# A Revision of the Swedish Ordovician Odontopleuridae (Trilobita)

By

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ABSTRACT.—All the material available of Swedish Ordovician odontopleurid trilobites has been studied and type specimens are refigured. Eight genera and 15 species have been distinguished. A new genus, *Periallaspis*, from the lowermost Arenig of Västergötland is one of the oldest so far known. At present, this genus cannot be referred to any known subfamily and its relation to other genera is not clear. Newly described species are *Periallaspis uncinus*, *Apianurus vikarbyensis*, *Miraspis solbergensis* and *Primaspis bestorpensis*. *Primaspis dalecarlica* (TÖRNQUIST) is considered a synonym of *P. evoluta* (TÖRNQUIST). The occurrence of *Apianurus vikarbyensis* in the Expansus Limestone indicates that the range of the genus *Apianurus* can be extended into the Lower Ordovician. The stratigraphic and geographic distribution of each species is presented and the relations with species from other areas are briefly discussed.

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## Introduction

A systematic treatment of the Swedish Ordovician odontopleurid trilobites is herein presented as part of a comprehensive study of the Odontopleuridae from Europe and North America. During the latter half of 1963, the writer had the opportunity to work in Swedish museums and universities and to visit some of the localities which yielded the original type material from the areas of Öland, Västergötland and the Siljan district, Dalarna. From the last two regions, some new material was collected and this has been described in the paper.

Much of the work for this paper was completed while at the Palaeontological Institute, University of Uppsala, and I am deeply indebted to Professor PER THORSLUND for allowing me to stay at the Institute and for guiding this paper through the press.

The following people kindly arranged the loan of specimens for study: Dr. HARRY MUTVEI, Swedish Museum of Natural History (Naturhistoriska riksmuseet, Stockholm; in this paper abbreviated RM), Dr. FRITZ BROTZEN, Museum of the Swedish Geological Survey, Stockholm (SGU), Dr. ROLAND SKOGLUND, Palaeontological Museum, University of Uppsala (UM), and Professor GERHARD REGNÉLL, Palaeontological Museum, University of Lund (LM). The types of BEYRICH, were borrowed on my behalf by Dr. ANDERS MARTINSSON and were sent by Dr. HERMANN JAEGER, Geological and Palaeontological Museum, Humboldt University, East Berlin (HU). Specimens at the Sedgwick Museum, Cambridge (SM), were made available to me through the kindness of Dr. C. L. FORBES.

At Uppsala, Mr. NILS HJORTH made all the photographs except those on Plate 4 which were made by the author. Mr. ERIC STÅHL produced the text figures.

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## Historical review

Numerous outstanding publications of Swedish trilobites have been produced and in them ANGELIN (1854), TÖRNQUIST (1884) and WARBURG (1925) described several species of odontopleurids, and LINNARSSON (1869), TROEDS-

SON (1918), OLIN (1906) and THORSLUND (1940) each described new species in their classic stratigraphic papers on Västergötland, Scania and Jemtland. In more recent years, WHITTINGTON & BOHLIN (1958) described new and interesting specimens from the Lower Ordovician of Öland, and KIELAN (1960) revised the uppermost Ordovician species.

WARBURG's study of the trilobites from the Leptaena Limestone (reef limestone of the Siljan type), still remains one of the foundations of modern trilobite study and in this and a later paper (WARBURG 1933), earlier material described by ANGELIN and TÖRNQUIST was redescribed along with additional material.

## Remarks on Stratigraphy

The stratigraphic terminology used is the same as that recommended by JAANUSSON (1960; 1963; 1964) with additions following the work of SKOGLUND (1963) and SKEVINGTON (1963). The Harju Series (Upper Ordovician) is defined as from the top of the Ordovician System to the base of the *Pleurograptus linearis* zone, Viru Series (Middle Ordovician), as from the top of the *Dicranograptus clingani* zone to the base of the *Didymograptus murchisoni* zone, and the Oeland Series (Lower Ordovician) as from the top of the *D. bifidus* zone to the base of the Ordovician System. For the reasons outlined by JAANUSSON (1960, p. 78), the terms Llanvirn, Llandeilo, Caradoc and Ashgill are still difficult to apply to the Balto-Scandian succession and are not used here.

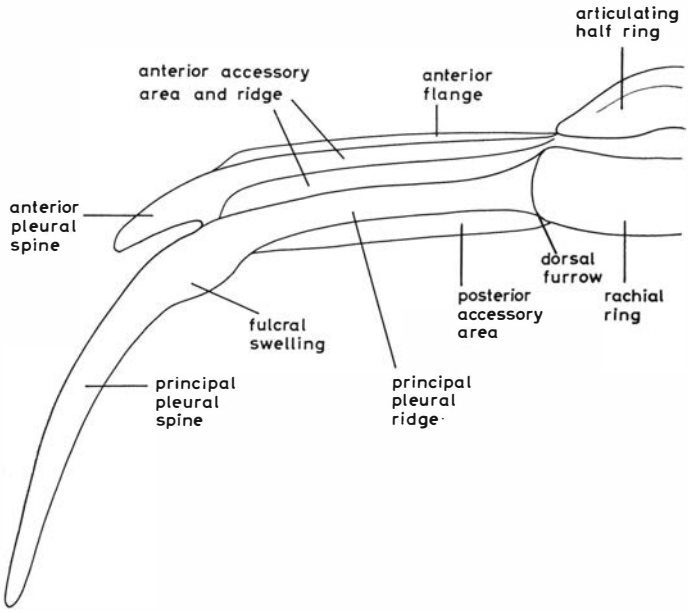
## Remarks on Terminology

The terminology used in the descriptions is the same as that outlined by WHITTINGTON (1956*a*, pp. 160–162) and BRUTON (1965) except that the terms anterior and posterior band (WHITTINGTON 1956*a*, p. 161) have not been used when describing the thoracic pleurae. Some of the terms which were used by BARRANDE (1852, Pl. 6, fig. 15) for the pleurae called "*type à bourrelet*" are more satisfactory because they afford a more detailed description. These terms (Text-fig. 1) are defined as:

*Principal pleural ridge* ("*bourrelet principal de la plèvre*" of BARRANDE) = the raised ridge which crosses the pleural area and is produced distally into the *principal pleural spine.*

*Anterior* and *posterior accessory area* = the areas on each side of the principal pleural ridge. The anterior accessory area is frequently divided into two parts, an inner flattened area and an outer raised ridge. When the ridge is present, it is convenient to refer to it as the *anterior accessory ridge* ("*bourrelets accessoires*" of BARRANDE 1852, p. 170).

Sometimes narrow flattened areas used for articulation occur along either the anterior or posterior edges of the pleural segment. These are *flanges* (cf. WHITTINGTON & EVITT 1954, pp. 21–22, Text-fig. 3), which may have an articulating




Text-fig. 1. Terminology used in the description of the odontopleurid thoracic pleural segment with a raised central ridge. Figure based on *Primaspis bestorpensis* n.sp.

boss or process at the fulcrum. In pleurae which have the principal pleural spine directed backwards, such flanges normally occur along the anterior edge and fit beneath the posterior part of the preceeding segment.

*Anterior pleural spine* is that which is directed outwards from the anterior accessory area.

## Systematic Descriptions

**Family Odontopleuridae** BURMEISTER, 1843

**Subfamily Odontopleurinae** BURMEISTER, 1843

**Genus *Primaspis*** R. & E. RICHTER, 1917

TYPE SPECIES.—*Odontopleura primordialis* BARRANDE, 1846 (cf. WHITTINGTON 1956*a*, p. 198).

***Primaspis evoluta*** (TÖRNQUIST, 1884)

Pl. 1, figs. 1–9; Pl. 4, fig. 9; Text-fig. 2 A

1884 *Acidaspis evoluta* n.sp. — TÖRNQUIST, p. 28; Pl. 1, fig. 24.
1884 *Acidaspis dalecarlica* n.sp. — TÖRNQUIST, p. 27; Pl. 1, figs. 22–23.
1906 *Acidaspis dalecarlica* TÖRNQUIST — REED, p. 119; Pl. 16, fig. 7.
1907 *Acidaspis dalecarlica* TÖRNQUIST — WIMAN, p. 133; Pl. VIII, fig. 37.
1908 *Acidaspis dalecarlica* TÖRNQUIST — GROOM and LAKE, p. 573.
1913 *Acidaspis* sp. — MARR, p. 7.

1914 *Acidaspis evoluta* TÖRNQUIST — REED, p. 35.
1916 *Acidaspis* sp. nov. — MARR, p. 199.
1925 *Acidaspis evoluta* TÖRNQUIST — WARBURG, p. 238; Pl. VI, figs. 5–6, [not fig. 9 = *Apianurus clevei* (WARBURG)].
1949 *Acidaspis dalecarlica* TÖRNQUIST — BANCROFT, p. 303.
1961 *Primaspis evoluta* (TÖRNQUIST) — WHITTARD, p. 201.

LECTOTYPE (selected herein).—The cranidium from the SGU Collection figured by TÖRNQUIST 1884, Pl. 1, fig. 24 and refigured in this paper as Pl. 1, figs. 3, 4, 6.

TYPE STRATUM AND TYPE LOCALITY.—Boda Limestone. Gulleråsen, Siljan district.

MATERIAL.—The above cranidium (SGU); the originals of WARBURG 1925, Pl. VI, fig. 6 (SGU) and fig. 5 (UM No. D 82); the cranidium of *A. dalecarlica* (LU 577T) original TÖRNQUIST 1884, Pl. 1, fig. 22; the pygidium (LU 578t) op. cit. fig. 23; one pygidium from the TÖRNQUIST Coll. (LU); the pygidium (UM No. B 164) figured by WIMAN, 1907, Pl. VIII, fig. 37.

DESCRIPTION.—Cranidium (Pl. 1, figs. 4, 9) approximately semicircular in outline, gently to moderately convex. Maximum width of glabella across L1 equal to maximum length including the occipital ring. Latter separated from median glabellar lobe by deep occipital furrow; low occipital lobe defined by lateral deepening of occipital furrow beneath L1 and the posterior extension of the longitudinal furrow which crosses occipital ring but does not reach the posterior margin. A small median occipital tubercle is positioned near the posterior margin of the ring. Three pairs of lateral glabellar lobes. L1 the larger, sub-oval and slightly lower than the level of adjacent median lobe; L2 more inflated, tear-shaped and expanding outwards; L3 a small ridge-like swelling directed obliquely outwards and forwards. S1 deep and slightly oblique to the sagittal line; S2 deepened at outer end and almost parallel to the longitudinal furrow; S3 a small pit inside the eye ridge. Median glabellar lobe approximately rectangular, longitudinal furrow broad and deep. Highest point of median lobe opposite inner end of S2. Frontal lobe separated by a change of slope from the anterior border furrow. Dorsal furrow deep alongside L1 but shallower anteriorly where it ends in a smooth depressed area inside the eye ridge. Inner fixed cheek narrow (tr.) with maximum convexity inside palpebral lobe. Latter positioned near the posterior margin on a transverse line through the occipital furrow. Fixed cheek curves inwards and downwards alongside L1 and slopes vertically down to the posterior margin. The anterior part of the cheek tapers forwards and dies out between L2 and the eye ridge. Latter moderately convex, uniform in width, and outlined by a well-defined furrow along the inner edge. Anterior branch of facial suture (Pl. 1, fig. 4) follows the line of a raised sutural ridge which curves inwards and crosses the anterior border opposite the outer part of L3. Outer fixed cheek twice as long (exs.) as the maximum width and deepened alongside the eye ridge. Posterior facial suture (Pl. 1, figs. 1, 2)

directed downwards from palpebral lobe, curved outwards and forwards until in line with anterior suture, and then curved backwards to cross posterior border inside the base of the librigenal spine. Free cheek with broad flattened border bearing 8 downwardly directed border spines. Librigenal spine (incomplete) with strongly swollen base. Cheek surface slopes steeply downwards from beneath the eye to border furrow.

Thorax of which only five segments are known, with very wide rachis occupying slightly more than one third total width. Pleura with broad flattened principal pleural ridge and the spine is bent rather steeply downwards from the swollen fulcrum of the principal ridge. Anterior accessory area with ridge which extends distally into a short anterior spine. Posterior accessory area very narrow and marked by the convexity of the principal pleural ridge. First segment short and facetted laterally to fit the outline of the posterior border of the cranidium. Rachis and principal pleural ridge with double row of granules and anterior accessory area with a single row of six granules.

Pygidium approximately four times as wide as long. Pleural ridge curved outwards and backwards and reaching the lateral margin at about one half pleural width. Posteriorly there are six secondary spines of which the outer spine is fused with the swollen base of the major spine and outside the major spine are two anterior secondary spines thus making a complement of 12 border spines.—Border furrow well developed and pleural area depressed. Rachis (Pl. 4, fig. 9) with narrow, convex ornamented first ring, lower second ring which tapers strongly backwards to a low terminal portion which is fused with the posterior border.

Cranidium and free cheek with closely spaced granules of moderate size, furrows smooth.—The hypostoma is not known.

DIMENSIONS.—Lectotype: width 12 mm; length including occipital ring 9.5 mm.

REMARKS.—Two odontopleurid cranidia from the Siljan district figured by TÖRNQUIST (1884, Pl. 1, figs. 22, 24) were referred to two different species. One cranidium, the lectotype of *Primaspis evoluta* (TÖRNQUIST) came from the Boda Limestone at Gulleråsen while the other (*Acidaspis dalecarlica*) came from the underlying Fjäcka ( = Black Tretaspis) Shale at Skattungbyn. Despite the slight compression of the specimen in shale, it is obvious that this and *P. evoluta* (cf. Pl. 1, figs. 4, 9) are identical and both have the similar rectangular median glabellar lobe, arrangement of lateral lobes and the shape of the fixed cheek. *Primaspis dalecarlica* (TÖRNQUIST) is thus considered to be a subjective synonym of *P. evoluta* (TÖRNQUIST).

No pygidia have been found from the type stratum, but two specimens thought to belong to *A. dalecarlica* by TÖRNQUIST (1884, Pl. 1, fig. 23) are known from the Fjäcka Shale. These two pygidia (Pl. 1, figs. 7, 8) and a third specimen (Pl. 4, fig. 9), from a Baltic erratic probably of Nabala ($F_1a$) stage, figured by WIMAN (1907, Pl. VIII, fig. 37) are now referred to *Primaspis evoluta*.

The specimen figured by REED (1906) from the Whitehouse Group of Shalloch Hill, Girvan, may well belong to *P. evoluta* but the figure does not show clearly whether the base of the major pygidial spine merges with the proximal half of the first succeeding secondary spine. At the Sedgwick Museum, Cambridge, England, are several specimens labelled as "*Acidaspis* cf. *dalecarlica*". All are rather poorly preserved, but the specimen (SM A 53773) listed by GROOM & LAKE (1908) from the Dolhir Beds, Denbighshire, and those listed by MARR (1913; 1916; SM A 29588a–b; 43119) from the Diacalymene marginata Beds of Cautley and the Phillipsinella Beds, Torver Beck, Lake District, appear to be very like the pygidia now assigned to *P. evoluta*.

