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CONODONT SUCCESSION ACROSS THE TOURNAISIAN-VISEAN BOUNDARY BEDS AT SALET, BELGIUM

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KEY WORDS : Conodonta, Tournaisian, Visean, Boundary, Salet, Dinant Synclinorium.

INTRODUCTION.

The taxonomy of the conodont genera as *Siphonodella, Gnathodus, Pseudopolygnathus, Scaliognathus, Mestognathus* , that exhibit a great importance for the Lower Carboniferous stratigraphy have recently been revised by SANDBERG *et al.* (1978), LANE, SANBERG, ZIEGLER (1980), Helka (1983) and LANE & ZIEGLER (1983). New concept of several species as well as descriptions of new taxa stimulated us to re-investigate the conodonts occurring in the classical sections of the Dinant Synclinorium. The purpose of this study is also to attempt an application, in the Dinantian type area, of the preliminary standard conodont zonation proposed by LANE, SANDBERG & ZIEGLER (1980) for the post- *Siphonodella* interval.

This study offers a revision of the conodont fauna recovered from the section called "Route de Salet" which is exposed along the Molignée Valley, in a small quarry and it continues along the road to Salet (Text-figs 1-2). The precise location and accessibility of this exposure is given by CONIL & GROESSENS (1974 : 24), GROESSENS (1975 : 45) and HANCE (1985). It is a classical and one of the most important sections for the Lower Carboniferous stratigraphy. As a parastratotype section for the Lower Viséan (CONIL, 1967) it attracted the interest of many workers being the area of an intense search for microfossils (see HANCE, 1985). Several foraminiferal taxa (*cf.* CONIL & LYS, 1964) have been

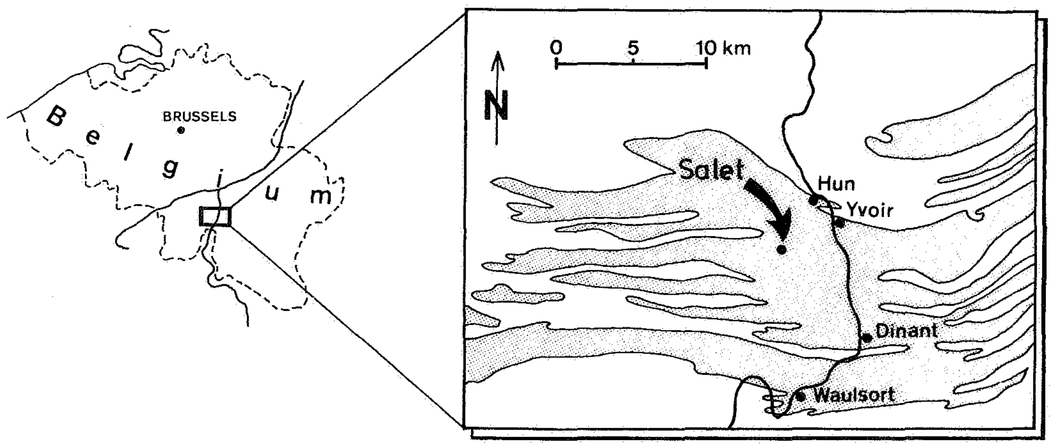

Fig. 1 - General location map. Patterned area shows extent of the Carboniferous deposits in the Dinant Synclinorium.

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described from this exposure for the first time and it is also a type locality for two stratigraphically important conodont species, *Dollymae bouckaerti* GROESSENS and *Eotaphrus bultyncki* (GROESSENS). The holotypes of these conodonts are reillustrated herein.

The section at Salet (Text-fig. 2), moreover, is a type section for two lithostratigraphical units of the classic Dinantian of Belgium, the Calcaire Noir de la Malignée (GROESSENS, 1975) and the Calcaire de Salet (GROESSENS, CONIL & LEES, 1976). The base of the Moliniacian, i.e. the stage of the Viséan, locally distinguished in Belgium, was also defined here at the Bed 52 (PAPROTH *et al.*, 1983 : 188).

The investigated conodont fauna includes the material collected and originally described by GROESSENS (1971, 1975) and also conodonts obtained during additional recent sampling that produced some new conodont occurrences. The samples were collected from the lower portion of the sequence only up to the Bed 285 where there occur slump structures at the top of the Calcaire de la Molignée (Text-fig. 2).

LITHOLOGY.

At Salet, a 320 meter thick section of the Lower Carboniferous carbonates is exposed, but only 130 m were covered by this study. The investigated portion of the section consists of three lithological units (Text-fig. 2) that constitute proximal lateral equivalents of the Waulsortian facies (*cf.* LEES, 1984).

The lowest unit is developed as crinoidal and bryozoan packstones that are massive or interbedded with thin shales in the lower part of this unit. These sediments pass laterally into the Bayard facies considered to be located in the neighborhood of the Waulsortian buildups.

Overlying is the Leffe facies, which comprises well-bedded wackestones and packstones that contain various allochems and first of all peloids, bioclasts of echinoderms and bryozoans, and coated grains. The Leffe facies extends landwards for many kilometers away from the buildups (LEES & CONIL, 1980; LEES, 1982) and it always separates the latter from the Molignée faciès.

The Calcaire de la Molignée forms the upper unit sampled for conodonts in the "Route de Salet" section. The limestones are wackestones and lime mudstones with numerous shaly interbeds. The composition of allochems is similar to that of the Leffe facies, but from the Bed 87 the increase of foraminifers in place of bryozoans is noted to occur. According to HANCE (1985 : 182), the lower part of the Calcaire de la Molignée at Salet reflects regressive conditions, whereas the Viséan transgression is indicated much later by the first appearance of the foraminiferal fauna dominated by the Archaediscidae in the Bed 215.

CONODONT DISTRIBUTION.

Very closely sampling of long intervals in the "Route de Salet" section provided substantial account of conodont succession in the late Tournaisian and early Viséan strata. Although the observed occurrences of the majority of conodont species (Table 1) agree with their recognized stratigraphic ranges (*cf.* LANE, SANDBERG & ZIEGLER, 1980), some species, however, demonstrate new occurrences that appear to be very significant for the phylogeny of these species and for the Lower Carboniferous conodont stratigraphy.

The most remarkable is the first appearance of *Gnathodus texanus*, a zonal marker of the *texanus* Zone. The lower range of this species was known to start simultaneously with the extinction of *Scaliognathus anchoralis* (LANE, SANDBERG & ZIEGLER, 1980 : Tab. 2; LANE & ZIEGLER, 1983). In contrast, *G. texanus* occurs at Salet just below the appearance of *Scaliognathus anchoralis europensis* (Text-fig. 3). Similary to that, the ranges of both species are recently noted to overlap in the Dinantian rocks of southwestern Ireland (THORNBURY, 1985) and VARKER & SEVASTOPULO (1985 : Tab. 6) indicated that for the Lower Carboniferous conodonts in Britain and Ireland the range of *Gnathodus texanus* extends from the middle

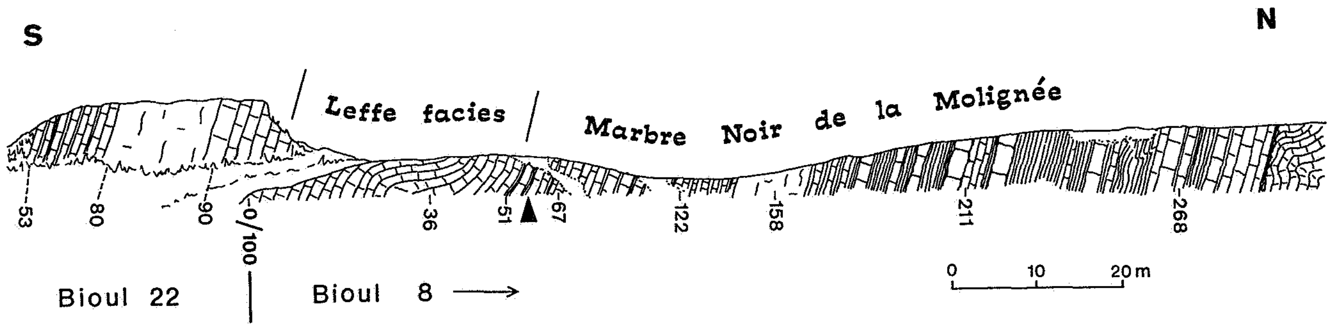

Fig. 2 - The lower part of the "Route de Salet" section sampled for conodonts. Black triangle indicates the position of the Tournaisian-Viséan boundary. Bed numeration after Overlau et Conil, 1965.

part of the *anchoralis* Zone. The record of *G. texanus* at Salet does not appear to be a freak of nature. It is well documented in our fauna by transitional forms (see Table 1 and Pl. 6, Figs 7-9) showing the evolutionary relation between *Gnathodus semiglaber* and *Gnathodus texanus*. The former species gave rise to *G. texanus* by the reduction of the inner parapet and platform ornamentation. The reduction trend of morphological changes in the conodont platform, as late Tournaisian gnathodontan Pa elements display (BELKA 1984 : fig. 10; 1985b) is also exemplified by the origin of *Gnathodus pseudosemiglaber* from *G. cuneiforms*. This is indicated by transitional forms (Pl. 5, Figs. 4-9) as well as by ontogenetic development of small specimens of *G. pseudosemiglaber* which recapitulate a character of *G. cuneiformis*. To show phyletic sequence of above mentioned species of *Gnathodus*, the transitional forms are separately presented in Table 1, but they are not considered herein to be the separate species.

