et al., p. 29, Figs. 14A, B

Derivatio nominis:
Referring to the sculpture of the distal ray.
Holotypus:
The specimen on Pl. 3, Figs. 1, 2.
Locus typicus:
Horse Gully near Ardrossan Yorke Penninsula, Southern Australia.
Stratum typicum:
Kulpera Limestone, Lower Cambrian.
Diagnosis:
The proximal ray is slender. The 8 paratangential rays are moderately long. The distal ray is strongly reduced and branched in an upwardly-directed ray border and a bifurcated tip.
Description:
The 8 moderately long paratangential rays have round cross sections and rounded ends. They are situated in one plane. The proximal ray is rather slender and not wider than the paratangential rays. The distal ray is branched in 7, upwardly-directed partial rays and has a bifurcated tip.
Occurrence:
Lower Cambrian of Southern Australia.
Remarks:
Conwaymorrisispongia bengtsoni has no distal ray.

Van Hinte et al. (1995) figured acanthine heteractinellid spicules that most probably belong to a new genus. However, there is insufficient material to define this genus.

4. Stratigraphic importance of the heteractinellid sponges

Rigby (1991) has shown the stratigraphic range of all "Heteractinida" (Heteractinellidae) known at that time, and he discussed the possible evolutionary development of these forms. Meanwhile, several papers about Heteractinellidae were published subsequently and yielded new data about the stratigraphic range of known heteractinellid taxa. The stratigraphic ranges of all known heteractinellid genera are shown in Table 1 and briefly discussed below.

Eiffelia does not begin only in the Middle Cambrian, but also is present in the Lower Cambrian. Bengtson et al. (1990) recognized that the Atdabanian (Lower Cambrian) *Lenastella araniformis* Missarzhevsky belongs to *Eiffelia*. Rigby (1991) conclueded that *Zangerlispongia* evolved from *Eiffelia*, and we agree with this view. The youngest *Eiffelia* that displays strong similarities to *Zangerlispongia* occurs in the Lower Silurian. The Lower Cambrian *E. araniformis* already displays, besides a strongly reduced distal ray, a typical tubercle sculpture that is characteristic for *Zangerlispongia*.

Jawonya, described by Kruse (1987) and regarded by Mehl & Reitner (1996) as representative of „coralline" sponges, is common in our Upper Cambrian material from Iran.

Several genera have a restricted range. *Conwaymorrisispongia* n. gen. is known only from the Lower Cambrian. *Contignatiospongia* is known from the base of the Ordovician, and *Toquimiella* from the Middle Ordovician, and neither has known successors in younger beds. Also *Astraeoconus* Rietschel (1968) is a phylogentically isolated form and restricted to the Middle Ordovician. *Wewokella* is restricted to the Upper Carboniferous, *Talpaspongia* to the Lower Permian.

Constellatospongia Rigby is present not only through the entire Ordovician, but also in the Lower Silurian, as shown by van Hinte et al. (1995, Pl. 6).