The cranidium of *P. evoluta* is similar to *P. semievoluta* (cf. DEAN 1962, p. 122; Pl. 17, figs. 3, 10, 15, 18) from the Lower Longvillian of Northern England, but the pygidium of *P. semievoluta* differs from that of *P. evoluta* in having a longer and less divergent pleural ridge, and the four posterior secondary border spines are equally spaced between the major spines.

OCCURRENCE.—Siljan district. Fjäcka Shale: Skattungbyn; Boda Limestone: Gulleråsen, Kallholn and Östbjörka.

### *Primaspis bestorpensis* n.sp.

Pl. 2, figs. 1, 2, 5–6; Text-fig. 2 B

1963 "*Acidaspis*" cf. *dalecarlicus* TÖRNQUIST — SKOGLUND, p. 9.

DERVIATION OF THE NAME.—After the name of the type locality.

HOLOTYPE.—The incomplete pygidium (UM No. Vg 800) figured Pl. 2, fig. 5; BRUTON Coll. 1963.

TYPE STRATUM AND TYPE LOCALITY.—Bestorp Limestone, basal Harju Series (for stratigraphy and section see SKOGLUND 1963, p. 17; Text-fig. 5). Near the old well at Bestorp, Mösseberg, Västergötland.

MATERIAL.—In addition to the holotype one incomplete pygidium (UM No. Vg 798); five thoracic segments (UM No. Vg 797) BRUTON Coll. 1963; one free cheek (UM No. Vg 801); one fragmentary pygidium (UM No. Vg 804); four badly preserved exoskeletons (UM Nos. Vg 803a–b; 802; 799).

DIAGNOSIS AND DESCRIPTION.—Free cheek excluding librigenal spine, forming an approximate quadrant of a circle. Border narrow, convex and bearing 13 stout spines which increase in length backwards. Librigenal spine long, gently curved backwards from a swollen base. Anterior facial suture forming a slow sinuous curve; posterior suture directed at right angles to anterior one from the base of eye, curving gently outwards for half cheek width and then strongly backwards inside the base of the librigenal spine. Cheek surface very gently convex near border furrow, more convex towards the eye; immediately behind latter, cheek slopes steeply down to the posterior margin. Border, border spines, and librigenal spine with small, densely packed granules, cheek surface with slightly larger granules.

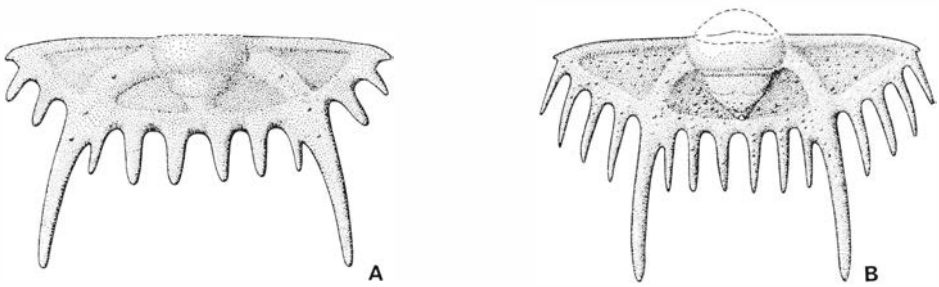
Thorax with 10 segments (known from four poorly preserved specimens). Rachis slightly wider than half pleural width, moderately convex and sloping backwards from the wide articulating furrow. Articulating halfring with anterior margin curved strongly forwards. Lateral part of rachis expanded forwards, merging with the proximal end of the principal pleural ridge. Latter narrow, strongly convex and swollen at the fulcrum. Posterior accessory area very narrow and smooth; anterior accessory area flattened, with narrow anterior accessory ridge produced distally into a short anterior spine. Principal pleural spine on anterior segments facetted, long and directed outwards and progressively backwards on posterior segments. Principal pleural and anterior accessory ridge with closely spaced granules which also occur on the spines. Anterior accessory area with single line of very small granules; rachis coarsely granulated.

Pygidium about three times as wide as long, with rachis of three segments. First ring strongly convex, twice as wide as long and separated from second ring by deep transverse furrow. Second ring lower, and separated from the third ring which reaches the posterior border. Dorsal furrow deeply impressed adjacent to transverse furrow and second ring, shallow to lacking posteriorly. Pleural region flat to gently sloping away from pleural ridge. Anterior border narrow near rachis, becoming wider outwards. Pleural ridge curved backwards from the first rachial ring, swollen at posterior margin and base of major spine. Between the major spines are six posterior secondary border spines of which the slim outermost spine is fused to the base of the major spine; outside major spine are four anterior secondary spines, thus making full complement of 16 border spines. Major spines incomplete on holotype, but additional material suggests that they are at least twice as long as the secondary spines and curved slightly inwards and upwards distally. Pleural area very coarsely granulated, posterior border with granules near the base of each spine, and border spines more finely granulated.

Dimensions.—Pygidium (holotype): width 10 mm, length (excluding spines) 3 mm; free cheek: length 3.5 mm, width (tr.) 4 mm; length of spine, 4 mm.

Discussion.—This species is quite common in the Bestorp Limestone at the type locality, and is one of the few shelly fossils to be found in this limited horizon (for faunal list see Skoglund 1963, p. 9). Recently collected specimens of pygidia show that *P. bestorpensis* differs from the younger species *P. evoluta* in the following ways: (1) the greater sagittal length; (2) the wider (tr.) outer pleural area with four (instead of two) secondary border spines (in both pygidia, the small outgrowth of the antero-lateral corner is part of the articulating process and not a border spine), (3) the longer and slimmer border spines, (4) the coarse granulation on the pleural area.

In *P. bestorpensis* the length of the posterior facial suture is approximately equal that of the anterior suture but only about half as long in *P. evoluta*. The sutural lengths govern the length of the cheek border and also the number of




Text-fig. 2. Reconstructions used to compare the pygidium of A, *Primaspis evoluta* (TÖRNQUIST), Fjäcka Shale, Skattungbyn, Siljan district (drawn from the originals of Pl. 1, figs. 7, 8), × 5. B, *Primaspis bestorpensis* n.sp., Bestorp Limestone, Bestorp, Mösseberg, Västergötland (drawn from the originals of Pl. 2, figs. 5, 6), × 4.

fringing spines. Thus along the longer border of *P. bestorpensis*, there are at least 13 spines as opposed to 8 in *P. evoluta*. The comparatively long posterior facial suture in *P. bestorpensis* is a characteristic not present in other slightly older species such as *P. harnagensis*, *P. caractaci* (cf. DEAN 1963, Pl. 44, figs. 8, 11, 14), and *P. ascitus* (cf. WHITTINGTON 1956*a*, p. 199; Pl. 1, figs. 1, 2, 4, 5) in which the free cheeks are all very similar.

The pygidium of *P. harnagensis* (cf. DEAN 1963, Pl. 44, fig. 6), is like that of *P. bestorpensis* in having four anterior secondary border spines and a rachis which reaches the posterior border furrow, but differs in having only four equally spaced posterior secondary border spines.

OCCURRENCE.—Found only in the type stratum at the type locality.

### Genus *Leonaspis* R. & E. RICHTER, 1917

TYPE SPECIES.—*Odontopleura leonhardi* BARRANDE, 1846.

### *Leonaspis olini* (TROEDSSON, 1918)

Pl. 2, figs. 3, 4

1821 *Entomostracites granulatus* n.sp. — WAHLENBERG, p. 30; Pl. II, fig. 4* [not Pl. II, fig. 4 = *Tretaspis granulatus* (WAHLENBERG, 1821)].
1869 *Acidaspis centrina* DALMAN — LINNARSSON, p. 65 (partim).
1918 *Acidaspis olini* n.sp. — TROEDSSON, p. 98; Pl. 1, fig. 29.
1921 *Acidaspis centrina* DALMAN — TROEDSSON, pp. 10 and 12 footnote (partim).
1952 *Acanthaloma mirka* n.sp. — MAREK, p. 452; Pl. 2, fig. 3.
1960 *Leonaspis olini* (TROEDSSON) — KIELAN, p. 98; Pl. VII, figs. 5–6; Pl. XIV, fig. 14; Pl. XV, fig. 4; not Pl. XVIII, fig. 6 [ = ? *Leonaspis* n.sp.].

HOLOTYPE.—The cranidium (LU 3935) figured by TROEDSSON 1918, Pl. 1, fig. 29, KIELAN 1960, Pl. XIV, fig. 4 and refigured herein as Pl. 2, fig. 3.

TYPE STRATUM AND TYPE LOCALITY.—Dalmanitina Beds. Röstånga, Scania.

MATERIAL.—In addition to the holotype, WAHLENBERG's specimen and counterpart (UM No. Vg 4a–b), additional material from the WAHLENBERG

Coll. (UM Nos. Vg 813–4), and a pygidium with three thoracic segments (RM No. Ar 15472).

DESCRIPTION.—Cranidium moderately convex. Frontal glabellar lobe widening forwards from inner end of S2. Two pairs of lateral glabellar lobes which are suboval with longest axis slightly oblique to the sagittal line. Longitudinal and dorsal furrows broad. Fixed cheek long (exs.), very convex and narrow (tr.). Eye positioned opposite inner end of S1. Occipital ring narrow (sag.), gently convex; occipital furrow well marked. Free cheek moderately convex with flattened border and well marked furrow; 12 border spines increasing in length backwards; Librigenal spine long, directed outwards and backwards. Thorax of 9 segments; principal pleural spines long and tapered, directed progressively backwards on posterior segments. Pygidium with 10 spines; rachis of two rings, the first narrow and convex, the second longer and semicircular.

DISCUSSION.—WAHLENBERG (1821, p. 30) described *Entomostracites granulatus* and figured two specimens which were thought to belong to the species. One (WAHLENBERG, Pl. II, fig. 4) has been selected as the lectotype (see STØRMER 1930, p. 69; 1945, p. 400) of *Tretaspis granulatus* (WAHLENBERG, 1821), and was collected from the *Staurocephalus* Beds, Ålleberg, Västergötland. The second specimen (WAHLENBERG, Pl. II, fig. 4*), which was collected from the Dalmanitina Beds, Bestorp, Mösseberg, Västergötland, is an external mould of an odontopleurid cranidium with 9 thoracic segments and a pygidium. Lying alongside the cranidium is a fragment of a free cheek. A latex cast of this specimen (Pl. 2, fig. 4) shows that slight compression has resulted in the formation of accidental grooves down the length of each pleural and pygidial border spine.

In the collections at Uppsala, there is a specimen collected in 1838 by A. JUENBERG from Bestorp and labelled as "*Acidaspis centrina*". This specimen (UM No. Vg 46) is without doubt the internal mould of the original of WAHLENBERG's Pl. II, fig. 4*, and both halves fit each other exactly!

TROEDSSON (1918) described *Acidaspis olini* from the Dalmanitina Beds of Scania, and the holotype (Pl. 2, fig. 3) is a well preserved juvenile cranidium. The pygidium figured by KIELAN (1960, Pl. XVII, fig. 6) from the Dalmanitina Beds, Ålleberg, Västergötland, may belong to a new species of *Leonaspis* since a latex cast of the counterpart (RM No. Ar 15475b) reveals that there is a well developed border furrow and the pleural area is smooth.

TROEDSSON (1921, p. 12 footnote) believed that his previously described species, *Acidaspis olini* was a synonym of *A. centrina* DALMAN, 1828, but KIELAN (1960, p. 103, Table 4) showed quite clearly how *Leonaspis olini* differs from *L. centrina*. The holotype of *L. centrina*, which occurs in a buff-coloured and baked silty shale, is labelled as having been found at Mösseberg, and KIELAN assumed that it came from the Dalmanitina Beds. However, at Mösseberg (see THORSLUND & JAANUSSON 1960, p. 14) the Dalmanitina Beds are overlain by

Llandoverian shales which have been baked beneath a dolerite sill and in appearance they are identical with the rock type in which DALMAN's specimen is preserved. Thus, the holotype of *L. centrina* evidently comes from the lowermost Llandoverian and not from the Dalmanitina Beds. The recognition by WÆRN (1948, p. 461) of *L. centrina* in the lowermost Llandovery of Västergötland lends support to this conclusion.

OCCURRENCE.—Dalmanitina beds. Röstånga, Scania; Bestorp and ?Ålleberg, Västergötland.

### Genus *Diacanthaspis* WHITTINGTON, 1941

TYPE SPECIES.—*Diacanthaspis cooperi* WHITTINGTON, 1941.

For a full diagnosis of the genus see WHITTINGTON (1956*a*, pp. 208 and 210).

### *Diacanthaspis decacantha* (ANGELIN, 1854)

Pl. 2, figs. 7, 8

1854 *Cyrtometopus* ? *decacanthus* n.sp. — ANGELIN, p. 35, Pl. XXII, Fig. 5 (only the thorax and pygidium but not the cephalon).
1899 *Acidaspis* (*Cyrtometopus* ?) *decacantha* ANGELIN — RAVN, p. 57.
1910 *Acidaspis decacanthus* ANGELIN — WESTERGÅRD, p. 12.
1960 *Diacanthaspis decacantha* (ANGELIN) — KIELAN, p. 103, Pl. XV, figs. 1–3; Pl. XVI, figs. 2–3; Pl. XVII, figs. 7–8; Text-fig. 27.
1962 *Odontopleurid* gen. et sp. ind. WHITTINGTON, p. 23, Pl. V, figs. 9, 16, 17, 20.
1965 *Diacanthaspis* cf. *decacantha* (ANGELIN) — WHITTINGTON, p. 33, Pl. IX, figs. 1–10.

LECTOTYPE (KIELAN 1960, Pl. XV, fig. 1). — The incomplete thorax and pygidium (RM No. Ar 15468) figured by ANGELIN 1854, is refigured herein as Pl. 2, fig. 8.

TYPE STRATUM AND TYPE LOCALITY.—Upper Jonstorp Formation (=Red Trataspis Mudstones). Mösseberg, Västergötland.

MATERIAL.—In addition to the lectotype: one partly complete specimen (RM No. Ar 15490); an incomplete thorax and damaged cranidium (RM Nos. Ar 15460–61); thorax and cephalon (RM No. Ar 15462); pygidium (RM Nos. Ar 15463–64); incomplete thorax and pygidium (RM Nos. Ar 15470–71); one juvenile specimen (RM No. Ar 15483).

DISCUSSION.—KIELAN (1960, p. 103) has given a very full and adequate description of the species.

Ravn (1899) recorded the species from Bornholm and was the first to suggest that it belonged to "*Acidaspis*". He also recognised that the cephalon referred to the species by ANGELIN did not belong there, and KIELAN selected as lectotype the pygidium with four complete and three incomplete thoracic segments figured by ANGELIN.

