Late Caradoc-early Ashgill trilobites of the central Oslo Region, Norway

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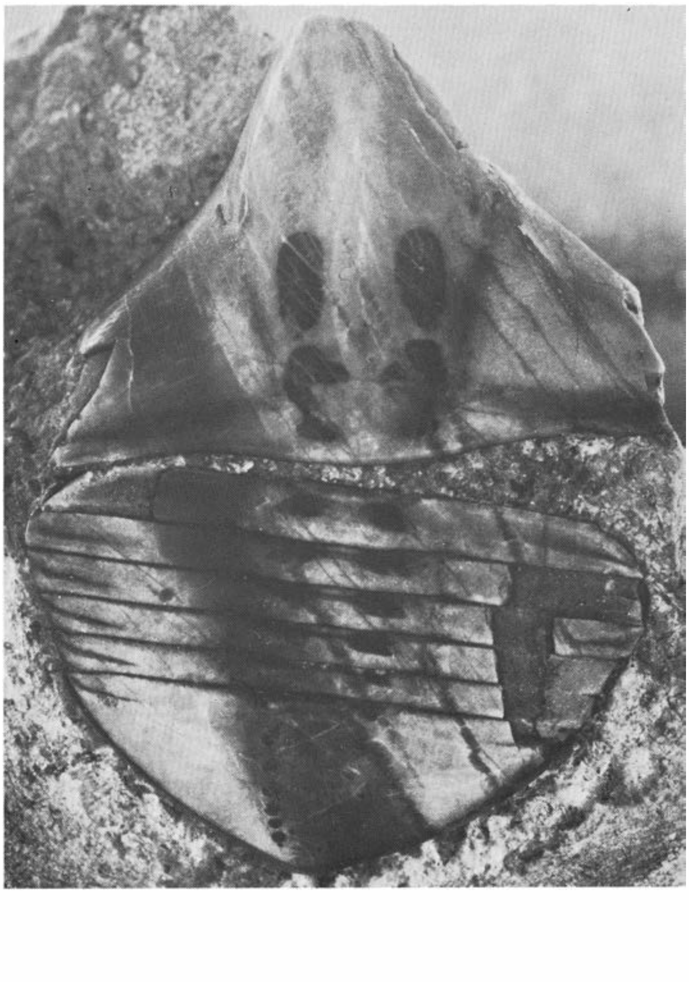

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Alan W. Owen & David L. Bruton: Late Caradoc-early Ashgill trilobites of the central Oslo Region, Norway.

38 trilobite species belonging to 31 genera are described from the late Caradoc – early Ashgill Upper Chasmops Limestone and Solvang Formation in Oslo-Asker, Ringerike, and Hadeland. The following species are new: *Mesotaphraspis bockeliei, Dionide magnifica,* and *Staurocephalus pilafrons.* A lectotype is chosen for *Ampyxella aculeata* (Angelin) and Angelin's original specimens of *Lichas sexspinus,* a synonym of *Platylichas laxatus* (McCoy), are refigured. The Swedish species *Stenopareia avus* (Holm, 1886) is considered a junior subjective synonym of *S. glaber* (Kjerulf, 1865) and original material of both is figured along with Swedish material of *S. linnarssoni* (Holm), *S. oviformis* (Warburg), and *Illaenus (Parillaenus) roemeri* Volborth.

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Contents

Introduction and acknowledgements

This monograph describes those trilobites from the late Caradoc-early Ashgill of the Oslo Region, Norway (Størmer 1953) which largely formed the basis for the faunal lists recently presented by us (Bruton & Owen 1979).

In preparing this work many hundreds of trilobite specimens have been collected and studied. These are now deposited in the Paleontologisk Museum, Oslo (hereafter abbreviated PMO) or in connection with Owen's earlier work (Owen 1977) in the Hunterian Museum, University of Glasgow (HM). New collections include specimens collected by Bruton, J. F. Bockelie and others while logging a series of profiles in the Oslo-Asker region and those collected by both of us from Ringerike. Some specimens collected from these areas and from Hadeland, together with those present in earlier museum collections, were described by Owen (1977) in an unpublished Ph. D. thesis. Some of these descriptions and accompanying data have since been revised in light of this present joint effort and the section on illaenids has been expanded and rewritten to include previously unpublished work by Bruton on type and topotype material of species from equivalent horizons in Sweden. Swedish specimens used for comparison are refigured herein. Included in Owen's thesis and in our faunal lists (Bruton & Owen 1979) but not included here are *Tretaspis, Chasmops* and remopleuridids which are being studied separately by Owen, Professor Leif Størmer † and Mr. Frank Nikolaisen respectively. Each of these studies, including the present, forms a contribution to a research project initiated by the late Professor Leif Størmer (Størmer 1953) on Middle Ordovician faunas of the Oslo Region. To date 27 contributions have been published including those dealing with the following trilobite groups: Scutelluidae (Skjeseth 1955), Asaphidae (Henningsmoen 1960), Cheiruridae, Telephinidae and rarer families (Nikolaisen 1961; 1963; 1965), Odontopleuridae (Bruton 1965), Proetidae (Owens 1970), and Calymenidae (Siveter 1977). Other trilobite descriptions are included in Angelin (1854), Størmer (1930; 1940; 1943; 1945), Warburg (1939) and Bruton (1976). Specimens belonging to species described by these workers are discussed herein and are figured when they add something new or are in need of reillustration. Important in the discussion is new information on the stratigraphical and geographical distribution of those previously described species identified in our new collections from measured profiles.

The catalogue numbers of all available specimens of new species are listed in the text, otherwise only the numbers of the types of Norwegian species are given. A list of all the specimens on which this work is based is housed with the collections at the Paleontologisk Museum, Oslo.

This work was completed in July 1978 but became delayed because of technical problems and because we met with difficulties in raising sufficient funds to publish it. The fact that it now appears in its present form is thanks to the late Professor Leif Størmer, Dr. Valdar Jaanusson, our colleague Natascha Heintz and an anonymous referee. Dr. Synnöve Irgens-Jensen also played a big part arranging the publishing which was made possible by a generous grant from Norges almenvitenskapelige forskningsråd (NAVF). The latter also financed Bruton's collecting and preparation of some of the material described herein. A. W. Owen thanks Dr. J. K. Ingham for guidance during his Ph. D. study and Professor H. B. Whittington F. R. S. for helpful comment on the resulting thesis (Glasgow 1977), of which this paper forms a part. A NERC Studentship at Glasgow (1973–77) and a NATO Postdoctoral Fellowship (1977–78) at the Paleontologisk Museum, Oslo, which allowed this study to be completed are gratefully acknowledged. Both of us thank the following for loan of material in their care: Dr. Valdar Jaanusson, Naturhistoriske Riksmuseet, Stockholm (RM); Professor R. A. Reyment, Paleontologiska Institutionen, Uppsala Universitetet (UM); Dr. Jan Bergström, formerly Paleontologiska Institutionen, Universitetet i Lund (LU); Dr.'s Roland Skoglund and Sven Laufeld, Sveriges geologiske undersökning, Uppsala (SGU); Dr. J. K. Ingham, Hunterian Museum, Glasgow University (HM). J. Fredrik Bockelie also gave us specimens from his collections and these have since been donated to the Paleontologisk Museum, Universitetet i Oslo (PMO). Finally we thank Dr. Richard A. Fortey for critically reading the manuscript and Gill Owen for typing it, catologuing material for us and compiling data on specimens.

Stratigraphy and trilobite distribution

The late Caradoc rocks of the central part of the Oslo Region (Fig. 1) include interbedded limestones and shales (the Upper Chasmops Limestone of Oslo-Asker and parts of the Solvang Formation in Ringerike and Hadeland) and tightly nodular limestones with little shale (part of the Solvang Formation on Frognøya, Ringerike, and the Nerby Member of this formation in Hadeland). In western Ringerike limestone deposition persisted into the lowest part of the Ashgill with the deposition of the Høgberg Member of the Solvang Formation. The Solvang Formation in Hadeland and Ringerike was described by Owen (1978; 1979). In all these districts the limestone units are overlain by shales which have a transgressive base.

Both the Upper Chasmops Limestone and the Solvang Formation contain a rich trilobite fauna, but only in Oslo-Asker and to a lesser extent in Ringerike are exposures sufficiently complete for detailed faunal logs to be made. Bruton & Owen (1979) illustrated 5 such logs for the trilobite distribution on Bygdøy, Fornebu, Ostøya, and

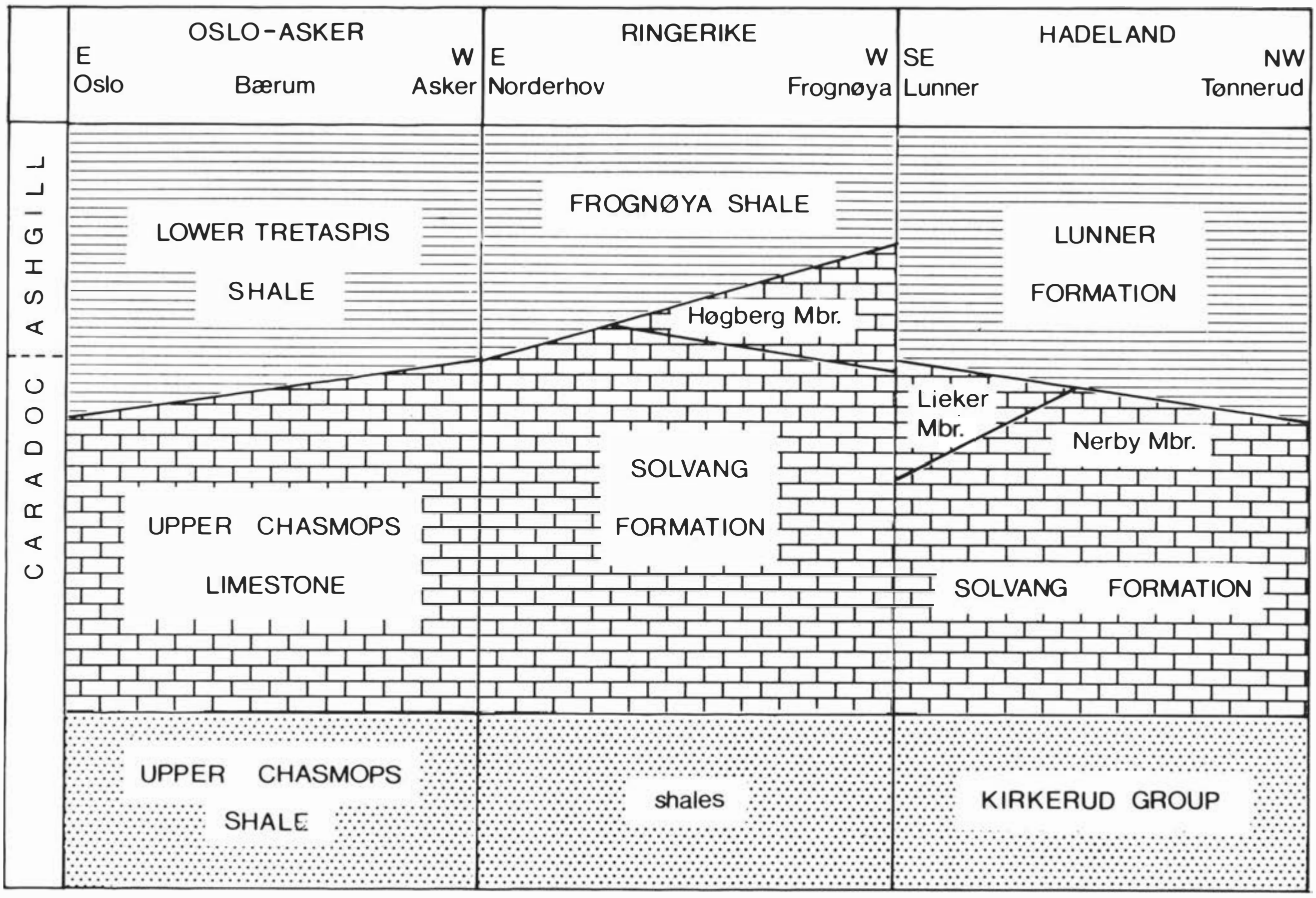

Fig. 1. The lateral relationships of the Upper Chasmops Limestone and the Solvang Formation (not to scale).

Raudskjer in Oslo-Asker (see Fig. 2) and at Norderhov in Ringerike. They also used the faunal list given by Owen (1979, Fig. 6) for the Høgberg Member on Frognøya, Ringerike. These logs and additional information from other profiles in Oslo-Asker show a progressive immigration of forms through the limestone units and a marked faunal shift (*sensu* Jaanusson 1976) at the diachronous base of the overlying shales. Thus, for example, much of the trilobite fauna in the uppermost part of the Upper Chasmops Limestone in Asker is not known from Oslo to the east where the contemporaneous shales of the Lower Tretaspis Shale have a much more restricted fauna. Similarly many elements in the fauna of the Høgberg Member are unknown from Asker.

All the localities in Oslo-Asker from which trilobites are known from the Upper Chasmops Limestone are shown on Fig. 2. Table 1 lists the localities from which each of the taxa described here have been found and clearly shows that localities in Bærum have a greater total number of species than those in Oslo and the fauna in Asker is even more diverse than that of Bærum. The distribution in our faunal logs, and precise horizon information for material from other localities shows that this increase is entirely the result of immigration of new forms into the shrinking area of dominantly carbonate deposition contemporaneously with the westward transgression resulting in the development of the Lower Tretaspis Shale.

The trilobite fauna of the Solvang Formation in Hadeland has a similar stratigraphical distribution to that in the Upper Chasmops Limestone in Oslo-Asker and the overlying shales of the Lunner Formation are transgressive southwards. A detailed study of the Ashgill trilobites of the Oslo Region by one of us (Owen, in prep.) will involve some consideration of species in the Solvang Formation in Hadeland and consequently only brief locality details will given here.

The significance of the trilobite faunas described herein, in terms of international correlation, is discussed in detail elsewhere (Bruton & Owen 1979).

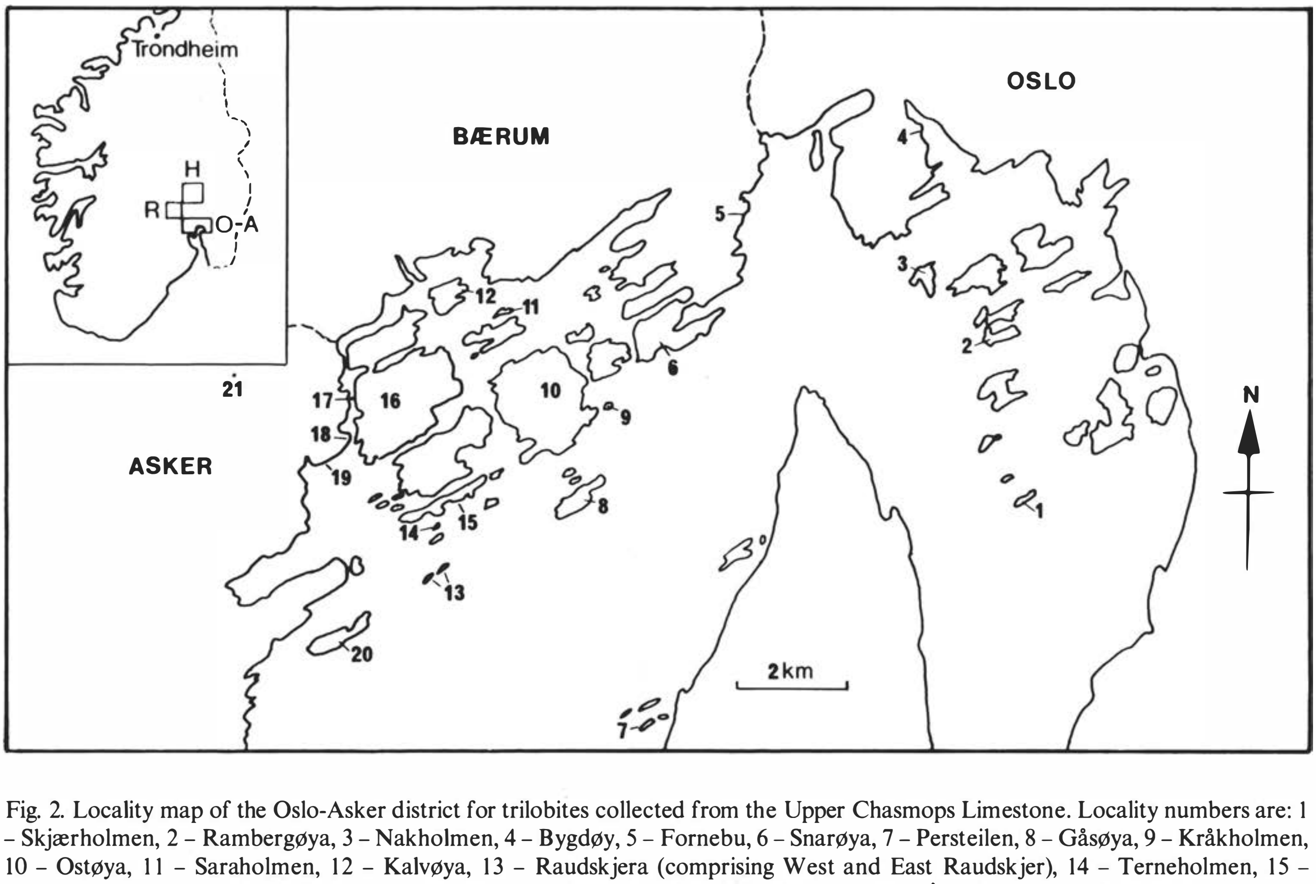

Fig. 2. Locality map of the Oslo-Asker district for trilobites collected from the Upper Chasmops Limestone. Locality numbers are: 1 – Skjærholmen, 2 – Rambergøya, 3 – Nakholmen, 4 – Bygdøy, 5 – Fornebu, 6 – Snarøya, 7 – Persteilen, 8 – Gåsøya, 9 – Kråkholmen, 10 – Ostøya, 11 – Saraholmen, 12 – Kalvøya, 13 – Raudskjera (comprising West and East Raudskjer), 14 – Terneholmen, 15 – Langåra, 16 – Nesøya, 17 – S. Kuholmen, 18 – Hestesund, 19 – Landøya, 20 – Bjørkøya, 21 – Åstaddammen. All spellings are consistent with the 1:50000 sheet 1814 I, Asker. Where possible precise localities are indicated but commonly old museum labels give no more than the name of an island. The Lower Palaeozoic succession in Oslo-Asker is tightly folded with north-eastward striking fold axes. Inset map shows the relative positions of Oslo-Asker (O-A), Ringerike (R) and Hadeland (H).

TABLE 1. The occurrence of trilobite species described in this monograph.

	OSLO						BÆRUM						ASKER											
LOCALITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	H	N	F
Trinodus aff. *tardus*					×								×	×								×		
Telephina sp.																								×
Phorocephala sp.	×																						×	×
Asaphus (Neoasaphus?) sp.			×	?									?			×								
Stygina minor										×		×	×	×	×	×	×			×	×	×	×	×
Bronteopsis sp.																								×
Phillipsinella preclara													×	×									×	×
Illaenus (Parillaenus) aff. *fallax*													×	×						×			×	×
Stenopareia glaber	×		×	×	×	×	×	×	×	×	×	×	×	×			×	×		×				
Decoroproetus solenotus												×	×	×									×	
Decoroproetus sp. A													×											
Decoroproetus sp. B																								×
Harpidella (s. l.) sp. A				×		×				×		×	×							×			×	
Harpidella (s. l.) sp. B																						×		×
Mesotaphraspis bockeliei				×									×											
Harpid gen. et sp. indet.																						×		×
Dionide magnifica													×	×										
Lonchodomas aff. *pennatus*		×	×	×	×	×	×			×		×	×	×	×	×	×	×	×	×		×	×	×
Raymondella sp.										×			×	×								×	×	×
Ampyxina sp.		×	×		×					×			×											
Ampyxella aculeata		×	×	×	×			×		×			×										×	
Frognaspis stoermeri																								×
Pseudosphaerexochus bulbosus													×	×										
Pseudosphaerexochus densigranulatus																								×
Sphaerocoryphe sp. ?nov.													×											
Deacybele gracilis										×		×	×	×						×	×	×	×	×
Staurocephalus pilafrons													×	×		×						×	×	×
Flexicalymene jemtlandica		×					×			×		×	×	×						×			×	
Flexicalymene scabustula			×	×	×																			
Flexicalymene sp.																								×
Prionocheilus narinosus						×						×	×											
Prionocheilus aff. *obtusus*													×			×							×	×
Calyptaulax aff. *norvegicus*					×					×			×				×					×	×	
Platylichas laxatus	×		×		×		×			×		×	×	×			×			×		×	×	
Primaspis sp.	×																							
Miraspis sp.																								×
Apianurus thorslundi				×									×	×										
Trilobite gen. et sp. indet																								×

Locality numbers are the same as in Fig. 2. N and F refer to the sections at Norderhov and Frognøya in Ringerike and H to localities in Hadeland. Old museum labels giving the locality 'Slependen', island in Lake Slepene' or 'island between Nesøya and the mainland' probably refer to S. Kuholmen (Locality 18) and mention of Upper Chasmops Limestone trilobites from Land Steilen in fact refers to Persteilen (pers. comm. J. F. Bockelie 1978). Detailed faunal logs for localities 4, 5, 10, 13 and N are given by Bruton & Owen (1979).

Techniques and material

All material figured has been prepared from limestones using a dental drill and a vibro tool. With the exception of Fig. 3, all specimens were photographed by D. L. Bruton. Fig. 3 was taken by Mr. Per Aas. Fig. 4 was photographed under alcohol, otherwise all specimens were painted using 'Opaque' and then coated with ammonium chloride before photographing. Apart from where a mounting pin has been blackened out (Pl. 2: 17), photographs have not been retouched.