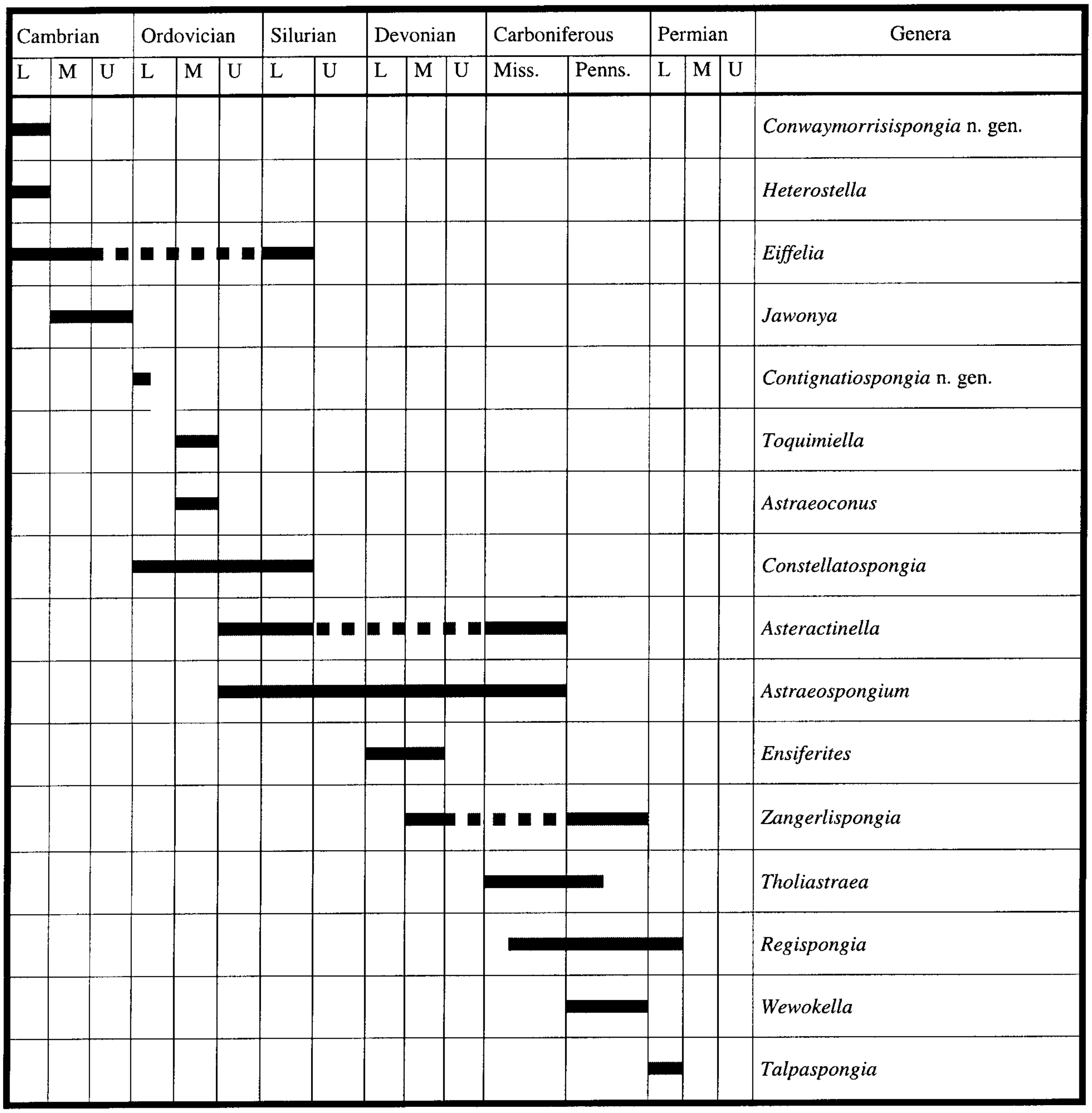

Table 1: Stratigraphic distribution of 16 heteractinellid genera.

Astraeospongium Roemer occurs from the Upper Ordovician to the Lower Carboniferous, according to Mehl & Reitner (1996). *Astraeospongium* is the best known genus with several species. Mehl & Reitner (1996) produced an excellent study of the constructional morphology and paleoecology of *Astraeospongium meniscum* (Roemer, 1848) from the Silurian of western Tennessee.

Asteractinella was known formerly only from the Lower Carboniferous. However, this genus is surely present in the Upper Ordovician and Lower Silurian, and it is only the youngest known distribution of this genus that is in the Lower Carboniferous. It has, therefore, the same range as *Astraeospongium*.

Formerly, *Ensiferites* Reimann, 1945, was restricted to the Middle Devonian, but it is also present in the Lower Devonian (Langer, 1991, van Hinte et al., 1995).

Zangerlispongia was restricted thus far to the Upper Carboniferous, but based on the material of one of the authors (HM), it occurs already in the Middle Devonian.

Tholiasterella occurs not only in the Lower Carboniferous, but also in the Upper Carboniferous.

Regispongia is not restricted to the Carboniferous, but occurs also in the lower part of the Lower Permian. The youngest heteractinellid genus is *Talpaspongia*; it occurs only in the Lower Permian. No representatives of the Heteractinellidae range into the Upper Permian; they died out within the Lower Permian. In the rich Middle and Upper Permian sponge spicule associations, investigated by the authors, no heteractinellid spicules have been found.

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Explanation of Plates

All figured sponge spicules of Plates 1 and 2 belong to *Contignatiospongia nevadensis* n. gen. n. sp.

Plate 1

Fig. 1: Spicule with 12 paratangential rays in one plane. The proximal ray is thick and massively developed. Lower view. x 288.

Fig. 2: Spicule with 10 paratangential rays in a horizontal plane. The lengths of the rays are different. The central part is disc-like. In the middle of the central part a short distal ray is developed, with 6 small upwardly-curved rays around the tip in form of a border. x 384.