The other anomaly which is worthy to note, is the record of *Pseudopolygnathus pinnatus*. This species (Pl. 2, Fig. 9) yields earlier appearance relative to *Pseudopolygnathus oxypageus, Dollymae bouckaerti*, and *Eotaphrus bultyncki*. It is much earlier than was recognized by LANE, SANDBERG & ZIEGLER (1980 : Tab. 2) but identical range of *Ps. pinnatus* reflecting, most probably, an actual stratigraphic range of this species is recorded from Britain and Ireland (VARKER & SEVASTOPULO 1985 : Tab. 6).

The genus *Scaliognathus* is represented by *Sc. praeanchoralis* (Pl. 1, Fig. 7), *Sc. anchoralis fairchildi* (Pl. 1, Figs. 8-11) and *Sc. anchoralis europensis* (Pl. 2, Fig. 2). LANE & ZIEGLER (1983 : 205-206) suggested that *Sc. a. europensis* probably developed from *Sc. a. fairchildi* although the appearance of *Sc. a. fairchildi* before *Sc. a. europensis* was not documented at that time. Now, such an evidence is recorded. In the "Route de Salet" section *Sc. a. fairchildi* comes 1.5 m before *Sc. a. europensis*.

The species *Gnathodus homopunctatus*, which together with *Mestognathus beckmanni* is considered to be diagnostic for earliest Viséan strata (GROESSENS 1975), appears much later (Text-fig. 3) than in other sections of the Dinant Basin. At the Tournaisian-Viséan boundary stratotype in Dinant it occurs before *M. beckmanni* following the Bed 141, at the base of which the boundary is placed (GROESSENS & NOEL, 1977 : Pls 1-2). New data, however, suggest that the range of *G. homopunctatus* may extend down to the middle of the *anchoralis* Zone, as formerly recorded in the Moravia-Silesia Basin in Poland (BELKA, 1985 : Fig. 3).

CORRELATION.

It was already the preliminary investigation of conodonts in several sections of the Dinantian of Belgium (GROESSENS, 1971) that showed these microfossils as excellent guides for correlation of the Tournaisian rocks. As a result, moreover, prospects of recognition of conodont zones in the Tn3a-V1b interval has also been outlined at that time. These zones were incorporated later by AUSTIN (1973) into his proposal of the Dinantian conodont zonation suggested for application in Europe.

The conodont zonal scheme for the Lower Carboniferous currently used in Belgium was established by GROESSENS (1975). Recently, it was in part modified to produce some new detailed subdivisions (PAPROTH *et al.*, 1983 : Tab. 2). Although the usefulness of this scheme for the Belgian stratigraphy remains unquestionable, its global application proves to be limited. This is because some species used for definition of subzones (e. g. *Dollymae hassi, Dollymae bouckaerti, Eotaphrus bultyncki*) are rather rare out of Belgium while other index forms as *Polygnathus communis carinus* and *Eotaphrus burlingtonensis* appear in Belgium significantly later than their lower ranges recognized in many Lower Carboniferous sections (see LANE, SANDBERG & ZIEGLER, 1980). Undoubtedly, this is why the framework of the world-wide preliminary standard conodont zonation (SANDBERG *et al.*, 1978; LANE, SANDBERG & ZIEGLER, 1980) differs considerably from that recognized in Belgium by GROESSENS (1975).

The investigated section yields all diagnostic forms which allowed to identify all the conodont zones of Upper Tournaisian and Lower Viséan strata *sensu* GROESSENS (1975), i. e. the *carinus* Zone, the *anchoralis* Zone, and the *beckmanni* Zone (Text-fig. 3), and also to correlate this section with other successions of Belgium (GROESSENS, 1975; GROESSENS, CONIL & LEES, 1976).

Of special interest in this classical section, however, was also to test up the preliminary standard conodont zonation. The results we received show the scheme is to be corrected.

The *typicus* Zone is recognized and its base is placed at the lowest occurrence of *Gnathodus cuneiformis* (Bed 22/69), the lower range of which appears to be very close to that of *Gnathodus typicus* Morphotype 2. In the investigated section, the zonal name-bearer appears erratically but much later than *G. cuneiforms* (see Table 1). Besides all that the zone is well documented by associated fauna including other gnathodids, as well as *Pseudopolygnathus pinnatus, Ps. oxypageus, Dollymae bouckaerti*, and *Eotaphrus bultyncki*.

In fact, the base of the *typicus* Zone can be identified in Belgium as well as in other regions of Europe by the first appearance of *G. cuneiformis*. Thus, it is only proper to replace the *typicus* Zone by the *cuneiformis* Zone, as proposed by BELKA (1985 : 46-47). The prominence of *Gnathodus typicus* in the studies of LANE, SANDBERG & ZIEGLER (1980) is not reflected within the composition of the Lower Carboniferous conodont faunas from Europe. Moreover, this species can be also difficult to recognize (THORNBURY, 1985 : 35-36). As a result of the examination of conodont fauna from Salet we

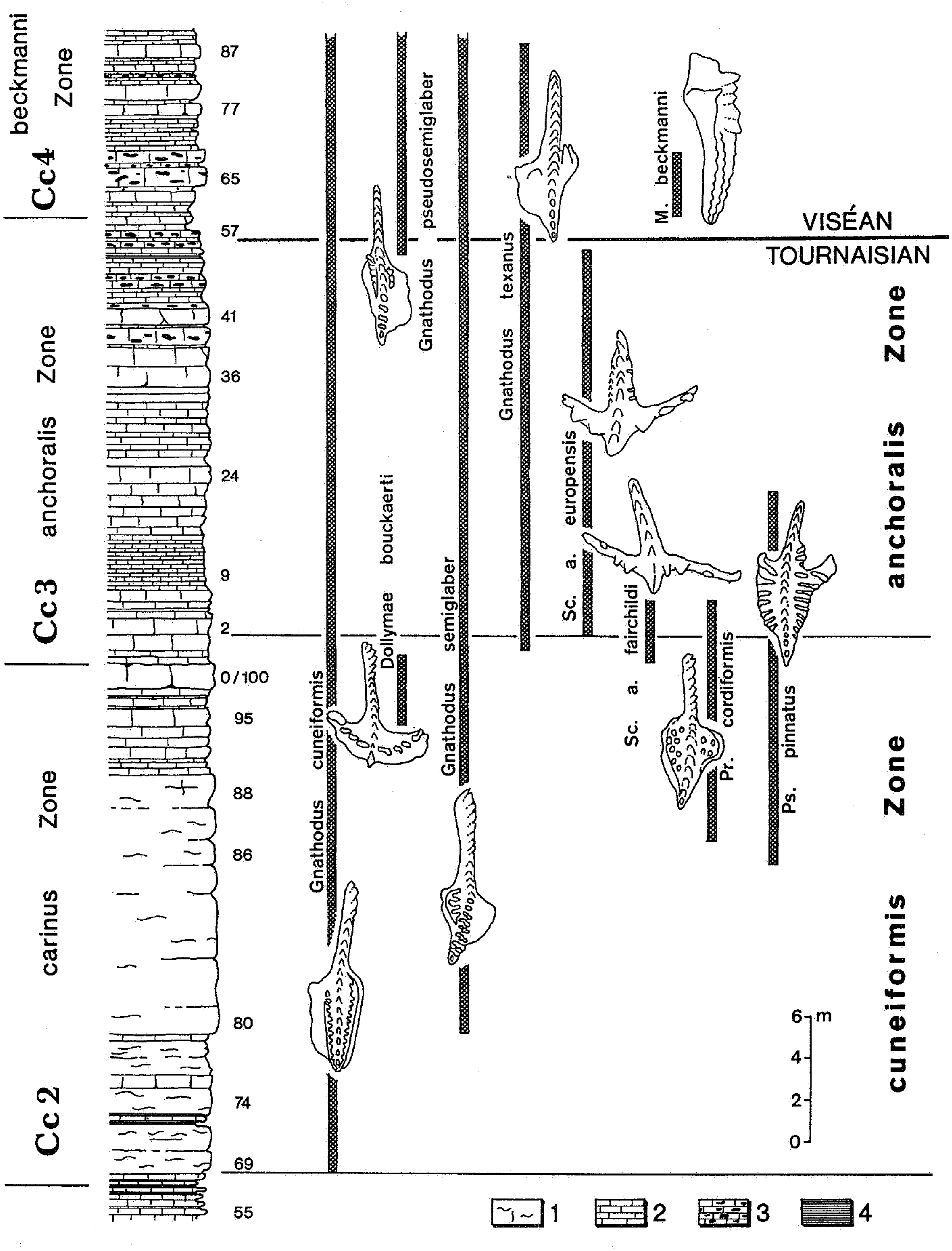

Fig. 3 - Ranges of the most important conodont taxa around the Tournaisian-Viséan boundary beds in the "Route de Salet" section *M.* - *Mestognathus*, *Sc. a.* - *Scaliognathus anchoralis*, *Pr.* - *Protognathodus*, *Ps.* - *Pseudopolygnathus*.
The recognized standard conodont zones (on the right) are compared with those (on the left) of GROESSENS (1975) and CONIL, GROESSENS & PIRLET (1977).
Lithology : 1 - massive limestones,
2 - bedded limestones,
3 - bedded limestones with cherts,
4 - shales;
for detailed lithology, see HANCE (1985).

expect that further studies will allow to subdivide the *cuneiformis* Zone into two or three parts. The records of easily recognizable forms as *Protognathodus cordiformis*, *Pseudopolygnathus pinnatus* and/or *Dollymae bouckaerti* seem to be very perspective.