In 1962, Professor KIELAN–JAWOROWSKA kindly allowed me to examine the material of this species collected by her from the Upper Ordovician (zone

*Staurocephalus clavifrons*) in the Holy Cross Mountain area, Poland. As stated by KIELAN (1960, p. 106), the swelling at the fulcrum of the principal pleural ridge is characteristic for *Primaspis* (cf. WHITTINGTON 1956*a*, p. 210), but the free cheek appears more like *Diacanthaspis* because of the short incurved librigenal spine not swollen at the base, the lateral border without any appreciable furrow, and the large tubercles on the cheek surface. The pygidium lacking the paired major spines, the paired occipital spines, and the absence of the third glabellar lobe (cf. WHITTINGTON 1965, p. 33) are additional features which are more characteristic for *Diacanthaspis* than they are for *Primaspis*. The hypostoma (KIELAN 1960, Pl. XVI, fig. 3) is like those known for *Diacanthaspis* (cf. WHITTINGTON 1956*a*, Pl. 5, figs. 15–16; Pl. 11, figs. 2, 3).

Having seen all of the material illustrated by WHITTINGTON (1962, 1965) from the Rhiwlas Limestone of the Bala district North Wales, it is easy to agree that the thorax, pygidium and free cheek (cf. WHITTINGTON 1962, Pl. V, figs. 9, 16, 17, 20; 1965, Pl. IX, figs. 5, 10) are indistinguishable from the Swedish and Polish specimens. The differences in the pygidium (WHITTINGTON 1965, p. 34, Pl. IX, figs. 4, 9) however, appear to be real.

OCCURRENCE.—Upper Jonstorp Formation (=Red Tretaspis Mudstones). Mösseberg, Västergötland.

### Subfamily *Apianurinae* WHITTINGTON, 1956

A new diagnosis of the subfamily was given by WHITTINGTON & BOHLIN 1958, p. 38.

### Genus *Apianurus* WHITTINGTON, 1956

TYPE SPECIES.—*Apianurus barbatus* WHITTINGTON, 1956.

### *Apianurus furcata* (LINNARSSON, 1869)

Pl. 3, fig. 1

1869 *Acidaspis furcata* n.sp. — LINNARSSON, p. 65, Pl. I, fig. 18.
1885 *Acidaspis furcata* LINNARSSON — SCHMIDT, p. 4.
1949 *Diacanthaspis furcata* (LINNARSSON) — PRANTL & PŘIBYL, p. 150.
1956*a* *Apianurus furcata* (LINNARSSON) — WHITTINGTON, p. 271.
not 1956*a* *Apianurus* aff. *furcata* (LINNARSSON) — WHITTINGTON, p. 270, Pl. 20, figs. 18, 20–25 [ = *Apianurus thorslundi* BRUTON].

HOLOTYPE.—The cranidium with incomplete occipital spines (SGU Coll.) figured by LINNARSSON 1869, and refigured herein.

TYPE STRATUM AND TYPE LOCALITY.—Dalby Limestone, Ålleberg, Västergötland.

DESCRIPTION.—Cranidium approximately circular in dorsal aspect, gently convex. Occipital ring slightly more than twice as wide as long with strongly convex median portion separated from the median glabellar lobe by wide,

shallow occipital furrow. Posterior occipital band narrowest medially, becoming wider outwards with separation from remainder of ring becoming less obvious. Raised median portion of ring with stout occipital spines (incomplete) and median spine, of which only the base is present, immediately behind the occipital furrow. Median glabellar lobe gently convex both transversely and longitudinally; frontal lobe slightly higher and convex. Longitudinal furrow forming a smooth area outlined by change of slope between the median lobe and the lateral glabellar lobes. Two pairs of fused lateral lobes approximately equal in size. S1 a deep triangular-shaped pit adjacent to median lobe; S2 parallel to the longitudinal furrow and directed outwards into a deep pit inside the eye ridge. Dorsal furrow a narrow smooth area between the outer convex part of the lateral lobes and the reversed slope of fixed cheek. Latter very narrow anteriorly but widening posteriorly where it overhangs the posterior margin and slopes down to it. Wide eye ridge curves backwards and slightly upwards distally; shape and position of palpebral lobe unknown. Course of anterior facial suture outlined by a sutural ridge outside and parallel to the eye ridge. Outer fixed cheek area deepened inside upturned and vertical lateral corner of anterior border. Posterior suture directed downwards to shallow posterior border furrow, curved slightly outwards, and then turned abruptly backwards in line with the anterior suture. Posterior border longest (exs.) at the suture but narrower inwards towards the point of fusion of occipital ring and inner corner of fixed cheek. Exoskeletal surface with coarse spine bases; changes of slope and furrow smooth. Fronto-median lobe with symmetrical arrangement of spine bases positioned so as to demarcate an arrow-shaped area on the highest part of the lobe. Lateral lobes with spine bases on the most convex parts; occipital ring with two transverse rows of spine bases posterior to occipital furrow and scattered spines between the bases of the occipital spines; remainder of ring and spines smooth.

Free cheek, hypostoma, thorax, and pygidium not known.

DIMENSIONS.—See Table 1.

OCCURRENCE.—Only the holotype is known from Ålleberg, Västergötland. The specimen referred to by LINNARSSON (1869, p. 65) from Högstenaberget near Skogastorp, Västergötland, has not been found in any Swedish museum collection.

### *Apianurus asklundi* (THORSLUND, 1940)

Pl. 3, fig. 2

1940 *Ceratocephala asklundi* n.sp. — THORSLUND, p. 154, Pl. 6, fig. 14.
1949 *Diacanthaspis asklundi* (THORSLUND) — PRANTL & PŘIBYL, p. 150.
1956*a* *Apianurus asklundi* (THORSLUND) — WHITTINGTON, p. 271.

HOLOTYPE.—The incomplete cranidium (SGU Coll.) figured by THORSLUND 1940, and refigured herein.

TYPE STRATUM AND TYPE LOCALITY.—Ludibundus Limestone. Central Lockne area, Jemtland.

DESCRIPTION.—Cranidium approximately hexagonal in dorsal aspect, moderately convex. Fronto-median lobe and occipital ring moderately to strongly convex. Lateral glabellar lobes indistinctly fused. L1 elongated (exs.) twice the size of the circular L2. Occipital furrow deeply impressed, occipital ring sloping steeply downwards between spine bases. Latter very stout. Exoskeletal surface with many closely spaced spine bases; furrows smooth.

Free cheek, hypostoma, thorax, and pygidium not known.

DIMENSIONS.—See Table 1.

REMARKS.—*A. asklundi* closely resembles *Apianurus thorslundi* (Pl. 3, fig. 7) from which it differs in the greater convexity of the fronto-median glabellar lobe and the occipital ring, the deeper and more obvious occipital furrow, the smaller and circular L2, the straighter more divergent eye ridge and the smaller more closely spaced exoskeletal spines.

OCCURRENCE.—Ludibundus Limestone. Lockne area, Jemtland.

### *Apianurus clevei* (WARBURG, 1925)

Pl. 3, figs. 3–6; Text-fig. 3

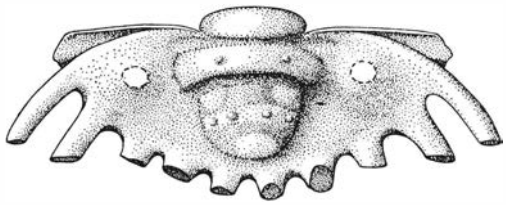
1925 *Acidaspis Clevei* n.sp. — WARBURG, p. 243, Pl. VI, fig. 1.
1925 *Acidaspis evoluta* TÖRNQUIST — WARBURG, p. 241, Pl. VI, fig. 9 (partim).
1925 *Acidaspis* sp. ind. a) — WARBURG, p. 252, Pl. VI, fig. 8.
1925 *Acidaspis* ? sp. ind. b) — WARBURG, p. 253, Pl. VI, fig. 7.
1956*a* *Apianurus clevei* (WARBURG) — WHITTINGTON, p. 271.

HOLOTYPE.—The incomplete cranidium with occipital spines (UM No. D 80) figured by WARBURG 1925, Pl. VI, fig. 1 and refigured herein.

TYPE STRATUM AND TYPE LOCALITY.—Boda Limestone. Arvet, Siljan District.

DESCRIPTION.—Cranidium trapezoidal in dorsal aspect with the occipital ring indistinctly separated from the remainder of glabella. Occipital spines at least four times as long as cranidium, slim and curved strongly upwards and backwards. L1 rounded posteriorly and fused with L2 which is more rectangular. Lateral furrows very deep, S1 triangular, S2 slot-like. Eye ridge straight and connected to a pronounced ridge-like expansion of the frontal glabellar lobe. Fixed cheek sloping almost vertically downwards from eye ridge to dorsal furrow. Posterior part of the cheek overhanging posterior border and palepbral lobe (not preserved) therefore positioned at least as far backwards as to be opposite base of occipital spines. Anterior facial suture long, following a course which is sub-parallel to eye ridge. Outer fixed cheek area deepened.

Hypostoma with gently curved anterior and more strongly rounded posterior margin. Middle furrow directed inwards from a deep depression at the antero-lateral corner, dividing middle body into a strongly convex triangular anterior lobe and a narrow (sag.) inflated crescent-shaped posterior lobe. Border furrow



Text-fig. 3. *Apianurus clevei* (WARBURG), ? Boda Limestone, Siljan district. Reconstruction (drawn from the original of Pl. 3, fig. 5), × 15.

deepened laterally but becoming shallower posteriorly where a change of slope separates the posterior lobe from the flat posterior border.

Pygidium approximately semicircular. Rachis with narrow strongly convex first ring and broad lower posterior area which does not reach the posterior margin. A transverse row of four spine bases, crossing this posterior area at its mid-point, marks the position of the second rachial ring. Anterior to this is a shallow area bounded laterally by a swollen unornamented area. This part, corresponding in position to the second ring furrow, is considered to represent a possible area of muscle attachment (cf. WHITTINGTON 1956*a*, pp. 259–260). Third rachial ring corresponding to a small swollen circular area near the tip of the rachis. Pleural area swollen alongside first ring and forming the base of the pleural spine which, from evidence on the counterpart of the specimen, curves upwards and slightly forwards. Border with 12 equally spaced spines (all incomplete) which are directed outwards and slightly upwards from the dorsal edge of the margin.

DIMENSIONS.—See Table 1.

DISCUSSION.—Two pygidia and one hypostoma figured herein are thought to belong to the species on account of their undoubted apianurinid features and their similar stratigraphic location to the holotype.

The pygidium (Pl. 3, fig. 5) from Unskarsheden, was considered by WARBURG (1925, p. 241) as most likely belonging to *Primaspis evoluta*. In her description she remarked that on the side (=pleural) lobes, "there are traces of a strong ridge running from the first axial ring backward ...", but examination of the specimen shows this observation to be incorrect. The pleural areas are incomplete, but it is possible to see that the rachis is typical of *Apianurus* and quite unlike that known in *Primaspis*.

The second pygidium (Pl. 3, fig. 4) from the ISBERG Collection is labelled as coming from the Lower Leptaena Limestone (=Kullsberg Limestone) at Amtjärn, whereas the holotype was found in the Boda Limestone at Arvet. However, Dr. JAANUSSON (verbal communication) believes that the ISBERG specimen has been either mislocated or labelled as coming from the wrong horizon. The latter suggestion would appear correct, since in the matrix surrounding the pygidium is a specimen of the ostracode *Oepikella* cf. *frequens*

(STEUSLOFF) which species is, in the Siljan district, known to occur only in the Boda Limestone.

*Apianurus clevei* differs from other Swedish species in having the glabella and occipital ring indistinctly separated, slimmer occipital spines, and the eye ridge connected to a marked ridge-like expansion of the frontal glabellar lobe.

*A. clevei* is to date the youngest species of *Apianurus* described. However, in the Uppsala Museum there are some fragmentary silicified specimens of *Apianurus* from Porkuni, Estonia, which were extracted by the late Professor CARL WIMAN from limestone of the Porkuni ($F_2$) stage. The rocks of the Porkuni age are contemporaneous with the uppermost part of the Boda Limestone in the Siljan district.

OCCURRENCE.—Boda Limestone. Siljan district: Arvet, Unskarsheden, and Kallholn.

### *Apianurus thorslundi* BRUTON, 1965

Pl. 3, fig. 7

1965 *Apianurus thorslundi* n.sp. — BRUTON, p. 344, Pl. 1, figs. 1–2; Pl. 3, figs. 2–4.

TYPE LOCALITY.—Guttormsberget, Modum, Norway.

TYPE STRATUM.—Upper *Chasmops* Limestone (4 bδ).

For description and affinities see BRUTON (1965, pp. 344–347).

DISCUSSION.—One well preserved cranidium lacking occipital spines has been found amongst the collections at the Swedish Natural History Museum. The exact locality and horizon is unknown other than that the specimen was collected in Västergötland. The matrix is far from diagnostic, but an horizon slightly older than the type horizon, is the Skagen Limestone. It seems likely that the specimen came from this horizon because, in Västergötland, the Skagen Limestone overlies the Dalby Limestone, the type horizon of *Apianurus furcata.*

DIMENSIONS.—See Table 1.

### *Apianurus vikarbyensis* n.sp.

Pl. 4, figs. 1–4

DERIVATION OF THE NAME.—After the name of the type locality.

HOLOTYPE.—The cranidium lacking occipital spines (UM No. D 1186; Coll. V. JAANUSSON and H. MUTVEI), figured herein.

TYPE STRATUM AND TYPE LOCALITY.—Expansus Limestone, 40 cm above the lower boundary (see section in JAANUSSON & MUTVEI, 1951, p. 632, Text-fig. 1). Kalkbackarna, Vikarbyn, Siljan district.

DIAGNOSIS AND DESCRIPTION.—Cranidium gently convex (sag. and tr.). Transverse width between palpebral lobes one and one half times the sagittal length of cranidium. Occipital ring approximately twice as wide as long; median portion gently convex, separated from remainder of glabella by smooth, un-

ornamented area (=occipital furrow). Posterior occipital band narrow and smooth medially, becoming wider and ornamented beneath bases of paired occipital spines (only the broken bases evident on specimen). Posterior margin of occipital ring curved gently forwards and concave between the spines. Fronto-median glabellar lobe with maximum transverse width in front of occipital furrow and tapering forwards to half this width at anterior margin. Frontal lobe projects only a short distance in front of S2 and is flattened (tr.). Lateral glabellar lobes partly fused, forming a gently convex area between smooth dorsal furrow and reversed change of slope outlining fronto-median glabellar lobe. Outer posterior part of L1 outlined by dorsal furrow. Latter deep and accentuated posteriorly by reason of steep reversed slope of fixed cheek. Dorsal furrow dies out alongside L2, and there fixed cheek becomes narrower (tr.) and flatter. S1 very shallow and directed transversally between L1 and L2, but curved inwards and backwards to deepened pit alongside median lobe at about one half its length. L2 very weakly convex and about half the size of L1; S2 a short, deep, slot-like depression declined inwards from anterior pit. Between the latter and S2 a small transverse triangular swelling at the side of the frontal lobe may represent a third lateral lobe (L3). Posterior part of the fixed cheek curves outwards and rises steeply to large palpebral lobe positioned on a transverse line drawn just in front of occipital furrow. Fixed cheek slopes vertically to posterior border beneath palpebral lobe. Palpebral lobe with well-defined rim which passes anteriorly into broad, flattened eye ridge. Latter almost straight but curved proximally and joined to frontal lobe by narrow, smooth, depressed band. Anterior branch of facial suture directed slightly forwards, curved inwards parallel to eye ridge, and then curved more abruptly inwards at upturned antero-lateral margin. Outer fixed cheek area considerably deepened towards the anterior margin. Posterior branch of suture forming a right angle to anterior branch immediately beneath palpebral lobe, curved forward then turned abruptly backwards to cross posterior margin. Latter approximately two thirds transverse width of occipital ring. Frontal glabellar lobe with two transverse rows of backwardly-directed thorn-like spines; remainder of exoskeleton with larger broken spine bases arranged without any definite pattern. Occipital ring with median spine base. Furrows smooth.