Fig. 3: Lateral view of a spicule with a strong proximal ray (partly broken), 8 paratangential rays and a strongly modified distal ray, divided into two ray levels with upwardly bent small rays. In the lower level are 6, in the upper one 5, small rays. x 192.

Fig. 4: Holotype, lateral view. A thick proximal ray having an angle of 90° degrees to the 10 paratangential rays is shown. A short modified distal ray consists of only one ray border that has 6 small strongly upwardly-curved rays. The central tip is much higher than the ray border. x 288.

Fig. 5: A ten-rayed paratangential disc with the proximal ray is shown. x 288.

Fig. 6: Spicule with a long, slightly curved, smooth proximal ray and a horizontal plane of paratangential rays (mostly broken). Further, a short distal ray is divided into two ray levels. x 192.

Fig. 7: Lateral view. 12 paratangential rays are arranged in a horizontal plane. The distal ray is strongly modified in two levels (ray borders); the lower level has 8 small upwardly-curved rays, the upper one is made of 6 long upwardly-bent, very small rays around the tip. x 288.

Fig. 8: Lateral view. Spicule with a very long proximal ray that is slightly curved. The paratangential rays are broken; the distal ray consists of two ray levels. x 192.

Fig. 9: Lateral view. The partition into two ray levels and the horizontal plane of the paratangential rays is shown. Note the difference of the first and second ray levels. The upper one shows the strongly curved small rays grouped around the short tip. x 384.

Fig. 10: Spicule with 5 paratangential rays, strongly variable in length, and the modified distal ray, divided into two-ray levels. x 192.

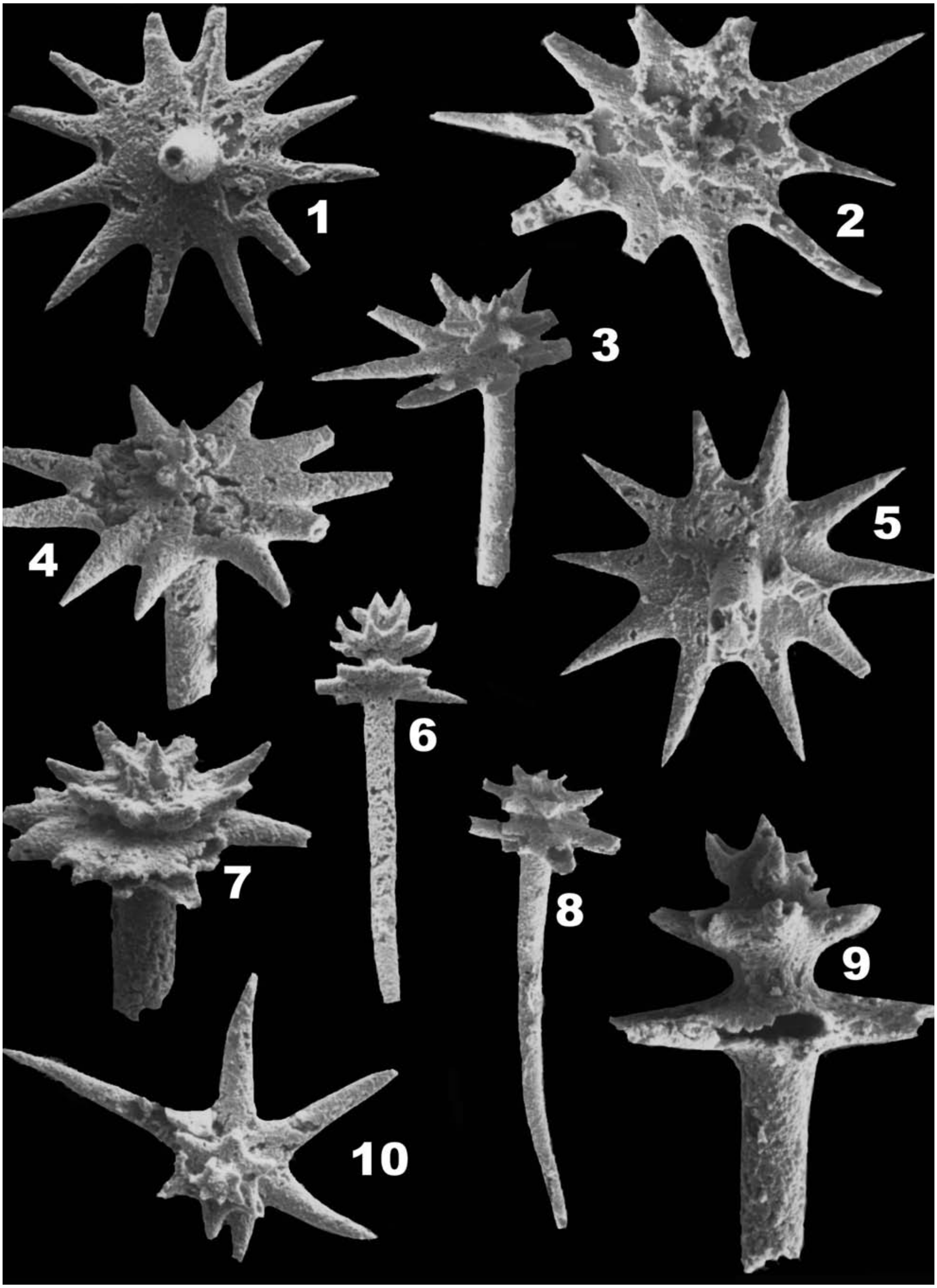
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Plate 2