Since the species *Scaliognathus anchoralis* has been subdivided to include three subspecies, the base of the *anchoralis* Zone is defined by the first appearance of *Sc. a. europensis* (LANE, SANDBERG & ZIEGLER, 1980; LANE & ZIEGLER, 1983 : Fig. 4). The zonal marker succeeds at Salet *Sc. a. fairchildi* (Table 1). Therefore, the base of the *anchoralis* Zone must be taken 1.5 m higher than it was traced out formerly (GROESSENS, 1975 : 46). The new concept of this limit is more useful in comparison to that of GROESSENS (1975), if there are disparities in lower ranges of particular subspecies of *Scaliognathus anchoralis*. Moreover, it provides a mutual control of this boundary by the occurrences of other forms of the genus, such as *Sc. praeanchoralis* and *Sc. a. fairchildi*.

The top of the *anchoralis* Zone being the base of the next *texanus* Zone is identified by the first appearance of *Gnathodus texanus* (LANE, SANDBERG & ZIEGLER, 1980 : 120). As mentioned above, this taxon appears in the investigated section earlier than *Sc. a. europensis* (Table 1 and Text-fig. 3). Consequently, the *anchoralis* Zone would be to eliminate here if following the concept of LANE, SANDBERG & ZIEGLER. This zone, however, constitutes the best recognized interval of the Lower Carboniferous that by means of conodonts can be traced throughout the world. Therefore, it is suggested to re-examine the concept of the *texanus* Zone in order to create another zone of a global use that will follow the *anchoralis* Zone. As long as the stratigraphic ranges of other Viséan gnathodids are not satisfactorily documented, *Mestognathus beckmanni* can be only tentatively used to define this zone. The species *Mestognathus beckmanni* is interpreted to have lived in shallow-water biofacies (AUSTIN, 1976; BELKA, 1983 : 81-82) whereas the preliminary standard conodont zonation for the Lower Carboniferous is essentially based on deep-water conodonts.

THE POSITION OF THE TOURNAISIAN-VISEAN BOUNDARY.

The Tournaisian-Viséan boundary as ratified by the Subcommission on Carboniferous Stratigraphy runs 34 meters below the base of the Marbre Noir de Dinant and it is located precisely at the base of Bed 141 of the boundary stratotype section at Dinant (*cf.* CONIL *et al.*, 1969). LANE & ZIEGLER (1983) discussed recently in detail the conodont occurrences around the boundary in that section. As a consequence,they correlated the Tournaisian-Viséan boundary with the preliminary standard conodont zonation to put it within the *anchoralis* Zone.

In the "Route de Salet" section, the Tournaisian-Viséan boundary has been distinguished at the base of Bed 8/52 (Text-figs 2 and 3) that forms the base of the Marbre Noir de la Molignée. The recognition is based, first of all, on such lithological evidences as the presence of an important argillaceous marker (*cf.*CONIL, GROESSENS & PIRLET, 1977) that occurs in the first meter above the boundary. In terms of conodonts and foraminifers the present position of the limit appears to be njustified. The order of ranges of conodonts such as *Scaliognathus anchoralis europensis* and *Mestognathus beckmanni* (Text-fig. 3) in relation to the appearance of the diagnostic foraminifer *Pachysphaerina pachysphaerica* is identical to that in the Tournaisian-Viséan Boundary Stratotype at Dinant (*cf.* GROESSENS & NOEL, 1977 : Pl. 1). The taxon *Scaliognathus anchoralis europensis* (together with *Hindeodella segaformis*), namely, ranges up to Bed 8/54 (Table 1) i.e. 0.5 m higher than hitherto was recognized, while *Mestognathus beckmanni* starts in Bed 8/60. The foraminifer *Pachysphaerina pachysphaerica* the first appearance of which is coincident at Dinant with the Tournaisian-Viséan boundary,ranges from Bed 8/57 (HANCE, 1985 : Tab. 18).

Although the range of *Mestognathus beckmanni* in the stratotype section at Dinant is considered to be artificial (LANE & ZIEGLER, 1983 : 210) the biostratigraphic data evidence that the Tournaisian-Viséan boundary at Salet should be displaced higher up to the base of Bed 8/57 (see Text-fig. 3).

SYSTEMATIC PALEONTOLOGY.

All type material and figured specimens are housed in the collection of the Geological Survey of Belgium, Brussels.

Genus *Staurognathus* BRANSON & MEHL, 1941.

TYPE SPECIES : *Staurognathus cruciformis* BRANSON & MEHL, 1941.

REVISED DIAGNOSIS :

A genus characterized by an *Icriodus*-like P element with a long anterior process bearing a double row of side denticles which may be fused to form transverse ridges. As many as two lateral processes and one shorter posterior process may be developed to produce the typical cruciform outline. Lateral processes are straight or very slightly concave anteriorly. They may also be ornamented by a double row of denticles on the upper surface. The posterior process is generally curved in wardly.

REMARKS :

The genus *Staurognathus*, as presently conceived, comprises two species : *St. cruciformis* BRANSON & MEHL, and *St. dionantensis* n. sp. which is described herein. The another earlier described species, *Staurognathus anchorarius* HASS (1959) has been transferred by CHAUFF & KLAPPER (1978) to *Bactrognathus* as it bears only a single row of denticles on the anterior process and it shows a morphologic gradation with *B. excavatus*. The species *St. dionantensis* appears to be an ancestor of *St. cruciformis*, at it is evidenced by a transitional form described by AUSTIN & GROESSENS (1972) as "New genus B GROESSENS → *Staurognathus* BRANSON & MEHL".

The both species of *Staurognathus* yield distinct exclusive geographic restriction in their distribution. The type species has so far been found to occur widely in North America (BRANSON & MEHL, 1941; COOPER, 1948; HASS, 1959; BURTON, 1964; THOMPSON, 1967; THOMPSON & FELLOWS, 1970; LANE, SANDBERG & ZIEGLER, 1980; CHAUFF, 1981). In contrast, *St. dionantensis* as a very rare element was only reported from Belgium, Germany (*cf.* LANE, SANDBERG & ZIEGLER, 1980), and Poland (BELKA, 1985a). The single Australian specimen of *Staurognathus cruciformis* (DRUCE, 1970), represents, most probably, another species of the genus just as forms described by CHAUFF (1985 : Figs. 1.27 and 1.29) as *Staurognathus* aff. *S. cruciformis*.

The hypothetic apparatus reconstruction of *Staurognathus cruciformis* was presented by CHAUFF (1981). Except for Pa and Pb elements this apparatus is believed to be identical with that of the genus *Doliognathus*. CHAUFF (1985 : 308) suggested, moreover, that *St. cruciformis* have evolved from an early form of *D. latus*.

The morphological similarities between *St. cruciformis* and some forms of *D. latus*, as demonstrated by CHAUFF (1985), are unquestionable. However, *St. cruciformis* with well-developed lateral processes is known to occur stratigraphically below the first appearance of *Doliognathus latus* (see LANE, SANDBERG & ZIEGLER, 1980; Tab. 2; CHAUFF, 1981 : Text-fig. 3 and Tab. 2). We believe that the evolution of *D. latus* to develop an inner lateral process reflects the general evolutionary trend observed among the uppermost Tournaisian conodonts to produce symmetrical Pa elements. This trend is easily recognizable in the evolution of the genus *Scaliognathus* for instance (cf. LANE & ZIEGLER, 1983).

RANGE :

Base of the *cuneiformis* Zone into the *anchoralis* Zone.

Staurognathus dionantensis n. sp.
Pl. 1, Figs 1-2

1959 *Icriodus latericrescens* BRANSON & MEHL ? - VOGES, p. 286 (specimens not illustrated).

1971 N. GEN. B. - GROESSENS, p. 17, Pl. 2, Figs. 5-6.

1980 *Eotaphrus ?* n. sp. V. - LANE, SANDBERG & ZIEGLER, Pl. 10, Figs. 9-10 (specimens from VOGES' collection).

1985 *Eotaphrus ?* sp. V of LANE, SANDBERG & ZIEGLER. - BELKA, p. 37, Pl. 9, Fig. 6.