Free cheek, hypostoma, thorax, and pygidium not known.

DIMENSIONS.—See Table 1.

DISCUSSION.—The straighter, more divergent eye ridge, the more forward position of the palpebral lobe, and the longer (sag.) occipital ring recognizably separated from the median glabellar lobe are features which suggest that the above species should be assigned to *Apianurus* rather than to *Boedaspis*. However, like *B. ensifer* (cf. WHITTINGTON & BOHLIN, 1958, p. 39, Pl. 2, figs. 1, 3) but unlike the younger species of *Apianurus* (cf. *A. furcata* and *A. thorslundi*, Pl. 3, figs. 1, 7), *A. vikarbyensis* has a short (sag.) and flat frontal glabellar lobe and a narrow depressed band which joins the proximal part of the eye ridge to

*Table 1.* Comparative cranidial measurements for the described species of *Apianurus*.

All measurements in millimetres. $A$ = Intra-marginal cranidial length; $A1$ = Total glabellar length; $A2$ = Length of frontal glabellar lobe; $\jmath 1$ = Palpebral cranidial width; $K$ = Median occipital width; $\theta°$ = Angular divergence of occipital spines. For a full explanation cf. BRUTON (1965, pp. 342–344; Text-fig. 1).

| | $A$ | $A1$ | $A2$ | $\jmath 1$ | $K$ | $K1$ | $\theta°$ |
|---|---|---|---|---|---|---|---|
| *Apianurus furcata* (LINNARSSON) | 5.0 | 3.2 | 0.7 | 7.? | 5.0 | 3.2 | 90 |
| *Apianurus asklundi* (THORSLUND) | 3.5 | 2.3 | 0.7 | 6.? | 3.8 | 2.4 | 80 |
| *Apianurus clevei* (WARBURG) | 3.7 | 2.5 | 0.6 | 6.0 | 3.7 | 2.5 | 85 |
| *Apianurus thorslundi* BRUTON | 6.5 | 3.8 | 1.0 | 8.? | 6.5 | 4.5 | — |
| *Apianurus vikarbynensis* n.sp. | 10.0 | 6.5 | 1.5 | 15.0 | 10.? | 7.5 | — |

the frontal lobe. This shows that, when only cranidia are available of these older apianurinid species, it is exceedingly difficult to distinguish between *Boedaspis* and *Apianurus*.

In terms of the Balto-Scandian Ordovician succession, the discovery of *A. vikarbyensis* in the Expansus Limestone (Kunda Stage) now means that the range of the genus *Apianurus* can be extended farther back from the Middle to within the Lower Ordovician.

OCCURRENCE.—See type data.

## Genus *Boedaspis* WHITTINGTON & BOHLIN, 1958

TYPE SPECIES.—*Boedaspis ensifer* WHITTINGTON & BOHLIN, 1958.

### *Boedaspis ensifer* WHITTINGTON & BOHLIN, 1958

Pl. 6, fig. 7; Text-figs. 4, 5

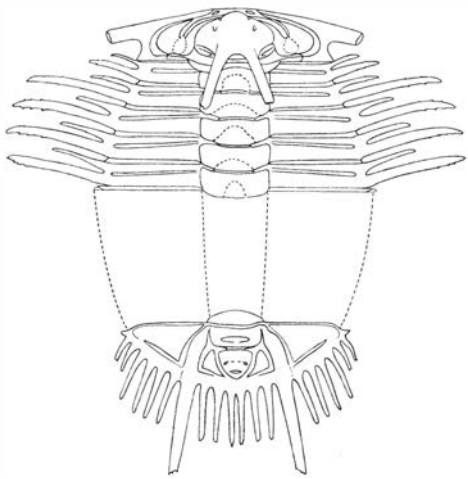
1958 *Boedaspis ensifer* n.gen., n.sp. — WHITTINGTON & BOHLIN, p. 39, Pl. 1; Pl. 2, figs. 1–7, but not fig. 8; Pl. 3, fig. 6, but not fig. 5.

HOLOTYPE.—The incomplete cephalon and thorax (UM No. Öl 817) figured by WHITTINGTON & BOHLIN 1958, Pl. 1.

TYPE STRATUM AND TYPE LOCALITY.—Lower Raniceps Limestone. Hagudden, Böda parish, Öland.

For diagnosis and description see WHITTINGTON & BOHLIN (1958).

DISCUSSION.—For the first time a reconstruction of the exoskeleton of this species (Text-fig. 4) has been made assuming the thorax to have possessed 10 segments, and that the type of pygidium shown belongs here. The reconstruction of the pygidium is composite and has been drawn from the specimen figured on Pl. 6, fig. 7 and from the two specimens figured by WHITTINGTON & BOHLIN (1958, Pl. 2, figs. 5–7). The former pygidium has recently been found amongst some old collections from Hälludden in the Riksmuseum,



Text-fig. 4. *Boedaspis ensifer* WHITTINGTON & BOHLIN. Lower Raniceps Limestone, Hagudden, northern Öland. The reconstruction assumes the thorax to have 10 segments and that the type of pygidium belongs to the species. Based on Holotype UM No. Öl 817 (cephalon and thorax) and UM No. Öl 818, LM No. 3901 t, RM No. Ar 47408 (pygidium); about 2/3 natural size.

Stockholm, and it shows features of the rachis more clearly than either of the latter pygidia. All three pygidia differ slightly from each other in the parts preserved, and it is noticeable that the specimen (Pl. 6, fig. 7) has slimmer secondary border spines which are only slightly flattened in cross-section. In this respect it is identical with the specimen figured by BOHLIN (1949, p. 560, Fig. 8) and WHITTINGTON & BOHLIN (1958, Pl. 3, fig. 6) from the same locality.

*Acidaspis solis* (ÖPIK 1925, p. 5, Fig. 2) from the Pakri calcareous sandstone [Aluoja ($B_{III}\gamma$) Substage], Estonia, has, after suggestions by WHITTINGTON & BOHLIN (1958, p. 41), been referred by MÄNNIL (1961, p. 44) to the genus *Boedaspis*. This species is slightly younger than those from Sweden, and it differs in having only three anterior secondary border spines. During a recent visit to Estonia, I had the opportunity to study the holotype of *Boedaspis solis* and, in a forthcoming paper, I intend to give a new figure and description of the specimen.

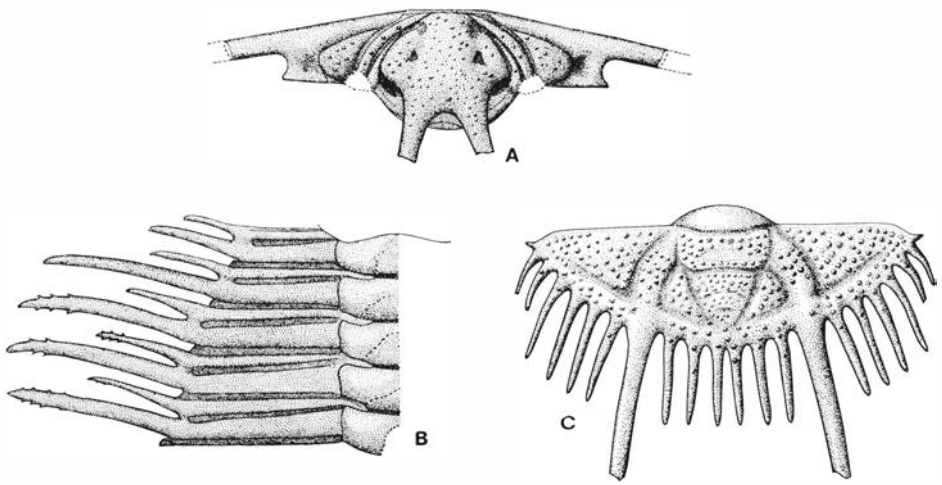
SKEVINGTON (1936*b*) has shown that on Öland, the boundary between the graptolite zones *Didymograptus hirundo* and *D. bifidus* roughly coincides in the shelly facies, with the junction between the zones of *Asaphus expansus* and *A. raniceps*. Thus, in terms of the British succession, the specimens of *Boedaspis* from the Raniceps Limestone of Öland are of Llanvirnian age.

OCCURRENCE.—N. Öland: Hagudden, Hälludden and Gunnarslund.

**Subfamily *Miraspidinae*** R. & E. RICHTER, 1917

**Genus *Miraspis*** R. & E. RICHTER, 1917

TYPE SPECIES.—*Odontopleura mira* BARRANDE, 1846.




Text-fig. 5. *Boedaspis ensifer*. Reconstructions showing details of A, cephalon orientated to lie in the horizontal plane; B, part thorax, × 1; C, pygidium, × 4.

### *Miraspis solbergensis* n.sp.

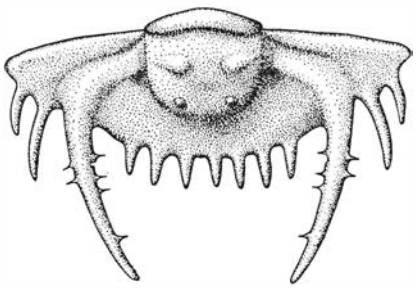
Pl. 5, figs. 1–3

DERIVATION OF THE NAME.—From the name of the type locality.

HOLOTYPE.—The cranidium (UM No. D 1151; BRUTON Coll.) figured herein.

TYPE STRATUM AND TYPE LOCALITY.—Boda Limestone. Solberga, Siljan district.

DIAGNOSIS AND DESCRIPTION.—Glabella outlined by the convexity of the lateral lobes, the dorsal furrow being broad and very shallow posteriorly and almost absent anteriorly. Maximum transverse width of glabella at mid-length of L1 equal to sagittal length including occipital ring. Latter with convex posterior band widest beneath spines, but narrowing laterally. Median part of occipital ring strongly convex with paired upwardly- and backwardly-directed occipital spines (only preserved in part). A small median spine is present on the occipital ring and is positioned slightly less than midway from the occipital furrow to posterior margin. Occipital furrow shallow across base of median glabellar lobe, deeper laterally beneath L1. Median glabellar lobe rectangular and separated from lateral lobes by the broad, shallow longitudinal furrow. Median lobe gently convex, highest point opposite the inner end of S1; frontal lobe very short (sag.) and ill-defined. Three pairs lateral lobes. L1 the larger, oval in outline and slightly lower than the level of the adjacent median lobe; L2 square and inflated to same level as median lobe; L3 much flatter, a little less than half the size of L2 and weakly separated from the frontal lobe. Lateral furrows deepest at their inner ends; S1 transverse and completely separating L1 from L2; S2 more oblique and not reaching the dorsal furrow; S3 shallow. Eye ridge narrow, strongly convex and slightly curved. Palpebral lobe (only



Text-fig. 6. *Miraspis cornuta* (BEYRICH). Dalmanitina Beds, Mösseberg, Västergötland. Reconstruction (drawn from the original of Pl. 5, fig. 4), × 6.

base preserved on left fixed cheek) produced upwards and outwards from point on a transverse line drawn through the occipital furrow. Fixed cheek widest (tr.) posteriorly where it slopes steeply downwards from the palpebral lobe to the dorsal furrow; anterior to S1, the cheek is narrower and becomes progressively flatter. Anterior branch of facial suture curves forwards subparallel to eye ridge and leaves between it and the eye ridge a small segment of the fixed cheek which is approximately four times as long (exs.) as wide. Posterior suture and border incomplete. Exoskeleton with large granules on most convex parts, remaining areas with granules of smaller size; deepest furrows and occipital ring smooth.

DIMENSIONS.—Length (including occipital ring) 10 mm, width of glabella (at L1) 10 mm, approximate maximum width 14 mm.

DISCUSSION.—*Miraspis solbergensis* differs from the Lower Ordovician species *M. ceryx* (cf. WHITTINGTON & BOHLIN 1958, Pl. 3, figs. 1–4) in the following ways: (1) the less impressed occipital furrow; (2) occipital spines directed more strongly upwards and more divergent; (3) posterior part of fixed cheek flattened and sloping steeply inwards to dorsal furrow; convex and sloping outwards in *M. ceryx;* (4) exoskeleton not as coarsely granulated.

*M. solbergensis* is remarkably like the younger species *M. mira* (BARRANDE, 1846) from the Upper Wenlock, Bohemia, but in the latter L3 is much reduced, indistinctly inflated, and defined only by the lateral furrows. The prominent median occipital spine is absent in the Silurian species.

OCCURRENCE.—See type data.

### *Miraspis cornuta* (BEYRICH, 1846)

Pl. 5, figs. 4–5; Text-fig. 6

1846 *Odontopleura cornuta* n.sp. — BEYRICH, p. 22, Pl. III, figs. 4*a–b*; not fig. 5 [ = *Miraspis mira* (BARRANDE, 1846)].
1847 *Odontopleura cornuta* BEYRICH — HAWLE & CORDA, p. 149.
1852 *Acidaspis cornuta* BEYRICH — BARRANDE, p. 738.
1869 *Acidaspis cornuta* BEYRICH — LINNARSSON, p. 65.
1896 *Acidaspis cornuta* BEYRICH — LAKE, p. 244 (footnote).
1921 *Acidaspis cornuta* BEYRICH — TROEDSSON, p. 9.

LECTOTYPE (selected herein).—The incomplete pygidium (HU No. K 198) figured by BEYRICH 1846, Pl. III, fig. 4*b*) and figured herein as Pl. 5, fig. 4.

TYPE STRATUM AND TYPE LOCALITY.—Dalmanitina Beds. Mösseberg, Västergötland.

MATERIAL.—In addition to the lectotype, one external mould of a cranidium (HU No. K 197) and one damaged cranidium. These specimens and the lectotype occur together on the same limestone block.

DESCRIPTION.—Pygidium with a short rachis not reaching posterior border, width (tr.) at first ring equal to length of pygidium. Articulating halfring as wide as first ring, articulating furrow shallow medially, narrow and deep laterally. First ring with two large tubercles on the lateral shoulder; second ring lower, indistinctly separated from first, and with two smaller tubercles. Dorsal furrow shallow alongside rings, but pit-like opposite the separating furrow. The pleural ridge, which is outlined by deep furrows, curves backwards from alongside the first rachial ring and reachs the posterior border at approximately one third pleural width. At the border, the ridge is bent and produced backwards into long, incurving and slightly upwardly directed barbed major spine (only the left spine is complete on the lectotype). Outside the major spine are two secondary spines the first of which is about one third the length of the major spine. Between the major spines are eight shorter secondary spines.