Fig. 1: Upper view of 10 paratangential rays in horizontal plane. x 280.
Fig. 2: Lateral view. A long slightly curved proximal ray, the horizontal plane of the paratangential rays, and the two-level distal ray are shown. x 186.
Fig. 3: Similar to Fig. 2. x 325.
Fig. 4: Lateral view. Spicule with a massive proximal spine and a broad disc of the confluent paratangential rays. The distal spine is very short and consists only of one small ray border. x 280.
Fig. 5: Lower view. 12 paratangential rays with different length. x 280.
Fig. 6: Upper view. Shown are the two ray borders of the strongly modified distal ray. The lower level with 7 relatively long rays, the upper one with 6 strong upwardly-curved small rays around the tip. x 465.
Fig. 7: Only the isolated modified distal ray is shown with the two ray levels. The lower level has 7 regularly diverging, slightly upwardly-curved rays; the upper level consists of 6 more strongly upwardly-curved small rays. x 465.
Fig. 8: Lateral view. Spicule with 6 paratangential rays and the two-level distal ray. x 280.
Fig. 9: The upper part of the massively developed proximal ray, the disc consisting only of 5 paratangential rays, and the one level distal ray are shown. x 280.
Fig. 10: Only the isolated distal ray with two ray levels (the lower one consists of 6, the upper one of 5 rays) is shown. x 325.

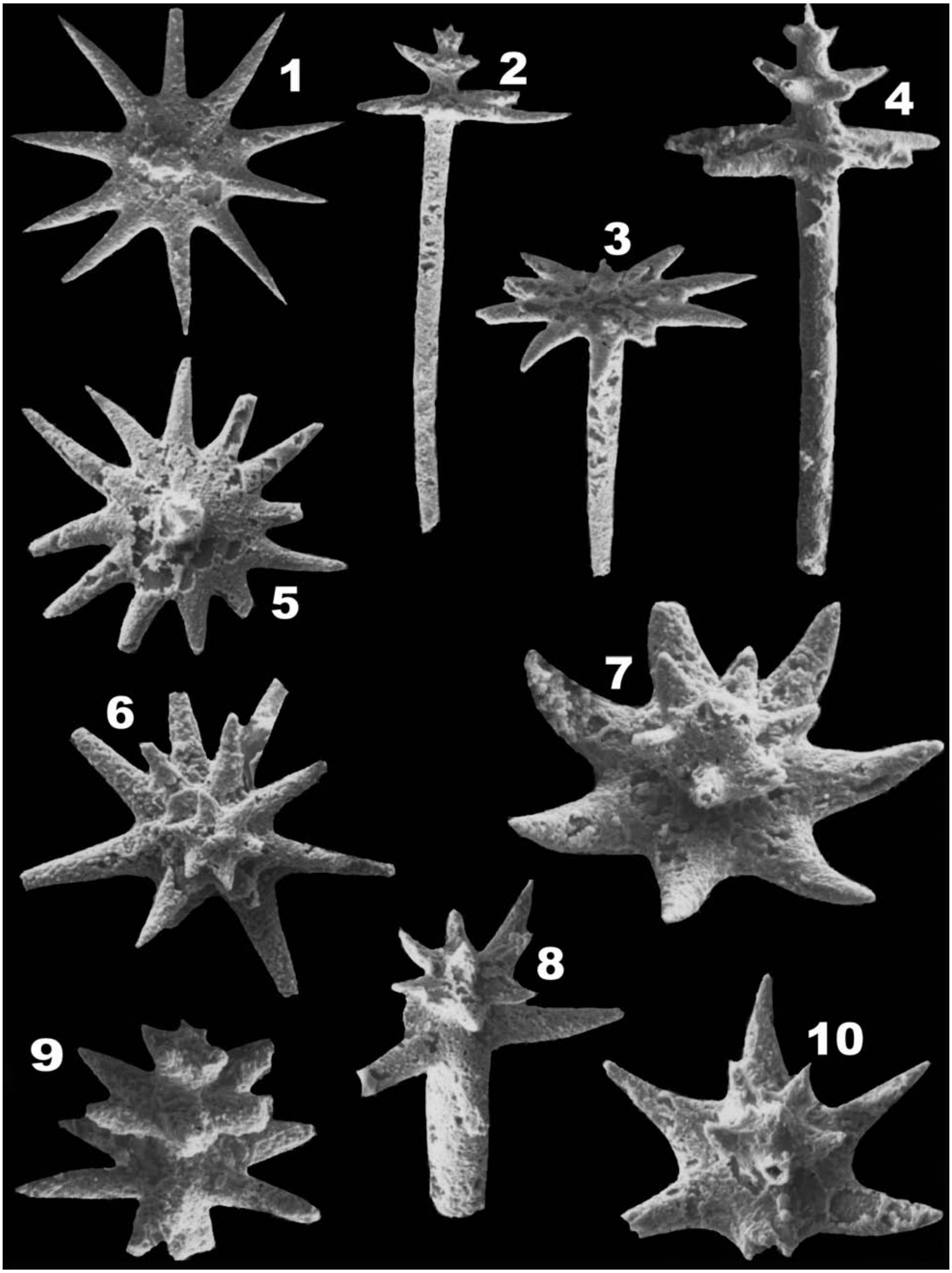
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Plate 3