Specimens are uncompressed and rarely distorted. Both external and internal exoskeletal features are well preserved and muscle scar patterns in *Lonchodomas* (Fig. 4) and *Stenopareia* (Pl. 3: 10), caeca in *Dionide* (Pl. 6: 1, 3, 4, 6, 7) and *Trinodus* (Pl. 1: 1) and various forms of surface granulation, pitting and terrace lines can be studied in detail. Many genera are rare in our collections (*Phorocephala, Mesotaphraspis, Raymondella* and the odontopleurids) being represented by 10 or less specimens, while others, such as *Stenopareia,* are represented by many hundreds of specimens which form coquinas of drifted exoskeletal parts, presumably exuviae (Fig. 3). Such illaenid coquinas form marker horizons which can be traced along strike from localities on Bygdøy (Oslo) to Raudskjer (Asker), a distance of about 13 km or more. With such drifted assemblages variation within specimens is considerable and it cannot be excluded that a series of sympatric species may be involved. In the case of *Stenopareia glaber,* however, we have recognised two morphs representing end members of a broad spectrum of variation. A corresponding variation is recognised within coquinas of *S. glaber* (= *S. avus* Holm) from approximately equivalent horizons in the Kullsberg Limestone of the Siljan district, Sweden. Here, unlike in the Oslo Region, such coquinas are associated with carbonate mounds which in places are biohermal with ecological niches in which sympatric species could have flourished.

Systematic Palaeontology

Terminology

The terminology used here is that advocated by Harrington (*in* Moore 1959) with the following exceptions:

The terms rachis and dorsal furrow are used instead of axis and axial furrow following Jaanusson (1956: 36–37).

The glabella is taken to include the occipital ring as advocated by Whittington (1962: 3–4) and glabellar lobes and furrows are numbered 1p, 2p etc. from posterior to anterior. Bruton's (1968b: 2–3) definition of dorsal and palpebral views for strongly convex cephala and cranidia is maintained as are the terms eye socle (Shaw & Ormiston 1964) and field (Evitt & Tripp 1977, Fig. 1).

In the Raphiophoridae the term bacculae (Öpik 1967: 53) is used for the areas abutting the posterior part of the glabella for the reasons given by Fortey (1975: 14–15).

Recently introduced terms for cybelids (Evitt & Tripp 1977) and lichids (Temple 1972) are discussed in the relevant sections.

For sake of convenience taxa are arranged according to the scheme used by Moore (1959) except that, following Bruton (1976), the family Phillipsinellidae is considered to be related to the Scutelluidae and therefore succeeds it in the text.

Family GERAGNOSTIDAE Howell, 1935

Genus *Trinodus* McCoy, 1846

Type species. – Original designation; *Trinodus agnostiformis* McCoy, 1846, p. 57, Pl. 4: 3, from the slates of Greenville, near Enniscorthy, Co. Wexford, Eire.

Discussion. The holotype cephalon of *T. agnostiformis* was redescribed by Whittington (1950, pp. 533–4, Pl. 68: 1–3, Text Fig. 1). No topotype pygidia are known. There has been considerable discussion in the literature on the characters differentiating *Trinodus* from *Geragnostus* Howell, 1935. Ingham (1970) followed Ross (1958; 1967) in emphasising the presence of a trans-glabellar furrow in *Geragnostus* whereas Dean (1966; 1971a) and more reservedly Whittington (1963) stressed the length and shape of the pygidial rachis. As the pygidium of *T. agnostiformis* is not known, there is a potentially circular argument in using pygidial characters for differentiation. The problems surrounding *Trinodus* are to be discussed by Fortey (pers. comm. 1979) in a forthcoming publication.

Trinodus aff. *tardus* (Barrande, 1846)

Pl. 1: 1–4.

1979 *Trinodus* aff. *tardus* (Barrande); Bruton & Owen, Figs. 2A, 4, 6.

Material, localities, and horizons. One complete specimen, a cephalon and two pygidia from the uppermost part of the Upper Chasmops Limestone in Bærum and Asker and a cranidium from the uppermost part of the Solvang Formation at Haga near Lunner in Hadeland.

Description. Sagittal length of cephalon slightly greater than posterior width. Glabella occupies 55 % of sagittal cephalic length, tapering gently forwards, slightly constricted at mid-length where it bears a prominent median tubercle on the internal mould (Pl. 1: 4). Basal lobes small, ridge-like, do not meet mesially. Dorsal and preglabellar furrows broad and shallow. Cheeks gently convex, fairly gently declined mesially, more steeply so laterally. Border very gently declined, broad anteriorly, narrowing rearwards.

Thorax of typical *Trinodus* type (e. g. Kielan 1960: 60), pleural tips not seen.

Pygidium strongly convex (tr.), sagittal length slightly less than anterior width. Rachis occupies 55 % of sagittal length and 45 % of anterior width of pygidium; composed of an anterior half-ring and three rings. Anterior ring only a little over 50 % of the length (sag.) of the other two. Posterior ring furrow complete, anterior one only present laterally; both weakly incised. Anterior two rings joined by a mesial, gently swollen (tr.) strip which is developed as a tubercle on the posterior 2/3 of the second ring (Pl. 1: 3). Pleural regions steeply declined from rachis. Border occupies 15 % of sagittal length of pygidium, flat-lying except for a very narrow outer portion which is gently declined; bearing a pair of short posterolateral spines. Rachis and pleural areas, except for the smooth border, bear a fine reticulation which is more strongly developed on the pleural areas (Pl. 1: 1).

Discussion. Material of *Trinodus tardus* including the lectotype from the Králův Dvůr Formation (Ashgill) in Bohemia has been figured by Pek (1977) and topotype specimens were figured by Whittington (1950). The species has also been described from Ashgill strata in Poland (Kielan 1960), Kazakhstan (Apollonov 1974), South Wales (Dean 1971a), North Wales (Whittington 1968) and northern England (Ingham 1970). Dean (1971a) compared specimens from Eire and northern England with *T. tardus*. The Norwegian specimens differ from *T. tardus* in having a slightly shorter (sag.) glabella the pygidial rachis occupying a little more of the total pygidial length (see Dean 1971a: 7) and the pygidial border which is broader anterolaterally has spines a little further forward.

The upper Ordovician agnostids are in need of considerable revision. *T. tardus* strongly resembles the poorly known type species *T. agnostiformis* (see Ingham 1970: 10). Kielan (1960: 59–62) placed in *T. tardus* the Swedish agnostids *Agnostus glabratus* Angelin, 1851 and specimens previously assigned to *Agnostus trinodus* Salter, 1848 by Linnarsson (1869), Ravn (1899) and Olin (1906). Kielan also considered *A. trinodus* from 'Wexford', Ireland to be synonymous with *T. tardus* but Ingham (1970: 10) suggested that Salter's illustrations were composite and may include more than one species.

Family TELEPHINIDAE Marek, 1952

Genus *Telephina* Marek, 1952

Type species. Original designation; *Telephus fractus* Barrande, 1852, p. 891, Pl. 18: 30–34, from the Králův Dvůr Formation (Ashgill) of Bohemia.

Telephina sp.

1963 *Telephina (Telephina) wegelini* (Angelin); Nikolaisen, p. 383–4. – 1976 *Telephina (Telephina) wegelini;* Bruton, p. 712. – 1979 *Telephina* sp.; Owen, Fig. 6. – 1979 *Telephina* sp.; Bruton & Owen, Fig. 6.

Material, locality, and horizon. Nikolaisen noted an almost complete cranidium from the Høgberg Member of the Solvang Formation, on Frognøya, Ringerike but this specimen can not be traced. An eye from the same horizon and locality is tentatively included here (Pl. 1: 9).

Discussion. Telephina wegelini (Angelin, 1854) is known from crushed material from the Fjäcka Shale of the Siljan district, Sweden. It is not clear whether the uncompressed cranidium from the Boda Limestone in the Siljan district described by Warburg (1925, pp. 90–92, Pl. 1: 16–18) as *T. wegelini* and assigned to a new species, *T. linnarssoni* by Ulrich (1930, p. 15, Pl. 2: 15–17) represents a distinct form (see Nikolaisen 1963: 383–4; Dean 1971a: 46–48). The Høgberg Member and the Fjäcka Shale are both low Pusgillian in age and the Norwegian form may well prove to be *T. wegelini.* It is important therefore that Nikolaisen's specimen or additional cranidia be found as specimens from this unit are distorted very little and comparisons with the Boda Limestone specimen would be possible.

Genus *Phorocephala* Lu, 1965

Type species. – Original designation; *Phorocephala typa* Lu, 1965, p. 587, Pl. 123: 14, from the Siliangssu Formation (Llanvirn), South Shensi, China.

Discussion. In an earlier paper (Bruton & Owen 1979), we listed the form described below as belonging to the genus *Carrickia* Tripp, 1965. However we now follow Tripp's (1976: 423) arguments for considering this name to be a junior subjective synonym of *Phorocephala.*

Ross & Ingham (1970: 396) listed *Carrickia* and *Goniophrys* Ross, 1951 as synonymous but subsequently Ross (1972: 29) ascribed material to *Carrickia.* All species previously placed in *Carrickia* seem to belong to *Phorocephala* including unidentified specimens figured by Ross (1951, Pl. 18: 21, 23, 24) from the garden City Formation (?Tremadoc to Arenig in age) see also Shaw 1968: 32, Dean 1971a: 51. Only the type species of *Goniophrys, G. prima,* from the Garden City Formation, now remains in the genus which is distinguished from *Phorocephala* in having the palpebral lobes very strongly convex abaxially, strongly convergent anterior branches of the facial suture and a very narrow (tr.) anterior border.

Phorocephala sp.

Pl. 1: 5–8.

1979 *Carrickia* sp.; Owen, Fig. 6. – 1979 *Carrickia* sp.; Bruton & Owen, Figs. 5, 6.

Material, localities, and horizons. Six cranidia from the uppermost bed of the Upper Chasmops Limestone on Skjærholmen in Oslo, the Solvang Formation at Norderhov and the Høgberg Member of the Solvang Formation on Frognøya, Ringerike.

Description. Cranidium strongly convex transversely, less so sagittally; trapezoidal in outline with sagittal length approximately 60 % of posterior width. Glabella moderately swollen, subquadrate; preoccipital length equal to 75 % of its maximum width, gently rounded frontally. Occipital ring occupies 20 % of the sagittal glabellar length, tapering very strongly laterally. Moderately deep occipital furrow, transversely directed except over a very short distance distally where it curves forwards a little. Dorsal furrows shallow and narrow (tr.) posteriorly, broadening anteriorly. Preglabellar field short (exsag.) laterally, absent mesially. Anterior border furrow weakly incised, gently convex forwards. Anterior border bearing four subparallel terrace lines (Pl. 1: 7). Fixed cheeks occupy approximately 45 % of the posterior cranidial width; narrowing forwards to about 50 % of their posterior width. Posterior borders diverge gently rearwards. Posterior border furrow deepening a little abaxially but shallowing markedly distally. Palpebral lobes long (exsag.), complete length not known; each defined by a gently sigmoidal furrow. Posterior and anterior branches of the facial suture very slightly convergent. Most of external surface of cranidium, except for anterior border, densely covered by fine granules but there is a large, almost smooth muscle scar on each side of the sagittal line at approximately the transverse mid-line of the glabella (Pl. 1: 5–6).

Remainder of exoskeleton not known.

Discussion. Phorocephala sp. is the only recorded representative of this genus from Scandinavia and is only known from older units in association with American faunal elements.

Phorocephala sp. most closely resembles *P. pelagia,* but is distinguished by its less convex glabella (tr., sag.), the transversely directed occipital furrow (that of *P. pelagia* is gently arched forwards mesially), in having narrower fixed cheeks anterior and in the sigmoidal rather than abaxially gently convex palpebral furrows. The cranidium described by Dean (1971, p. 15, Pl. 6: 11) as *Carrickia* cf. *pelagia* from the Summerford Group (Llandeilo) of New World Island, Newfoundland, is too incomplete for adequate comparisons to be made, but like *Phorocephala* sp. it has a transversely directed occipital furrow. *P. pinguimitra* (Chatterton & Ludvigsen, 1976) from the lower part of the Esbataottine Formation (Llandeilo) of the Mackenzie District, Canada lacks a preglabellar field but has an occipital furrow like that of *P. pelagia,* a proportionally broader (tr.) glabella, the anterior branches of the facial sutures further apart and a coarser external surface granulation than in the Norwegian *Phorocephala* sp.

P. seatoni (Shaw, 1968) from the Chazy Limestone (Llandeilo) of New York State has a long (sag., exsag.) preglabellar field and the anterior branches of the facial sutures diverge forwards slightly. *P. breviceps* (Billings, 1865) described by Whittington (1965) from the Table Head Formation (Llanvirn) of Newfoundland has a proportionally longer, more tapered glabella than the Norwegian form as does the unnamed *Phorocephala* species occurring with *Goniophrys prima* in the Garden City Formation (see discussion of genus). *Phorocephala* sp. 1 of Ross (1972) from an early Middle Ordovician bioherm in Nevada has much broader anterior parts of the fixed cheeks than does the Norwegian form.

The only described Upper Ordovician species of *Phorocephala* is *P. athleta* Dean, 1971a from the Chair of Kildare Limestone (probably Rawtheyan) in Eire which is characterized by a very strongly inflated glabella which frontally overhangs the anterior border in some specimens.

Family ASAPHIDAE Burmeister, 1843

Subfamily ASAPHINAE Burmeister, 1843

Genus *Asaphus* Brongniart, 1822

Subgenus *Asaphus* (*Neoasaphus*) Jaanusson, 1953a

Type species. Original designation; *Asaphus ludibundus* Törnquist, 1884, pp. 71–2, Pl. 3: 4–5, from the Ludibundus Limestone (lower Caradoc) of Kårgärde, Siljan district, Sweden.

Asaphus (*Neoasaphus*?) sp.

1960 *Asaphus (Neoasaphus?)* sp. B; Henningsmoen, p. 235, Pl. 14: 10. – 1979 asaphids; Bruton & Owen, Fig. 6, ?Figs. 2A, 4.

Material, localities, and horizons. A pygidium from the Upper Chasmops Limestone on Nakholmen, Oslo. An hypostoma from 2 m below the top of this unit at Nesøy bridge, Asker.

Discussion. Little can be said about the pygidium which was illustrated by Henningsmoen (1960) and which differs from that of *A. (N.) ludibundus* in being more elongate, the median length being equal to 80% of the anterior width compared with 50% in *A. (N.) ludibundus.* Henningsmoen (1960, p. 235, Pl. 14: 9) also described a pygidium as *A. (N.?)* sp. A from the Encrinite Limestone (late Caradoc) at Ås, Frierfjord, Skien-Langesund. The Skien-Langesund specimen is slightly shorter than that from Oslo and has the rachial ring furrows on the internal mould very poorly incised.

The hypostoma (Pl. 1: 18) is broken anteriorly but resembles that of *A. (N.) ludibundus* (see Jaanusson 1953a, Pl. 1: 11) and thus is probably correctly placed in this subgenus.

A few asaphid fragments are known from the Upper Chasmops Limestone on East Raudskjer (16.50–16.90 m below top) and on Bygdøy (7–8 m below top) (Bruton & Owen 1979, Figs. 2A, 4) but these are too incomplete for even a tentative generic assignment to be made.

Family SCUTELLUIDAE Richter & Richter, 1955

Discussion. ICZN Opinion 1004 (Melville, 1974) validated the family name Scutelluidae and thereby suppressed Thysanopeltidae Hawle & Corda, 1847. Whittington (1963: 83) argued that the distinction between the Scutelluidae and the

Styginidae Vogdes, 1890 is at best tenuous and he advocated that the two families should be merged. This view is accepted here. As Dean (1974: 67) indicated, Vogdes' name has historical priority over the name Scutelluidae but there has been no consistency in the assignment of genera which had been ascribed to the Styginidae before 1963. Thus the name Scutelluidae was used by Whittington (1963; 1965; 1966), Tripp (1965; 1976), Ingham (1970), Lane (1972) and Dean (1973a-text) whilst Styginidae was used by Tripp (1967), Dean (1971; 1973a-index; 1974) and Apollonov (1974). The recent revision of the rules governing priority, Article 23 of the International Code of Zoological Nomenclature (1974: 78, 81), stress the importance of stability of usage. Whilst no consistent usage is apparent in the works cited above, there are many papers in which the name Scutelluidae has been used without mention of the name Styginidae or genera historically assigned to that family (e. g. Ormiston 1967; Shaw 1968; Werner 1970; Chatterton 1971; Přibyl & Vaněk 1971; Webby 1974; Campbell 1977). In view of this, it is advocated that despite its historical priority, the name Styginidae should be suppressed in favour of Scutelluidae.

Subfamily STYGININAE Vogdes, 1890

Genus *Stygina* Salter, 1853

Type species. Subsequently designated by Vogdes (1890: 84); *Asaphus latifrons* Portlock, 1843, p. 292, Pl. 7: 6, from the Killey Bridge Beds (low Cautleyan) of Co. Tyrone, Northern Ireland.

Stygina minor Skjeseth, 1955

Pl. 1: 10–14, 16

1934 *Stygina latifrons;* Størmer, p. 330. – 1945 *Stygina latifrons* Portlock; Størmer, p. 410, Pl. 4: 11, 12. – 1953 *Stygina minor* Skjeseth; Størmer, pp. 68, 87, 93, 94. – 1955 *Stygina minor* Skjeseth, p. 13–16, Pl. 3: 1–6. – 1955 *Stygina* cf. *latifrons* (Portlock), Skjeseth, Pl. 1: 3; Pl. 2: 6. – 1973 *Stygina minor;* Lauritzen, p. 29. – 1976 *Stygina minor;* Bruton, p. 712. – 1979 *Stygina minor* Skjeseth; Owen, Fig. 6. – 1979 *Stygina minor* Skjeseth; Bruton & Owen, Figs. 3–6.

Holotype. A cranidium (PMO 67010) from the Upper Chasmops Limestone on Bjerkøya, Asker.

Material, localities, and horizons. This species is fairly common in the upper part of the Upper Chasmops Limestone in west Bærum and Asker, the middle and upper parts of the Solvang Formation in Hadeland and on Frognøya (Høgberg Member) in Ringerike.

Description. Skjeseth's original description of this species (1955) is short and a more lengthy description is given here although little additional material is figured.

Cephalon (excluding genal spines) almost semicircular in outline. Cranidium gently convex (tr., sag.), narrowest at the palpebral lobes which are situated directly in front of the posterior border furrows. Glabella weakly swollen but distinct, occupying 90 % of the sagittal length of the cranidium; clavate in outline with a maximum width equal to twice its posterior width. Occipital ring bears a small median tubercle and occupies 10 % of the sagittal glabellar length. Dorsal furrows weakly impressed, bearing a pair of shallow anterior fossulae a short distance behind the maximum glabellar width. Anterior border gently convex forwards, flat-lying and continuous with the anterior, flat-lying parts of the fixed cheeks. Palpebral lobes strongly convex abaxially with only a narrow connection to the rest of the fixed cheek, maximum length (exsag.) approximately equal to that of the occipital ring. Posterior branches of the facial suture diverge rearwards at approximately 150°, anterior branches diverge forwards at 80° over ½ their length in front of which each curves adaxially through 20°. The fixed cheeks (Pl. 1: 11) are gently convex (exsag.) except frontally where there is a long (exsag.), flat-lying border. Each free cheek bears a genal spine and has a gently swollen inner part and a flat border which narrows (tr.) posteriorly.

One scutelluid hypostoma, associated with cranidia and pygidia of *S. minor* is known (Pl. 1: 10) and is ascribed to this species although less expanded frontally than the hypostoma of the type species *S. latifrons* (see Whittington 1950, Pl. 72: 10) such that it is only slightly broader at the wings than at the lateral borders. Median body swollen, bearing a pair of tubercle-like maculae at the proximal ends of a pair of deep furrows which diverge forwards at 60°. Anterior margins transversely directed. Wings narrow (tr.). Lateral and posterior border furrows deep. Anterior parts of lateral borders broad (tr.), posterior parts ridge-like and converging rearwards at 80°. Posterior border transversely directed. External surface of hypostoma bears a large number of terrace lines which are transversely directed mesially but parallel to the borders laterally.

Thorax of nine segments (Pl. 1: 16). Rachis occupies approximately 25 % of the width of each segment and tapers rearwards at 5°. Dorsal furrow very weakly impressed. Pleurae gently inclined from the rachis from which they are directed at right angles for the proximal 2/3 of their length; laterally declined steeply and deflected very slightly rearwards. Tips of pleurae pointed. On the abaxial side of the fulcrum each pleura bears approximately 10 terrace lines, stepping down rearwards and arranged in broad arcs which are concave forwards.

Pygidium (Pl. 1: 13, 14, 16) almost semicircular in outline with sagittal length equal to 55 % the anterior width. Gently convex (tr.) rachis occupies approximately 65 % of the sagittal length and 20 % of the anterior width of the pygidium, tapering rearwards at about 10°. Up to seven rachial rings are present but these are very weakly developed on the external surface. A posterior rachial ridge commonly is seen. Dorsal furrows broad (tr.) and shallow. Pleural lobes very gently convex (tr.) where they abut the dorsal furrows, abaxially to which they are steeply declined, flattening out marginally. External surface of pleural lobes smooth in all but the smallest specimens which bear up to seven pairs of ribs (Pl. 1: 12). Internal moulds show very weakly developed ribs. Outer ½ of each anterior margin of pygidium developed as an articulating facet which bears 12 terrace lines stepping down rearwards. Doublure very broad, outer part flat-lying, inner part fairly steeply inclined (Pl. 1: 14), bearing approximately 16 faint, concentric terrace lines stepping down rearwards (Pl. 1: 13).

Discussion. Stygina minor is technically a *nomen nudum* of Størmer (1953) who used the name in the fossil lists giving Skjeseth »1953b« as the author. Skjeseth's paper did not appear until 1955 but the name was not used between these dates. Skjeseth adequately diagnosed and illustrated the species from the horizons referred to by Størmer and thus there is no confusion over what the name *S. minor* refers to.

The cephalon and pygidium figured by Skjeseth (1955) as *Stygina* cf. *latifrons* from Lunner are indistinguishable from *S. minor* and are probably from the Solvang Formation. The type species of *Stygina, S. latifrons,* was redescribed by Whittington (1950, pp. 547–9, Pl. 72: 1–6, 9). One of his specimens (Pl. 72: 6) is slightly distorted and the posterior part of the cephalon is missing mesially but the complete specimens figured by him and topotype material in the Hunterian Museum, Glasgow mentioned by Reed (1952: 115), have a more elongate cephalon and pygidium, shorter genal spines and a slightly less well defined glabella. The small cranidium figured by Whittington (Pl. 72: 4, 5), however, has a well defined glabella. Skjeseth (1955) figured Swedish specimens which he assigned to *S. latifrons* but none of these seem to be attributable to Portlock's species (see Kielan 1960: 83; Ingham 1970: 17). Kielan (1960: 83) considered an unnamed form from the zone of *Staurocephalus clavifrons* (mid-Ashgill) in Poland to be conspecific with a specimen lacking a preglabeller field from the Tretaspis Shales of Västergötland figured by Skjeseth (1955, Pl. 2: 3) as *S. latifrons* and Whittington (1966) and Ingham (1970) described similar material from the Rhiwlas Limestone (probably Rawtheyan) and Ashgill Zone 7 (mid-Rawtheyan) from North Wales and northern England respectively.