REMARKS.—The cranidium has been flattened but, nevertheless, the chief differences from *Miraspis mira* (BARRANDE) appear to be, the shorter occipital ring and the presence of a median spine. The lateral glabellar lobes of *M. cornuta* are smaller and more rounded than those of *M. solbergensis*.

The pygidium of *M. mira* differs from that of *M. cornuta* in the presence of 14 posterior secondary border spines and a pleural ridge which is directed straight outwards before curving backwards to reach the posterior border at about two-thirds pleural width.

Other pygidia of *Miraspis* are known from the Caradocian of North Wales (WHITTINGTON & WILLIAMS 1955; Pl. 40, fig. 119) and the Ashgillian of Scotland (WHITTINGTON 1956*b*, p. 515, Pl. 60, figs. 7–8), but differ from *M. cornuta* in having a longer and more transverse pleural ridge.

DISCUSSION.—BEYRICH described and figured the cranidium and pygidium of this species which was collected from the Dalmanitina Beds at Mösseberg, Västergötland. A second cranidium was also figured from the Silurian of St Yvan, Bohemia, under the same name. In the discussion BEYRICH remarked "Es wäre auch leicht möglich, dass sich noch Verschiedenheiten zwischen der böhmischen und der schwedischen *O. cornuta* herausstellen, wenn von ersterer wird der Schwanz gefunden sein ..."

In the same year BARRANDE (1846, p. 57) described *Odontopleura mira* from the same locality as BEYRICH's Bohemian cranidium, and later (BARRANDE 1852, p. 735, Pl. 39, figs 1–11) fully described and figured complete specimens of this species to which he also referred BEYRICH's specimen. In the discussion BAR-

RANDE (1852, p. 738) considered the possibility that the Swedish specimens of *cornuta* were different from *mira* on account of the pygidia. HAWLE & CORDA (1847, p. 149) for the same reasons believed that the Bohemian and Swedish specimens belonged to distinct species, and all subsequent workers have agreed with them. However, it would appear that none of these people ever saw BEYRICH's Swedish material which is thus refigured in this paper for the first time since 1846.

The species *Miraspis cornuta* is very rare and both LINNARSSON (1869) and TROEDSSON (1921) were unable to find further specimens from the type locality. I have also failed to find any specimens in the Swedish museum collections.

There seems no doubt that the material is from the Dalmanitina Beds, since on the same block of limestone are many pygidia and cranidia of *Dalmanitina mucronata* (BROGNIART) and *Lichas laciniatus* (WAHLENBERG) including the originals of BEYRICH (1845, Pl. 1, fig. 17; 1846, Pl. 1, fig. 5*b*; HU No. k 160; and 1846, Pl. 1, fig. 5*a*; HU No. k 177).

OCCURRENCE.—See the type data.

### *Miraspis* sp. indet.

1948 *Odontopleura* sp. — THORSLUND, p. 365, Pl. XXI, fig. 9.
1964 *Miraspis* sp. — JAANUSSON, p. 68 (table).

DISCUSSION.—An incomplete free cheek belonging to a species of *Miraspis* was obtained by THORSLUND from the 64.24–64.27 metre level of the deep boring which penetrated the Ordovician strata at Kullatorp, Kinnekulle, Västergötland (see THORSLUND, 1948). This level corresponds to the Skagen Limestone (JAANUSSON 1964, p. 12).

The specimen (UM No. Vg 36) shows the narrow triangular free cheek with raised border bearing 10 fringing spines and a long thinly tapered librigenal spine. Part of the long stalked palpebral lobe is also preserved and the convex part of the cheek has four prominent tubercles.

In the collections of the Natural History Museum Stockholm, is a specimen (RM No. Ar 9160) of a *Miraspis* sp. from a loose erratic block of the Upper Ludibundus Limestone, Ytterhallen, Jemtland. The specimen is too incomplete for full description, being preserved as an external mould, but a latex cast reveals the stalked eye lobe, part of the occipital ring with median spine and a long tapering occipital spine. The exoskeleton is very delicately spinose.

In terms of stratigraphic position, the occurrence of these two specimens is between that of *Miraspis ceryx* from the Upper Ontikan (upper part of the Lower Ordovician) and the two Upper Ordovician species *M. solbergensis* and *M. cornuta*.

## Genus *Ceratocephala* WARDER, 1838

(Subjective synonyms, *Onchaspis* [*Onychaspis* SIC] RAYMOND, 1925; see WHITTINGTON & EVITT 1954, p. 53. *Trapelocera* HAWLE & CORDA, 1847; see PRANTL & PŘIBYL, 1949, pp. 180–181.)

TYPE SPECIES by monotypy.—*Ceratocephala goniata* WARDER, 1838.

### *Ceratocephala laticapitata* (WARBURG, 1925)

Pl. 4, figs. 5–8, Pl. 5, figs. 6–8

1925 *Acidaspis* (*Ceratocephala* ?) *laticapitata* sp. nov. — WARBURG, p. 245, Pl. VI, fig. 4.
1933 *Ceratocephala laticapitata* WARBURG — WARBURG, p. 14, Text-fig. 3.
1949 *Onychaspis laticapitata* (WARBURG) — PRANTL & PŘIBYL, p. 133.

HOLOTYPE (by original designation).—The poorly preserved cephalon (UM No. D 81a) figured by WARBURG 1925, Pl. VI, fig. 4, and refigured herein as Pl. 5, figs. 6–8.

TYPE STRATUM AND TYPE LOCALITY.—Boda Limestone. Kallholn, Siljan District.

MATERIAL.—In addition to the holotype, a small internal mould of a cranidium (UM No. D 1188), an external mould of a cephalon (UM No. D 816), and a small free cheek (UM No. D 1189), all syntypes from the WARBURG Coll., and one well preserved cephalon (UM No. D 1174a, b) collected in 1964 by K. WÄNGBERG-ERIKSSON and L. KARIS.

DESCRIPTION.—Cephalon elliptical in dorsal aspect, free cheeks sloping steeply downwards. Length of glabella equal to width across L1. Highest part of median lobe at inner end of S1; frontal lobe slopes steeply down to anterior border furrow and slightly overhangs it. Three pairs of lateral lobes. L1 large, oval in outline, defined posteriorly by deepened dorsal furrow, anteriorly unlimited (dorsal furrow being completely eliminated) and outer part fused with fixed cheek. L2 shorter, directed outwards and downwards from median lobe and separated from fixed cheek by broad, shallow dorsal furrow. L3 a small sunken transverse ridge. S1 directed obliquely forwards but deepened and incurved backwards adjacent to median lobe. S2 deep and subparallel to S1; S3 a small transverse pit immediately inside antero-lateral swelling of frontal lobe. Longitudinal furrow very shallow and inner part of lateral lobes and medan lobe only separated by the convexity of the latter. Occipital ring about four and half times as wide (tr.) as long. Posterior band separated from remainder of ring by a vertical slope and narrow deep furrow. Small elongated occipital lobe outlined by the deepened posterior continuation of the longitudinal furrow and the deepened lateral part of the occipital furrow beneath L1. Median part of occipital ring with paired spine bases (spines broken off and leaving small tubercle-like protuberances; cf. WARBURG 1925, p. 246) and small median spine behind occipital furrow. Eye positioned well forward so that a transverse line drawn through the midpart is level with the inner end of S2. Narrow,

straight eye ridge connected to a smooth lateral expansion of the frontal glabellar lobe. Fixed cheek sloping steeply outwards and downwards from the dorsal furrow, maximum transverse width level with the midpart of L1. Anterior branch of facial suture outlined by faint sutural ridge which diverges from eye ridge and crosses anterior margin on an exsagittal line drawn through the middle of L1. Posterior branch of suture directed backwards and curving inwards posteriorly to cross posterior border inside base of librigenal spine.—Free cheek triangular in outline with rounded antero-lateral margin. Border narrow and flattened adjacent to anterior suture, broad, flat and downwardly sloping laterally, narrow and convex with a deepened furrow towards the librigenal angle. Only the broken base of the librigenal spine is visible on the right cheek of the specimen figured on Pl. 4: 5. From the base of this spine a short, curved swollen ridge crosses the cheek surface but dies out and becomes only faintly defined immediately behind the eye.—Exoskeletal surface with large tubercles or spine bases, furrows smooth. Three paired spine bases occur on the fronto-median lobe, and the most conspicuous pair occur on the highest part of the lobe level with the midpart of L2.

DIMENSIONS.—Of the holotype: width (tr.) 8.5 mm, length 4.5 mm, width across L1 3.5 mm, width of occipital ring 4.5 mm.

DISCUSSION.—The cephalon (Pl. 5, figs. 6–8) is the holotype since WARBURG (1925, p. 247) refers to this as the "type specimen".

WARBURG (1925, p. 248) while noticing slight differences in the glabellar lobes and fixed cheek, referred this species to *Ceratocephala sensu stricto*, i.e. in the sense of CLARKE (1892, p. 93; see WARBURG 1925, p. 235). Later WARBURG (1933, p. 14 footnote) suggested that it may represent a distinct subgenus of *Ceratocephala*.

In my opinion, there seems very little in favour of separating the Ordovician species of *Ceratocephala* from those of the Silurian and Devonian. In all species, the highest part of the median glabellar lobe is level with the antero-lateral portion of L1, the eye ridge is straight, the eye lobe is positioned on the outer part of the inflated fixed cheek, and L3 is present but faintly defined in the Devonian species *C. vesiculosa* (BEYRICH, 1846).

In the Ordovician species, the glabella is often more discrete with L1 being smaller and less swollen and not totally confluent with the adjacent fixed cheek. However, depth of furrows and inflation of adjacent lobes are variable characters which can hardly be used as a sound basis for separating specimens at the subgeneric let alone generic level (for remarks on this problem cf. WHITTINGTON 1963, p. 105). The remarkable similarity between features of the thorax, pygidium and hypostoma of both Ordovician and Siluro-Devonian species of *Ceratocephala*, is further evidence for keeping them in the same genus.

*C. laticapitata* is the only known species from the European Upper Ordovician, although there are several older species recorded from North America and Scotland. Closely related are *C. exigua* (WHITTINGTON 1963, p. 103,

Pl. 31, figs. 18, 21; Pl. 32, figs. 1–3) from the Whiterock Stage (Llanvirn in part) of Newfoundland, *C. triacantheis* and *C. laciniata* (WHITTINGTON & EVITT 1954, pp. 54–60, Pls. 6–9; Pl. 25) from the Lincolnshire and Edinburg Limestones (Llandeilo-Caradoc) of Virginia, and *C. confinis* (TRIPP 1962, p. 33, Pl. 4, figs. 33–36) from the Confinis Flags (=lowermost Edinburg Formation) of Girvan, Scotland. *C. rarispina* (WHITTINGTON 1956*a*, p. 242, Pl. 15, figs. 1–29) from the Oranda Formation, Virginia is different. *C. laticapitata* resembles *C. laciniata* (WHITTINGTON & EVITT 1954, Pl. 6, figs. 1, 3–4) with regard to, the relatively long (sag.) and expanded frontal glabellar lobe, the elongated L2, the very narrow occipital ring with small median spine and the eye position, but differs in having a slightly narrower fixed cheek and a more rounded free cheek. In the last feature, *C. laticapitata* is like *C. triacantheis*. TRIPP (1962, p. 34) noted that the free cheek of *C. confinis* was more rounded than that of *C. laciniata*. Although not well preserved, it is obvious that *C. confinis* differs from *C. laticapitata* in having a longer (sag.) occipital ring.

OCCURRENCE.—Boda Limestone, Siljan district: Kallholn, Solberga.

## Genus *Whittingtonia* PRANTL & PŘIBYL, 1949

TYPE SPECIES (by monotypy) *Acidaspis bispinosus* M'COY, 1846. For full diagnosis of the genus see WHITTINGTON 1956*b*, p. 516, and KIELAN 1960, p. 109.

### *Whittingtonia bispinosa* (M'COY, 1846)

Pl. 6, figs. 1–3

1846 *Acidaspis bispinosus* n.sp. — M'COY, p. 45, Pl. IV, fig. 7.
1853 *Acidaspis bispinosus* M'COY — SALTER, p. 4, Pl. VI, fig. 4.
1854 *Trapelocera* ? *breviloba* n.sp. — ANGELIN, p. 38, Pl. XXII, figs. 16*a*.
1892 *Ceratocephala bispinosa* (M'COY) — CLARKE, p. 5.
1910 *Acidaspis breviloba* ANGELIN — WESTERGÅRD, p. 12.
1925 *Acidaspis* (*Ceratocephala* ?) *bispinosa* M'COY — WARBURG, p. 248, Pl. VI, figs. 2–3.
1925 *Onychaspis bispinosus* (M'COY) — REED, p. 428.
1933 *Ceratocephala* (n. subgen.?) *bispinosa* (M'COY) — WARBURG, p. 17.
1949 *Whittingtonia bispinosa* (M'COY) — PRANTL & PŘIBYL, p. 205, Pl. V, fig. 7.
1952 *Whittingtonia bispinosa* (M'COY) — ERBEN, p. 309, Text-fig. 1*c*.
1956*a* *Whittingtonia bispinosa* (M'COY) — WHITTINGTON, p. 248, Text-fig. 17.
1956*b* *Whittingtonia bispinosa* (M'COY) — WHITTINGTON, p. 516, Pl. 59, figs. 4–5, 7–8.
1959 *Whittingtonia bispinosa* (M'COY) — WHITTINGTON in MOORE, 0508, figs. 2*a–c*.
1960 *Whittingtonia bispinosa* (M'COY) — KIELAN, p. 111.
not 1844 *Odontopleura bispinosa* — EMMRICH, p. 17, Pl. 1, fig. 12; [ = *Odontopleura ovata* Emmrich, 1839].
not 1845 *Odontopleura bispinosa* — EMMRICH, p. 44, Pl. 1, fig. 12; [ = *Odontopleura ovata* Emmrich, 1839].
not 1848 *Acidaspis bispinosus* M'COY — SALTER, Pl. I, figs. 4*a–b*; [ = *Ceratocephala barrandei* (FLETCHER in SALTER, 1853)]; figs. 5*a–b* [ = *Miraspis jamesi* (SALTER)].

TYPE STRATUM AND TYPE LOCALITY.—Kildare Limestone (Upper Ordovician). Chair of Kildare, Co. Kildare, Eire.

MATERIAL (from Sweden).—ANGELIN's type of *Trapelocera breviloba* (RM No. Ar 11440) figured Pl. 6, figs. 1–3, and one very small cranidium (RM Coll.) from Kallholn, Siljan district.