Fig. 1: *Conwaymorissispongia ornata* n. gen. n. sp., upper view of holotype; 8 paratangential rays, regularly diverging in a horizontal plane and with a strongly modified distal ray, branched in an upwardly-directed ray border; in the center of the distal rays is a dichotomously forked tip. Upper view, holotype. x 93. From Bengtson et al. (1990, Fig 14 A).

Fig. 2: *Conwaymorissispongia ornata* n. gen. n. sp., lateral view of holotype, with upper part of the massively developed proximal ray, the paratangential rays grouped in one horizontal plane, and the modified distal ray with upwardly-directed rays. x 93. From Bengtson et al. (1990, Fig. 14 B).

Figs. 3, 8: *Conwaymorrisispongia bengtsoni* n. gen. n. sp., with 8 relatively constant massive paratangential rays; the ends of the rays are rounded. No distal ray is developed. x 93. From Bengtson et al. (1990, Fig. 14C = Fig. 3 and Fig. 14 E = Fig. 8).

Fig. 4: *Ensiferites langeri* n. sp., upper view, having 6 paratangential rays in one plane and a strongly modified distal ray which is trichotomously forked (compare with Fig. 6). x 55. From Langer (1991, Pl. 5, Fig. 11).

Figs. 5, 6: *Ensiferites langeri* n. sp., holotype. Spicule with a long massive proximal ray, with 6 paratangential rays and a three-forked distal ray. Fig. 5: x 37. From Langer (1991, Pl. 5, Fig. 9).; Fig. 6: x 186. From Langer (1991, Pl. 5, Fig. 8)

Fig. 7: Heteractinellidae ? gen. et spec. indet. Distal view of an acanthous heteractinellid spicule, showing a large central disc and 7 paratangential rays. x 140. From van Hinte et al. (1995. Pl. 6, Fig. 4).