Genus *Bronteopsis* Nicholson & Etheridge, 1879

Type species. By monotypy; *Bronteopsis scotica* Nicholson & Etheridge, 1879, p. 167 (a subjective synonym of *Ogygia? concentrica* Linnarsson, 1869 – see Skjeseth 1955: 15), from the Balclatchie Mudstones (low Caradoc) of Girvan, Scotland.

Bronteopsis sp.

Pl. 1: 17.

1979 *Bronteopsis* sp.; Owen, Fig. 6. – 1979 *Bronteopsis* sp.; Bruton & Owen, Fig. 6.

Material, locality, and horizon. Four pygidia from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike.

Description. All pygidia less than 1 cm long (sag.), semicircular in outline, poorly convex centrally, gently declined marginally. Rachis occupies 65 % of sagittal length and approximately 20 % of the anterior width of the pygidium and tapers evenly rearwards at 10°. Rachis composed of an anterior articulating half-ring, seven rings defined by weakly impressed, transversely directed furrows and a long terminal piece which is produced posteriorly as a strongly tapering posterior rachial ridge. Seven pairs of pleural ribs present, broadening abaxially and defined by broad, shallow furrows. Doublure very broad, steeply inclined from the pygidial margin, mesial part gently concave upwards. Faint, concentric terrace lines, stepping down rearwards are developed on the doublure.

Discussion. Bronteopsis scotica Nicholson & Etheridge, 1879 was redescribed by Whittington (1950, pp. 544–7, Pl. 71: 9–12). Original material of a junior synonym, *B. concentrica* (Linnarsson, 1869), from the Ludibundus Limestone (Llandeilo-low Caradoc) in Västergötland was refigured by Skjeseth (1955, Pl. 5: 1–3, 5) along with a Norwegian specimen ascribed to the same species from the Ampyx Limestone (low Caradoc) of Asker (Skjeseth 1955, Text Fig. 1). The pygidia from Ringerike differ from that of *B. concentrica* in being considerably broader and in having a longer, evenly tapered, rachis. The pygidium of *B. holtedahli* Skjeseth (1955, Pl. 5: 7) from the Ogygiocaris Shale (Llandeilo) of the Mjøsa area and the closely related *B. panderi* (Schmidt, 1904) (see Skjeseth 1955: 19) from the Kukruse Stage (C_1) (Llanvirn-Llandrilo) of Estonia are of similar size to *Bronteopsis* sp. but are proportionally more transverse, have less well defined rachial rings and pleural ribs and a shorter rachis.

Family PHILLIPSINELLIDAE Whittington, 1950

Genus *Phillipsinella* Novák, 1885

Type species. Original designation; *Phacops parabola* Barrande, 1846, p. 6, from the Králův Dvůr Formation (Ashgill), in Bohemia.

Phillipsinella preclara Bruton, 1976

Pl. 1: 15.

1953 *Phillipsinella parabola;* Størmer, p. 87. – 1970 *Phillipsinella parabola aquilonia* Ingham (*pars*) p. 38 (Cross Fell specimens only). – 1976 *Phillipsinella preclara* Bruton, p. 710, Pl. 104: 1–8; Pl. 105: 1–3, 4, 6, 8, 9; Pl. 106: 1–4; Pl. 108: 9. – 1979 *Phillipsinella preclara* Bruton; Owen, Fig. 6. – 1979 *Phillipsinella preclara* Bruton; Bruton & Owen, Figs. 4–6.

Holotype. A cranidium (PMO 94278) from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike.

Material, localities, and horizons. In addition to the holotype, Bruton (1976) described cranidia, a free cheek and pygidia from the type horizon and locality and from the Upper Chasmops Limestone on Terneholmen and Raudskjer, Asker. New material includes four cranidia, three pygidia and an hypostoma from the Solvang Formation (0.48–1.60 m below top) at Norderhov, Ringerike and two cranidia and two pygidia from the Upper Chasmops Limestone (1.15–2.15 m below top) on Raudskjer, Asker.

Discussion. Among the new material is the hypostoma (Pl. 1: 15) not previously known for the species. Hypostomata of *Phillipsinella parabola parabola* figured by Whittington (1950, Pl. 75: 6, Text Fig. 8) and Kielan (1960, Pl. 5: 2, Text Fig. 19) and of *P. parabola aquilonia* Ingham, 1970 by Ingham (1970, Pl. 5: 14, 17) are similar but none shows the faint constriction of the median body at approximately mid-length seen in the Norwegian speciman. A similar feature in which the median body is more distinctly divided into two unequal lobes is shown on a specimen thought by Dean (1974, Pl. 44: 2, 12) to belong to *Phillipsinella.* This specimen also has terrace lines on the median body while other specimens of *Phillipsinella,* including *P. preclara,* do not. The Norwegian specimen, however, does have terrace lines on the lateral borders.

Family ILLAENIDAE Hawle & Corda, 1847

Genus *Illaenus* Dalman, 1827

Subgenus *Illaenus (Parillaenus)* Jaanusson, 1954

Type species. Original designation; *Illaenus fallax* Holm, 1882, p. 82, Pl. 2: 11–13, 15–20; Pl. 5: 15–24; Pl. 6: ?16, from the Chasmops (probably Dalby Limestone) and Kullsberg limestones (Caradoc), Sweden.

Discussion. Although originally introduced by Jaanusson (1954: 574) as a group name for a number of allied species of *Illaenus* in which the inner margin of the doublure is a simple curve, *Parillaenus* has been used by subsequent authors as a subgenus of *Illaenus* (e. g. Dean 1963; 1978, Whittington 1966, Ingham 1970).

Illaenus (Parillaenus) aff. *fallax* Holm, 1882

Pl. 2: 1–8.

1979 *Illaenus (Parillaenus)* aff. *fallax* Holm; Owen, Fig. 6. – 1979 *Illaenus (Parillaenus)* aff. *fallax* Holm; Bruton & Owen, Figs. 4–6.

Material, localities, and horizons. Two partly articulated exoskeletons, seven cranidia, two free cheeks and 12 pygidia are known from the uppermost parts of the Upper Chasmops Limestone in Asker and the Solvang Formation at Norderhov and on Frognøya (Høgberg Member) in Ringerike.

Description. Cranidium (Pl. 2: 1, 4–6) strongly convex longitudinally, gently convex (tr.), glabella with independent transverse convexity. Glabella broad, occupying almost 2/3 cranidial width; outlined by shallow furrows which on internal mould diverge outwards from lunette and extend forwards, dying out level with a transverse line drawn through anterior edge of palpebral lobes. The latter are long (exsag.), situated about their own length from the posterior margin. Posterior branches of facial suture straight to slightly convergent behind palpebral lobe, anterior branches curve outwards so that maximum width of frontal part of cranidium is near anterolateral margin which is curved sharply ventrally. Cranidial doublure narrow. Surface of internal mould smooth although a small median occipital tubercle is developed. Surface of dorsal exoskeleton with prominent terrace lines on cranidial doublure and frontal area. Surface on some small specimens with minute pits arranged in sinuous lines convex forwards on glabella and fixed cheeks. A free cheek (Pl. 2: 2–3) found associated with cranidia and pygidia is characteristic for the genus in having long, low crescentic eye lobes and broad (tr.) flap-like cheeks. The latter are finely pitted and bear a series of terrace lines: those on the genal areas lie at an angle to those along anterior margin and adjacent to anterior branches of the facial suture.

Details of rostral plate and hypostoma unknown.

Thorax poorly known, the best specimen (Pl. 2: 1) shows parts of nine thoracic segments and has a broad rachis.

Pygidium semicircular in outline, gently convex (tr., sag.) except marginally where it is steeply declined. Rachis poorly defined dorsally, anterior margin projects forwards mesially. On internal moulds (Pl. 2: 7, 8) rachis better defined, forming a raised triangular area behind which a faint median ridge extends to posterior margin. Faint transverse ridges cross rachis, the anteriormost extending laterally to cross pleural areas behind furrow. Doublure widest (sag.) mesially, gently convex upwards with slight turned up margin. 10–12 terrace lines, parallel to inner margin and cross weak median indentation. Dorsal surface of exoskeleton bears weak pits, terrace lines along facet and just behind; internal mould lacks pits.

Discussion. We have examined type material of *I. fallax* from the Chasmops and Kullsberg limestones of Sweden and cannot distinguish cranidia of this from our material. *I. fallax, I. roemeri* Volborth, 1864 (= *I. vivax* Holm, 1882, see Holm 1886: 125; Warburg 1925: 108) and the present material all have the characterically diverging anterior branches of the facial suture, best seen in palpebral view (Pl. 2: 1), and long crescent-shaped eye lobes. We have prepared the rostral flange of the speimen of *I. roemeri* figured by Warburg (1925 Pl. 1: 26, 27; Pl. 1: 19 herein) and this shows the axe-shaped outline characteristic for *Illaenus* (see Jaanusson 1954, Fig. 7c; Whittington 1963: 68) and is more like that of *I. bucculentus* Whittington (1963, Pl. 18: 15, Text Fig. 4H) than that of the type species, *I. sarsi* (see Jaanusson 1954, Pl. 2: 1, 2). Thus features of the cephalon suggest that the present material should be assigned to *Illaenus* and the shape of the pygidial doublure corresponds to that of the subgenus *I. (Parillaenus)*.

Our material differs from *I. (P.) fallax* which we have identified from older Chasmops beds in Norway and equivalents in Sweden, in having a narrower (sag.) pygidial doublure, although this feature seems variable. It is, however, less variable among the Swedish Kullsberg material studied and this is more like our material and is likewise more strongly convex laterally. In this respect, *I. (P.)* aff. *fallax* can be confused with specimens of *I. (P.) roemeri* Volborth, 1864 which we have examined from the younger Boda Limestone (Ashgill) of Sweden. The complete specimen of this species figured by Warburg (1925, Pl. 1: 28, 29) is refigured herein (Pl. 5: 1–3) and shows the doublure of the pygidium to be much narrower than in *I. (P.)* aff. *fallax* and moreover, it is strongly concave with an almost vertical inner margin. Thus Ingham (1970) was correct in identifying his Cautleyan Zone 2 material as *I. (P.)* cf. *roemeri* and his older Pusgillian material as *I. (P.)* cf. *fallax* (for complete discussion see Ingham 1970: 19–21). As noted by Bruton & Owen (1979: 219), *I.* aff. *fallax* replaces *Stenopareia glaber* in the uppermost parts of the Upper Chasmops Limestone in Asker and the Solvang Formation in Ringerike and thus is latest Caradoc to earliest Pusgillian in age.

I. (P.) roemeri occurs at various horizons in the Norwegian Upper Ordovician and has been identified amongst recent collections and older museum specimens (Brøgger 1887: 32; Kiær 1897: 6, 33, 74).

Genus *Stenopareia* Holm, 1886

Type species. Original designation; *Illaenus linnarssoni* Holm, 1882, from the Boda Limestone, Siljan district, Sweden. For diagnosis of genus see Jaanusson (1954: 570).

Stenopareia glaber (Kjerulf, 1865)

Pl. 2: 13, 14; Pl. 3; Pl. 4; Pl. 5: 1–3; Fig. 3.

– 1865 *Illaenus glaber* Kjerulf, p. 14, Fig. 28. – 1882 *Illaenus Linnarssoni* Holm *(pars)*, p. 103, Pl. 4: 13–20; Pl. 5: 1–5, 7, 8. (*non* Pl. 4: 23, 27 = *Stenopareia oviformis* (Warburg)). – 1886 *Illaenus Linnarssoni* forma *avus;* Holm, p. 150, Pl. 10: 10, ?13. (*non* Pl. 10: 12, 14–23 = *Stenopareia* linnarssoni (Holm)). – ?1887 *Illaenus glaber* Kjerulf; Brøgger, p. 24. – 1925 *Illaenus avus* Holm; Warburg, p. 125, Pl. 2: 28–35; Pl. 11: 35–37. – ?1934 *Illaenus linnarssoni* Holm; Størmer, p. 330. – 1934 *Illaenus linnarssoni* Holm; Størmer, p. 331. – 1940 *Illaenus linnarssoni* Holm; Størmer, p. 121. – 1943 *Illaenus glaber* Kjerulf; Størmer, p. 47–51, Text Fig. 1. – 1945 *Illaenus glaber* Kjerulf; Størmer, p. 386, 410–11, Pl. 2: 12, 13. – 1953 *Illaenus glaber* Kjerulf; Størmer, p. 68. – 1953 *Illaenus* sp.; Størmer, p. 92. – 1954 *Stenopareia avus* (Holm); Jaanusson, p. 570, Fig. 10E. – 1979 *Stenopareia glaber* (Kjerulf); Bruton & Owen, Figs. 2–6.

Lectotype. Designated by Størmer (1943); a complete exoskeleton (PMO 63891), probably from the Upper Chasmops Limestone, Bygdøy, Oslo. The lectotype has been prepared slightly and is refigured (Pl. 3: 1, 2).

Material, localities, and horizons. In addition to the lectotype, three cranidia and one pygidium, all paralectotypes; 10 cranidia and two pygidia, all topotypes. Other material includes three more or less complete individuals, many hundreds of cranidia and pygidia, tens of free cheeks and rostral plates and five hypostomata identified amongst material from various levels in the Upper Chasmops Limestone in Oslo-Asker (except the uppermost part in Asker) and all but the upper few metres of the Solvang Formation at Norderhov, Frok and Rud in Ringerike. Museum collections from other localities include specimens labelled as coming from both older and younger beds. These, however, are considered to be too poorly located to include here.

Description. Cranidium strongly convex in lateral view, gently so transversely. Shape of cranidium variable between two morphs, »long« (Pl. 3: 4, 9–11, 14, 15) and »short« (Pl. 2: 13; Pl. 3: 8, 12, 13) referring to ratio of sagittal length of cranidium to its posterior width. Both morphs occur together in large numbers. Specimens are commonly disarticulated but when complete, a long cranidium such as that of the lectotype (Pl. 3: 1, 2) is associated with a proportionately long (sag.) pygidium (Pl. 3: 16, 17). Likewise, a short cranidium occurs with a short pygidium (Pl. 3: 3, 5, 6). Intermediates among cranidia are rare although they occur among pygidia. The majority of our collections are of drifted exuviae which form coquinas but both morphs are known in other well localised non-coquina occurrences suggesting that the proportion of length to width of cranidia reflects dimorphism. A similar tendency towards long and short forms was discussed by Warburg (1925: 126) in material from Sweden since studied by us and considered identical with that from Norway.

In short cranidia, the longitudinal convexity is greater than in the long form (cf. Pl. 3: 11, 13) but in other features they are similar. The glabella lacks independent convexity (tr.) and occupies approximately 50 % of the posterior width of the cranidium. Dorsal furrows on internal mould converge slightly forwards and are weakly sinuous behind the oval lunette, their length independent of cranidial length to width ratios. Surface of

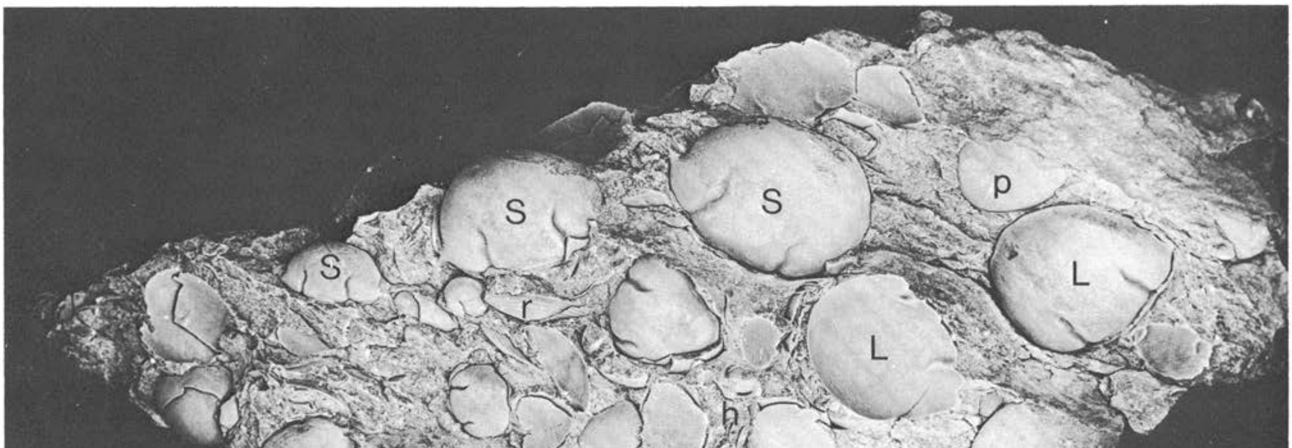

Fig. 3. Coquina of *Stenopareia glaber* (Kjerulf). Note 'long' (L) and 'short' (S) cranidia, pygidia (p), rostral plate (r) and hypostoma (h), approximately x1, PMO 101554, 0.6 m below top of Upper Chasmops Limestone, Fornebu, Bærum. Coll. D. L. Bruton 1968.

internal mould bears a small posterior occipital tubercle, in front of which is a smooth median ridge (seen as a white line on Pl. 3: 10) and a series of lateral glabellar muscle scars bearing faint bifurcating ridges. Four paired muscle scars are present, decreasing in size forwards. The first two pairs are the largest and are situated between the dorsal furrows with the second pair extending slightly in front of them (Pl. 3: 10). The anterior pairs are situated on the anterior part of the glabella (Pl. 3: 9). Similar scars have been described on *S. oviformis* (Jaanusson 1954, Pl. 2: 7, Text Fig. 3; also Pl. 2: 17 herein) but in *S. glaber* the basal pair of scars are more rounded in outline. Remainder of surface of internal mould finely punctate.

Palpebral lobes short (exsag.) about the same distance from the posterior margin of the cranidium as their length. Posterior branches of facial suture short, more or less straight behind eye, slightly curved outwards posteriorly (Pl. 4: 1). Anterior branches long, gently curved, convex outwards at mid-length, curving inwards anteriorly and joining with rostral suture to form a narrow cranidial doublure (Pl. 4: 13). Rostral plate (Pl. 4: 4, 8, 9, 13) widest (tr.) along curved anterior margin, length (sag.) half width, posterior margin with slight median projection. Connecting sutures straight and delimiting broad triangular rostral flange on underside (Pl. 4: 9). Free cheek (Pl. 3: 20) flat to gently convex with smooth posterolateral margin. Margin with broad flat-lying doublure adjacent to connective sutures, becoming narrower posteriorly and almost vertical in front of and below eye, where there is a deep notch and a vincular groove (Pl. 4: 3, 7). The latter accommodates the tips of pleurae during enrolment (Pl. 4: 1) while the flat lateral part of the pygidial doublure behind the facet (Pl. 4: 2) nestles in the notch of the cheek doublure. The notch varies in depth and there is a corresponding extension of the lateral cheek margin in this area. An extreme example is illustrated by Warburg (1925, Pl. 11: 32, 33). Similar but isolated cheeks are known amongst the Norwegian material.

Hypostoma associated with one cephalon (Pl. 4: 4) and known from several isolated specimens (Pl. 4: 10–12). Outline typical for genus (Jaanusson 1954: 588), more or less square with straight anterior margin, curved lateral angles and dorsally directed wings. Plate tapers slightly from behind wings and has gently rounded posterolateral corners with longer triangular wings. Median body with greatest convexity at mid-length, outlined laterally by broad, deep furrows and posteriorly by a gentle change in slope from the less convex border. Paired lateral maculae at base of median body, surface smooth.

Exoskeletal surface of cranidium smooth except for eight terrace lines which step down away from anterior margin and spacing increases in same direction. One tiny specimen (Pl. 3: 5–7) has terrace lines over much of dorsal surface. Lowest lines on cranidium continue laterally onto free cheek, the highest dying out below the eye, the lowest forming a marginal rim (Pl. 4: 7). On doublure, terrace lines step down in same direction as on cranidium, directed parallel to the margins but anastomose laterally in the vincular furrow and form a reticulate pattern (Pl. 4: 3). Lines on cheek doublure continuous with those on rostral plate; the latter sinuous mesially and associated with secondary lines. Lines also extend onto rostral flange which otherwise is smooth posteriorly.

Thorax of nine segments. Rachis broad, approximately half width of each segment, gently tapering posteriorly. Rachial rings gently convex, dorsal furrows shallow. Pleurae flat proximally, deflected steeply downwards and rearwards distally, with rounded tips. External surface smooth, facets and doublure with faint terrace lines.

Pygidium bearing exoskeleton broadly rounded with smooth outline behind facets (Pl. 4: 17) or more angulate in this region and tapering slightly rearwards (Pl. 4: 15). Flat to gently convex, others more steeply sloping laterally and posteriorly. Variation in convexity is reflected in length (sag.) and shape of underlying doublure, especially in smaller specimens. Rachis indistinct, but projecting forwards anteriorly and delimited by short dorsal furrows. On internal mould, rachis more obvious and some specimens show faint pleural furrows and a series of faint transverse ridges (Pl. 4: 6, 14). Internal mould of doublure longest mesially, convex here, lateral margin concave. Inner margin with median embayment behind tip of rachis and lateral cusp-like projections. Median furrow broad, shallow (Pl. 4: 5) or narrow and deep (Pl. 4: 14), dying out towards posterior margin. This furrow is the mould of a median ridge on the outer surface of doublure. Terrace lines on latter step down away from inner margin, outer lines closely spaced and parallel to border, laterally curving out on flattened platform area beneath facet. Towards inner margin, lines more widely spaced, sinuous and associated with a few secondary lines. Lines become less marked mesially, some cross median ridge, others are deflected rearwards. Mould of inner surface of dorsal exoskeleton pitted, the pits being impressions of granules (Pl. 4: 2, 6 cf. Whittington 1965, Pl. 46: 10; Pl. 54: 5). Dorsal exoskeleton smooth except for terrace lines on facet.