DISCUSSION.—The whereabouts of the type specimen of the type species is not known. Dr. J. S. JACKSON, Keeper of Natural History, National Museum of Ireland, Dublin, informs me (personal communication 20.10.64) that the specimen is not in the GRIFFITH Collection and its whereabouts is not recorded in the museum catalogue of M'COY's types. The specimen has not been located at the Sedgwick Museum, Cambridge, or the Geological Survey Museum, London, and it is assumed to be lost.

A second more complete cephalon from the type locality (SALTER, 1853, Pl. VI, fig. 4) which was examined by PRANTL & PŘIBYL (1949) has also been lost from the Museum of the Geological Survey, London, and efforts to locate it by Professor WHITTINGTON in 1953 (WHITTINGTON, verbal communication) and by museum staff have been to no avail.

Among the existing topotype material, the specimens at the Palaeontological Institute, Uppsala, collected by WARBURG (see WARBURG, 1925, p. 250) are very distorted, but the cephalon from the Sedgwick Museum, Cambridge, figured by WHITTINGTON (1956*b*), is more complete and is quite sufficient for defining the species.

WARBURG (1925, p. 251) has mentioned that the original diagnosis was based on an incomplete cephalon (the holotype), while a short description of the thorax and pygidium was based on specimens since shown to belong to another genus. These specimens were those formerly thought by SALTER (1848, Pl. IX, figs. 5*a–b*) to belong to *Acidaspis bispinosus* but later, SALTER (1853, Pl. VI, figs. 1–3) described them as a new species, *A. jamesi*. I have seen these specimens at the Geological Survey Museum, London, and can now confirm that they belong to the genus *Miraspis*.

ANGELIN's type of *Trapelocera* ? *breviloba*, an incomplete cephalon from the Boda Limestone at Osmundsberget, was refigured and described by WARBURG (1925) who, after collecting topotype material from Kildare, was convinced that the Swedish and Irish specimens were conspecific. I believe this to be correct and thus *breviloba* ANGELIN becomes a junior subjective synonym of the older species *bispinosa* M'COY, 1846. The Swedish specimen (Pl. 6, figs. 1–3) is smaller than the specimen figured by WHITTINGTON (1956*b*), and Table 2 illustrates the differences in size.

KIELAN (1960, p. 109, Pl. XVI, fig. 5; Pl. XVIII, figs. 1–4) described a closely related species *Whittingtonia whittingtoni* from the Upper Ordovician of Poland, and specimens very like it have been recently described from the Rhiwlas Limestone, North Wales (WHITTINGTON, 1965, pp. 34–35, Pl. IX, figs. 11–17). KIELAN distinguished her species from *W. bispinosa* on account of the lack of

*Table 2.* Dimensions (in mm) for two cranidia of *Whittingtonia bispinosa.* Swedish specimen from the Boda Limestone, the British specimen from the type stratum at the type locality.

| | Siljan district: Osmundsberget RM Ar 11440 | Eire: Chair of Kildare SM A 14016a |
|---|---|---|
| Length of cranidium (including occipital ring) | 4.7 | 8.3 |
| Length of glabella | 4.0 | 7.0 |
| Width (tr.) across palpebral lobes | 4.6 | 8.2 |
| Width (tr.) of glabella at mid-length | 2.5 | 4.5 |
| Total width of cephalon | 6.8 | 10.? |

the third glabellar lobe, larger eye lobe, shorter occipital and genal spines and the coarser granulation of the exoskeleton. In all of the known specimens of *W. bispinosa*, the occipital and genal spines are incomplete, only the broken eye base is known, and the specimen (Pl. 6, figs. 1–3) shows that the exoskeleton is as coarsely granulated as that of *W. whittingtoni*. In my view, the absence in *W. whittingtoni* of the third glabellar lobe and the profile of the median lobe, prove the more reliable features when separating this species from *W. bispinosa.* In anterior view, the median glabellar lobe of *W. whittingtoni* (cf. KIELAN 1960, Pl. XVIII, figs. 1*b*, 3*b*) is wider (tr.) and more convex with the sides tapering inwards; in lateral view (cf. KIELAN op. cit. figs. 1*c*, 3*c*; WHITTINGTON 1965, Pl. IX, fig. 16) the frontal lobe considerably overhangs the anterior margin. These features can be compared with similar profiles of *W. bispinosa* as illustrated by WHITTINGTON (1956*b*) and the specimen figured in this paper (Pl. 6, figs. 1–3).

OCCURRENCE.—Boda Limestone, Siljan district; Osmundsberget and Kallholn; Kildare Limestone, Ireland: Chair of Kildare.

### Subfamily uncertain

### Genus *Periallaspis* n.gen.

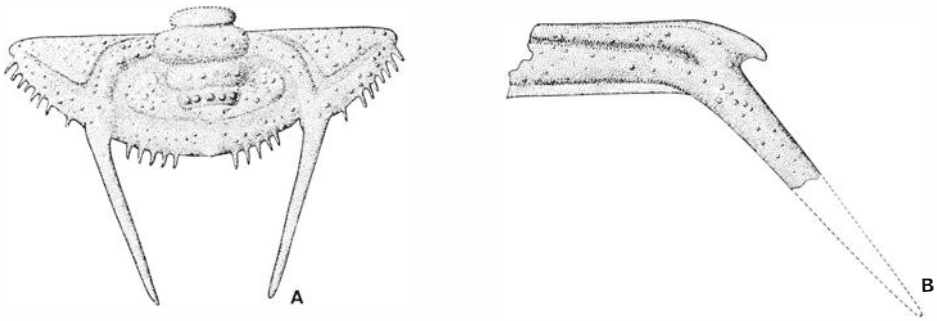
TYPE SPECIES.—*Periallaspis uncinus* n.gen., n.sp.

DERIVATION OF THE NAME.—Greek—*periallos*, before all others, referring to one of the earliest members of the family Odontopleuridae.

DIAGNOSIS.—Pygidium semicircular with rachis of three well defined rings; border furrow well developed. Border with long paired upwardly directed major spines and minute secondary spines from lower edge.

Pleura of posterior segment with well developed diagonal pleural furrow; principal pleural spine flattened in cross section; anterior spine short and hooked.

GEOLOGICAL RANGE.—Basal Oeland Series, Hunneberg Stage.




Text-fig. 7. *Periallaspis uncinus* n.gen., n.sp. Lowermost Arenig zone of *Megistaspis armata*, Stenbrottet, Västergötland. Reconstruction (drawn from the originals of Pl. 6, figs. 4, 5) of A, pygidium, ×4; B, right posterior pleural segment, ×5.

### *Periallaspis uncinus* n.gen., n.sp.

Pl. 6, figs. 4–6; Text-figs. 7 A, B

1956 Odontopleurid trilobite — TJERNVIK p. 264.
1958 Odontopleurid subfam. indet. — WHITTINGTON & BOHLIN, p. 43.

DERIVATION OF THE NAME.—Latin *uncinus*, hooked, referring to the shape of the anterior pleural spine of the thoracic segment.

HOLOTYPE.—The well preserved but partly complete pygidium (UM No. Vg 409) figured Pl. 6, fig. 5.

OTHER MATERIAL.—One right posterior pleural segment lacking rachis (UM No. Vg 410); small incomplete pygidium (UM Nos. Vg 411a–b) TJERNVIK Coll.

TYPE STRATUM AND TYPE LOCALITY.—Arenig zone *Megistaspis armata*, Section 1; 56–58 cm level (see TJERNVIK 1956, p. 123). Stenbrottet, Västergötland.

DESCRIPTION.—Pygidium approximately semicircular. Rachis with three rings and a short terminal portion. Width of first ring equal to length of rachis, strongly convex with a pair of conspicuous spine bases; first ring furrow very deep laterally. Second ring narrower and less convex than first and with six smaller spine bases; second ring furrow less deep than first. Third ring of equal convexity to second and with five spine bases. Terminal portion triangular and just reaching the inner edge of border furrow. Pleural ridge curves strongly backwards from alongside first ring and reaches the posterior border at about midpleural width. Distal part of ridge enlarged where it meets the posterior border and connects with the base of major border spine. Latter apparently longer than pygidium and directed upwards and inwards distally. Outside of major spine at least 8 very short secondary spines directed outwards and downwards from the lower margin, and at least 10 secondary spines, hardly visible on Pl. 6, fig. 5, between the major spines. Posterior border broad and gently convex with well marked shallow furrow. Broad smooth furrows outline the

pleural ridge from the gently raised pleural area. Latter and posterior border with prominent spine bases with finer granulation between.

A smaller incomplete pygidium (Pl. 6, fig. 6) has a pleural ridge straighter than that of the pygidium described above, and rachis with a short semicircular articulating halfring.

The pleural segment (Pl. 6, fig. 4) is assumed to belong to the posterior part of a thorax because of the backwardly directed pleural spine. Pleura flat and crossed by a deep diagonal pleural furrow distally curved and deepened at the base of the pleural spine. Latter flattened to elliptical in cross-section. Posterior part of pleura narrow (exs.) distally, but wider and flatter proximally; anterior part narrow proximally, widening distally and produced outwards into a short, curved anterior spine. The anterior and posterior margins are straight and there is a narrow (exs.), flattened posterior flange. Pleural area with large tubercles and spine bases, pleural spine more finely granulated.

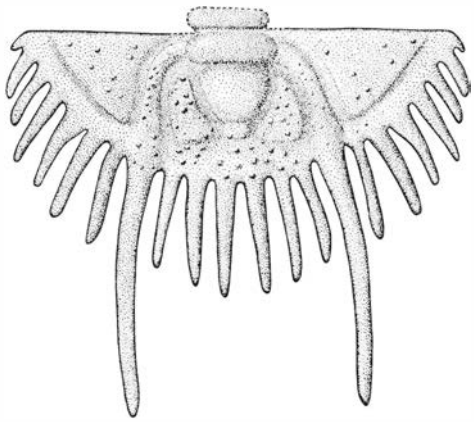
Examination of other material has failed to prove the presence of a free cheek (cf. TJERNVIK 1956, p. 264; see remarks by WHITTINGTON & BOHLIN 1958, p. 43).

DIMENSIONS.—Width of pygidium approximately 11 mm; length 4 mm.

DISCUSSION.—The present material was collected in 1953 by Dr. TORSTEN TJERNVIK from limestones of the Arenig zone of *Megistaspis armata* in Västergötland. Beds of this zone immediately overlie the Tremadoc (zone *Apatokephalus serratus*) and in turn, are followed by the zone of *Megistaspis planilimbata* which can be equated with the first two recognisable graptolite zones (*Tetragraptus phyllograptoides* and *Didymograptus balticus*) of the Lower Didymograptus Shale. The base of the latter would appear to correlate well with the base of the Arenigian thus indicating that beds belonging to the zone of *M. armata* are older than the oldest beds of the British Arenig succession. However, as outlined by SKEVINGTON (1963*a*) correlation between the Scandinavian and British Lower Ordovician is difficult because evidence suggests that in Britain the basal Arenig is partly missing or devoid of graptolites at the type locality.

The earliest record of an odontopleurid from Britain is that of *Selenopeltis buchi macrophthalmus* (cf. WHITTARD 1961, p. 199, Pl. XXVI, figs. 2, 3) from beds presumed to be near the top of the *Didymograptus extensus* zone (WHITTARD 1955, p. 4). In North America, HINTZE (1953, Pl. 19, figs. 14, 15, 16*a–b*) has illustrated odontopleurid parts from the zones G2 and H of the Canadian Pogonip Group, Utah. Recent work by ROSS & BERRY (1963, p. 64) indicates that beds equivalent to zone G range upwards to include the lower part of the *D. extensus* zone of the British Arenig, while zone H lies within the zone of *D. extensus* or may even reach the zone of *D. hirundo*. Thus to date, the Swedish specimens of *Periallaspis* represent one of the oldest known odontopleurid species.

The material of *Periallaspis* is insufficient to enable the genus to be assigned to any known odontopleurid subfamily, and its possible relationship to other



Text-fig. 8. Odontopleurid gen. and sp. indet. a. Lower Raniceps Limestone, Hälludden, northern Öland. Reconstruction (drawn from the original of Pl. 6, fig. 8). × 1.25.

genera is not clear. WHITTINGTON & BOHLIN (1958, p. 44) concluded that, while the general form of the pygidium was like that of *Selenopeltis*, the pleura was not. This last observation is only true if the pleura of *Periallaspis* is compared with the anterior segments of *Selenopeltis* on which the pleural ridge has a characteristic knee-shaped bend forwards. The degree of curvature, however, becomes less accentuated backwards until on the posterior segments and especially on the 9th segment, the pleural ridge is almost straight (cf. WHITTARD 1961, Pl. XXVI, figs. 4–5, 7–8; PRANTL & PŘIBYL 1949, Pl. VIII, figs. 2, 7; Pl. IX, fig. 2) and not at all unlike that of *Periallaspis*. The short hooked anterior pleural spine and the flattened pleural spine of *Periallaspis* is also characteristic of *Selenopeltis*.

OCCURRENCE.—Armata Limestone. Stenbrottet, Västergötland.

### ***Odontopleurid*** gen. and sp. indet. a

Pl. 6, fig. 8; Text-fig. 8

1958 *Boedaspis ensifer* n.gen. n.sp. ? WHITTINGTON & BOHLIN, p. 41, Pl. 3, fig. 5.

MATERIAL.—One pygidium (UM No. Öl 819) preserved from the ventral side.

DESCRIPTION.—Pygidium semicircular in outline. Rachis of two rings and small ill-defined terminal portion which does not reach the posterior border. First ring strongly convex and as wide as the length of rachis. First ring furrow broad and deep; second ring about twice as long as first ring, moderately convex and sloping backwards. The long second ring may contain the third fused ring but no ring furrow is present. Pleural ridge narrow and convex alongside rachis but swollen at the border. Major border spine round in cross-section and curved inwards and very strongly upwards distally; length nearly

twice that of pygidium. Between major spines are six closely spaced secondary spines which curve upwards distally in a manner similar to the major spines; length about one half major spine. Outside the major spine are seven secondary spines which decrease in length outwards and become less strongly curved upwards distally. Posterior border broad and flattened with border furrow weakly defined beneath rachis. Doublure broad and flat. Pleural area and posterior margin with large tubercles.

DIMENSIONS.—Width and length about 20 mm.

DISCUSSION.—This type of pygidium differs from that now associated with *Boedaspis* in the following ways: (1) the shortened rachis with two segments and a short terminal portion well within the posterior border, (2) almost straight pleural ridge relatively close to the rachis, (3) border spines deflected strongly upwards.

***Odontopleurid*** gen. and sp. indet. b

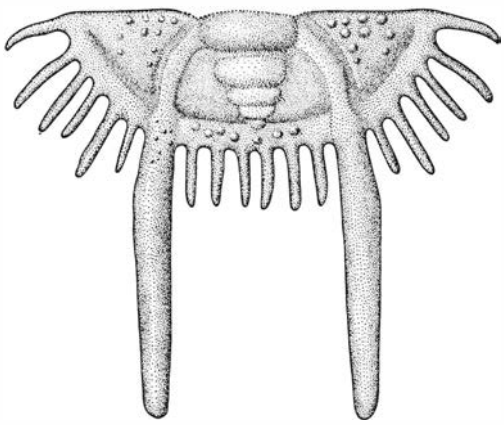
Text-fig. 9

1958 ? *Boedaspis* sp. — WHITTINGTON & BOHLIN, p. 41, Pl. 2, fig. 8.