HOLOTYPE :

The specimen illustrated by GROESSENS (1971, Pl. 2, Fig. 5a-b) and reillustrated herein in Pl. 1, Fig. 2.

DERIVATIO NOMINIS :

From Dinant, where this species was found for the first time in Belgium.

STRATUM TYPICUM :

Bed of crinoidal packstone, Bed 8/0 of the Route de Salet, 20 m below the base of the Marbre Noir de la Molignée.

LOCUS TYPICUS :

Salet, Molignée Valley, the Ardennes; Belgium.

DIAGNOSIS : A species of *Staurognathus* characterized by only germinal development of lateral processes. The posterior process is marked by a group of nodes or a short ridge that diverges (at the angle of 45°) inwards from the axis of the anterior process. The large open basal cavity flares beyond the spindle. The posterior margin of the basal cavity is corrugated to form three lobe-like extensions.

MATERIAL : 5 sepcimens.

REMARKS :

Since the time when this element has been recognized it is difficult to assign it, beyond any doubt, to any Lower Carboniferous conodont genus. This was because it displays many similarities, but also differences to such genera as *Icriodus*, *Eotaphrus*, *Staurognathus* and *Dollymae* (*cf.* GROESSENS, 1976). Recently, this unit was commonly regarded as a possible species of *Eotaphrus*, but lack of a large cusp, diagnostic for *Eotaphrus*, was noticed. Although a resemblance to the genus *Eotaphrus* was suggested, a very close connection with the genus *Staurognathus* was also indicated (AUSTIN & GROESSENS, 1972).

LANE, SANDBERG & ZIEGLER (1980) confined the stratigraphic range of this species to the lower part of the *anchoralis* Zone. The appearance of this species earlier than *Scaliognathus anchoralis* was, however, known in Belgium (GROESSENS, CONIL & LEES, 1976). Recently, in the Moravia-Silesia Basin in Poland, a single specimen of this species was found to occur at the base of the *cuneiformis* Zone (BELKA, 1985a). This record precedes considerably the lower limit of *Eotaphrus evae*, which is considered to be the most primitive form of *Eotaphrus*. Thereby, a phylogenetic relation of the newly described species to the *Eotaphrus* lineage (as given by LANE, SANDBERG & ZIEGLER 1980) seems to be doubtful. As a consequence, we assign this species to *Staurognathus*, on the basis of the tendency in morphologic gradation to form the cruciform outline.

The new species, *Staurognathus dionantensis* n. sp. differs from *St. cruciformis* in lacking of well-developed posterior and lateral processes. It resembles *Eotaphrus burlingtonensis*, which can be, however, distinguished by the prominent cusp at the posterior end.

The origin of *St. dionantensis* is problematic. Two forms, at first *Peleksygnathus* sp. A of VOGES and later *Dolymae* sp. A of VOGES are suggested to have been an ancestor of this species (*cf.* AUSTIN & GROESSENS, 1972; GROESSENS, 1976).

RANGE : Same as for the genus.

Zone			unzoned interval												unzoned interval																										
Sample no.	56	57	60	66	67	68	70	71	76	78	83	86	87	88	91	97	98	99	104	113	122	124	125	131	143	151	158	163	169	173	178	183	190	194	198	205	211	216	260	263	268
Gnathodus cuneiformis	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. cuneiformis → pseudosemiglaber	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	1	6	-	26	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. pseudosemiglaber	-	-	-	2	8	-	1	2	4	1	-	1	5	1	3	-	9	1	36	3	9	5	6	22	8	3	-	1	-	-	-	-	1	-	4	-	2	-	3	1	1
G. homopunctatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	1	-	-	6	1	-	-	-
G. cf. homopunctatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	-
G. semiglaber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
G. symmutatus	-	-	-	-	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-	1	-	-	-	-
G. texanus	-	-	-	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. typicus M2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. sp. juv.	-	-	2	-	-	-	1	-	2	2	-	-	2	1	-	-	2	-	17	3	5	-	-	2	3	-	1	-	-	-	-	1	3	-	2	1	-	-	1	1	1
Anchignathodus penescitulus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
An. scitulus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
An. simplicatus	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bispathodus aculeatus aculeatus	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. bispathodus	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idioprioniodus conjunctus	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mestognathus beckmanni	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygnathus communis communis	-	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. flabellus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
P. inornatus	4	1	-	-	-	-	-	1	5	1	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	4	1	9	1	1	-	-	-	-	-	-	-	-	-	-
P. sp.	-	-	-	-	-	-	-	-	-	3	-	1	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
"Spathognathodus" macer	4	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gnathodus praebilineatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	-	-	-	-	-	-	-	-

TABLE I - Numerical data on the conodont collection from the "Route de Salet" section. Conodont sample numbers are bed numbers.

Zone					cuneiformis									cuneiformis										anchoralis															
Sample no.	53	56	59	67	69	78	80	86	87	88	90	91	92	93	94	95	96	97	99	0/100	1A	1B	1C	2	3AB	9	10	12	17	23	36	38	40	44	48	51	53	54	55
Gnathodus cuneiformis	-	-	-	-	7	1	3	-	2	5	2	-	-	-	-	1	-	-	1	8	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
G. cuneiformis → pseudosemiglaber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
G. pseudosemiglaber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
G. delicatus	-	-	-	-	1	-	-	2	2	-	1	-	-	-	-	-	-	2	3	11	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
G. punctatus	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. semiglaber	-	-	-	-	-	-	4	2	1	-	-	-	-	-	-	-	-	-	4	72	52	1	10	-	-	-	-	-	5	-	-	2	-	1	-	-	-	-	-
G. semiglaber → texanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	13	-	-	-	-	-	-	-	-	1	-	3	-	-	-	-	-
G. texanus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. typicus M1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G. typicus M2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
G. sp. juv.	-	-	1	-	2	-	4	7	-	1	-	-	-	-	-	-	-	-	3	17	9	2	16	-	-	-	-	-	-	-	-	-	1	-	1	-	-	2	-
Bispathodus aculeatus aculeatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. costatus	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. bispathodus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. stabilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clydagnathus sp.	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Doliognathus dubius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D. latus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Dollymae bouckaerti	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	3	1	77	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eotaphrus bultyncki	-	-	-	-	-	-	-	-	-	-	5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hindeodella segaformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	1	-	2	-	-	-	4	-	-	2	1	4	-
Idioprioniodus conjunctus	-	-	-	-	-	1	-	-	-	11	-	-	-	-	-	-	-	-	-	3	-	-	-	3	4	1	-	-	1	-	-	-	-	-	-	1	-	1	-
Mestognathus beckmanni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygnathus bischoffi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	6	12	-	-	-
P. communis communis	-	14	4	2	-	6	21	20	10	1	-	-	-	-	-	-	-	-	2	33	5	-	-	40	46	45	17	20	-	-	2	-	-	-	-	-	-	-	-
P. communis carinus	-	-	-	2	1	-	-	6	6	8	40	6	6	1	15	18	7	17	51	43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. flabellus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	-	-	-
P. inornatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	12	5	1	-	13	11
P. longiposticus	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	36	16	2	12	1	36	5	9	11	24	1	2	-	-	1	-	-	-	2	-
P. mehli	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
P. cf. purus	1	3	-	1	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	2	-	-	10	7	3	-	-	-
Protognathodus cordiformis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	19	12	-	7	30	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pr. praedelicatus	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pr. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	5	14	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudopolygnathus multistriatus	-	3	-	-	-	1	-	1	1	-	14	1	4	-	-	-	-	1	-	4	1	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ps. nudus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ps. oxypageus	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	1	1	11	-	4	4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ps. pinnatus	-	-	-	-	-	-	-	1	-	9	-	1	-	1	-	-	-	2	-	-	3	7	8	15	3	1	-	-	-	2	-	-	-	-	-	-	-	-	-
Scaliognathus praeanchoralis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sc. anchoralis europensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	13	-	1	-	-	1	-	1	12	-	3	2	-	8	-
Sc. anchoralis fairchildi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
"Spathognathodus" discretus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
"Sp." macer	-	-	-	-	-	3	-	4	1	3	-	-	-	-	-	1	-	-	-	39	18	-	-	-	5	-	2	-	15	-	1	1	-	12	4	5	-	1	-
"Sp." laterigranosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Staurognathus dionantensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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PLATE CAPTIONS

P L A T E I

All upper view, except as noted.

Figs. 1-2 *Staurognathus dionantensis* n. sp.
1 - Bed 8/0, x65
2 - *Holotype*, Bed 8/0, x45.

Fig. 3 *Eotaphrus bultyncki* (GROESSENS, 1971)
Rephotograph of holotype (GROESSENS, 1971; Pl. 1, Figs. 4a, b),
Bed 22/92, x75, lateral view.

Figs. 4-6 *Dollymae bouckaerti* GROESSENS, 1971
4 - Rephotograph of holotype (GROESSENS, 1971; Pl. 1, Figs. 7a, b)
Bed 8/0, x55.
5 - Bed 8/0, x60, lower view.
6 - Bed 8/0, x90, Juvenile specimen.