Discussion. Much of the history of the species name *glaber* was given by Størmer (1940: 121; 1943) who explained the reluctance of Holm (1882: 82, 83) to use this name for material from the Kullsberg and Boda limestones (= Leptaena Limestone) which he named *linnarssoni.* Warburg (1925: 117) restricted this name, *linnarssoni,* to only two of Holm's specimens, a pygidium and a hypostoma, but in redefining the species figured two new specimens including a cephalon with incomplete thorax and pygidium. Details of the cranidium are thus as defined by Warburg, Holm's other specimens being assigned either to *Stenopareia oviformis* (Warburg, 1925) or *S. avus* (Holm, 1886). The latter, first defined by Holm as a variant of *linnarssoni,* was based on an enroled specimen and an isolated pygidium from older beds in Estonia but judging from the illustrations (Holm 1886, Pl. 10: 10a–d, ?13), they are identical to specimens from approximately equivalent beds in Sweden (Kullsberg Limestone) figured by Warburg (1925, Pl. 2: 28–35) and redefined as *avus.* Examination of this and additional material of *Stenopareia avus* from Sweden (Pl. 2: 13, 14; Pl. 3: 4, 8) and of *S. glaber* from Norway confirms the suggestion by Størmer (1943: 50) that they are synonymous. This view was expressed also by Jaanusson (1954: 570) who reassigned Kjerulf's species to *Stenopareia.*

As defined by Warburg (1925: 117–123), *S. linnarssoni* (Holm, 1882) (see also Jaanusson 1954, Pl. 2: 4–6; Text Fig. 16) is younger than *S. glaber* and comes from the Boda Limestone (Ashgill) of the Siljan district, Sweden. We have examined Warburg's material together with additional specimens from the Boda Limestone at Kallholm and Osmundsberget. This includes complete specimens and isolated cephala, cranidia and pygidia (Pl. 2: 11, 12, 15, 16). All cranidia examined are much larger than any of *S. glaber,* the largest having a palpebral width of 45 mm. Cephala of both species are similar but those of *S. linnarssoni* differ in that the glabella occupies approximately 60 % (cf. 50 %) of the posterior width of the cranidium. On the internal mould, the muscle scars seem more discrete (Pl. 2: 12) while the external surface of the dorsal exoskeleton is pitted (Pl. 2: 11). The rostral flange of *S. linnarssoni* (cf. Jaanusson 1954, Pl. 2: 5) is smaller than that of *S. glaber* though the rostral plate in each is similar. The hypostoma figurred by Warburg (1925, Pl. 2: 18) and Jaanusson (1954, Pl. 2: 6) may not belong to *S. linnarssoni* since it is isolated but, if it does, it has a shorter area posterior to the maculae than that of *S. glaber.* The pygidium of a complete specimen (RM Ar. 10307) of *S. linnarssoni* is identical with isolated specimens, one of which has been prepared (Pl. 2: 15, 16) to reveal the narrow median projection of the inner margin of the doublure. In this feature, *S. linnarssoni* differs from *S. glaber* and is like *S. oviformis* (Warburg, 1925), also from the Boda Limestone. The lectotype (Jaanusson 1954, Pl. 2: 7) is figured here (Pl. 2: 17–19) together with two pygidia (Pl. 2: 9, 10) formerly assigned to *linnarssoni* by Holm (1882, Pl. 4: 23–26); all show the characteristic triangular outline with the posterior and posterolateral parts of the pleural lobes very strongly bent downwards. The cranidium of *S. oviformis* is more like that of *S. glaber,* with regard to glabellar proportions, than *S. linnarssoni,* although it is more pointed than both of them when seen in dorsal view. We have examined the material in the Swedish Geological Survey collections of *S. avus lissbergensis* (Warburg, 1925) and conclude that it may well be a synonym of *S. glaber.* Material of *Stenopareia* recently figured by Dean (1978) from the Chair of Kildare Limestone (probably Rawtheyan) comprises several forms and it is clear that, as defined here, his cranidia of *S. linnarssoni* (1978, Pl. 47: 1–6; Pl. 48: 5) differ from the Swedish material primarily in the terrace line pattern. Likewise, only one of the pygidia assigned to *S. linnarssoni* (Pl. 49: 5) has the narrow median projection of the doublure which is characteristic for *S. linnarssoni.*

Tripp (1954, pp. 666–7, Pl. 2: 16–18) described *S. convergens* (Reed, 1935) from the Kiln Mudstones (Caradoc) of Craighead Quarry, near Girvan, Scotland and noted some similarity with *S. glaber (= avus).* The Scottish material differs markedly in having the dorsal furrows on the cranidium more strongly convergent and the palpebral lobes broader (tr.). The latter suggests that Reed's species belongs to *Illaenus (Illaenus).*

Family PROETIDAE Salter, 1864

Subfamily TROPIDOCORYPHINAE Přibyl, 1946

Genus *Decoroproetus* Přibyl, 1946

Type species. Original designation; *Proetus decorus* Barrande, 1846, p. 64, from the Liteň Formation (Wenlock), Lodeniče, Prague district, Czeckoslovakia.

Decoroproetus solenotus Owens, 1970

1970 *Decoroproetus solenotus* Owens, pp. 320–325, Figs. 6K, 7A–K. – 1979 *Decoroproetus solenotus* Owens; Bruton & Owen, Figs. 4, 6.

Holotype. A cranidium (PMO 70437) from 1.7m below the top of the Upper Chasmops Limestone, East Raudskjer, Asker.

Material, localities, and horizons. Cranidia, free cheeks and pygidia occur rarely in the upper part of the Upper Chasmops Limestone in Bærum and Asker and one cranidium is known from the upper part of the Solvang Formation at Ringsåsen near Norderhov, Ringerike.

Discussion. Nothing can be added to the description and discussion of this species given by Owens (1970). *Decoroproetus furubergensis* Owens (1970, pp. 312–6, Figs. 5A–K; 6E, G–M; 7L, M) was described from the Cyclocrinus Shale of the Nes Hamar district, the shales below the Solvang Formation in Ringerike and from horizons termed the Upper Chasmops Shale and Upper Chasmops Limestone in Hadeland. The precise stratigraphical levels of these Hadeland specimens, from 'between Nerby and Helgehagen' and 'the road to Lyngstad' respectively, are not known. The horizon information on museum labels for specimens from these localities indicates considerable doubt at the time of collection. The lithology and fauna, including *Diacanthaspis* sp. indet. of Bruton (1965, pp. 354–5, Pl. 3: 7), from both localities are very similar and these collections are probably from the same unit, almost certainly the uppermost part of the Kirkerud group (Owen 1978) which has yielded *D. furubergensis* elsewhere. Proetids have not been found in the Solvang Formation in Hadeland.

Decoroproetus sp. A

Pl. 5: 4, 5.

1979 *Decoroproetus* sp. A; Bruton & Owen, Figs. 4, 6.

Material, locality and horizon. Three free cheeks from the middle part of the Upper Chasmops Limestone, East Raudskjer, Asker.

Discussion. The general proportions of these cheeks are very like those of *D. solenotus* but they are distinguished by their very large eye socles. *Decoroproetus* sp. A therefore resembles such species as *D. jamesoni* (Reed, 1914), *D. piriceps* (Ingham, 1970), *D. papyraceous* (Törnquist, 1884), *D.* cf. *subornatus* (Cooper & Kindle, 1936) of Owens (1973a) and *Decoroproetus* sp. 2 of Owens (1973) which Owens (1973a: 50) considered may be a close phylogenetic group. Of these forms, *Decoroproetus* sp. A most closely resembles *Decoroproetus* sp. 2 described by Owens from the Boda Limestone (Ashgill) of the Siljan district, Sweden, differing only in having shallower border furrows.

Decoroproetus sp. B

Pl. 5: 6.

1970 *Decoroproetus* sp. A; Owens, pp. 325, 326, 328, Fig. 6C, F. – 1979 *Decoroproetus* sp.; Owen, Fig. 6. – 1979 *Decoroproetus* sp. B; Bruton & Owen, Fig. 6.

Material, locality, and horizon. A cranidium and a free cheek from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike.

Discussion. The cranidium was described in detail by Owens (1970) who noted some similarity with *'Proetus' kullsbergensis* (Warburg, 1925) from the Kullsberg Limestone (Caradoc) of the Siljan district, Sweden and an unnamed lower Ashgill species from Britain. The cranidium of *Decoroproetus* sp. B differs from *D. solenotus* in having a shorter (sag., exsag.) preglabellar field, which lacks an anterior depression and continuous rather than discontinuous surface striations. The free cheek of *Decoroproetus* sp. B has a slightly larger eye socle than that of *D. solenotus* and also has the posterior border furrow arched forwards a little and the anterior part of the field is narrower.

Decoroproetus sp. B most closely resembles undescribed specimens from the Lunner Kirke Member of the Lunner Formation in Hadeland, differing only in having the glabellar outline a little more tapered and consequently the preglabellar field is shorter mesially (sag., exsag.). Both *Decoroproetus* sp. B and the Hadeland form differ from *D. asellus* (Esmark, 1833) redescribed by Owens (1973, pp. 135, 137, Figs. 4A, B, D–I) from the Tretaspis Shale in Skien-Langesund, the Lower Tretaspis Shale of Oslo, the Boda Limestone of the Siljan district, Sweden and the Upper Drummuck Group in south-west Scotland, primarily in having a slightly constricted glabella and a very gently sigmoidal (cf. concave) longitudinal profile of the preglabellar field.

Family AULACOPLEURIDAE Angelin, 1854

Subfamily AULACOPLEURINAE Angelin, 1854

Genus *Harpidella* McCoy, 1849

Type species. By monotypy; *Harpes? megalops* McCoy, 1846, pp. 54–5, Pl. 4: 5, from the Upper Llandovery at Boocaun, Cong, Co. Galway, Ireland.

Discussion. Thomas & Owens (1978) have presented a major revision of the genera constituting the Aulacopleuridae (= Otarionidae) based almost exclusively on a consideration of type species. Many of the Ordovician forms which historically have been ascribed to *Otarion* Zenker, 1833 should be excluded from this genus in the light of Thomas & Owens' work but their generic affinities remain unclear. The Norwegian forms described here have cranidia which are intermediate between the type species of *Harpidella* and that of *Cyphaspis* Burmeister, 1843 (*Phacops ceratopthalmus* Goldfuss, 1843). Thus the glabella has only one pair of lateral furrows and is more convex than in *H. megalops* but does not overhang the preglabellar field as in *C. ceratopthalmus.* Similarly the fixed cheeks rise steeply from the dorsal furrows opposite the mid-part of the glabella but the eyes are not actually stalked as in *Cyphaspis.* The free cheeks are known in the Upper Chasmops Limestone form and lack the deep pits at the base of the genal spines seen in *C. ceratopthalmus.* Thus, on balance, the Norwegian material is provisionally ascribed to *Harpidella (s. l.)* until the results of a review of British and Scandinavian aulacopleurid species by Owens is complete.

Harpidella (s. l.) sp. A

Pl. 5: 9, 10, 12–15, 18.

1979 *Harpidella (s. l.)* sp. A; Bruton & Owen, Figs. 2A, 3–6.

Material, localities, and horizons. Cranidia and free cheeks occur at various levels throughout the Upper Chasmops Limestone in Oslo-Asker and in the Solvang Formation at Norderhov in Ringerike. The species also occurs in the upper parts of the Upper Chasmops Shale in Oslo-Asker and the Kirkerud group in Hadeland.

Description. Glabella swollen (tr.; sag.) but its convexity in lateral view is very variable (cf. Pl. 5: 10 with Pl. 5: 14). Glabella occupies 60 to 75 % of sagittal length of cranidium in dorsal view (*sensu* Bruton 1968b); commonly rounded anteriorly but it one specimen (Pl. 5: 9, 10) it is blunt ended. This specimen shows an usually low sagittal convexity of the glabella but is viewed as no more than an extreme variant as it follows and is succeeded stratigraphically by more 'normal' cranidia. Maximum width of glabella (at basal lobes) equal to 85 to 95 % of the sagittal length. Occipital ring long (sag., exsag.) mesially, bearing a large median tubercle which bears four minute pits at its tip (Pl. 5: 13). Occipital furrow shallow mesially, deepening laterally. Basal glabellar lobes circumscribed by furrows, triangular in outline, length (exsag.) equal to 35 % of the preoccipital glabellar length and together they occupy a maximum of 40 % of the glabellar width. Lobes much less swollen than the remainder of preoccipital part of the glabella which is oval in outline. Dorsal furrows moderately deep, converging evenly forwards. Preglabellar furrow long (sag., exsag.), convex in lateral profile, steeply declined forwards. Anterior border arched fairly gently forwards, roll-like, defined posteriorly by a very marked break in slope. Fixed cheeks opposite mid-part of glabella rising steeply from the dorsal furrows, flattening out distally. Posterior half of palpebral lobes situated opposite anterior half of basal glabellar lobes, defined adaxially by very shallow furrows and situated on a level with the central part of the glabella. Posterior border broadening (exsag.) abaxially. Posterior branches of the facial suture very strongly divergent; anterior branches very gently so. External surface of glabella and preglabellar field coarsely tuberculate, also bearing a fine granulation and in the case of the preglabellar field, a coarse pitting. Fixed cheeks and anterior border bear a dense granulation.

Free cheek triangular in outline (Pl. 5: 18). Eye large. Lateral and posterior borders swollen, genal spine long. Surface of whole cheek, especially the field, bears a very dense, coarse tuberculation.

Remainder of exoskeleton not known.

Discussion. Harpidella (s. l.) sp. A is similar in overall cranidial proportions to *Otarion* sp. of Dean (1962, pp. 123–4, Pl. 17: 4, 12) from Upper Longvillian strata in the Cross Fell Inlier in northern England but the English form is too poorly preserved for adequate comparisons to be made. Another unnamed species described by Dean (1963, pp. 242–3, Pl. 45: 1), from upper Marshbrookian and Actonian strata in the Welsh Borderlands, has a more elongate glabella which frontally tapers more than the Upper Chasmops Limestone form. *Otarion* sp. C of Tripp (1962, p. 14, Pl. 2: 18a, 18b) from the *confinis* Flags (Llandeilo) of south-west Scotland has a slightly narrower glabella than the Norwegian form and also a shorter preglabellar field. Specimens described by Størmer (1945: 409) as *Cyphaspis* sp. from the Gagnum Shale Member of the Lunner Formation in Hadeland along with recently collected material are very similar to *Harpidella (s. l.)* sp. A, differing only in having the body of the glabella more elongate, the 1p lobes a little more swollen and the glabellar tuberculation somewhat denser.

Harpidella (s. l.) sp. A resembles a number of forms which various authors have assigned to *Otarion* but which eventually will have to be reappraised in the light of Thomas & Owen's work. Of these forms *Harpidella* (s. l.) sp. A most closely resembles *Otarion planifrons* (Eichwald, 1860) from the Kukruse Stage (C_2) (Llandeilo-lowest Caradoc) of Estonia which was redescribed by Öpik (1937, pp. 27–28, Pl. 1: 4; Pl. 2: 1, 2; Pl. 4: 6; Text Fig. 5). However, the Estonian form differs in having a slightly more elongate glabella and a coarser glabellar tuberculation which is very much denser on the occipital ring. *O. rotunda* (Lamont, 1935, pp. 321–3, Pl. 8: 8, 9; Text Fig. 4A) from the Lower Drummuck Group (Cautleyan) and *O. beggi* Tripp (1954, p. 670, Pl. 3: 5, 6) from the Kiln Mudstones (Caradoc) both from the Girvan area, south-west Scotland have a more rounded glabellar outline and a shorter preglabellar field than *Harpidella (s. l.)* sp. A. *O. tridens* Ingham (1970, pp. 32–3, Pl. 5: 1–9; Text Fig. 5) from late Pusgillian and lower Cautleyan strata in northern England also has a shorter preglabellar field as well as more steeply inclined fixed cheeks and a finer free cheek ornament.

Harpidella (s. l.) sp. B

Pl. 5: 16, 17.

1979 *Harpidella (s. l.)* sp.; Owen, Fig. 6. – 1979 *Harpidella (s. l.)* sp. B; Bruton & Owen, Fig. 6.

Material, localities, and horizons. One cranidium from 1.5–1.6 m below the top of the Høgberg Member of the Solvang Formation, Frognøya, Ringerike. Two cranidia from the uppermost part of the Solvang Formation at Lunner and Haga, Hadeland.

Description. This form differs from the Upper Chasmops Limestone specimens in the following respects: the glabella, especially the body of the preoccipital part, is more elongate and almost parallel-sided in front of the basal lobes which are proportionally shorter (exsag.); the preglabellar area is less convex (sag., exsag.); the tuberculation of the glabella and the preglabellar field is denser and there are a few large granules on the anterior border arranged in a transverse line which curves gently forwards mesially.

Discussion. This form most closely resembles *Otarion tenue* Kielan (1960, pp. 63–4, Pl. 2: 1, 2; Text Fig. 15) from Ashgill strata in Poland, especially in the elongate body of the glabella and the dense, coarse ornament of the glabella, preglabellar field and free cheek. However, the Polish species differs in having much narrower (tr.) basal lobes, a more arched preglabellar furrow and a coarse ornament on the central parts of the fixed cheeks. *O.* cf. *tenue* of Dean (1974, p. 28, Pl. 28: 5, 8, 10, 12, 13; Pl. 29: 3, 5) from the Chair of Kildare Limestone (probably Rawtheyan) in Eire is close to Kielan's species but differs from it and *Harpidella (s. l.)* sp. B in having more strongly divergent anterior branches of the facial suture. *O. convexus* Apollonov (1974, pp. 42–3, Pl. 19: 5) has a similar glabellar shape to *O. tenue* and *Harpidella (s. l.)* sp. B but a much shorter preglabellar field.

Family DIMEROPYGIDAE Hupé, 1953

Subfamily MESOTAPHRASPIDINAE Jaanusson, 1956

Genus *Mesotaphraspis* Whittington & Evitt, 1954

Type species. Original designation; *Mesotaphraspis parva* Whittington & Evitt, 1954, pp. 46–48, Pl. 3: 31–36; Pl. 4: 11; Text Fig. 11, from the Edinburg Limestone (Middle Ordovician) of Virginia, U.S.A.

Mesotaphraspis bockeliei n. sp.

Pl. 5: 7, 8, 11.

1979 *Mesotaphraspis* sp. nov.; Bruton & Owen, Figs. 2, 4, 6.

Derivation of name. In honour of Johan Fredrik Bockelie Esq., who collected a large amount of the material described in this study.

Holotype. A cranidium (PMO 100388–9) from 10–11 m below the exposed top of the Upper Chasmops Limestone on Bygdøy, Oslo.

Paratypes. Two cranidia (PMO 100376–7; 100381) from 18.10–18.25 m below the top of the Upper Chasmops Limestone on East Raudskjer, Asker.

Diagnosis. Glabella tapering forwards very gently; bearing two pairs of shallow furrows, the posterior pair extending to the occipital furrow. Long (sag., exsag.) preglabellar field bears a median pit posteriorly. Shallow furrows directed from anterior parts of dorsal furrows to anterior end of palpebral lobes.

Description. Cranidium gently convex (tr., sag.). Glabella occupies 75 % of sagittal cranidial length, tapering forwards slightly, gently rounded frontally. Occipital ring long (sag., exsag.) mesially, tapering strongly laterally and bearing a weakly swollen median tubercle. Occipital furrow gently arched forwards and shallow mesially, deepening considerably laterally. Poorly convex glabella bears two pairs of weakly incised furrows. The posterior pair extend rearwards to the occipital furrow and define a pair of elongately oval lobes which together occupy approximately 60 to 65 % of the glabellar width and have a maximum length (exsag.) equal to 30 % of the sagittal glabellar length. Anterior pair of furrows diverge forwards at 55°. Preglabellar furrow shallow. Preglabellar field occupies 20 % of the sagittal cranidial length, declined forwards, gently convex upwards in lateral view and bearing a deep, triangular median pit posteriorly. Anterior border furrow shallow, anterior border flat, declined forwards a little more gently than the preglabellar field. Dorsal furrows moderately well impressed. Palpebral lobes long (exsag.), arched gently abaxially and defined adaxially by broad (tr.), shallow palpebral furrows. Each fixed cheek bears a very shallow furrow directed from the dorsal furrow to the anterior end of the palpebral lobes at an angle of 80° to the sagittal line in the holotype and at 50° in PMO 100381 which is somewhat flattened. This is reminiscent of *Toernquistia* Reed, 1896 (e. g. see Dean 1974, Pl. 28: 4). Posterolateral part of fixed cheek known only in one specimen (PMO 100381) where it is broken behind the palpebral lobe and is directed fairly steeply downwards and forwards slightly. Anterior branches of the facial suture diverge forwards very slightly, curving very gently adaxially over the anterior border. External surface of cranidium bears a dense fine granulation with a few scattered pits on the preglabellar field. This pitting is much more marked on the internal mould where it also occurs on the anterior border (Pl. 5: 8).

Dimensions (mm) * – estimated

	Holotype PMO 100388 external surface	Paratype PMO 100381 internal mould
Sagittal length cranidium	1.7	1.8
Sagittal length glabella	1.3	1.3
Sagittal length occipital ring	0.2	0.3
Sagittal length 1p lobes	0.4	0.4
Sagittal length preglabellar field	0.3	0.4
Exsagittal length palpebral lobe	0.5*	–
Transverse width glabella (max.)	1.2	1.1
Transverse width 1p lobes (together)	0.7	0.7
Transverse width between palpebral lobes (max.)	2.0*	–
Transverse width anterior border	1.7	–

Discussion. All previously described material of *Mesotaphraspis* is found in American faunas from North America and Scotland. However, Dr. M. G. Lockley of Glasgow University has shown us a photograph of a cranidium belonging to this genus from the Upper Llanvirn of Wales. *M. bockeliei* n. sp. differs from the Welsh form primarily in its less strongly tapered glabella and the development of furrows linking the anterior part of the glabella with the anterior ends of the palpebral lobes.

Mesotaphraspis bockeliei n. sp. differs from the type species, *M. parva,* in having a less tapered, more blunt ended glabella, the 1p furrows reaching the occipital furrow, shallow furrows between the glabella and palpebral lobes and the occipital ring less convex in lateral view. *M. inornata* Whittington & Evitt (1954, p. 48, Pl. 24: 1–39) from the same unit as *M. parva* is very similar to the type species and in addition to the above features, differs from the Norwegian form in having only one pair of glabellar furrows, a transversely directed occipital furrow which is not deepened significantly laterally and much shorter (exsag.) palpebral lobes.