OCCURRENCE.—Lower Raniceps Limestone. Hälludden, northern Öland.

MATERIAL.—One pygidium (UM No. Öl 822).

DESCRIPTION.—Pygidium with rachis of three rings and a short terminal portion which reaches the posterior border. First ring slightly more than half pleural width, moderately convex; first ring furrow shallow medially, becoming much wider and deeper laterally. Second ring of equal convexity to first; third ring lower and separated by deep ring furrow from terminal portion. Latter triangular with a large tubercle at the tip. The pleural ridge, outlined by broad shallow flanking furrows, curves slightly from alongside the first rachial ring and is then directed almost straight backwards to reach the posterior border at about one-third pleural width. Major border spine with very broad base,



Text-fig. 9. Odontopleurid gen. and sp. indet. b. Expansus Limestone, quarry north of Högsrum Church, central Öland. Reconstruction based on specimen UM No. Öl 822, ×2.

*Table 3.* The stratigraphic and geographic distribution of the known Swedish Ordovician odontopleurid trilobite species.

| | ONTIKA SUB-SERIES | | | VIRU SERIES | | HARJU SERIES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Armata Limestone | Expansus Limestone | Raniceps Limestone | Dalby Limestone | Skagen Limestone | Bestorp Limestone | Fjäcka Shale | Jonstorp Formation | Dalmanitina Beds | Boda Limestone | Scania | Västergötland | Öland | Siljan district | Jämtland, autochthonous |
| *Primaspis evoluta* (TÖRNQ.) | – | – | – | – | – | – | + | – | – | + | – | – | – | + | – |
| *P. bestorpensis* n.sp. | – | – | – | – | – | + | – | – | – | – | – | + | – | – | – |
| *Leonaspis olini* TROEDS. | – | – | – | – | – | – | – | – | + | – | + | + | – | – | – |
| *Diacanthaspis decacantha* (ANG.) | – | – | – | – | – | – | – | + | – | – | – | + | – | – | – |
| *Apianurus furcata* (LINNARS.) | – | – | – | + | – | – | – | – | – | – | – | + | – | – | – |
| *A. asklundi* (THORS.) | – | – | – | + | – | – | – | – | – | – | – | – | – | – | + |
| *A. clevei* (WARB.) | – | – | – | – | – | – | – | – | – | + | – | – | – | + | – |
| *A. thorslundi* BRUTON | – | – | – | – | ? | – | – | – | – | – | – | + | – | – | – |
| *A. vikarbyensis* n.sp. | – | + | – | – | – | – | – | – | – | – | – | – | – | + | – |
| *Boedaspis ensifer* WHIT. & BOHLIN | – | – | + | – | – | – | – | – | – | – | – | – | + | – | – |
| *Miraspis ceryx* WHIT. & BOHLIN | – | – | + | – | – | – | – | – | – | – | – | – | + | – | – |
| *M. solbergensis* n.sp. | – | – | – | – | – | – | – | – | – | + | – | – | – | + | – |
| *M. cornuta* (BEYR.) | – | – | – | – | – | – | – | – | + | – | – | + | – | – | – |
| *Ceratocephala laticapitata* (WARB.) | – | – | – | – | – | – | – | – | – | + | – | – | – | + | – |
| *Whittingtonia bispinosa* M'COY | – | – | – | – | – | – | – | – | – | + | – | – | – | + | – |
| *Periallaspis uncinus* n.gen., n.sp. | + | | – | – | – | – | – | – | – | – | – | + | – | – | – |

elliptical in cross-section and directed upwards distally; length twice that of pygidium. Posterior border gently convex with border furrow which is broad and deepened except beneath rachis and at antero-lateral corner. Pleural area flat to gently convex margin outside of major spine with six narrow secondary spines of which the outer spine is curved backwards at the tip. Between the major spines are six posterior secondary spines all directed outwards and downwards; length about one-third that of major spine. Posterior border with large tubercles arranged near the base of each secondary spine and tubercles of similar size occur on the pleural area; border spines with granules of smaller size.

DIMENSIONS.—Width about 35 mm; length 8.5 mm.

DISCUSSION.—This specimen, which is slightly older than other pygidia from the Ontikan of northern Öland, was tentatively referred to *Boedaspis* by WHITTINGTON & BOHLIN (1958, p. 43), but they remarked that the configuration of the rachis, the presence of the border furrow, and the general outline of the

pygidium were similar to those found in the new genus *Periallaspis*. However, *Periallaspis* does not have such stout major and secondary border spines.

OCCURRENCE.—Expansus Limestone, about 85 cm above the "Limbata" Limestone. Quarry N of Högsrum Church, Central Öland.

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## Explanation of Plates

The specimens, except where indicated, are internal moulds. Each specimen lightly coated with ammonium chloride. Not retouched. Photographs appearing on Plates 1–3, 5–6 made by Mr Nils Hjorth, those on Plate 4 by the author.

### Plate 1

*Primaspis evoluta* (TÖRNQUIST, 1884)

1–2. Dorsal and right lateral view of incomplete cephalon and five thoracic segments, ×3. Specimen, original of WARBURG (1925, Pl. VI, fig. 6) from Boda Limestone, Kallholn, Siljan district. SGU.
3, 4, 6. Lectotype. Right lateral, dorsal and anterior view of cranidium, ×4. Boda Limestone, Gulleråsen, Siljan district. SGU.
5. Oblique anterior view of cephalon, ×3. Specimen, original of WARBURG (1925, Pl. VI, fig. 5) from Boda Limestone, Östbjörka, Siljan district. UM No. D 82.
7. Incomplete pygidium, ×10. TÖRNQUIST Coll. Lund.
8. Incomplete pygidium, ×6. Specimen, original of TÖRNQUIST (1884, Pl. I, fig. 23; figured as *Acidaspis dalecarlica*) from Fjäcka Shale, Skattungbyn, Siljan district, LU 578t.
9. Dorsal view of slightly compressed cranidium in shale, ×6. Specimen, original of TÖRNQUIST (1884, Pl. I, fig. 22; figured as *A. dalecarlica*) from same horizon and locality as fig. 8. LU 577T.

### Plate 2

*Primaspis bestorpensis* n.sp.

All specimens from Bestorp Limestone, Bestorp, eastern side of Mösseberg, Västergötland. ×6.

1. Latex cast from external mould of five thoracic segments. UM No. Vg 797.
2. Free cheek with original exoskeleton preserved. UM No. Vg 801.
5. Holotype. Incomplete pygidium. UM No. Vg 800.
6. Latex cast from external mould of pygidium showing configuration of rachis. UM No. Vg 798.

*Leonaspis olini* (TROEDSSON, 1918)

3. Holotype. Latex cast of juvenile cranidium, ×15. Dalmanitina Beds, Röstånga, Scania. LU 3935.
4. Latex cast from external mould of incomplete specimen, ×3. Specimen, the original of WAHLENBERG (1821, Pl. II, fig. 4*; figured as *Entomostracites granulatus*) from the Dalmanitina Beds, Mösseberg, Västergötland. UM No. Vg 4.

*Diacanthaspis decacantha* (ANGELIN, 1854)

7. Dorsal view of incomplete individual, ×3. Upper Jonstorp Formation (= Red Tretaspis Mudstone), Mösseberg, Västergötland. RM No. Ar 15460.
8. Lectotype. Incomplete thorax and pygidium, ×3. Specimen, original of ANGELIN (1854, Pl. XXII, fig. 5; figured as *Cyrtometopus? decacanthus*), from same locality and horizon as fig. 7. RM No. Ar 15468.

### Plate 3

*Apianurus furcata* (LINNARSSON, 1869)

1. Holotype. Dorsal view of incomplete cranidium, ×8. Dalby Limestone, Ålleberg, Västergötland. SGU.

*Apianurus asklundi* (THORSLUND, 1940)

2. Holotype. Dorsal view of incomplete cranidium, ×8. Ludibundus Limestone, central Lockne area, Jemtland. SGU.

*Apianurus clevei* (WARBURG, 1925)

3. Holotype. Dorsal view of incomplete cranidium, ×8. Boda Limestone, Arvet, Dalarna. UM No. D80.
4. Incomplete pygidium, ×10. Specimen, original of WARBURG (1925, Pl. VI, fig. 8; figured as *Acidaspis* sp. ind. *a*) from ? Boda Limestone (specimen labelled as Lower Leptaena = Kullsberg Limestone, Amtjärn), Siljan district. LU 3121.
5. Damaged pygidium. ×10. Specimen, original of WARBURG (1925, Pl. VI, fig. 9; figured as ? *Acidaspis evoluta*) from Boda Limestone, Unskarsheden, Siljan district. RM No. Ar 11439.
6. Hypostoma, ×10. Specimen, original of WARBURG (1925, Pl. VI, fig. 7; figured as ? *Acidaspis* sp. ind. *b*) from Boda Limestone, Kallholn, Siljan district. UM No. D 83.

*Apianurus thorslundi* BRUTON, 1965

7. Incomplete cranidium, ×8. Horizon unknown, but most likely to be Skagen Limestone, Västergötland. RM No. Ar 15479.

## Plate 4

*Apianurus vikarbyensis* n.sp.

1–4. Holotype. Dorsal, anterior, posterior and oblique lateral views of cranidium lacking the occipital spines, ×3.5. Expansus Limestone (40 cm above the base). Kalkbackarna, Vikarbyn, Siljan district. UM No. D 1186.

*Ceratocephala laticapitata* (WARBURG, 1925)

5–7. Dorsal, posterior and anterior views of almost complete cephalon, ×8.
8. Oblique view showing the posterior branch of the facial suture and the swollen cheek ridge, ×10. Boda Limestone, Solberga, Siljan district. UM No. D 1174a.

*Primaspis evoluta* (TÖRNQUIST, 1884)

9. Dorsal view of incomplete pygidium, ×6. Specimen, original of WIMAN (1907, Pl. VIII, fig. 37; figured as *Acidaspis dalecarlica* TÖRNQUIST). From a Baltic erratic probably of Nabala ($F_{1a}$) Stage. Norrskedika. UM No. B 164.

## Plate 5

*Miraspis solbergensis* n.sp.

1–3. Holotype. Dorsal, right lateral, and oblique posterior view of cranidium, ×4. Boda Limestone, Solberga, Siljan district. UM No. D 1151.

*Miraspis cornuta* (BEYRICH, 1846)

4. Lectotype. Incomplete pygidium, ×8. Specimen, the original of BEYRICH (1846, Pl. 3, fig. 4b) from the Dalmanitina Beds, Mösseberg, Västergötland. HU k198.
5. Paralectotype. Latex cast of cranidium, ×5. Specimen, original of BEYRICH (1846, Pl. 3, fig. 4a) from the same limestone block as fig. 4. HU k197.

*Ceratocephala laticapitata* (WARBURG, 1925)

6–8. Holotype. Dorsal, anterior, and left lateral view of damaged cephalon, ×6. Specimen, the original of WARBURG (1925, Pl. VI, fig. 4) from Boda Limestone, Kallholn, Siljan district. UM No. D 81.

## Plate 6

*Whittingtonia bispinosa* (M'COY, 1846)

1–3. Dorsal, anterior, and right lateral view of partly exfoliated cephalon, ×6. Specimen, the original of ANGELIN (1854, Pl. XXII, fig. 16; figured as *Trapelocera* ? *breviloba*) from Boda Limestone, Osmundsberget, Siljan district. RM No. Ar 11440.

*Periallaspis uncinus* n.gen., n.sp.

All specimens from the early Arenig, zone *Megistaspis armata*, Stenbrottet, Västergötland.

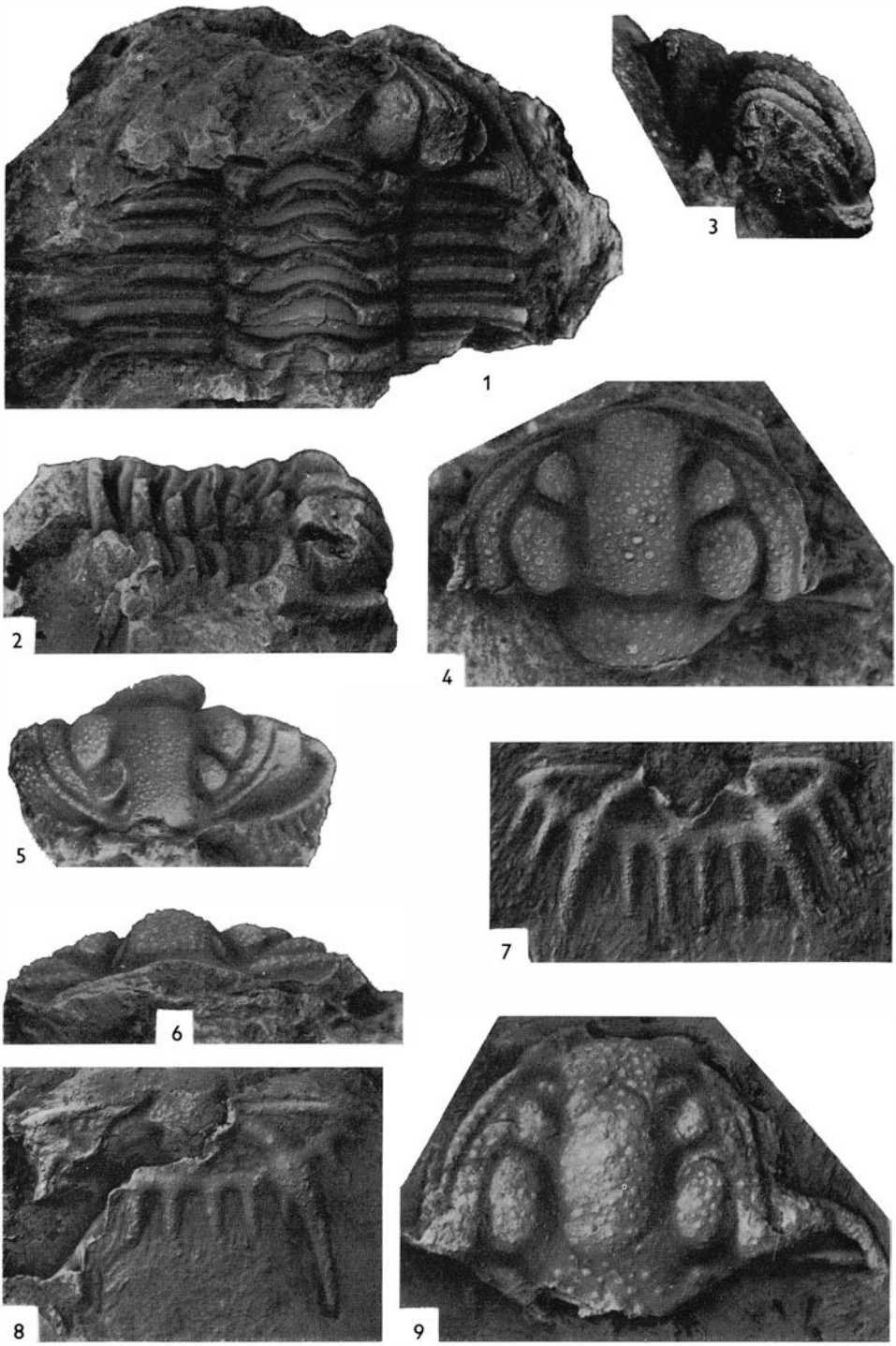
4. Incomplete right posterior thoracic segment, ×10. UM No. Vg 410.
5. Holotype. Incomplete pygidium, ×6. UM No. Vg 409.
6. Latex cast from external mould of small damaged pygidium, ×10. UM No. Vg 411.