Fig. 7 *Scaliognathus praeanchoralis* LANE, SANDBERG & ZIEGLER, 1980
Bed 8/3, x100.

Figs.8-11 *Scaliognathus anchoralis fairchildi* LANE & ZIEGLER, 1983
8a, b - Bed 8/1C, x75, lower and upper views. Specimen with larger posteriorly directed cusp.
9 - Bed 8/2, x115. Juvenile specimen.
10 - Bed 8/3, x130. Juvenile specimen.
11 - Bed 8/1A, x85. Specimen transitional to *Scaliognathus anchoralis europensis*.

PLATE 1

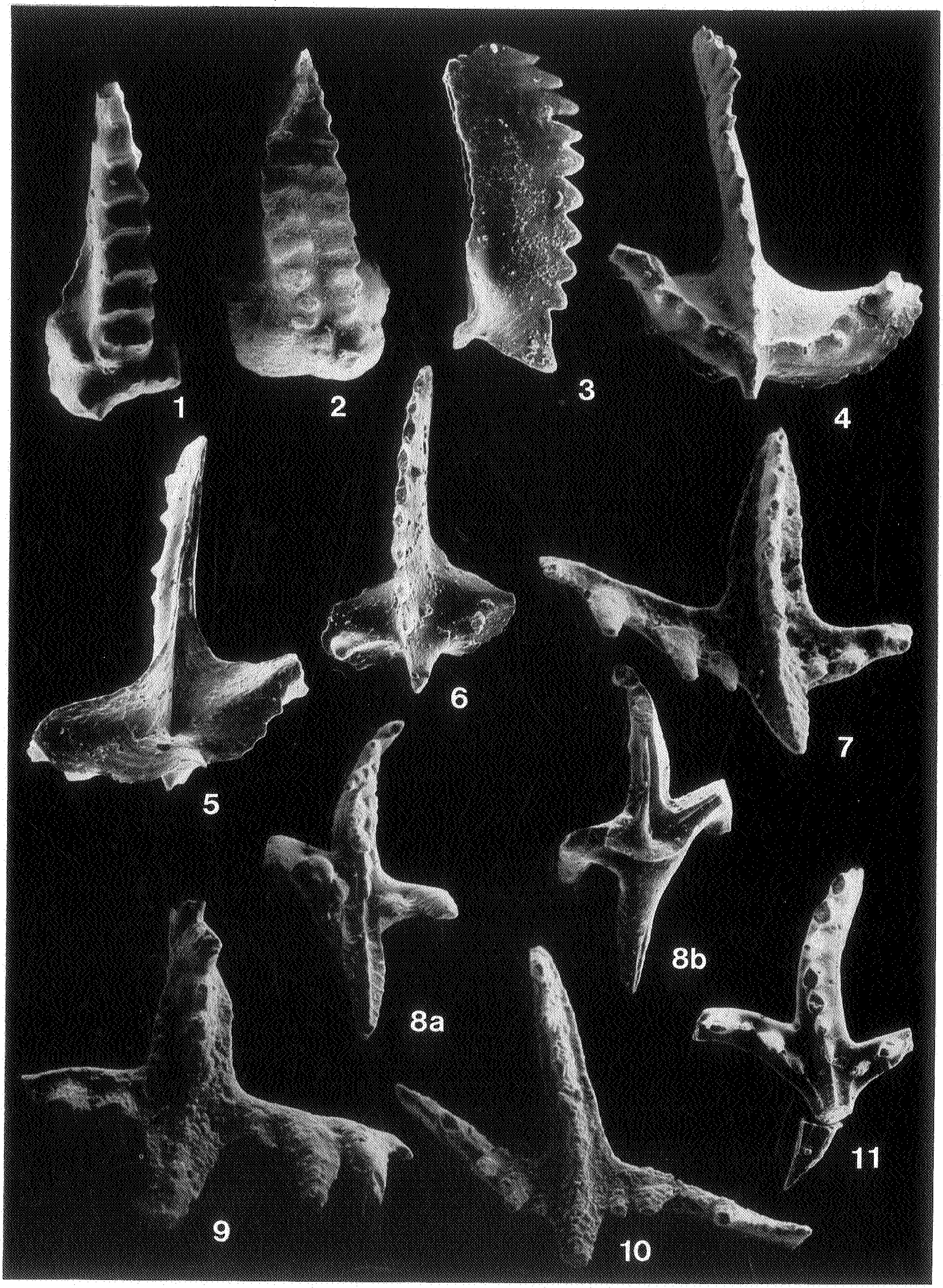


PLATE 2

Fig. 1 *Doliognathus dubius* BRANSON & MEHL, 1941.
Bed 8/2, x100, upper view. Juvenile specimen.

Fig. 2 *Scaliognathus anchoralis europensis* LANE & ZIEGLER, 1983.
Bed 8/51, x70, upper view.

Figs.3a,b *Mestognathus beckmanni* BISCHOFF, 1957
Bed 8/67, x50, upper and lateral views.

Fig. 4 *Bispathodus bispathodus* ZIEGLER, SANDBERG & AUSTIN, 1974.
Bed 8/57, x85, upper view.

Figs 5a,b *"Spathognathodus" laterigranosus* GEDIK, 1974.
Bed 8/2, x95, lateral and upper views.

Figs 6-7 *"Spathognathodus" macer* (BRANSON & MEHL, 1934).
6 - Bed 8/17, x65, lateral view.
7a,b - Bed 8/56, x60, upper and lateral views.

Fig. 8 - *Anchignathodus simplicatus* (RHODES, AUSTIN & DRUCE, 1969).
Bed 8/68, x150, lateral view. Juvenile specimen.

Fig. 9 - *Pseudopolygnathus pinnatus* (VOGES, 1959).
Bed 8/1B, x40, upper view.

Figs. 10-12 - *Pseudopolygnathus multistriatus* MEHL & THOMAS, 1947.
10 - Bed 22/86, x40, upper view. Morphotype 1.
11 - Bed 22/92, x45, upper view. Morphotype 2.
12 - Bed 22/92, x50, upper view, Morphotype 2.

Fig. 13 - *Pseudopolygnathus oxypageus* LANE, SANBERG & ZIEGLER, 1980.
Bed 8/3, x65, upper view. Morphotype 2.