The general cranidial proportions of *M. bockeliei* are similar to those of *Mesotaphraspis* sp. of Tripp (1976, p. 390, Pl. 4: 19) from the basal *superstes* Mudstones (Llandeilo-Caradoc) of the Girvan district, south-west Scotland. This form has shallow furrows between the dorsal furrows and the anterior branches of the facial suture but lacks glabellar furrows. *M. circumflexa* Tripp (1967, pp. 56–7, Pl. 2: 33–35) from the Upper Stinchar Limestone (probably late Llandeilo) of the Girvan district has a more tapered glabella, a transversely directed occipital furrow, a poorly declined preglabellar field and the anterior branches of the facial suture directed very strongly adaxially over the anterior border. An unnamed form described by Tripp (1965, p. 585, Pl. 81: 13, 14) from another Girvan unit, the Albany division (Caradoc), has a much more tapered glabella than *M. bockeliei,* a transversely directed occipital furrow and lacks a median pit in the preglabellar field.

M. spinosa Lisogor (1965, p. 169, Pl. 1: 5) from upper Ordovician strata in Kazakhstan has strongly incised 1p glabellar furrows and a much more elongate glabella than the Norwegian species.

Family HARPIDAE Hawle & Corda, 1847

Discussion. Beu (1971) brought to the attention of the International Commission on Zoological Nomenclature the fact that the name Harpidae was used by H. & A. Adams (1853) for a gastropod family based on the genus *Harpa* [Röding] 1798. He argued therefore that the name Harpidae for the group of trilobites based on *Harpes* Goldfuss, 1839 should be replaced by the name Harpetidae. This view was endorsed by Rheder (1972; 1973: 3) who pointed out that Harpidae Bronn (1849) was an earlier usage for the gastropod family, and in essence by Cernohorsky (1972). Pending a ruling by the Commission, the name Harpidae is used reservedly herein.

Harpid gen. et sp. indet.

Pl. 6: 10.

1965 *Paraharpes ottawaensis* (Billings) *similis* Nikolaisen, *(pars)* p. 236 (Ringerike specimens only). – 1979 harpid indet.; Owen, Fig. 6. – 1979 harpid gen. et sp. indet.; Bruton & Owen, Figs. 5, 6.

Material, localities, and horizons. Nikolaisen (1965) noted several fringe fragments from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike and three more have recently been found. Fringe fragments from the Solvang Formation at Norderhov, Ringerike and from the middle part of this unit at Lunner, Hadeland are included here also.

Discussion. This material is too incomplete for even generic assignment. A metal replica of the holotype of *Hibbertia ottawaensis* (Billings) was figured by Shaw (1968, Pl. 6: 18) and it is clear that the Norwegian *H. ottawaensis similis* differs in having a much finer pitting on the brim and genal prolongations and in having the cheek roll less steeply declined frontally. *H. ottawaensis similis* is now known only from the Cyclocrinus Shale (mid-Caradoc) in the Nes-Hamar district.

Family DIONIDIDAE Gürich, 1907

Genus *Dionide* Barrande, 1847 (I. C. Z. N. Opinion 350)

Type species. Original designation; *Dione* [sic] *formosa* Barrande, 1846, p. 32, from the Zahořany Formation (mid-Caradoc) of Bohemia.

Discussion. Lu (1975: 44) included *Paradionide* Chang & Fan, 1960 as a subgenus of *Dionide.* The type species, *P. anmenensis* Chang & Fan, 1960 from Llanvirn strata in West Kansu, China, differs from species of *Dionide* primarily in having a very small, circular glabella, undifferentiated genae and fringe, and a thorax of nine (cf. six) segments of similar length (sag., exsag.) (the anterior one is longer is *Dionide*) with a very narrow (tr.) rachis. These features are here considered sufficient for the complete generic separation of *Paradionide.*

Dionide magnifica n. sp.

Pl. 6: 1–7.

1979 *Dionide* sp. nov.; Bruton & Owen, Figs. 4, 6.

Derivation of name. From the Latin, *magnifica* – splendid.

Holotype. A cephalon (PMO 6528; 6527) with three thoracic segments from the Upper Chasmops Limestone ('rich horizon in upper part') on Terneholmen, Asker.

Paratypes. A pygidium (PMO 6528) on the same block as the holotype and an hypostoma (PMO 81151) from the uppermost part of the Upper Chasmops Limestone at the type locality.

Other material, localities, and horizons. A topotype pygidium (PMO 81349), two topotype cranidia: one (PMO 5653) labelled in the same way as the holotype, the other (PMO 81209) labelled '2 m below the top'; this is probably the type horizon. A cranidium (PMO 100585) from 1.30 m below the top of the Upper Chasmops Limestone on East Raudskjer, Asker.

Diagnosis. Cranidium with sagittal length equal to 40 % of posterior width. Fringe long (sag., exsag.) mesially and very poorly differentiated from the genae laterally.

Description. Sagittal length of cranidium equal to 40 % of posterior width. Strongly swollen glabella very slightly longer (sag.) than wide, almost parallel-sided, gently contricted at ½ its constricted at ½ its preoccipital length, defined laterally by weakly incised dorsal furrows and anteriorly by a shallow preglabellar furrow which is fairly gently convex forwards. A median swelling situated directly behind the level of the glabellar constriction comprises two, longitudinally disposed tubercles, the posterior one being very much the larger (Pl. 6: 6, 7). Occipital ring very short (sag., exsag.), tapering abaxially, strongly convex in transverse view, posterior edge arched rearwards. A pair of narrow (tr.), fairly deep longitudinal furrows extends from the shallow occipital furrow for a distance equal to approximately 20 % of the sagittal glabellar length and define the posteromesial parts of a pair of elongately oval lobes which together occupy 50 % of the glabellar width. These lobes are delimited anteromesially by a very gentle break in slope extending from the longitudinal furrows to the glabellar constriction. Posterior borders very narrow (exsag.) mesially where they extend to behind the glabellar lobes, broadening markedly abaxially from the dorsal furrows, arched gently forwards. Genal lobes poorly differentiated from fringe. Each lobe bears two prominent caeca extending from the dorsal furrow at the glabellar constriction to a point at the posterior border furrow, a short distance from the genal angle (e. g. Pl. 6: 1, 3). There are also many more subdued, strongly anastomosing caeca on each lobe (Pl. 6: 6, 7). Fringe gently declined laterally, gently concave mesially where it occupies 25 % of the sagittal cephalic length. Surfaces of fringe finely pitted with an arc of larger pits situated just inside the broad, smooth, gently upturned border along the outer edge of which lies the facial suture. Posteriorly the suture is deflected sharply adaxially over the base of the genal spine. Marginal band of the free cheek directed steeply rearwards and downwards bearing approximately eight concentric terrace lines which step down forwards.

To our knowledge, the hypostoma of *Dionide* has never been described before and we are very grateful to Dr J. K. Ingham of Glasgow University for identifying PMO 81151 as a *Dionide* hypostoma. Hypostoma incompletely known. Median body strongly swollen, bearing a few irregularly distributed granules mesially and a row of coarse granules on each side of the sagittal line arched very gently abaxially. Anterior border very narrow (sag., exsag.), arched gently forwards and poorly defined from median body. Anterolateral border arched strongly abaxially with a gently declined (in ventral view) area between it and the median body. Posterior parts of hypostoma not known.

Thoracic segments very slightly pointed, of typical *Dionide* type (e. g. see Whittington 1952: 2), anterior segment slightly longer than second. Pleural furrows deep, anterior ribs slightly swollen at the fulchrum.

Pygidium semicircular in outline (Pl. 6: 2). Poorly convex rachis occupies 20 % of anterior pygidial width, tapering evenly at 10° and terminating a short distance in front of posterior margin. Rachis of 17–19 rings and an anterior articulating half-ring. Rings gently arched forwards mesially. Dorsal furrows shallow, narrow (tr.). Pleural lobes gently declined laterally and posteriorly, bearing 17–19 pairs of ribs defined by deep pleural furrows which diverge progressively less strongly rearwards along the pygidium and which terminate a short distance inside the narrow (tr.) border. Anterior nine ribs bear weakly impressed interpleural furrows which are directed from the posteromesial corner of each rib obliquely to the pleural furrow, dying out laterally and progressively less well impressed posteriorly along the pygidium.

Dimensions. (mm) * – estimated

Holotype cephalon (external surface)	
Sagittal length cephalon	7.8
Sagittal length glabella	6.0
Sagittal length to major tubercle	3.0
Posterior width cranidium	19.0
Width (tr.) occipital ring	3.8
Maximum width glabella	6.0
Width glabella at constriction	5.2
Width glabella between anterior ends of longitudinal furrow	2.6
Paratype pygidium (latex cast of external mould)	
Sagittal length pygidium	8.5
Sagittal length rachis	8.3
Anterior width pygidium	16.8*
Anterior width rachis	3.5*

Discussion. The extremely wide cephalon and broad fringe which is poorly differentiated from the genal lobes distinguish *D. magnifica* from all described species of *Dionide*. The type species, *D. formosa*, was redescribed by Whittington (1952, pp. 6–7, Pl. 1: 1, 2, 5; Text Fig. 1) and together with the closely related *D. speciosa* (Hawle & Corda, 1847) also differs from the Norwegian form in having the fringe pits increasing in size towards the facial suture.

D. euglypta (Angelin, 1851, p. 12, Pl. 9: 6) from the Upper Jonstorp Formation (probably Rawtheyan) of Västergötland is in need of modern redescription and is characterized by a long (sag., exsag.) glabella with no fringe in front of it. Angelin's drawing of a complete individual (1851, Pl. 9: 6) has seven thoracic segments but specimens with a complete thorax in the collections of the Riksmuseum, Stockholm, probably including Angelin's originals, all have six segments as is typical of *Dionide*.

Asklund (1936, pp. 4–5, Pl. 2: 1–6) identified material from an erratic block of 'Trinucleusstufe' found in Jemtland as *D. euglypta* but which clearly differs from Angelin's species in having a fairly long (sag., exsag.) fringe mesially. Asklund's material closely resembles *D. magnifica* but differs in having the posterior edge of the occipital ring and the posterior border furrows more transversely directed, the glabella more gently tapered frontally and genal caecae are not developed. *D. euglypta quadrata* Whittard (1958, pp. 101–2, Pl. 13: 9, 10) from the Aldress Shales (low Caradoc) of the Shelve district in the Welsh Borderlands differs from Angelin's species in having a much narrower (tr.), more rounded, cranidial outline and a shorter (sag.) pygidium.

Ingham (1974: 64) noted that *D. richardsoni* Reed, 1903 was based on two distinct forms from different horizons: the Upper Drummuck Group (high Rawtheyan) and the upper Whitehouse Group (?Onnian and Pusgillian), at Girvan, southwest Scotland. Both have a long fringe in front of the glabella but differ from *D. magnifica* in their less transverse cephalic outline, in having small longitudinal ridges on the thoracic pleurae and fewer (*circa* 15) rings on the pygidial rachis.

Family RAPHIOPHORIDAE Angelin, 1854

Genus *Lonchodomas* Angelin, 1854

Type species. Subsequently designated, Bassler 1915, p. 41; *Ampyx rostratus* Sars, 1835, Figs. 3a–e, from the Ampyx Limestone (late Llandeilo or early Caradoc) of Bygdøy, Oslo.

Lonchodomas aff. *pennatus* (La Touche, 1884)

Pl. 7: 1–13; Fig. 4.

1921 *Ampyx;* Kiær, p. 200. – 1945 *Lonchodomas* sp.; Størmer, p. 387. – 1949 *Lonchodomas* sp.; Størmer, p. 178, Fig. 14. – 1953 *Lonchodomas* sp.; Størmer, pp. 68, 87, 93, 94. – 1973 *Lonchodomas* sp.; Lauritzen (*pars*), p. 29 (*non* 31, 32, 33, 34 = *L.* aff. *rostratus* Sars). – 1976 *Lonchodomas;* Bruton, p. 712. – 1979 *Lonchodomas* aff. *pennatus* (La Touche); Owen, Fig. 6. – 1979 *Lonchodomas* aff. *pennatus* (La Touche); Bruton & Owen, Figs. 2–6. – *non* 1970 *Lonchodomas* aff. *pennatus* (La Touche); Ingham, p. 65, Pl. 11: 4, 5.

Material, localities, and horizons. This species is very common, although rarely found complete, throughout the Upper Chasmops Limestone of Oslo-Asker and cranidia are known also from the lowest part of the Lower Tretaspis Shale on Nakholmen. It also occurs throughout the Solvang Formation in Ringerike where it is very abundant in the Høgberg Member and is found in the middle and upper parts of the Solvang Formation and the Gagnum Shale Member of the Lunner Formation in Hadeland.

Description. Cranidium triangular in outline, sagittal length to base of glabellar spine equal to approximately 70 % of the posterior width. Glabella moderately convex in transverse view, very gently so longitudinally, extending for up to ½ of its length in front of the fixed cheeks. The glabella has a maximum width equal to 35 % more than its basal width and bears a faint median carination. Occipital ring arched gently rearwards, weakly convex. Occipital furrow weakly incised, in some specimens bearing transversely oval muscle scars distally (e. g. Pl. 7: 1). On the glabella a short distance in front of the occipital furrow is a pair of concentric muscle scars, their long axes diverging abaxially rearwards at 90°, each expanded in its middle part and gently convex forwards. In front of and almost confluent with these scars is a third pair of markings which are oval in outline and parallel to the sagittal line (Pl. 7: 1, 3). One specimen (Fig. 4) shows a fourth, very small pair of scars abutting the dorsal furrows just behind the maximum glabellar width. Median spine quadrate in section, bearing a dorsal median groove, length unknown. Dorsal furrows weakly incised, diverging forwards at about 30° over most of their length, frontally directed adaxially a little and bearing small, deep anterior fossulae. Fixed cheeks poorly convex (exsag.), gently declined anteriorly and abaxially. Narrow, poorly convex, transversely directed posterior borders defined by shallow border furrows which distally bear deep fossulae. Facial suture (Pl. 7: 9) moderately convex forwards below the projecting part of the glabella and laterally for a short, variable, distance posterior to which it curves in a broad arc which is gently concave abaxially and is directed at 45° to the sagittal line directly in front of the posterior border furrow where it curves in a short arc which is strongly convex abaxially. Free cheeks narrow (tr.), each extended posteriorly as a long spine; quadrate in section and proximally directed abaxially at approximately 50° to the sagittal line, curving gently adaxially through approximately 90° and extending to a level behind the pygidium equal to at least 50 % more than the sagittal distance between the tip of the pygidium and the base of the glabellar spine (Pl. 7: 13). Exoskeleton and internal mould of cranidium commonly smooth except for longitudinal terrace lines, stepping down dorsally, on the anterolateral part of the glabella. The doublure of the free cheeks is narrow posteriorly but expands markedly below the glabella where it develops a posterior rim. In complete cephala, no connective sutures are visible but isolated free cheeks show an anterior break at the point where the facial suture becomes marginal. On some specimens a fairly coarse pitting is developed on the cranidium (Pl. 7: 1). These specimens are associated with smooth forms and it is possible that the pitting represents an exoskeletal layer which is most commonly lost before fossilization. Free cheeks commonly finely pitted on the external surface except on the spines which bear longitudinal ridges on their inner and outer edges (Pl. 7: 12).

Hypostoma almost circular in outline (Pl. 7: 7), sagittal length slightly less than maximum width which is at mid-length. Width (tr.) at posterior margin 66 % that frontally; moderately convex transversely, less so sagitally. Median body poorly defined, almost circular in outline, slightly indented posterolaterally. Borders narrow, gently swollen. Anterior and lateral borders gently convex outwards; posterior border transversely directed.

Thorax with five segments, slightly barrel-shaped (Pl. 7: 2, 3). Rachis gently convex (tr.) occupying 35 % the width of each segment. Dorsal furrows indistinct. Pleurae flat-lying, parallel-sided and bearing furrows which are very shallow proximally, deepening and directed transversely from the rachis except distally where they are deflected forwards a little.

Sub-semicircular pygidium has a median length a little less than 50 % of the anterior width. Poorly convex (tr.) rachis occupies almost 35 % of anterior pygidial width, tapering at 25 % and reaching the steeply declined border. Up to seven furrows present on rachis, each bearing a large muscle scar distally (Pl. 7: 2, 4, 5). On well preserved specimens (Pl. 7: 4, 5) a second pair of small geniculate scars, convex forwards, is present adaxially to the anterior five pairs of large markings and there is a continuous, transversely directed, linear scar linking the anterior small pair and extending abaxially to just under the larger one. Two pairs of small scars are situated between the sixth large pair and behind the seventh large pair are three very small pairs extending onto the inner edge of the pygidial border. Dorsal furrows broad and shallow. Pleural lobes flat-lying, bearing one pair of pleural furrows which are deep anterolaterally but shallow considerably towards the dorsal furrows. In some specimens additional, indistinct, pairs of furrows are present. Border broadest posteriorly and bearing up to 12 discontinuous terrace lines which step down towards the body of the pygidium (Pl. 7: 5). Remainder of pygidial surface smooth. A small, ?immature pygidium (Pl. 7: 8) has pits which are concentrated along the pleural furrows.

Discussion. L. pennatus (La Touche, 1884) from the upper part of the Onnian Stage in Salop, England was redescribed by Dean (1960, pp. 82–3, Pl. 11: 2,8–12) who included material from the Actonian Stage in Salop and later (1962, pp. 78–9, Pl. 6: 1, 3–5, 9, 12) described the species from Onnian and Pusgillian strata in the Cross Fell Inlier, northern England. The Norwegian material differs from *L. pennatus* in having a slightly more elongate glabella (excluding spine) and a shorter pygidium with seven rather than eight pairs of large muscle scars on the rachis. Ingham (1974, pp. 64–5, Pl. 11: 4, 5) compared specimens from the Onnian and Pusgillian stages in the Cautley district of northern England with *L. pennatus.* Although poorly preserved these specimens closely resemble La Touche's species. Ingham also described material from the Cautleyan Stage which he termed *L.* aff. *pennatus* and which is closer to *L. pennatus* than the Norwegian form described above. Some of Ingham's smaller Cautleyan pygidia, like a few of the Norwegian specimens, show more than one pair of pleural furrows.

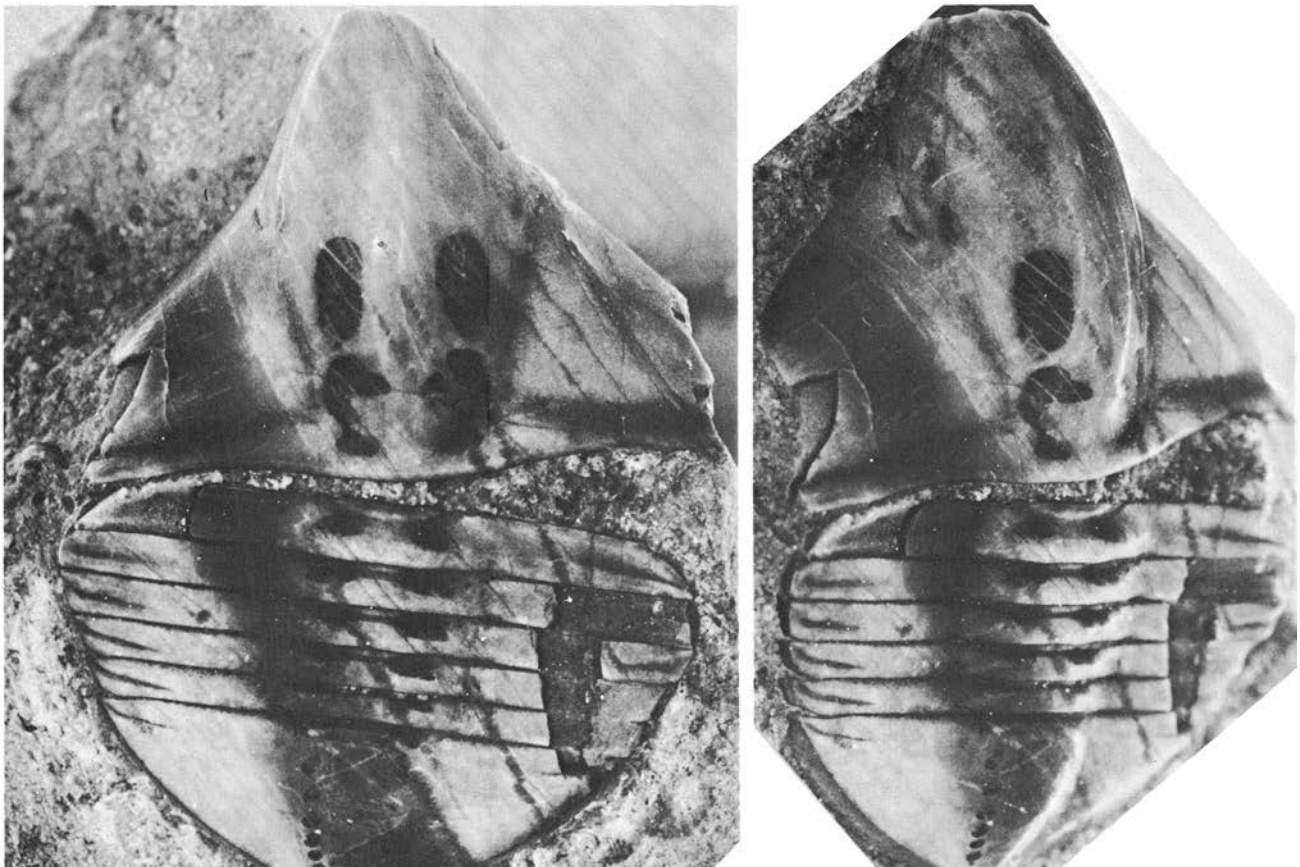

Fig. 4. *Lonchodomas* aff. *pennatus* (LaTouche). Photographed under alcohol. A. Dorsal view showing paired muscle scars on glabella, thorax and pygidium. B. Oblique left lateral view showing the anterior fourth glabellar muscle scar near the dorsal furrow. The broad diagonal colour band is probably a weathering phenomenon while dark narrow bands follow cracks in the exoskeleton. Free cheeks are lacking and cranidium and thorax have separated in a manner which suggests that the specimen might be a moult stage. x5, PMO 65022, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. J. Kiær 1921. Original of Størmer 1949, fig. 14.