*Boedaspis ensifer* WHITTINGTON & BOHLIN, 1958

7. Dorsal view of pygidium which still retains the exoskeleton, ×5. From unknown horizon, Hälludden, northern Öland. RM No. Ar 47408.

*Odontopleurid* gen. and sp. indet a

8. Latex cast from external mould of incomplete pygidium, ×1.5. Specimen, the original of WHITTINGTON & BOHLIN (1958, Pl. 3, fig. 5), from the Lower Raniceps Limestone, Hälludden, northern Öland. UM No. Öl 819.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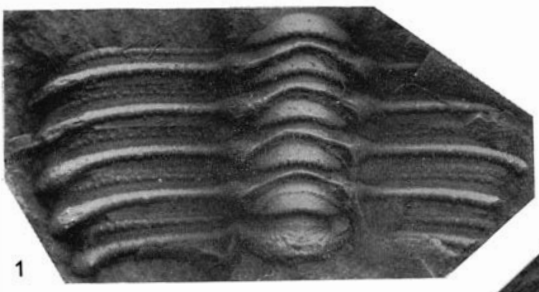
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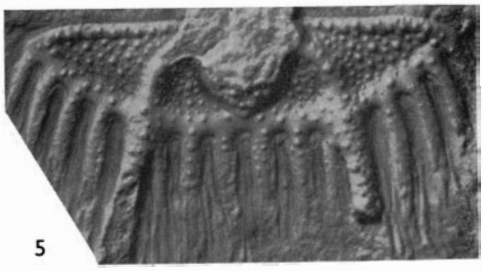
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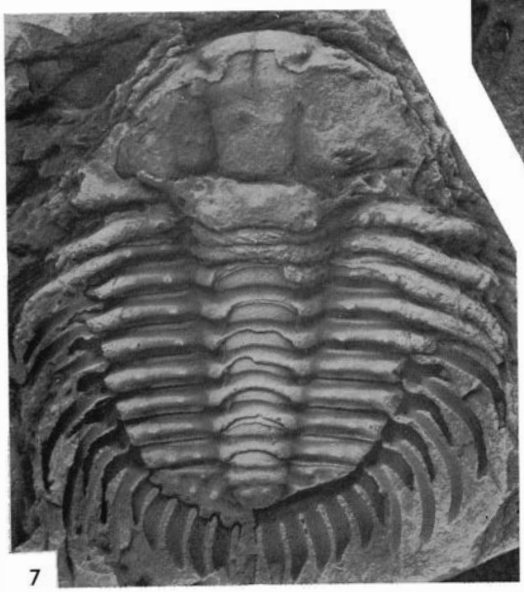
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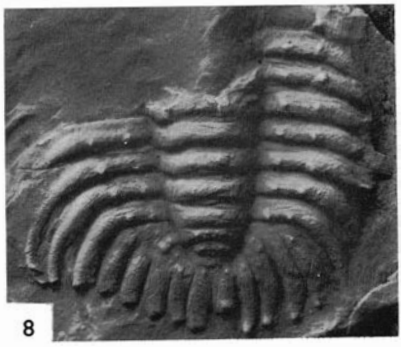
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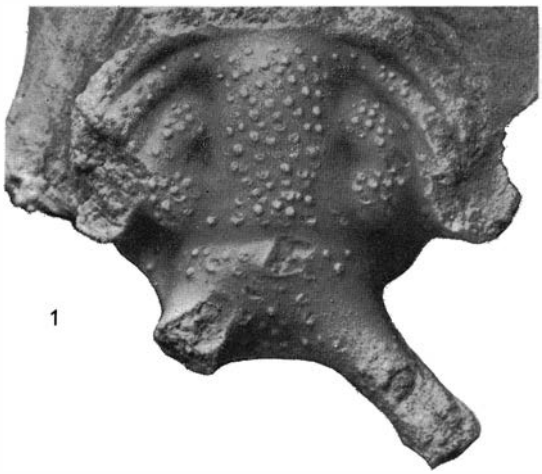
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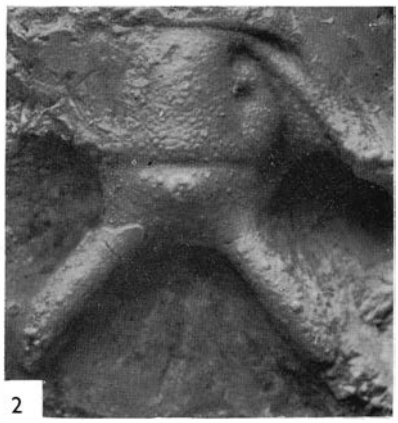
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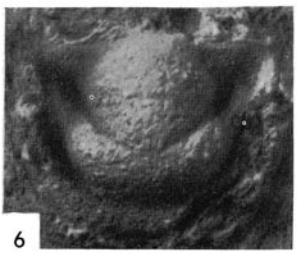
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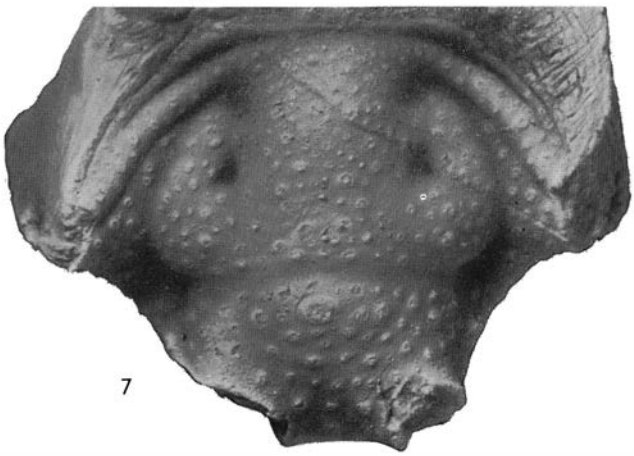
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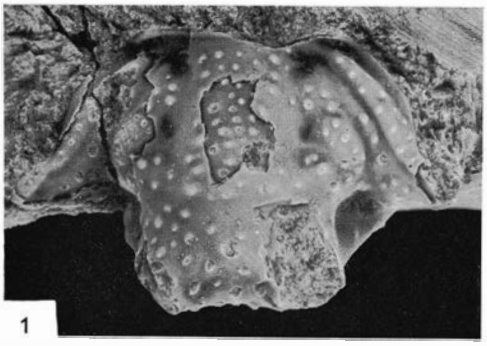
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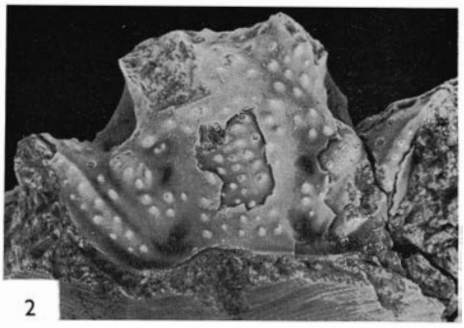
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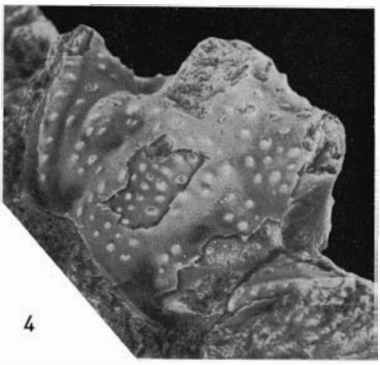
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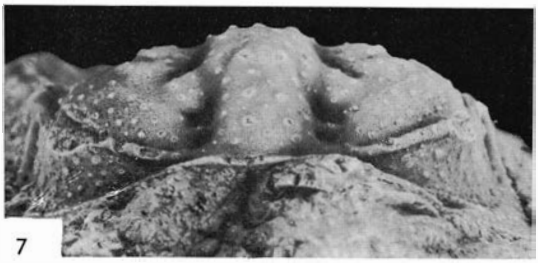
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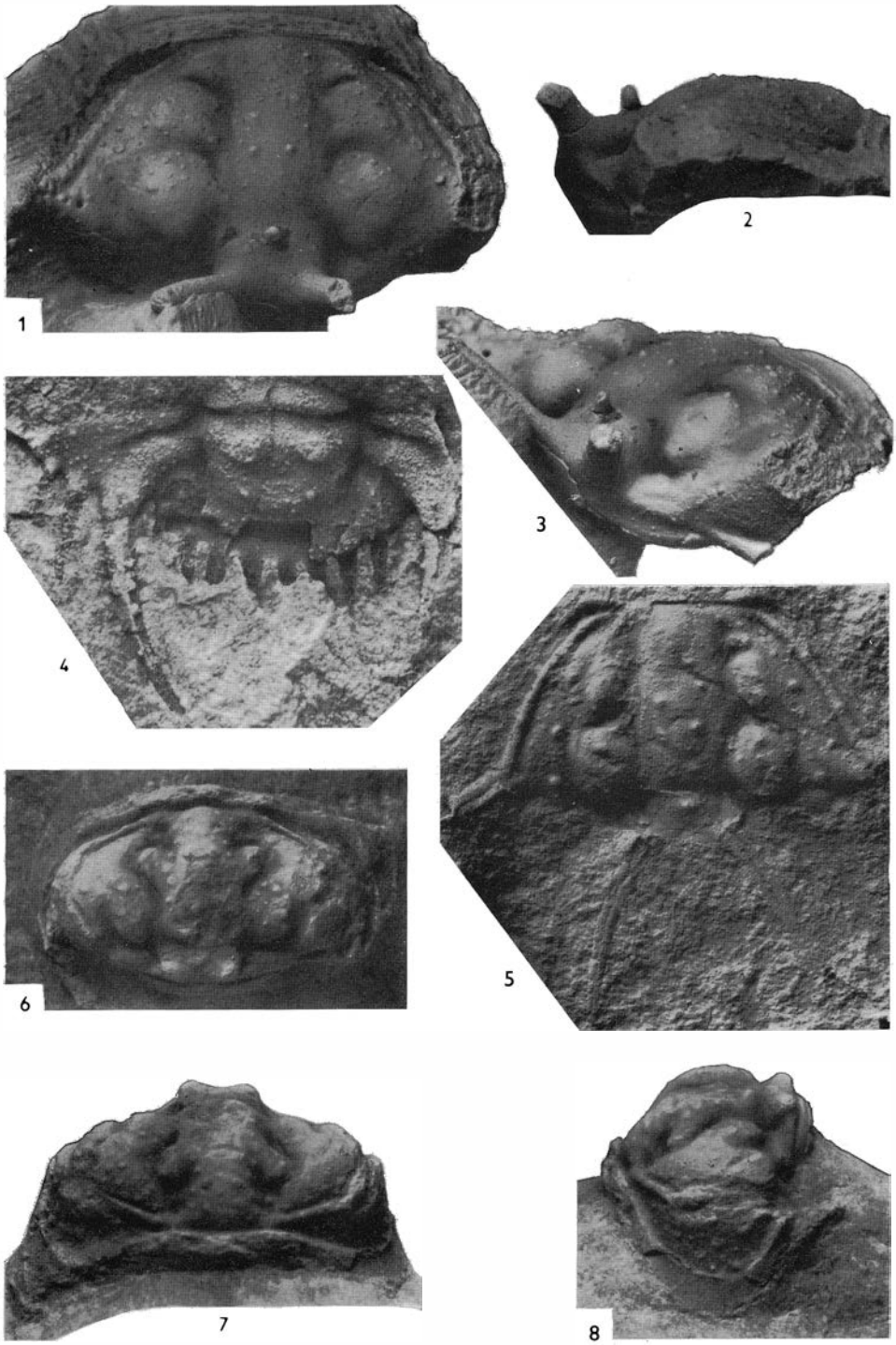
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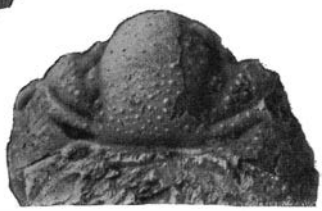

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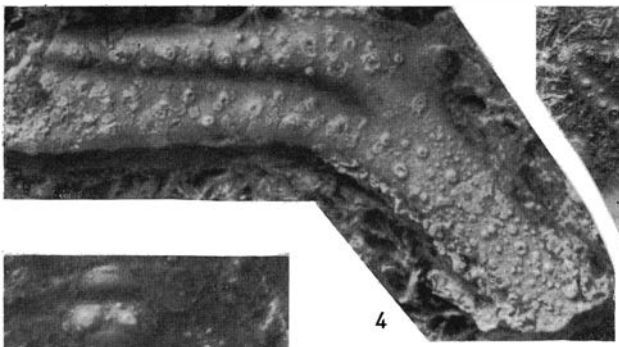

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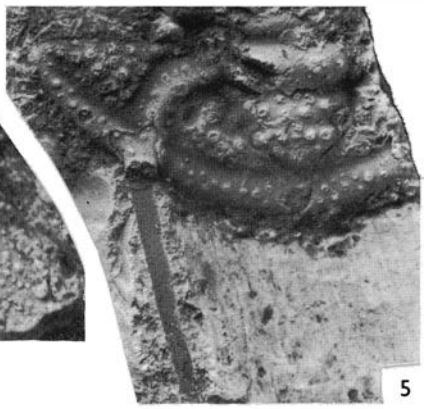

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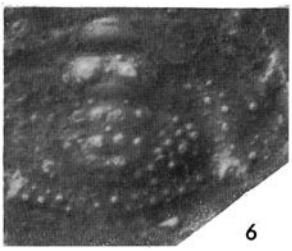

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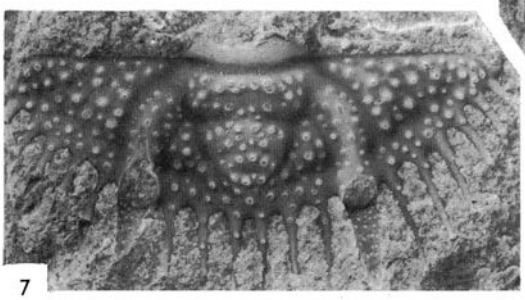

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