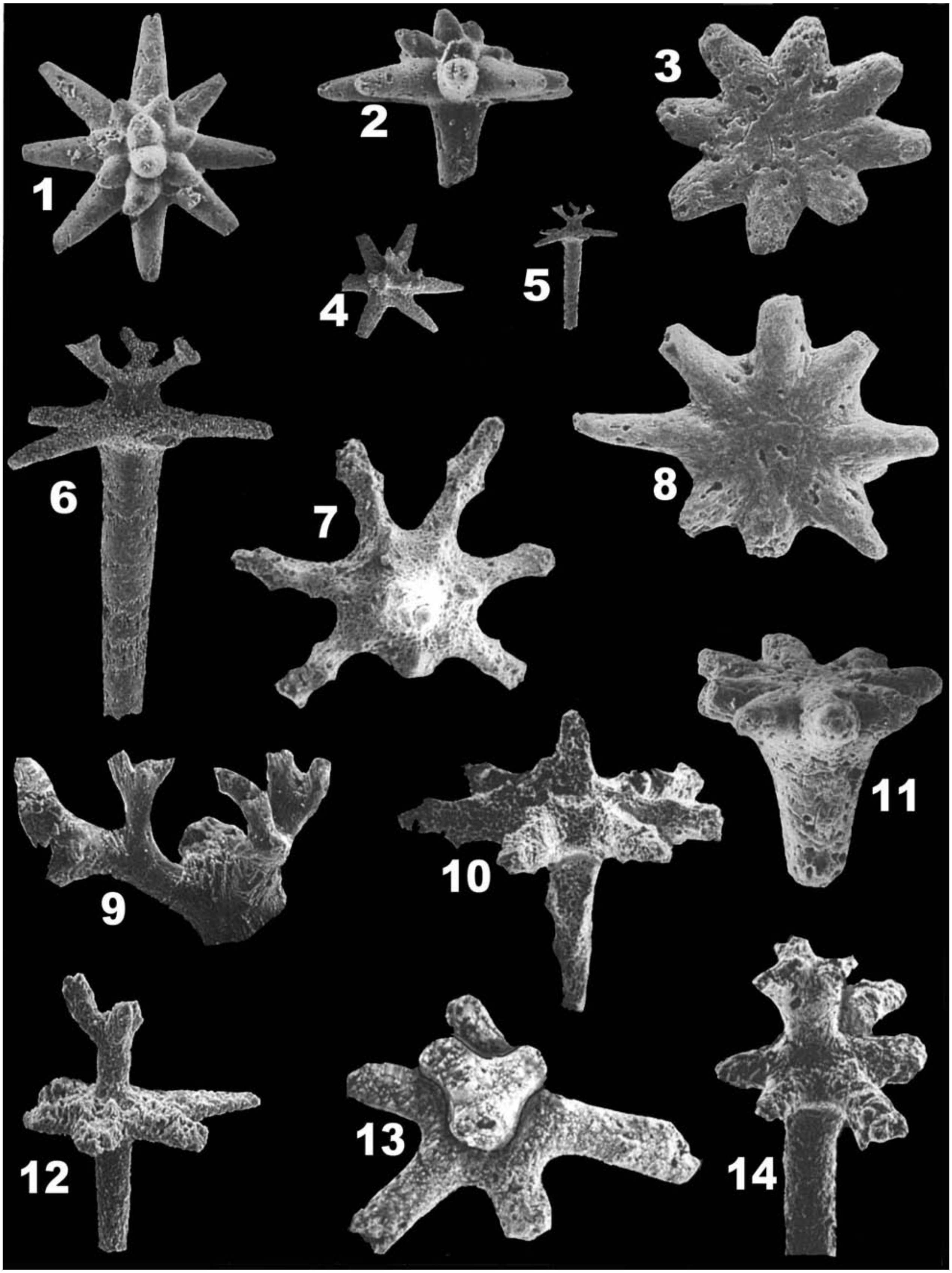
Fig. 9: *Ensiferites langeri* n. sp., showing the strongly modified secondary rays of the distal ray. x 214. From Langer (1991, Pl. 6, Fig. 4).

Fig. 10: The same spicule as shown in Fig. 7 (lateral view). Proximal ray is massively-developed. The paratangential rays are spined, the distal ray is short. From van Hinte et al. (1995, Pl. 6, Fig. 4a).

Fig. 11: *Conwaymorrisispongia bengtsoni* n. gen. n. sp., holotype, lateral view, showing the very massively developed upper part of the proximal ray and the central disc with the 8 massive paratangential rays. x 93. From Bengtson et al. (1990, Fig. 14 D).

Fig. 12: *Ensiferites langeri,* n. sp., lateral view. The distal ray is longer than that of the holotype. x 186. From Langer (1991, Pl. 5, Fig. 4).

Figs. 13, 14: *Ensiferites langeri* n. sp. from the lower Middle Devonian of Orphan Knoll. x 130. Fig. 13: upper view, with the three-forked distal ray and 5 paratangential rays; From van Hinte et al. (1995, Pl. 6, Fig. 1A). Fig 14: lateral view, shows the massive proximal ray, 6 paratangential rays, and the modified distal ray. From van Hinte et al. (1995, Pl. 6, Fig. 1).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