The type species of *Lonchodomas, L. rostratus* (Sars) was redescribed by Størmer (1940, pp. 128–130, Pl. 2: 1–4) and Whittington (1950, pp. 556–7, Pl. 74: 11–15; Text Figs. 7A, B) and differs from *L.* aff. *pennatus* in having a more strongly developed glabellar carination, the flexure in the facial suture on either side of the glabella more pronounced and further away from the sagittal line, a marked break in slope on the fixed cheeks a short distance from the anterolateral portions of the dorsal furrows, in consistently having two pairs of distinct pleural furrows on the pygidium and six large pairs of muscle scars with six or seven pairs of smaller scars on the pygidial rachis.

Genus *Raymondella* Reed, 1935

Type species. By monotypy; *Ampyx*(?) *macconochiei* Nicholson & Etheridge, 1879, pp. 183–4, Pl. 14: 1, from the Balclatchie Mudstones (low Caradoc) of Girvan, south-west Scotland.

Raymondella sp.

Pl. 7: 19–21.

1979 *Raymondella* sp.; Owen, Fig. 6. – 1979 *Raymondella* sp.; Bruton & Owen, Figs. 2B, 3, 4, 6.

Material, localities, and horizons. One pygidium and a large number of cranidia are known from the uppermost part of the Upper Chasmops Limestone in Asker, the uppermost part of the Solvang Formation at Norderhov and on Frognøya (Høgberg Member) in Ringerike and in the upper part of the Solvang Formation in Hadeland.

Description. All cranidia less than 5 mm along the posterior border. Cranidium triangular in outline (Pl. 7: 21), sagittal length equal to approximately 50 % of posterior width. Occipital ring weakly convex (sag., exsag.), arched very gently rearwards. Shallow occipital furrow bearing a pair of shallow pits distally. Remainder of glabella strongly inflated, oval in dorsal view, extending for approximately 30 % of its length in front of the fixed cheeks. Directly in front of the occipital furrow the glabella is narrow (tr.) over a short distance behind a pair of weakly impressed, pit-like furrows. Directly in front of these, on the sides of the more expanded (tr.) part of the glabella is a very weakly developed pair of large, oval muscle scars. A median spine, in some instances merely a tubercle, is present on most of the specimens although absent in a few. Posteriorly the glabella is bounded by gently convex (tr.), elongately triangular bacculae; anteriorly by the shallow dorsal furrows which also bear anterior fossulae. Fixed cheeks moderately convex (tr., exsag.). Posterior borders transversely directed, maintaining constant width (exsag.) except distally where they broaden a little a short distance in from the shallow posterior fossulae. Preglabellar field short (sag., exsag.), declined vertically. Facial suture transversely directed mesially; gently convex abaxially laterally (Pl. 7: 21). Cranidium commonly smooth on internal moulds. On the external surface the glabella bears a fine, dense granulation (Pl. 7: 21), the fixed cheeks excluding posterior borders and bacculae bear fine, anastomosing ridges which are approximately parallel to the facial suture and less well defined towards the posterior borders (Pl. 7: 20, 21).

Pygidium 1.5 mm wide (tr.) anteriorly which equals approximately four times the sagittal length (Pl. 7: 19). Poorly defined rachis becomes more swollen and broader (tr.) rearwards. Flat-lying pleural lobes bear three pairs of weakly incised furrows. Posterior margin of pygidium transversely directed.

Discussion. The type species of *Raymondella, R. macconochiei* (Nicholson & Etheridge), was redescribed by Whittington (1950, pp. 558–9, Pl. 74: 10; Pl. 75: 1, 2) and differs from *Raymondella* sp. in having larger bacculae and the anterior part of the glabella almost circular in outline. *Raymondella* sp. resembles *R. elegans* (Cooper, 1953) from the Lower Edinburg Formation (Middle Ordovician) of Virginia, U.S.A., redescribed by Whittington (1959, pp. 488–491, Pl. 36: 1–36), which, however, has a larger preglabellar field and better defined pleural ribs on the pygidium than the Norwegian form. *Raymondella* sp. also resembles *R. nevadensis* Ross & Shaw (1972, pp. 25–6, Pl. 6: 11–13, 15, 17) from Middle Ordovician units in Nevada but this species has larger bacculae which are gently swollen adaxially. Larger bacculae occur also in *R. abundans* Tripp (1976, pp. 394–5, Pl. 5: 5–16) from the basal *superstes* Mudstones (Llandeilo, ?lowest Caradoc) of south-west Scotland. *R. pamirica* Balashova (1966, pp. 232–3, Pl. 1: 1a, 1b) from middle Ordovician strata in Pamir, U.S.S.R. differs from the Norwegian form primarily in its shorter glabella with the frontal lobe almost circular in outline.

R. erratica Krueger (1972, pp. 856–8, Figs. 1–4) from erratic blocks of Ashgill age derived from the Baltic area differs from *Raymondella* sp. primarily in having the frontal lobe almost circular in outline, the posterior part of the glabella is longer (sag., exsag.) and bears two pairs of lobes and in possessing very large bacculae.

Genus *Ampyxina* Ulrich, 1922

Type species. Original designation; *Endymionia bellatula* Savage, 1917, p. 273, Pl. 1: 3, from the Thebes Sandstone (Middle Ordovician) of Illinois, U.S.A.

Ampyxina? sp.

Pl. 7: 14–18.

1979 *Ampyxina*? sp.; Bruton & Owen, Figs. 2B, 3, 4, 6.

Material, localities, and horizons. Cranidia are common over a fairly restricted thickness of the Upper Chasmops Limestone in Oslo-Asker (see Bruton & Owen, 1979: 218, for discussion).

Discussion. The cranidium of *Ampyxina* is very similar to that of *Raymondella* although the thoracic segments and pygidia of the two genera are easily distinguishable (see Whittington 1959: 488). However, the field of the fixed cheek in *Ampyxina* lacks the anastomosing ridges characteristic of *Raymondella* and on this basis alone, the above material is tentatively assigned to Ulrich's genus. The cranidium of *Ampyxina*? sp. strongly resembles that of *Raymondella* sp. but in addition to having smooth or finely pitted fixed cheeks, differs in having the posterior borders expanding (exsag.) abaxially more strongly and over a greater distance and the course of the facial suture is more sinuous.

The type species of *Ampyxina, A. bellatula,* was refigured by Whittington (1950, Pl. 73: 7, 8; 1959, Pl. 34: 1, 2) and differs from *Ampyxina*? sp. primarily in having a much more circular glabellar outline. *Ampyxina powelli* (Raymond, 1920) from the Edinburg Formation (Middle Ordovician) of Virginia, U.S.A. was also redescribed by Whittington (1959, pp. 482–5, Pl. 34: 3–13; Pl. 35: 1–25) along with a new species, *A. lanceola,* from the same unit (1959, pp. 486–7, Pl. 34: 14–28; Pl. 35: 26–35). These forms have an oval glabella but not as elongate as *Ampyxina*? sp. and also differ from the Norwegian form in having the posterior borders expanding much less (exsag.) and in having the bacculae distinctly swollen. Moreover, *A. powelli* has only a very short, tubercle-like median glabellar spine.

A. wothertonensis Whittard (1955, pp. 24–5, Pl. 3: 1–4) has swollen bacculae, a more pear-shaped glabella and broader fixed cheeks than *Ampyxina*? sp. *A. aldonensis* (Reed, 1935) from the basal *superstes* Mudstones (Llandeilo, ?basal Caradoc) of south-west Scotland was redescribed by Tripp (1976, p. 395, Pl. 5: 17–23) and differs from all the above mentioned species and *Ampyxina*? sp. in having the outer parts of the fixed cheeks bearing a series of anastomosing ridges. *Ampyx acus* Troedsson (1918, pp. 75–6, 98, Pl. 2: 24) from the Brachiopod Shale (upper Ashgill) og southern Sweden was reassigned to *Ampyxina* by Whittard (1955: 25) who considered that Troedsson's reconstruction of a median glabellar spine was probably in error. Troedsson described ridges on the fixed cheeks almost parallel to the facial sutures and thus his species probably belongs in *Raymondella.*

Genus *Ampyxella* Dean, 1960

Type species. Original designation; *Ampyx (Raphiophorus) edgelli* Reed, 1932, pp. 207–9, Pl. 11: 1–4, from the Actonian and Onnian stages (late Caradoc) in the Onny Valley, south Salop, England.

Discussion. The cephalon and pygidium of *Ampyxella* very strongly resemble those of *Cnemidopyge* Whittard, 1955 (type species *Trinucleus nudus* Murchison, 1839 probably from Upper Llandeilo strata in the Builth area, Central Wales). *Cnemidopyge* was revised by Hughes (1969: 62–77) who assigned to it species of Llandeilo and early Caradoc age from Britain, Sweden and the Oslo Region. The only major differences between *Cnemidopyge* and *Ampyxella* are that the former genus has six thoracic segments and the latter five and the median glabellar spine is quadrate in section in *Ampyxella* but commonly circular or triangulate in *Cnemidopyge.* A further reassessment of Whittard's genus is being undertaken by Hughes (1969: 63) and in the meantime, *Ampyxella* is previsionally retained for late Caradoc forms from England, ?Eire, Norway and Sweden (see below).

Ampyxella aculeata (Angelin, 1854)

Pl. 6: 8, 9, 11–17.

1854 *Ampyx*? *aculeatus* Angelin, p. 81, Pl. 40: 5a–d. – 1878 *Ampyx*? *aculeatus* Angelin, p. 81, Pl. 40: 5a–d. – ?1940 *Ampyx*? *aculeatus* Angelin; Thorslund, p. 153, Pl. 9: 10, 11. – 1979 *Ampyxella aculeata* (Angelin); Bruton & Owen, Figs. 2–6.

Lectotype. Here selected; a cranidium (RM Ar 36892) from the Upper Chasmops Limestone, probably on Gåsøya, Bærum. Figured by Angelin (1854, Pl. 40: 5, 5a, 5c, 5d).

Paralectotyype. Here selected; an external mould of a pygidium (RM Ar 36891) from the same horizon and locality as the lectotype. Figured by Angelin (1854, Pl. 40: 5b).

Other material, localities, and horizons. Although rarely complete, this species occurs commonly but with a fairly short stratigraphical range in the Upper Chasmops Limestone of Oslo-Asker (see Bruton & Owen, 1979: 218). It also occurs in the Solvang Formation at Norderhov, Ringerike.

Diagnosis. Glabella diamond-shaped, swollen frontally; extending for no more than 25 % of its length (excluding median spine) in front of cheeks. Occipital spine very long. Large swelling in dorsal furrows at maximum glabellar width. Pleural and ring furrows on pygidium weakly impressed on external surface; deeper on internal moulds.

Description. Cephalon, excluding spines, triangular in outline, sagittal length equal to 50 % of posterior width. Diamond-shaped glabella swollen frontally, strongly carinate; expands to almost double its basal width. Glabella extends no more than 25 % of its length in front of the cheeks, frontally produced as a long spine which is quadrate in section. Occipital ring bears a long, dorsally directed spine which is equal in length to at least the 50 % of the glabellar length to the base of the anterior spine (Pl. 6: 11). In the lectotype (Pl. 6: 15), this spine is directed rearwards slightly but this is partially the result of displacement at small fractures. A pair of large swellings abutting the median carination is situated on the glabella directly in front of the shallow occipital furrow. Directly in front of each of these swellings, mid-way between the carination and the shallow dorsal furrow is a large, longitudinally oval, slightly depressed area. A large swelling is situated in the dorsal furrow at or a little behind the maximum glabellar width. Shallow fossulae situated in anterior parts of dorsal furrows. Short preglabellar area steeply declined forwards, overhung by glabella. Facial suture becomes marginal in front of or slightly adaxially to the anterior fossulae (Pl. 6: 16). Posterior border furrows broad (exsag.) and shallow, bearing deep fossulae distally. Genal spines at least as long as the sagittal length to the base of the median spine, diverging abaxially backwards at 120° proximally, curving round to become parallel (Pl. 6: 14). Spines bear a shallow longitudinal furrow. External and internal surfaces of cephalon smooth.

Hypostoma unknown.

Barrel-shaped thorax of five segments, the first slightly longer (sag., exsag.) than the others (Pl. 6: 11). Fairly convex (tr.) rachis occupies 20 to 25 % of each segment width. Each rachial ring bears a gently swollen median tubercle on its anterior edge and is slightly swollen where it abuts the weakly impressed dorsal furrows. Pleurae flat-lying, bearing shallow but distinct furrows which are directed from their anteromesial to their posteromesial corners.

Pygidium triangular in outline, sagittal length equal to 50 % of anterior width. Weakly convex (tr.) rachis tapers at 20° and comprises up to 14 rings and an anterior lenticular half-ring which is defined posteriorly by a deep furrow. Anterior ring attenuated (sag.) mesially and bears a very gentle median swelling on its anterior edge. The rings behind it are progressively less well defined rearwards. Dorsal furrows weakly impressed. Flat-lying pleural lobes bear up to seven ribs which commonly are only defined laterally on the external surface. Pleural furrows more deeply incised on internal moulds where they extend to the dorsal furrows. Marginal rim narrow. Border almost vertically declined, narrowing a little abaxially and bearing up to 10 subcontinuous terrace lines which step down dorsally (Pl. 6: 12). External and internal surfaces of pygidium smooth (Pl. 6: 8) or finely pitted (Pl. 6: 17).

Discussion. The cranidium attributed to *A. aculeata* by Thorslund (1940) from the Upper Chasmops Limestone of Jämtland, Sweden strongly resembles the Norwegian species but has a narrower (tr.), more convex glabella. This may, however, be related to its small size, the sagittal length to the base of the median spine is 5 mm, and so it is tentatively assigned to Angelin's species.

A. aculeata is very similar to the type species, *A. edgelli.* A lectotype of Reed's species was selected by Dean (1960) and is a flattened cranidium. An uncrushed glabella figured by Dean (1960, Pl. 11: 4) is broader posteriorly, more diamond-shaped and projects further in front of the fixed cheeks than in *A. aculeata.* Moreover, *A. edgelli* lacks swelling in the dorsal furrows of the cranidium and has more deeply incised pleural and rachial ring furrows on the pygidium.

Harper (*in* Harper & Rast 1964, p. 15, Pl. 2: 7) figured a very poorly preserved pygidium, tentatively ascribed to *Ampyxella,* from upper Caradoc strata in County Meath, Eire. As noted above, pygidia are insufficient for unequivocal assignment to *Ampyxella* rather than *Cnemidopyge.*

Family ITYOPHORIDAE Warburg, 1925

Genus *Frognaspis* Nikolaisen, 1965

Type species. Original designation; *Frognaspis stoermeri* Nikolaisen, 1965, pp. 239–44, Pl. 2: 1–8; Pl. 3: 1–8, from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike.

Frognaspis stoermeri Nikolaisen, 1965

1965 *Frognaspis stoermeri* Nikolaisen, pp. 239–44, Pl. 2: 1–8; Pl. 3: 1–8. – 1979 *Frognaspis stoermeri* Nikolaisen; Owen, Fig. 6. – 1979 *Frognaspis stoermeri* Nikolaisen; Bruton & Owen, Fig. 6.

Holotype. An incomplete cephalon (PMO 11a) from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike.

Material, localities, and horizons. Nikolaisen listed several topotype cranidia, hypostomata and pygidia. Additional topotype cranidia, hypostomata and pygidia have been collected recently (HM A14527/1-5).

Discussion. Nothing further can be added to Nikolaisen's thorough description of this species which is only known from the type unit.

Family CHEIRURIDAE Hawle & Corda, 1847

Subfamily DEIPHONINAE Raymond, 1913

Genus *Sphaerocoryphe* Angelin, 1854

Type species. Subsequently designated Vogdes, 1890, p. 147 (I. C. Z. N. Opinion 614); *Sphaerocoryphe dentata* Angelin, 1854, p. 66, Pl. 34: 6, from the Upper Ordovician of Sweden.

Sphaerocoryphe n. sp.?

Pl. 8: 11–13.

1979 *Sphaerocoryphe* sp. ?nov.; Bruton & Owen, Figs. 4, 6.

Material, locality, and horizon. The only specimen known is a complete cranidium (PMO 100399) from 2 m below the top of the Upper Chasmops Limestone, East Raudskjer, Asker.

Description. Sagittal length (excluding spines) of the cranidium equal to 55 % of the width at the posterior borders. Occipital ring fairly gently convex transversely, weakly so sagittally. Occipital furrow very shallow. Basal glabellar lobes weakly swollen but distinct. Subspherical frontal lobe occupies 80 % of sagittal length of cranidium. Dorsal furrows shallow. Posterior borders flat-lying proximally, gently declined abaxially, defined by moderately deep furrow which are arched very gently rearwards. Field of each fixed cheek moderately convex in transverse view and gently declined rearwards. Palpebral lobes situated mid-way between the dorsal and lateral border furrows, each steeply inclined from the field of the cheek, becoming much more gently so distally (Pl. 8: 13). Lateral borders poorly defined adaxially, diverging gently rearwards, becoming confluent with the posterior borders and extending as broad (tr.) genal spines which diverge rearwards at 90° proximally, curving gently adaxially a little. Genal spines taper rearwards and are equal in length to at least the sagittal cranidial length. Each lateral border bears a stout spine directly behind the anterior branch of the facial suture (Pl. 8: 13) which is directed forwards very slightly. Border spines directed downwards at a very low angle to the horizontal. External surface of glabella behind frontal lobe bears a very fine, dense granulation (Pl. 8: 11). Anterior lobe bears a very coarse, fairly dense, granulation on its posterodorsal half. Laterally this ornament becomes slightly finer and continues in a broad strip around the front of the lobe (Pl. 8: 13). Anterodorsally it grades into an area of much finer granulation which is centred slightly to the right of the sagittal line (Pl. 8: 12). Remainder of the cranidium, including genal spines, bears a dense granulation, which is a little coarser than that of the posterior part of the glabella. This ornament is densest and slightly coarser on the palpebral lobes and is set on a shallow pitted surface on the field of the fixed cheeks (Pl. 8: 12).

Discussion. The strongly granular palpebral lobes in the Upper Chasmops Limestone cranidium and the granulation of the frontal lobe distinguish it from all other described species but until additional specimens become available, a new taxon is not formally introduced.

Sphaerocoryphe is known from middle and upper Ordovician strata in Europe, North America and Australia (Shaw 1968; Lane 1971; Webby 1974; Neuman & Bruton 1974) but as Shaw (1968: 77) has noted, many of the described species are poorly known and may prove synonymous. Many workers (e. g. Lane 1971; Ingham 1974; Webby 1974) have placed taxonomic weight on the number of spines on the lateral border of the fixed cheek and in this respect, *Sphaerocoryphe* n. sp.? resembles such species as *S. psiles* Tripp, 1954, *S. akimbo* Tripp, 1967 and *S. hastata* Begg, 1940 (redescribed by Tripp 1976) from late Llandeilo and Caradoc strata in south-west Scotland and *S. exserta* Webby, 1974 from Caradoc strata in New South Wales. However, Shaw (1968, pp. 75–7, Pl. 13: 18–38; Pl. 14: 2, 3, 5) described silicified material of *S. goodnovi* Raymond, 1905 from the Chazy Limestone (Middle Ordovician) of New York State showing two spines to be present on each cheek in the smaller specimens whilst the larger individuals have only one spine or one and a small remnant of a second spine. One specimen noted by Shaw (1968: 75) has two spines on one side and one on the other. Thus the usefulness of this features in distinguishing species-groups or even individual species within *Sphaerocoryphe* is questionable.

Subfamily ECCOPTOCHILINAE Lane, 1971

Genus *Pseudosphaerexochus* Schmidt, 1881

Type species. Subsequently designated by Reed, 1896a, p. 119; *Sphaerexochus hemicranium* Kurtorga, 1854, p. 112, Pl. 1: 2, from Llandeilo strata in Estonia.

Pseudosphaerexochus bulbosus Nikolaisen, 1965

Pl. 8: 1–3, 10.

1965 *Pseudosphaerexochus (Pseudosphaerexochus) bulbosus* Nikolaisen, pp. 244–5, Pl. 4: 5, 6. – 1979 *Pseudosphaerexochus bulbosus* Nikolaisen; Bruton & Owen, Figs. 4, 6.

Holotype. An incomplete cranidium (PMO 73660) from the Upper Chasmops Limestone on Terneholmen, Asker.

Material, locality, and horizon. Two incomplete cranidia and a free cheek from the lower part of the Upper Chasmops Limestone on East Raudskjer, Asker have recently been found.

Discussion. The Raudskjer cranidia add nothing to Nikolaisen's description of this species. The free cheek is an incomplete ventral surface, has a broad border, shallow border furrow and a pitted surface. Nikolaisen noted a similarity of *P. bulbosus* to *P. elongatus* Thorslund (1940, pp. 155–6, Pl. 10: 1, 2) from the Lower Chasmops Limestone (mid-Caradoc) in Jämtland. Whilst both species have a relatively long (sag., exsag.) glabella, that of the Norwegian form is more strongly inflated. In this respect, and in the sparsely distributed large tubercles on the glabella, *P. bulbosus* is more like *P. tvaerensis* Thorslund (1940, pp. 156–7, Pl. 10: 3, 4) from the same beds as *P. elongatus.*

Pseudosphaerexochus densigranulatus Nikolaisen, 1965

Pl. 8: 4–9.

1965 *Pseudosphaerexochus (Pseudosphaerexochus) densigranulatus* Nikolaisen, pp. 245–7, Pl. 4: 1–4. – 1974 *Pseudosphaerexochus* aff. *tectus* Ingham; Ingham, p. 70, Pl. 13: 1–7. – 1976 *Sphaerexochus;* Bruton, p. 712. – 1979 *Pseudosphaerexochus densigranulatus* Nikolaisen; Owen, Fig. 6. – 1979 *Pseudosphaerexochus densigranulatus* Nikolaisen; Bruton & Owen, Fig. 6.

Holotype. An incomplete cranidium (PMO 9093) from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike.

Material, locality, and horizon. 6 cranidia and 3 pygidia from the type horizon and locality.

Description. Glabella strongly swollen, slightly longer (sag.) than maximum width which is just behind 2p furrows, evenly convex in lateral profile. Deep 1p furrows extend almost to occipital furrow. 1p lobes almost square. 2p furrows deep. 3p furrows shallow. Dorsal furrows deep and overhung by the glabella. Fixed cheeks declined steeply abaxially. Glabella bears a very close fine granulation on both the external surface and the internal mould. Fixed cheeks coarsely pitted.