PLATE 2

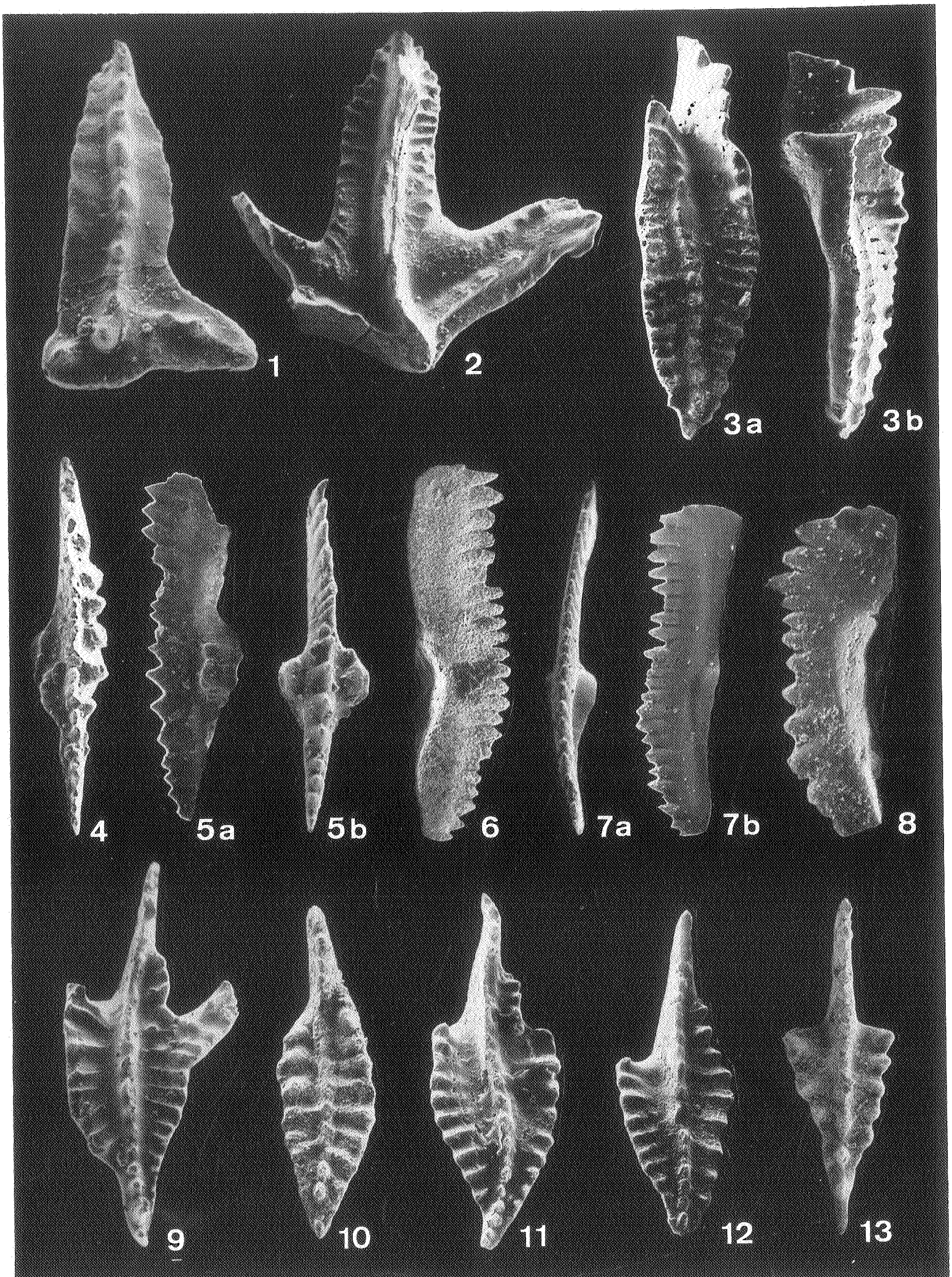


PLATE 3

Figs. 1 - 2	*Polygnathus* cf. *purus* VOGES, 1959. 1 - Bed 22/86, x90, upper view. 2 - Bed 22/86, x95, lower view.
Figs. 3 - 4	*Polygnathus communis communis* BRANSON & MEHL, 1934. 3 - Bed 8/57, x75, upper view. 4 - Bed 8/57, x105, lower view. Juvenile specimen.
Fig. 5	*Polygnathus flabellus* (BRANSON & MEHL, 1938). Bed 8/51, x60, upper view.
Figs. 6 - 7	*Polygnathus bischoffi* RHODES, AUSTIN & DRUCE, 1969. 6 - Bed 8/44, x75, upper view. 7 - Bed 8/44, x50, lower view. Advanced form.
Figs. 8 - 10	*Polygnathus inornatus* E. R. BRANSON, 1934. 8 - Bed 8/158, x75, upper view. Specimen transitional to *P. flabellus*. 9 - Bed 8/56, x70, upper view. 10a, b - Bed 8/44, x50, lower and upper views.
Figs. 11 - 15	*Polygnathus longiposticus* BRANSON & MEHL, 1934. 11 - Bed 8/0, x75, lower view. Juvenile specimen with a wide, inverted basal cavity. Compare with large specimen (Pl. 3, Fig. 14a) showing an extremely small basal cavity. 12 - Bed 8/0, x50, lower view. 13 - Bed 8/3, x60, lower view. 14a,b - Bed 8/17, x40, lower and upper views. Large, advanced form with a gerontic, lobe-like extension of the platform margin. 15 - Bed 8/17, x40, upper view.

PLATE 3

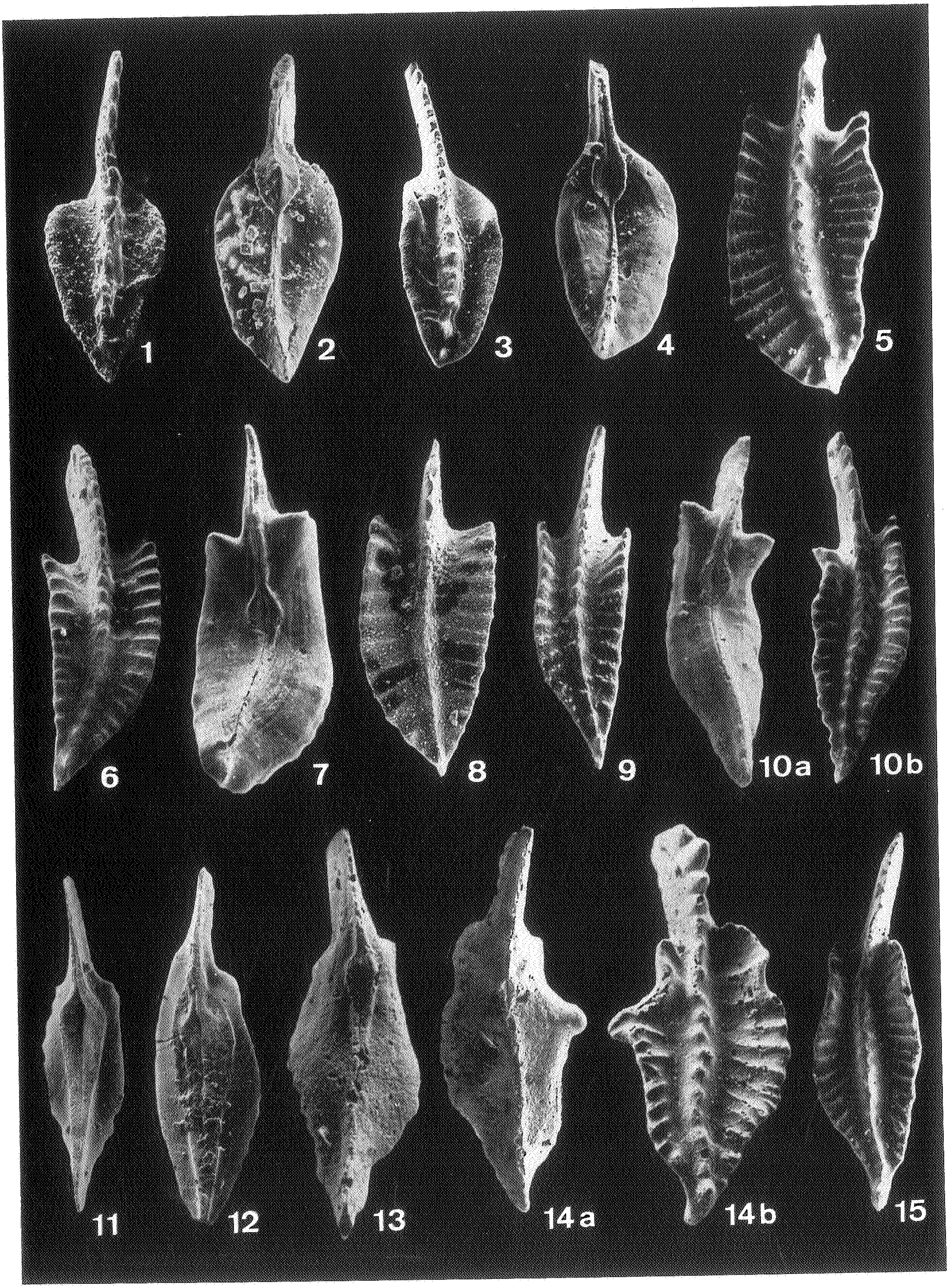


PLATE 4

All upper views, except Fig. 5.

Fig. 1 — *Protognathodus praedelicatus* LANE, SANDBERG & ZIEGLER, 1980.
Bed 22/86, x75.

Figs. 2 - 5 — *Protognathodus cordiformis* LANE, SANDBERG & ZIEGLER, 1980.
2 - Bed 8/3, x85. Juvenile specimen.
3 - Bed 8/3, x75.
4 - Bed 8/1C, x85. Juvenile specimen.
5 - Bed 8/2, x85. Margin of the cup partially broken.