Free cheeks, hypostoma and thorax unknown.

Pygidium described here for the first time (Pl. 8: 8, 9). Sagittal length, excluding spines, slightly less than 50 % of anterior width. Rachis convex (tr.) anteriorly, progressively less so rearwards in which direction it tapers at about 40°; composed of an anterior articulating half-ring, three rings and a short (sag.) terminal piece. Four pairs of pleural ribs present, produced as round ended spines terminating along a line which is very gently convex rearwards. Ribs and spines progressively less divergent rearwards along the pygidium; anterior pair lie at right-angles to the sagittal line proximally, curving rearwards through 55°. Posterior pair almost parallel. External surface of pygidium smooth. Internal moulds densely pitted.

Discussion. P. aff. *tectus* of Ingham (1974) from the Pusgillian Stage at Cautley and Cross Fell in northern England differs from the Frognøya material only in having slightly shorter pygidial spines and is here synonymized with *P. densigranulatus.* This species differs from *P. tectus* Ingham (1974, p. 70, Pl. 13: 1–7) from the lower part of the Cautleyan Stage in northern England in having a more elongate glabella and more distinct pitting on internal moulds of the fixed cheeks. Both are closely related to *P. octolobatus* (McCoy, 1849) which was redescribed by Lane (1971, pp. 48–50, Pl. 8: 1–8) from Rawtheyan strata in North Wales, south-west Scotland and ?northern England but are distinguished in having more strongly radiating pygidial pleural spines.

Ingham (1974: 70) suggested that *P.* aff. *tectus* may be closely related to *Pseudosphaerexochus* sp. of Dean (1961, pp. 316–7, Pl. 49: 2, 7, 8) from the Onnian Stage in Salop, England. Dean's figured cephalon is rather flattened but appears to have broader (tr.) 1p lobes and narrower (tr.) fixed cheeks than *P. densigranulatus.*

Family ENCRINURIDAE Angelin, 1854

Subfamily CYBELINAE Holliday, 1942

Genus *Deacybele* Whittington, 1965a

Type species. Original designation; *Calymene arenosa* McCoy, 1846, p. 47, Pl. 4: 12, from ?Caradoc strata at Ballygarvan Bridge, New Ross, Co. Wexford, Eire.

Discussion. Work by Evitt & Tripp (1977: 115–6, 153–5) on ontogenetic series of *Cybeloides* Slocom, 1913 has shown that the so called compound glabellar lobes (termed 'pulvini') are composed partly of glabellar outgrowths and partly of a portion of the fixed cheeks and are not simply the product of adaxial migration of the 1p and 2p glabellar furrows. *Deacybele* strongly resembles *Cybeloides* in its preglabellar and pygidial morphology but discrete lobes are developed on the cephalic axial structure. Whether these are true glabeller lobes or homologous with the pulvini of *Cybeloides* is not known. The standard glabellar terminology is used provisionally here.

Deacybele gracilis (Nikolaisen, 1961)

Pl. 8: 14–17.

1887 *Cybele* sp.; Brøgger, p. 23. - 1961 *Atractopyge gracilis* Nikolaisen, pp. 302–4, Pl. 4: 5–9. - 1979 *Deacybele gracilis* (Nikolaisen); Owen, Fig. 6. - 1979 *Deacybele gracilis* (Nikolaisen); Bruton & Owen, Figs. 4–6.

Holotype. A cranidium (PMO 6531) from the Upper Chasmops Limestone on Terneholmen, Asker.

Material, localities, and horizons. Cranidia, free cheeks and pygidia are common in the upper few metres of the Upper Chasmops Limestone in Bærum and Asker, in the middle and upper parts of the Solvang Formation in Hadeland and rare in the upper part of the Solvang Formation at Norderhov and on Frognøya in Ringerike.

Description. Many additional specimens have been collected since Nikolaisen first described this species and a more complete description can be given.

Posterior width of cranidium three times sagittal length. Glabella swollen, parallel-sided or expanding forwards very slightly. Occipital ring occupies 15 % of sagittal glabellar length, tapers considerably distally, bearing a small median tubercle. Glabellar furrows very deep proximally, shallowing markedly a short distance in from dorsal furrow. 1p glabellar furrows diverging forwards at 150° laterally. 2p furrows diverging forwards at 160°. 3p furrows diverge and broaden forwards at 120°. 1p lobes transversely directed, strongly attenuated proximally. 2p lobes slightly narrower (tr.) than the other lobes, diverging forwards at 155°. 3p lobes broader (exsag.) than other pairs, diverging forwards at 165°. Glabellar lobes occupy approximately 50 % of transverse glabellar width. Glabella fairly densely covered in small tubercles, many distributed symmetrically about the sagittal line and in most specimens there are larger tubercles on either side of the sagittal line directly in front of the 2p and 3p furrows and further forward on the anterior lobe. The glabella is defined anteriorly by the facial sutures except mesially where there is a shallow furrow in front of which is a tubercle-like projection similar to the structure described by Ingham (1968: 302) in *Cybeloides (Paracybeloides) girvanensis* (Reed, 1906) (Pl. 8: 15, 16). Dorsal furrows broad (tr.) and shallow, bearing large anterior fossulae directly behind the anterior branches of the facial suture (Pl. 8: 15) Fixed cheeks very broad (tr.) posteriorly where they occupy almost 75 % of the cranidial width; strongly swollen and laterally steeply declined. Posterior border narrow proximally, lengthening abaxially and produced distally as a broad based posteriorly directed spine of unknown length. Posterior border furrow shallow. Eye stalks situated opposite the 2p glabellar furrows. Eye ridges strongly developed, meet the dorsal furrows opposite the 3p glabellar furrows. Fixed cheeks bearing irregularly distributed small tubercles. Posterior branches of the facial suture diverge very slightly rearwards and cut the lateral cephalic borders a short distance in front of the genal spine (Pl. 8: 14). Anterior branches of the facial suture converge very gently to a level opposite the maximum glabellar width, in front of which they converge at 115°, meeting in front of the median tubercle.

Free cheeks triangular in outline (Pl. 8: 17). Smooth eye stalks long, slightly overhung by domed visual surfaces. Lateral border furrows weakly impressed. Lateral borders broad. Surface of each cheek between eye stalk and border furrow bears fine, anastomosing ridges which become less pronounced abaxially and bear a few irregularly distributed small tubercles.

Thorax unknown.

Pygidial median length 30 % more than maximum width. Rachis tapering evenly rearwards and markedly concave upwards in lateral profile, occupying 60 % of median length of pygidium. Posterior rachial ridge distinct. 17 to 20 ring furrows on rachis, anterior furrow complete mesially. Pleural lobes steeply declined laterally, bearing four pairs of ribs originating opposite the anterior four rachial rings and separated by broad (tr.), flat-lying areas. Ribs splayed out from dorsal furrows with the anterior pair directed almost transversely, posterior pair parallel. Ribs gathered a short distance behind the tip of the rachis posteriorly to which they flare slightly and terminate in short free spines which are rounded distally and arranged en echelon. External surface of pygidium finely pitted. Internal surface smooth.

Discussion. Only two other species of *Deacybele* have been described. The type species, *D. arenosa,* was redescribed by Whittington (1965a, pp. 48–9, Pl. 14: 1–6; Text Fig. 3A) and differs from *D. gracilis* in having the glabella expanding forwards from the occipital furrow and in lacking a genal spine. *D. pauca* Whittington (1965a, pp. 49–50, Pl. 14: 7, 10, 13, 14, 16; Text Figs. 3B, C) from the Gelli grîn Group (Longvillian) of the Bala district of North Wales is very similar to the Norwegian species but is distinguished by its relatively broader (tr.) 2p lobes and shorter (sag.) occipital ring.

A cranidium and pygidium from the Gagnum Shale Member of the Lunner Formation in Hadeland were described by Størmer (1945, pp. 388, 414–5, Pl. 4: 1, 5) as *Cybele (Cybeloides)* sp. Additional material from this unit has been found recently and whilst belonging to *Deacybele* this form is distinguished from *D. gracilis* by its stronger abaxial shallowing of the lateral glabellar furrows, its more posteriorly situated eye stalks and in the denser surface granulation of the glabella.

Ross & Ingham (1970: 396) listed *Deacybele* from the Albany Mudstones (Llandeilo) near Girvan, south-west Scotland. Examination of this material in the Hunterian Museum, Glasgow shows it to differ from *Deacybele* in having very narrow (exsag.), deep, 1p and 2p lateral glabellar furrows, shallow 3p furrows each containing two deep pits, deep anterior fossulae, a relatively long (sag.), flat-lying projection in front of the mesial part of the glabella, a very dense fine granulation on the cranidium. The pygidium has very narrow (tr.) pleural ribs separated by large, flat, finely pitted areas. The Albany form is probably congeneric with '*Cybele (Cybelina)*' *monoceras* Reed (1931, pp. 101–3, Pl. 5: 1, ?*non* 2, 3) from the Balchatchie Mudstones (low Caradoc) of Girvan.

Family STAUROCEPHALIDAE Prantl & Přibyl, 1948

Genus *Staurocephalus* Barrande, 1846

Type species. Original designation; *Staurocephalus Murchisoni* Barrande, 1846, p. 53, from Welock and Ludlow strata in Bohemia.

Staurocephalus pilafrons n. sp.

Pl. 9: 1–7.

1957 *Staurocephalus* sp. a; Kielan, pp. 161–2, 167–9, Pl. 4: 3; Text Fig. 4. – 1961 *Staurocephalus* sp.; Nikolaisen, p. 306. – 1976 *Staurocephalus;* Bruton, p. 712. – 1978 *Staurocephalus* sp. nov.; Owen, p. 9. – 1979 *Staurocephalus* sp. nov.; Owen, Fig. 6. – 1979 *Staurocephalus* sp. nov.; Bruton & Owen, Figs. 4–6.

Derivation of name. From the Latin, *pila* – a ball, *frons* – front, referring to the characteristic shape of the glabella.

Holotype. A cranidium (PMO 67044) from the Upper Chasmops Limestone (almost certainly uppermost part) on Terneholmen, Asker. Figured by Kielan (1957, Pl. 4: 3; Text Fig. 4).

Paratype. A pygidium (PMO 100829) from 2.60–2.65 m below the top of the Solvang Formation at Norderhov, Ringerike.

Material, localities, and horizons. A glabellar fragment (PMO 81466) from the Upper Chasmops Limestone (5.5 m below the top) between Nes and Nesøya and a cranidium (PMO 100477) from 1.7 m below the top of this unit on East Raudskjer, Asker. Two cranidia (PMO 99427–8; 94432) from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike and four cranidia and a pygidium (HM A11517/1–3 , 14411/1, 2) from the middle and upper parts of the Solvang Formation in Hadeland.

Diagnosis. Glabella broad (tr.) behind the moderately inflated frontal lobe. Short median occipital spine present. Palpebral lobes situated well away from the glabella.

Description. Cranidium triangular in outline, sagittal length approximately equal to 75 % of posterior width. Glabella strongly convex (tr.) with a broad, parallel-sided stem and a subspherical frontal lobe with a maximum diameter approximately twice that of the stem. Occipital ring occupies 10 % of sagittal glabellar length, tapering considerably abaxially, bearing a short, broad based median spine which is directed upwards and very slightly rearwards. Occipital furrow transversely directed, weakly incised, bearing a pair of deep pits distally. Lateral glabellar furrows developed as three pairs of circular depressions on sides of the glabellar stem (Pl. 9: 4). The anterior, shallowest, pair lie at the ends of a shallow transglabellar furrow which marks the posterior edge of the frontal lobe. Kielan (1957: 168, Text Fig. 4) considered that each of these anterior depressions was represented by four small pits but recent study of all available material does not substantiate this. Frontal lobe occupies 50 % of the sagittal glabellar length, moderately inflated. External surface of frontal lobe densely covered in large tubercles (Pl. 9: 3) which are less well developed on internal moulds. Glabellar stem more sparsely tuberculate. Dorsal furrows broad (tr.) and shallow. Fixed cheeks broad posteriorly where they occupy 75 % of posterior cranidial width, narrowing strongly in front of palpebral lobes, inclined from the dorsal furrows such that the palpebral lobes are elevated to the same level as the median part of the glabellar stem. Palpebral lobes situated well away from the glabella opposite 2p depressions. A well defined line of flexure (tr.) extends from the palpebral lobes to just behind the anterolateral corner of the glabellar stem and delimits a flat, triangular portion of the cheek which is declined forwards (Pl. 9: 3). Posterior borders narrow (exsag.), directed at right angles to the sagittal line for about 60 % of their length, curving a little rearwards and downwards laterally (Pl. 9: 4). Posterior border furrows weakly incised. Posterior branches of the facial suture diverge rearwards very slightly. Anterior branches of suture directed forwards at an angle to the sagittal line which is less than that of the flexure line for most of the length, anteriorly curving abaxially a little and meeting the frontal glabellar lobe in front of the dorsal furrows. Fixed cheeks smooth anteriorly and where they abut the dorsal furrows but bearing a few large tubercles posteriorly and adaxially from the eyes.

Free cheeks, hypostoma and thorax not known.

Pygidium (Pl. 9: 6, 7) almost square in outline, sagittal length to level of tips of spines a little less than maximum width. Rachis strongly convex frontally (tr.) progressively less so posteriorly, tapering rearwards very gently over the anterior 50 % of its length and at 50° behind this and occupying 75 % of the pygidial length (including spines). Rachis composed of three well defined rachial rings, an anterior articulating half-ring and a carinate triangular terminal piece. Rachial rings confluent with three pairs of pleural ribs which are narrow proximally, broaden considerably abaxially and are produced as tapering spines which terminate along a transverse line with their slightly swollen tips evenly spaced. Shallow furrows present on proximal parts of anterior two pairs of ribs. Anterior pair of ribs directed at right angles to the sagittal line over a short distance abaxially to which they are flexed sharply to lie parallel with it. Posterior two pairs of ribs parallel. Each rib bears a tubercle at the point where it becomes a free spine. Tubercles arranged along a line which is arched gently rearwards. In PMO 100829 (Pl. 9: 6) there are two tubercles situated proximally to this main tubercle on each of the outer two pairs of ribs.

Dimensions. (mm)

	Holotype			
	PMO	PMO	HM A	HM A
Cranidia	67044	94427	$11517/_2$	14411
Sagittal length cranidium	2.5	5.5	–	3.5
Sagittal length frontal lobe	1.2	2.0	2.0	1.5
Transverse width frontal lobe	1.3	2.8	2.0	2.0
Transverse width glabellar stem	0.7	1.3	–	1.0

	Paratype	
	PMO	HM A
Pygidia	100829	$11517/_1$
Sagittal length pygidium	–	1.0
Sagittal length rachis	–	0.8
Maximum transverse width pygidium	1.8	1.3
Maximum transverse width rachis	0.8	0.5

HM A14411 is a latex cast of an external mould, the other specimens have the exoskeleton preserved.

Discussion. The relatively large width of the glabellar stem compared with that of the frontal lobe, the occipital spine and the position of the palpebral lobes well away from the dorsal furrows distinguish *S. pilafrons* from all other described species of *Staurocephalus.*

Kielan (1957) described the holotype (then only known specimen) of *S. pilafrons* but without formally naming it. She described the various Ordovician and Silurian species assigned to the genus and also two unnamed forms from Sweden and the apparently widespread Ashgill species *S. clavifrons* Angelin, 1854. Kielan's *Staurocephalus* spp. b and c from the Upper Jonstorp Formation (probably Rawtheyan) of Dalarna and Västergötland respectively are much closer to *S. clavifrons* and its allies than to *S. pilafrons.* Ingham (1977: 89) has shown that specimens from the Rawtheyan Stage in northern England strongly resemble *S. clavifrons* but are distinguished by their tuberculation and he notes that once topotype material of Angelin's species has been described the reinterpretation of other material previously ascribed to it might be necessary. The stratigraphical implications of *S. clavifrons (sensu lato)* were discussed by Price (1973a) and it is clear that the genus is strongly facies controlled in its distribution (see also Ingham 1974: 85), being restricted to calcareous sediments. *S. pilafrons* conforms to this distribution and is the oldest known species of a genus which persists until the Lower Ludlow.

Family CALYMENIDAE Milne Edwards, 1840

Subfamily FLEXICALYMENINAE Siveter, 1977

Discussion. Siveter (1977: 353–4) excluded forms lacking buttress structures between the lateral glabellar lobes and the fixed cheeks from the subfamily Calymeninae Milne Edwards, 1840 and erected the subfamily Flexicalymeninae to accomodate them. As Siveter himself noted (1977: 354), this concept may need modification once phylogenetic relationships within the Calymenidae have been clarified. The development of albeit small buttresses between the frontal glabellar lobe and the fixed cheeks in *Thelecalymene* Whittington, 1971a, a derivative of the non-buttressed genus *Gravicalymene* Shirley, 1936 (Ingham 1977: 97), throws doubt on the monophyletic nature of such structures (see also Ingham 1977: 100).

Extensive discussion of the nature of the region in front of the glabella in genera assigned to the Calymeninae and Flexicalymeninae have been given by Whittington (1971: 459), Temple (1975: 146–9) and Ingham (1977: 89–90). For the reasons given by Ingham (1977: 90) the term preglabellar area is used here.

Genus *Flexicalymene* Shirley, 1936

Type species. Original designation; *Calymene Blumenbachii* var *Caractaci* Salter, 1865, p. 96, Pl. 9: 3, from the Upper Longvillian and Marshbrookian stages in south Salop, England.

Discussion. Dean (1962: 112–3) proposed a new genus, *Onnicalymene* (type species *Flexicalymene onniensis* Shirley, 1936), to include a number of British and Scandinavian late Caradoc and early Ashgill forms characterized by a short steeply inclined preglabellar area (anterior border of Dean) and the palpebral lobes situated opposite the anterior parts of the 1p lobes and the 1p furrows. Both Siveter (1977: 356–7) and Ingham (1977: 90) have recently discussed the degree of variation in these features. It is clear that the length and shape of the preglabellar area should be given little weight in calymenid taxonomy (see also Whittington 1971) and that the position of the palpebral lobes in populations of forms ascribed to *Onnicalymene* is variable and closely approaches, if not overlaps with, the range of variation seen in *Flexicalymene (sensu stricto).* Siveter argued that some taxonomic recognition should be given to species which tend to have the palpebral lobes situated further back on the cranidium and retained *Onnicalymene* as a subgenus of *Flexicalymene.* Ingham advocated the suppression of *Onnicalymene* and this is followed here. An informal term such as 'the *onniensis* species-group' is considered sufficient to characterize forms previously assigned to *Onnicalymene.*

Flexicalymene jemtlandica Thorslund, 1940

1934 *Calymene;* Størmer, p. 331 (Bærum and Asker specimens). – 1940 *Flexicalymene jemtlandica* Thorslund *(?pars),* pp. 147–8, Pl. 12: 19, 20, *?non* 21, 22 *(?F. scabustula).* – 1977 *Flexicalymene (Onnicalymene) jemtlandica* Thorslund; Siveter, pp. 357-366, Fig. 4, H–K; Fig. 5, A–I; Fig. 6, A–I, K. – 1979 *Flexicalymene jemtlandica* Thorslund; Bruton & Owen, Figs. 3–6.

Material, localities, and horizons. Cranidia, free cheeks, rostral plates, hypostomata, thoracic segments and pygidia are abundant in the upper part of the Upper Chasmops Limestone in Bærum and Asker and in the Solvang Formation at Norderhov in Ringerike. The species is known from only one locality, Rambergøya, in Oslo.

Discussion. The holotype of *F. jemtlandica* is from the allochthonous zone of *Dicranograptus clingani* in Jämtland, Sweden. A very extensive description of this species, based largely on material from the Oslo region was given by Siveter (1977) who noted that the Norwegian cranidia differ from the holotype only in having the preglabellar area less steeply upturned. Siveter excluded from *F. jemtlandica* a cephalon from the autochthonous Upper Chasmops Limestone at Slandrom, Jämtland, originally included in the species by Thorslund. This cephalon was tentatively reassigned to *F. scabustula* (see below). A comparison of *F. jemtlandica* with various British species was given by Siveter. The recently described form *F. onniensis lata* Ingham (1977, pp. 90–92, Pl. 19: 11–21) from Onnian strata in northern England differs from *F. jemtlandica* in most of the respects noted by Siveter for *F. onniensis onniensis* and also in its longer (sag., exsag.) preglabellar area. As Ingham (1977, Text Fig. 27) illustrated, like *F. jemtlandica, F. onniensis lata* differs from F. *onniensis onniensis* in the greater width (tr.) of the middle portion of the glabella.

Flexicalymene scabustula Siveter, 1977

1934 *Calymene;* Størmer, p. 331 (Oslo specimens). – ?1940 *Flexicalymene jemtlandica* Thorslund *(pars),* pp. 147–8, Pl. 12: 21, 22, *non* 19, 20. – 1977 *Flexicalymene (Onnicalymene) scabustula* Siveter, pp. 366–72, Fig. 6, J; Fig. 8, A–I; Fig. 9, A–O. – 1979 *Flexicalymene scabustula* Siveter; Bruton & Owen, Figs. 2A, 2B, 6.

Holotype. A cranidium (PMO 81250) from the uppermost bed of the Upper Chasmops Limestone on Nakholmen, Oslo.

Material, localities, and horizons. Cranidia, free cheeks, rostral plates, hypostomata, thoracic segments and pygidia are abundant at various levels in Upper Chasmops Limestone of Oslo and east Bærum.

Discussion. Nothing can be added to the description of this species given by Siveter (1977). *F. scabustula* closely resembles *F. jemtlandica* but, as Siveter noted, is distinguished by its slightly swollen upturned part of the preglabellar area, its straighter anterior branches of the facial suture, its less evenly curved lateral glabellar profile and in its much coarser tuberculation on the external surface of the cranidium, especially the glabella. The two forms, however, may prove to be no more than subspecies. As Siveter stated (1977: 372), the coarse glabellar tuberculation of *F. scabustula* distinguishes it from the British species previously assigned to *Onnicalymene*.

Flexicalymene sp.

Pl. 9: 8, 9.

1976 *Diacalymene;* Bruton, p. 712. – 1979 *Flexicalymene* sp.; Owen, Fig. 6. – 1979 *Flexicalymene* sp.; Bruton & Owen, Fig. 6.