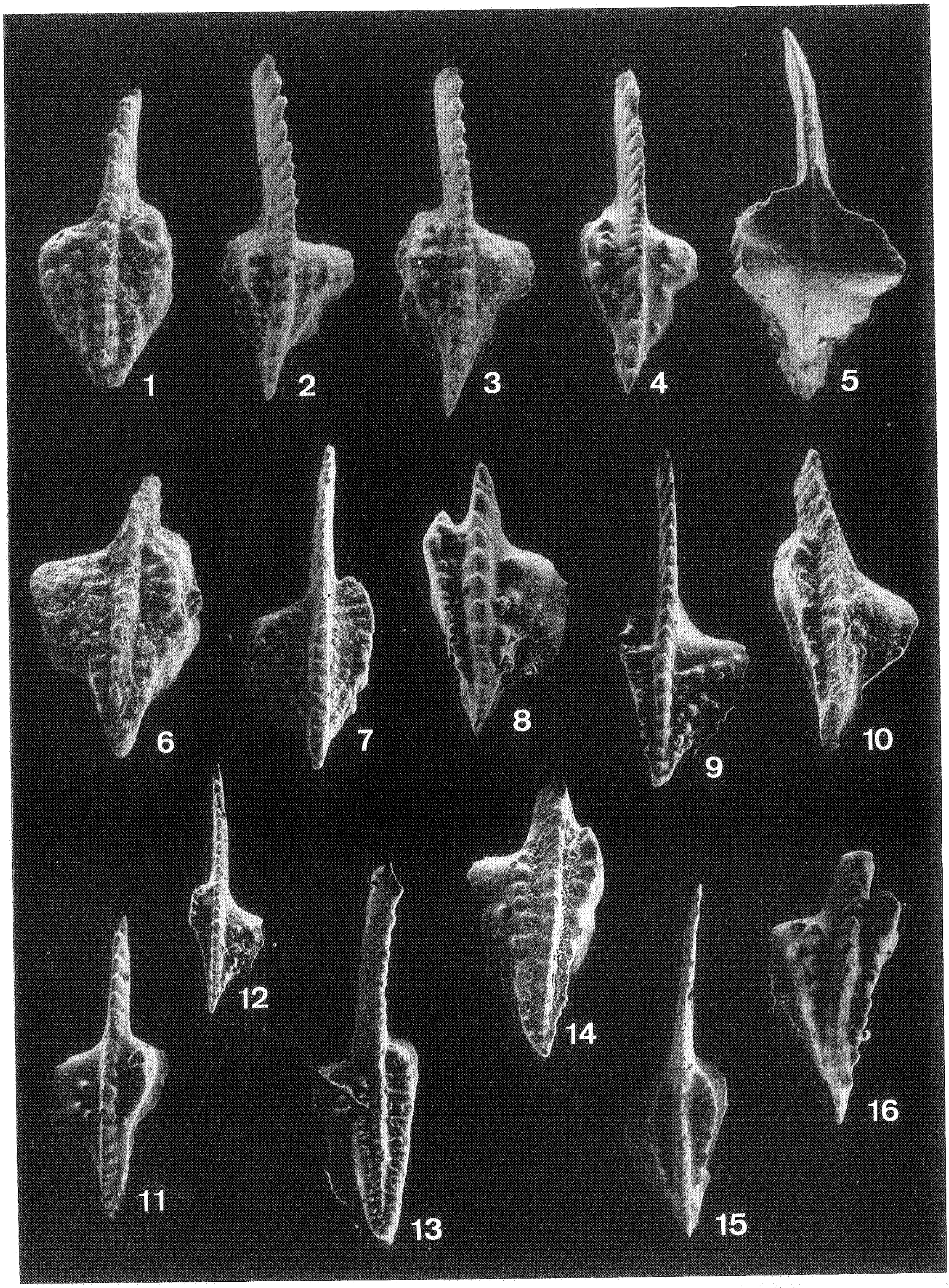
Fig. 6 — *Gnathodus punctatus* COOPER, 1939.
Bed 22/86, x70.

Figs. 7 -10 — *Gnathodus delicatus* BRANSON & MEHL, 1938.
7 - Bed 8/17, x60. Specimen transitional to *G. punctatus*.
8 - Bed 8/1A, x85.
9 - Bed 8/0, x75.
10 - Bed 22/69, x75.

Figs. 11-12 — *Gnathodus typicus* COOPER, 1938, Morphotype 1.
11 - Bed 8/0, x70.
12 - Bed 8/0, x55.

Figs. 13-16 — *Gnathodus cuneiformis* MEHL & THOMAS, 1947.
13 - Bed 22/88, x45.
14 - Bed 8/0, x90.
15 - Bed 8/53, x75. Younger morphotype.
16 - Bed 8/1A, x80.

PLATE 4



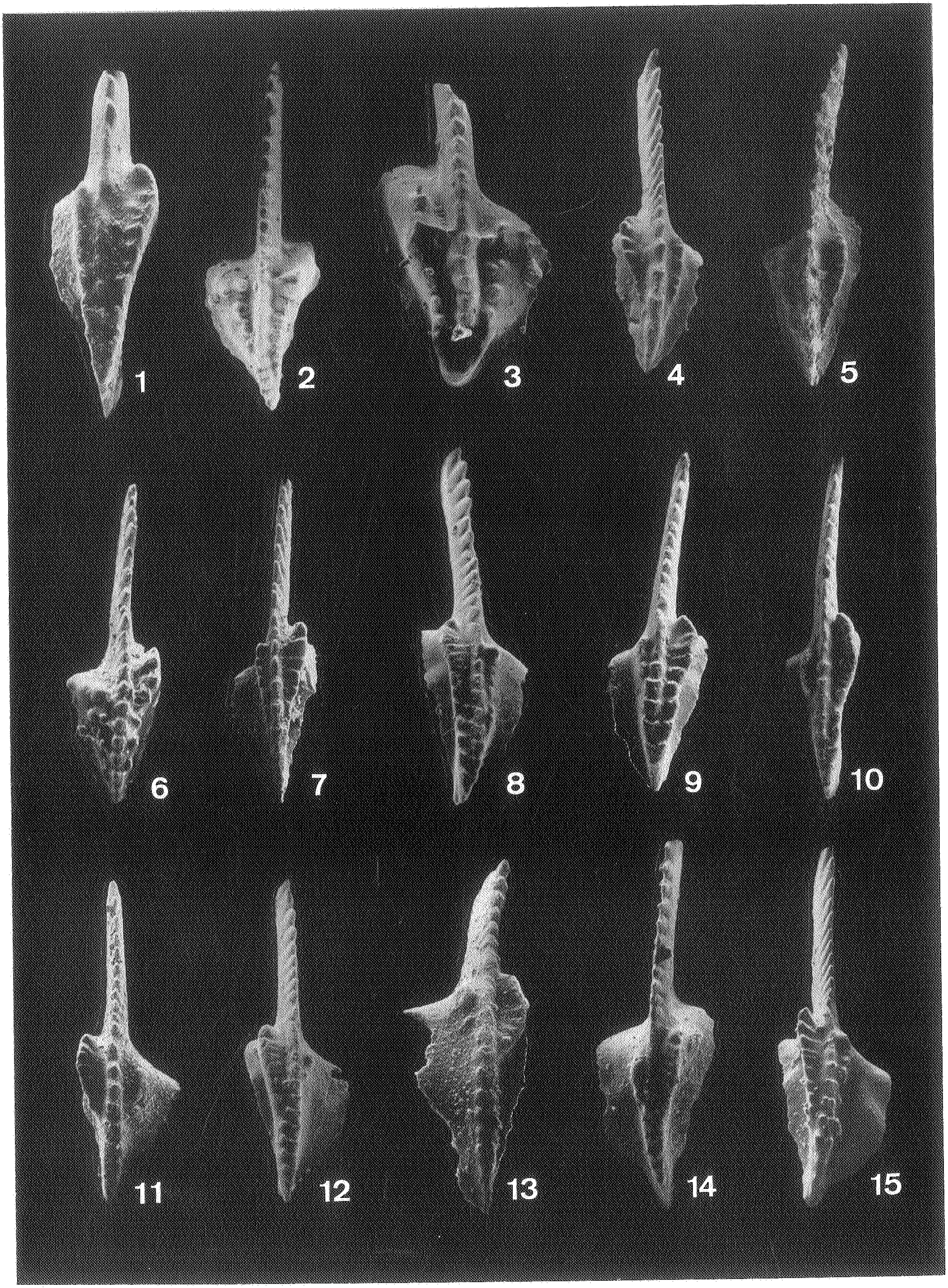
P L A T E 5

Figs. 1 - 3 *Gnathodus cuneiformis* MEHL & THOMAS, 1947.
1 - Bed 8/98, x70.
2 - Bed 8/1A, x55. Specimen transitional to *G. delicatus*.
3 - Bed 8/1A, x80. Specimen with a peculiar transverse ridge perpendicular to the blade.

Figs. 4 - 9 *Gnathodus cuneiformis* MEHL & THOMAS, 1947 → *Gnathodus pseudosemiglaber* THOMPSON & FELLOW, 1970.
4 - Bed 8/53, x95. Juvenile specimen.
5 - Bed 8/57, x80.
6 - Bed 8/97, x85. Juvenile specimen.
7 - Bed 8/76, x85. Juvenile specimen.
8 - Bed 8/104, x60 .
9 - Bed 8/104, x55.

Figs. 10 - 15 *Gnathodus pseudosemiglaber* THOMPSON & FELLOWS, 1970.
10 - Bed 8/104, x50.
11 - Bed 8/54, x70.
12 - Bed 8/104, x55.
13 - Bed 8/76, x75.
14 - Bed 8/91, x60.
15 - Bed 8/98, x60.

PLATE 5



P L A T E 6

All upper views.

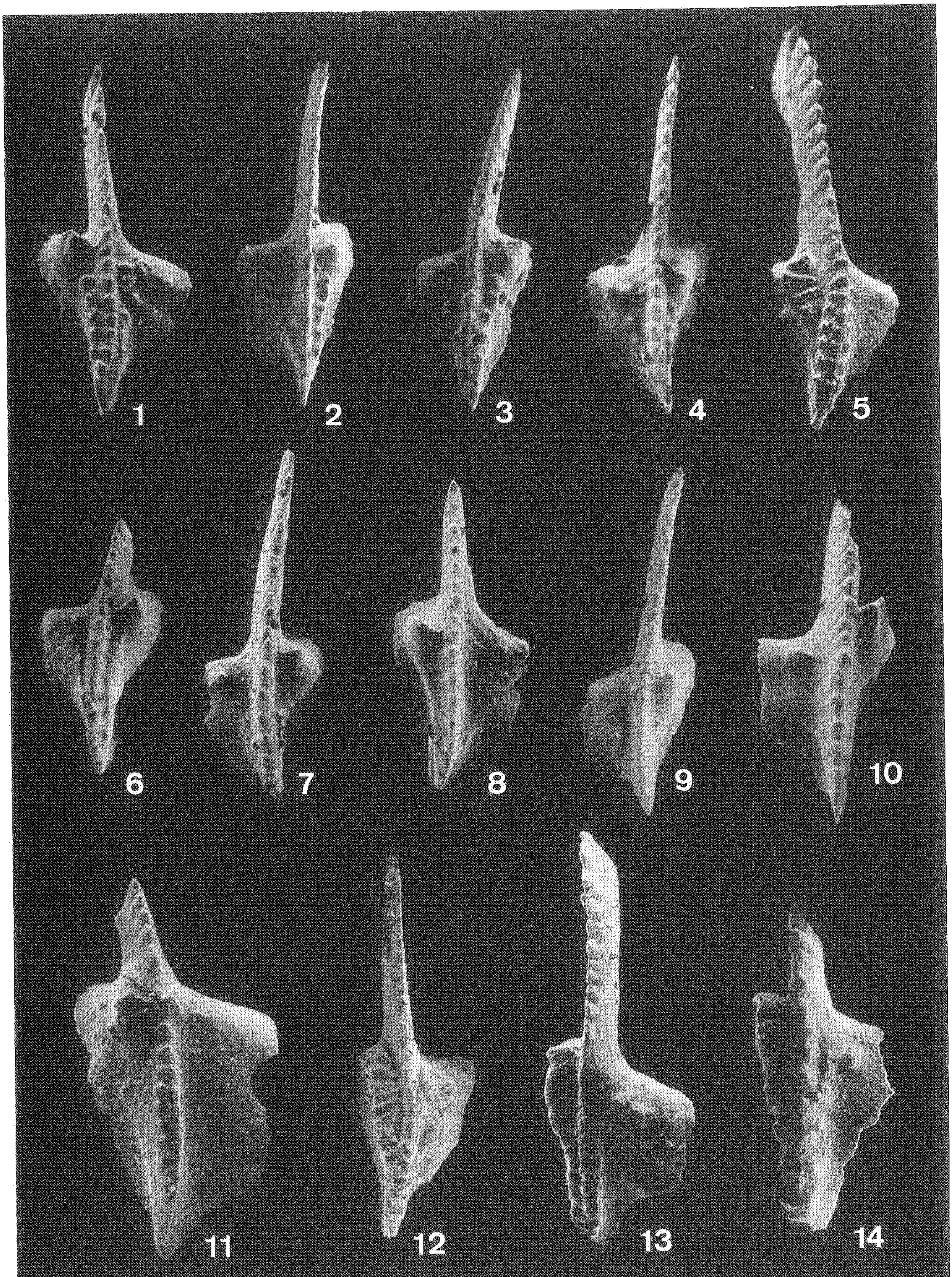
Figs. 1 - 6 *Gnathodus semiglaber* (BISCHOFF, 1957).
1 - Bed 8/1C, x75.
2 - Bed 8/1C, x75.
3 - Bed 8/1C, x60.
4 - Bed 8/1C, x75.
5 - Bed 8/44, x40.
6 - Bed 8/1A, x60.

Figs. 7 - 9 *Gnathodus semiglaber* (BISCHOFF, 1957) →
Gnathodus texanus ROUNDY, 1926.
7 - Bed 8/1C, x75.
8 - Bed 8/1A, x95. Juvenile specimen.
9 - Bed 8/1C, x70.

Figs. 10 - 11 *Gnathodus texanus* ROUNDY, 1926.
10 - Bed 8/1C, x90. Juvenile specimen.
11 - Bed 8/76, x65.

Figs. 12 - 14 *Gnathodus praebilineatus* BELKA, 1985.
12 - Bed 8/163, x45.
13 - Bed 8/190, x45.
14 - Bed 8/190, x100. Juvenile specimen.

PLATE 6



P L A T E 7

All upper views.

Figs. 1 - 3 *Gnathodus pseudosemiglaber* THOMPSON & FELLOWS, 1970.
1 - Bed 8/122, x55.
2 - Bed 8/260, x75.
3 - Bed 8/104, x60.

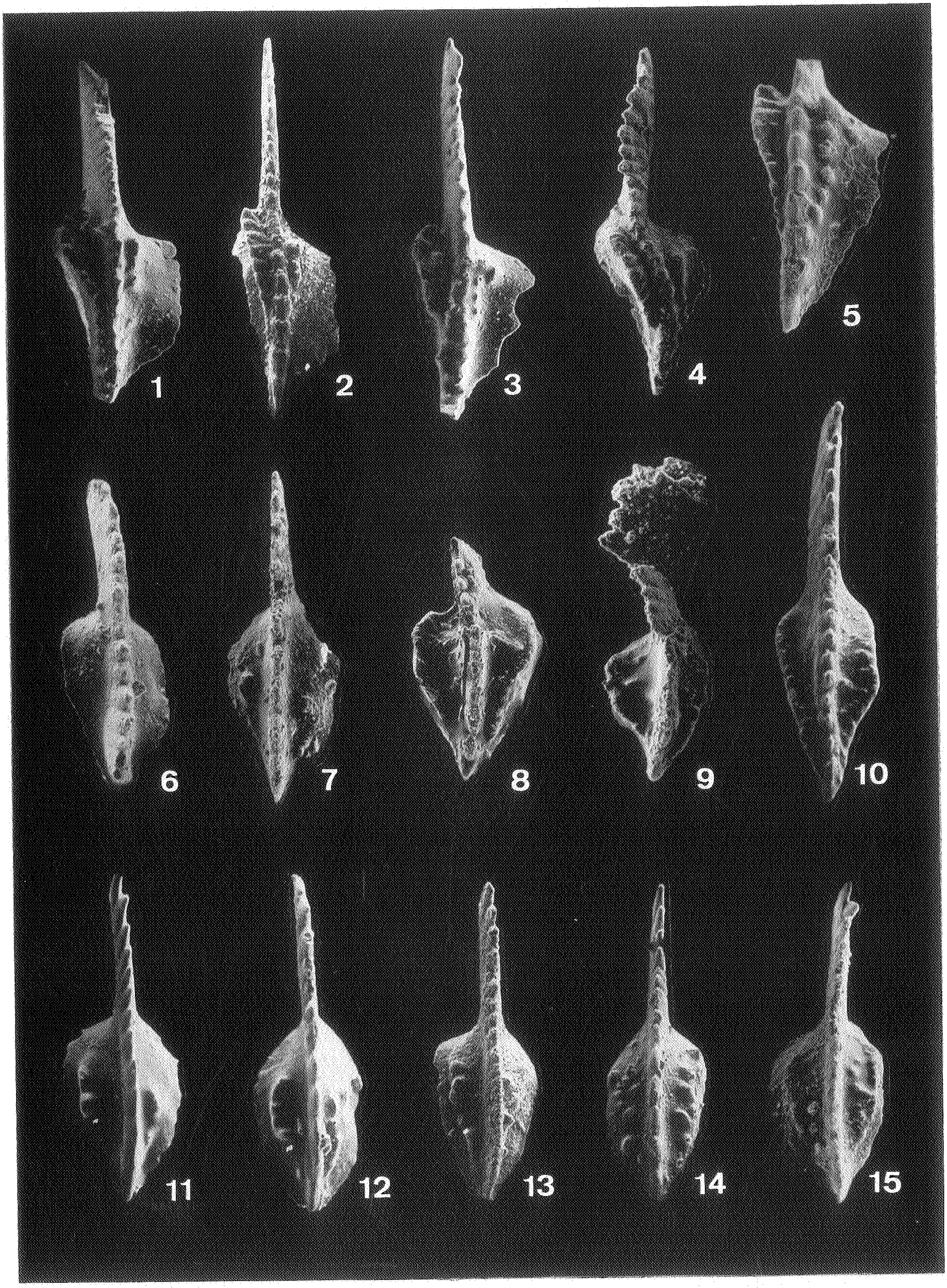
Figs. 4 - 5 *Gnathodus pseudosemiglaber* THOMPSON & FELLOWS, 1970 → *Gnathodus girtyi* HASS, 1953.
4 - Bed 8/268, x70.
5 - Bed 8/263, x95.

Figs. 6 - 7 *Gnathodus symmutatus* RHODES, AUSTIN & DRUCE, 1969.
6 - Bed 8/83, x80.
7 - Bed 8/211, x120. Juvenile specimen.

Figs. 8 - 10 *Gnathodus* cf. *homopunctatus* ZIEGLER, 1962.
8 - Bed 8/263, x102.
9 - Bed 8/216, x 90.
10 - Bed 8/205, x 80.

Figs. 11 - 15 *Gnathodus homopunctatus* ZIEGLER, 1962.
11 - Bed 8/211, x140. Juvenile specimen.
12 - Bed 8/211, x155. Juvenile specimen with an asymmetrical ornamented cup.
13 - Bed 8/211, x135. Juvenile specimen.
14 - Bed 8/178, x110. Specimen transitional to *G. mermaidus*.
15 - Bed 8/183, x 95.

PLATE 7



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