Material, locality, and horizon. Two cranidia and a pygidium from the uppermost bed of the Høgberg Member of the Solvang Formation and a pygidium from 1.5–1.6 m below the top of the member, Frognøya, Ringerike.

Discussion. The cranidia from the Høgberg Member have a surface granulation similar to that of *F. jemtlandica* but are distinguished from both Upper Chasmops Limestone forms primarily in having a proportionally narrower (tr.) median part of the glabella, a transversely directed anterior edge of the preglabellar area and much straighter anterior branches of the facial suture. The pygidia strongly resemble those from the Upper Chasmops Limestone.

Siveter (1977: 375–7, Fig. 10, A–D) described a cranidium as *Flexicalymene* aff. *F. (Reacalymene) pustulosa* (Shirley, 1936) from what he termed the Upper Chasmops Limestone at Ballangrud, Hadeland. The Solvang Formation (termed the Upper Chasmops Limestone by earlier workers – see Owen 1978) does not crop out at Ballangrud and this specimen is almost certainly from a younger Ordovician unit.

Subfamily PHAROSTOMATINAE Hupé, 1953

Genus *Prionocheilus* Rouault, 1847

Type species. By monotypy; *Prionocheilus verneuili* Rouault, 1847, p. 32, Pl. 3: 3, 31, from Middle Ordovician strata at Poligné, Brittany.

Discussion. Dean (1964) demonstrated that *Prionocheilus* Rouault, 1847 is the senior synonym of *Pharostoma* Hawle & Corda, 1847 (type species *Pharostoma pulchrum* Beyrich, 1846) and proposed that this priority should be respected. The subsequent history of the debate over this point was summarized by Ingham (1977: 103) who advocated that in accordance with the revised articles 23 and 79 of the International Code of Zoological Nomenclature (1974) stability of usage is now best served by retaining the name *Prionocheilus.* This is concurred with here although Whittington's case for *Prionocheilus* being considered a *nomen oblitum* (1965a: 56) was justified and strict application of the current Article 79(b) (iii) of the International Code should see the case being put to the Commission. Siveter (1977: 393) noted the revision of articles 23 and 79 in an addendum to his work and it is hoped that his promised reappraisal of the *Priococheilus* vs. *Pharostoma* problem will satisfactorily conclude the argument.

Prionocheilus narinosus (Siveter, 1977)

Pl. 9: 12.

1977 *Pharostoma narinosum* Siveter, pp. 344–8, Fig. 3, A–H. – 1979 *Prionocheilus narinosus* (Siveter); Bruton & Owen, Fig. 6.

Holotype. An incomplete cranidium (PMO 81266) from the Upper Chasmops Limestone on East Raudskjer, Asker.

Other material, localities, and horizons. Siveter noted two cranidia from 1 m below the top of the Upper Chasmops Limestone on Kalvøya, Bærum. Another incomplete cranidium (Pl. 9: 12) has been found 4 m below the top of the Upper Chasmops Limestone near Strøm Farm, Snarøya, Bærum.

Discussion. The Snarøya cranidium adds nothing to Siveter's description and discussion of this rare calymenid.

Prionocheilus aff. *obtusus* (McCoy, 1846)

Pl. 9: 10, 11, 13–15.

1977 *Pharostoma* sp. A; Siveter, pp. 348–352, Figs. 4, A, D–G. – 1979 *Prionocheilus* aff. *obtusus* (McCoy); Owen, Fig. 6. – 1979 *Prionocheilus* aff. *obtusus* (McCoy); Bruton & Owen, Figs. 5, 6.

Material, localities, and horizons. A total of seven cranidia and three pygidia are known from the uppermost part of the Upper Chasmops Limestone in Asker and the Solvang Formation at Norderhov and on Frognøya (Høgberg Member) in Ringerike.

Description. The two cranidia from Raudskjer described by Siveter (1977) as *Pharostoma* sp. A have the exoskeleton preserved and have a fairly short (sag., exsag.) preglabellar field and lack spines on the anterior border. Many of the newly collected cranidia are internal moulds and have longer preglabellar fields and in most instances a series of broad-based anterior border spines. The internal mould also bears a dense fine pitting especially on the preglabellar area and fixed cheeks. In all other respects the material is very similar and Siveter's description of the cranidium is adequate.

Pygidium (internal mould) semicircular in outline. Rachis strongly convex (tr.), tapering only very gently rearwards, occupying approximately 25 % of the anterior width and almost all of the sagittal length of the pygidium. Six rings and a short terminal piece present. Ring furrows progressively less well incised rearwards. Pleural lobes flat-lying mesially, steeply declined marginally; bearing 5 pairs of ribs delimited by deep pleural furrows. Interpleural furrows shallow but distinct.

Discussion. The holotype of *Prionocheilus obtusus* (McCoy, 1846) from the Chair of Kildare Limestone (probably Rawtheyan) Eire was redescribed by Whittington (1965a, pp. 55–6, Pl. 16: 1–3, 6) and Dean (1971a, pp. 42–4, Pl. 8: 2, 4–6, 8, 10, 12–15; Pl. 19: 5–8, 10, 12) who also figured topotype material. *P.* aff. *obtusus* differs from the Irish species in having a shorter (sag., exsag.) preglabellar field when exoskeleton is preserved on this part of the cranidium, a more upturned anterior border, a coarser external surface granulation and the pygidium is more elongate. As Siveter (1977: 352) has pointed out, the anterior border of *P. obtusus* is spinose in at least some specimens. Whittington (1965a, pp. 56–7, Pl. 16: 4, 5, 7, 8) compared material from the Rhiwlas Limestone (probably Rawtheyan) of the Bala district, North Wales with *P. obtusus* which seems to correspond well with this species.

Siveter (1977: 350) suggested that the Raudskjer cranidia may be close to *P. rarus* (Cooper & Kindle, 1936) from the Whitehead Formation (Ashgill) of Quebec, Canada – a form based on a small cranidium. Whether *P. rarus* is closely related to *P. obtusus* must await the description of topotypes from Canada (see also Dean 1971a: 44). *P. leptaenarus* (Törnquist, 1884) from the Boda Limestone (Ashgill) of the Siljan district, Sweden was synonymized with *P. obtusus* by Dean who figured topotype material from Sweden (1971a, Pl. 18: 11).

Pharostoma sp. B of Siveter (1977, pp. 352–3, Fig. 4 B, C) from the Upper Chasmops Shale of Hvalstad, Asker resembles *Prionocheilus* aff. *obtusus* but is distinguished primarily by its broader (tr.) posterior parts of the fixed cheeks and in its denser external surface granulation.

Family PTERYGOMETOPIDAE Reed, 1905

Subfamily PTERYGOMETOPINAE Reed, 1905

Genus *Calyptaulax* Cooper, 1930

Type species. Original designation; *Calyptaulax glabella* Cooper, 1930, pp. 388–9, Pl. 5: 9–11, from the Whitehead Formation (Upper Ordovician) of the Percé region, Quebec, Canada.

Calyptaulax aff. *norvegicus* Størmer, 1945

Pl. 9: 16–22; Pl. 10: 1–4.

non 1962 *Calyptaulax* aff. *norvegicus* Størmer; Whittington, pp. 12–14, Pl. 2: 17, 18; Pl. 3: 15, 16. – 1979 *Calyptaulax* aff. *norvegicus* Størmer; Bruton & Owen, Figs. 2B, 3–6.

Material, localities, and horizons. Although only one cephalon and one hypostoma are known, cranidia and pygidia occur at various horizons in the Upper Chasmops Limestone in Oslo-Asker as well as in the Solvang Formation at Norderhov in Ringerike, and in Hadeland.

Description. Cranidium, excluding lateral parts of posterior borders, very weakly convex (tr., sag.). Occipital ring occupying approximately 20 % of sagittal glabellar length, tapering strongly behind 1p lobes, defined anteriorly by weakly impressed occipital furrow. 1p lobes pentagonal in outline. 1p furrows shallow, converge rearwards from dorsal furrows at 130° over 2/3 their length, turning sharply to lie parallel to the sagittal line and extending to the occipital furrow. 2p and 3p lobes fused laterally. 2p furrows shallow, diverging rearwards at 110 °, dying out abaxially. 3p furrows shallow, very slightly geniculate, diverging forwards at 130° proximally, curving adaxially a little to diverge at 120°. Frontal lobes elongately lozenge-shaped, occupying 50 % of sagittal glabellar length. Dorsal furrows shallow, diverging forwards at 35° to the abaxial parts of the 1p furrows in front of which they diverge at 50° to where they meet the palpebral furrows, curving adaxially through 40° around the anterolateral part of the 3p lobes. Fixed cheeks between the glabella and palpebral lobe occupy a maximum of 35 % of the cranidial width (Pl. 9: 19). Palpebral lobes broad (tr.), arched strongly abaxially, terminating directly in front of the posterior borders. Posterior borders narrow (exsag.) and flat-lying proximally, broadening considerably and declined abaxially from the palpebral lobes at about 45°. Genal angles rounded. Posterior border furrow moderately deep, curving forwards a little abaxially from the palpebral lobes, dying out a short distance from the lateral margin. Each posterior branch of the facial suture curving around the base of the eye to a level just behind the maximum width of the fixed cheeks, abaxially cutting the cheeks in a broad arc which is gently convex forwards (Pl. 9: 21). Anterior branches of the facial suture diverge forwards slightly over a short distance, curving round to converge at 130°. Free cheeks steeply declined from the cranidium, broad, uniting mesially where they become almost horizontal. Visual surface of eye inclined from field of free cheeks at about 45° and thus are approximately vertical when the cephalon is in the dorsal position (Pl. 9: 18). Details of eye poorly known but in PMO 100375 (Pl. 10: 3) there are approximately 40 vertical files with a maximum of 12 lenses per file. External surface of glabella bears a dense but subdued granulation (Pl. 9: 16), on internal moulds only the largest of these granules are present (Pl. 9: 19), in some instances distributed in an ovoid pattern on the frontal glabellar lobe similar to that described by Eldredge (1971) as characterizing the Pterygometopidae. A fine pitting in also developed on internal mould of the cranidium.

Hypostoma (Pl. 10: 4) oval in outline with a transverse convexity which increases rearwards. Median body occupies 85 % of sagittal length of hypostoma and bears weakly swollen maculae. Anterior margin of hypostoma arched strongly forwards. Anterior wings broad (tr.). Lateral borders essentially parallel, ridge like. Posterior border flat-lying lengthening (sag., exsag.) abaxially.

Thorax not known.

Pygidium shield-shaped, maximum width slightly greater than the median length. Rachis occupies 70 % of sagittal length of pygidium, cut by approximately 12 sinuous furrows which are progressively less well incised rearwards. Tip fairly rounded and poorly delimited from the posterior border which is gently arched upwards (Pl. 10: 2). Dorsal furrows shallow, diverging rearwards at 10° over the anterior 50 % of the rachial length behind which they are almost parallel. Pleural lobes gently declined proximally, more steeply so laterally where they are very gently concave in profile. Anterolateral parts of pleural lobes declined steeply abaxially and slightly forwards. Six or seven pairs of pleural furrows present, moderately deep proximally, dying out a short distance abaxially from the fulchrum. Outer parts of pleural ribs cut by shallow interpleural furrows. External and internal surfaces of pygidium smooth.

Discussion. Shaw (1974: 40–42) has shown that many of the features upon which North American species of *Calyptaulax* have been recognized are unreliable and reflect no more than intraspecific variation and preservational differences. The same is undoubtedly true of the European forms and the genus is in need of considerable revision.

C. aff. *norvegicus* differs from Størmer's species from the Gagnum Shale Member of the Lunner Formation in Hadeland (1945, pp. 417–8, Pl. 4: 2, 3) in having broader (tr.) palpebral lobes which are more strongly curved such that the areas between them and the glabella are broader. The limited material available suggests that there are more lens files in the eye in *C.* aff. *norvegicus* (about 40 cf. about 32).

C. actonensis Dean, 1961 was based on material from Actonian and lowest Onnian strata in Salop, England. The fixed cheeks in one of Dean's paratypes (1961, Pl. 51: 1) falls within the range seen in *C. norvegicus* but in a second paratype (Pl. 51: 2) from the same locality, the one exposed fixed cheek is much broader and the posterior part of the palpebral lobe is directed much less strongly adaxially than in *C. norvegicus* or *C.* aff. *norvegicus.* The Salop form is also characterized by hooked 2p furrows. *C. planiformis* Dean (1962, pp. 98–100, Pl. 13: 1–5) was based on material from mid-Onnian and late Pusgillian strata in the Cross Fell Inlier in northern England. Dr J. K. Ingham of Glasgow University has pointed out to us that the Onnian cranidium figured by Dean (1962, Pl. 13: 3) has hooked 2p furrows and thus probably belongs to *C. actonensis,* possibly leaving *C. planiformis* with a more restricted stratigraphical range. Dean's material of *C. planiformis* is poor and comparisons are difficult. The palpebral lobes are broad, as in *C.* aff. *norvegicus,* but less strongly curved. The 3p furrows seem to be very strongly geniculate in the Cross Fell species but this may be the result of compression. *C. planiformis* and *C. actonensis* are so similar to *C. norvegicus* that it seems unlikely that separation at specific level is warranted.

C. aff. *norvegicus* of Whittington (1962) from the Rhiwlas Limestone (probably Rawtheyan) of the Bala district, North Wales differs from *C. norvegicus* and the Upper Chasmops Limestone form in having the 3p lobes very narrow (tr.) anteriorly and the 3p furrows markedly geniculate.

Family LICHIDAE Hawle & Corda, 1847

Discussion. Chatterton (1971, pp. 30–41, Pl. 6; Pl. 7; Pl. 8: 1–17) has demonstrated that during the ontogeny of the middle Devonian lichid *Acanthopyge (Mephiarges) bifida* (Edgell, 1955) the 'bicomposite lobes' originate as a pair of swellings in the dorsal furrows opposite what are interpreted as the 2p glabellar lobes. Temple (1972: 374) termed these swellings 'bullae' and the lobes formed by their anterior extension 'bullar lobes'.

Subfamily HOMOLICHINAE Phleger, 1936

Genus *Platylichas* Gürich, 1901

Type species. Original designation; *Lichas margaritifer* Nieszkowski, 1857, p. 568, Pl. 1: 15, from the Porkuni Limestone (F_2) (late Ashgill) of Estonia.

Platylichas laxatus (McCoy, 1846)

Pl. 10: 5–15.

1846 *Lichas laxatus* McCoy, p. 51, Pl. 4: 9. – *non* 1851 *Trochurus nodulosus* McCoy *in* Sedgwick & McCoy, p. 151, Pl. iF: 16. – 1854 *Lichas sexspinus* Angelin, p. 74, Pl. 38: 7–8a. – 1854 *Lichas aculeatus* Angelin, p. 75, Pl. 38: 7, 7a. – 1857 *Lichas 6-spinus* Ang.; Kjerulf, p. 94. – ?1866 *Lichas segmentatus* Linnarsson, p. 18, Pl. 2: 4. – 1878 *Lichas sexspinus* Angelin, p. 74, Pl. 38: 7–8a. – 1878 *Lichas aculeatus* Angelin, p. 75, Pl. 38: 7, 7a. – ?1885 *Lichas laxata* McCoy; Schmidt, pp. 125–6 Pl. 6: 24. – ?1906 *Lichas laxatus* McCoy; Olin, p. 53, Pl. 1: 27, 28. – *non* 1908 *Lichas laxatus* McCoy; Wiman, p. 133, Pl. 8: 23. – 1939 *Platylichas laxatus* (McCoy); Warburg, pp. 118–125 *(pars),* Pl. 12: 3, 4, 6, 8, 10–12 (*non* 1, 2, 5, 7, 9 – see below). – 1945 *Platylichas laxatus* (McCoy); Størmer, p. 417, Pl. 4: 15. – ?1953 *Platylichas laxatus* McCoy; Jaanusson, p. 102. – 1958 *Platylichas laxatus* (McCoy); Tripp, p. 579, Pl. 85: 3, 4 (*non* 5 = *P. nodulosus* McCoy). – 1963 *Platylichas laxatus* (McCoy); Dean, pp. 235–7, Pl. 43: 1, 2, 5, 8–12. – *non* 1966 *Platylichas laxatus* (McCoy); Bursky, p. 52, Pl. 4: 5. – ?1967 *Platylichas laxatus* (McCoy); Modlinsky, p. 72. – 1968 *Platylichas laxatus* (McCoy); Grieg *et al.*, p. 338. – ?1971 *Platylichas laxatus* (McCoy); Neben & Krueger, Pl. 47: 10–13. – 1979 *Platylichas laxatus* (McCoy); Bruton & Owen, Figs. 2A, 3–6.

For a more complete list of British and Irish forms ascribed to this species see Dean (1963: 235).

Material, localities, and horizons. Cranidia, free cheeks, hypostomata, pygidia and thoracic segments are abundant in the upper part of the Upper Chasmops Limestone in Oslo and Bærum and throughout the unit in Asker and are rare in the uppermost part of the Kirkerud group, the upper part of the Solvang Formation and the Gagnum Shale Member of the Lunner Formation in Hadeland and the Solvang Formation at Norderhov in Ringerike.

Discussion. A very extensive description of material ascribed to *P. laxatus* was given by Warburg (1925). Although some of her specimens are here excluded from this species, it is unnecessary for a description to be given here except to note that there seems to be distinct narrow and broad glabellar forms amongst the Norwegian material (cf. Pl. 10: 13 with Pl. 10: 9, 10). There is no apparent stratigraphical or geographical control on the distribution of these types which are viewed as dimorphs of the same species.

Platylichas laxatus is based on an incomplete, slightly compressed cranidium (refigured by Dean, 1963, Pl. 43: 10) from the Caradoc strata at Ballygarvan Bridge, New Ross, Eire. A more complete topotype cranidium was figured by Tripp (1958, Pl. 85: 4) but other topotype exoskeletal elements have never been described. The Scandinavian material here included in *P. laxatus* (including Angelin's *Lichas sexspinus* from the Upper Chasmops Limestone of Asker) corresponds closely to broadly coeval specimens from the Actonian and lowest Onnian stages in Salop assigned to McCoy's species by Dean (1963). All have cranidia which are very close to the New Ross specimens but clearly a major reassessment may be necessary once new topotypes are known.

Tripp (1958) and Dean (1963) synonymized *Platylichas nodulosus* (McCoy *in* Sedgwick & McCoy, 1851) from the Longvillian Stage of the Bala district, North Wales with *P. laxatus.* The Bala species was redescribed and maintained by Whittington (1962, pp. 25–8, Pl. 6: 12, 13; Pl. 7: 1–14, 19; 1968, pp. 100–1, Pl. 31: 5, 6, 8–11, 14) on account of its shorter (sag., exsag.) frontal lobe, angulate posterior parts of the bullar lobes, a more prominent basal glabellar ring and a median occipital spine. Moreover, the anterior border of *P. nodulosus* is longer (sag., exsag.) than in *P. laxatus*. *P. glenos* Whittington (1962, pp. 28–31, Pl. 7: 15, 16; Pl. 8) from the Rhiwlas Limestone (probably Rawtheyan) of the Bala district differs from *P. laxatus* in having furrows adaxially defining the bullar lobes parallel over most of their length, narrower (tr.) bullar lobes, more evenly divergent dorsal furrows and longer (exsag.) palpebral lobes. Specimens from the Chair of Kildare Limestone in Eire and possibly the Keisley Limestone (both units probably Rawtheyan) in northern England were assigned to *P. glenos* by Dean (1974, pp. 81–3, Pl. 33: 12; Pl. 36: 3–5, 7, 9–11; Pl. 37: 1–3, 5, 7, 10; Pl. 38: 3, 4, 7, 11, 12) and correspond well to the Welsh species. Pygidia from the Kildare contrast markedly with those of *P. laxatus* in having the outer edges of the anterior pair of pleural ribs strongly concave abaxially and the spines fairly strongly divergent.

Warburg (1939) included in *P. laxatus* material from the Upper Chasmops Limestone, Fjäcka Shale, Upper Jonstorp Formation and Boda Limestone in Sweden. She also included a cranidium (1939, Pl. 12: 5a, b) ascribed to *P. laxatus* by Wiman (1908) from an erratic block of Östersjö Limestone (upper Ordovician) but which clearly differs from McCoy's species as it is interpreted here in having a very short (sag., exsag.) frontal lobe and a long (sag., exsag.) anterior border and this strongly resembles *P. nodulosus*.

Specimens figured by Warburg (1939, Pl. 12: 1, 2, 7, 9) from the Upper Jonstorp Formation differ from *P. laxatus* in having considerably shorter (exsag.) palpebral lobes and from specimens from Salop and Norway here included in McCoy's species in having the lateral edges of the anterior two pairs of pygidial ribs convex abaxially. In the Salop and Norwegian specimens the anterior pair have straight slightly divergent edges, the second pair are gently concave abaxially. Warburg mentioned but did not figure a distorted cranidium possibly from the Boda Limestone (Ashgill) in the Siljan district, which the included in *P. laxatus*. *P. segmentatus* (Linnarsson, 1866) was based on an incomplete distorted pygidium from the Fjäcka Shale (Pusgillian) in Västergötland which was incorrectly restored according to Warburg (1939: 123) and so its synonymy with *P. laxatus* is only tentative.

Schmidt (1885) figured a pygidium closely resembling those ascribed here to *P. laxatus* from the Lykholm Group (high-Caradoc to Ashgill) of Estonia. Material figured by Olin (1906) from the Upper Chasmops Limestone of southern Sweden is too fragmentary for accurate determination. Bursky (1966) assigned specimens from the upper Ordovician of Arctic Russia to *P. laxatus* but the incomplete cranidium which he figured has a very narrow (tr.) frontal glabellar lobe and a long (exsag.) basal glabellar ring and should be excluded from McCoy's species. Specimens figured by Neben & Krueger (1971) from erratic block of Backstein Limestone in the Baltic region probably belong to *P. laxatus* but unlike McCoy's species have a large occipital tubercle.

Dean (1962, pp. 121–2, Pl. 17: 1, 7) compared specimens from the highest Pusgillian in northern England with *P. laxatus*. These differ from McCoy's species primarily in having a proportionally longer glabella, more elongate bullar lobes more evenly divergent dorsal furrows and shorter (exsag.) palpebral lobes. An incomplete pygidium from the same strata has much longer (exsag.) tear-drop-shaped adaxial portions of the posterior pair of pleural ribs than is seen in specimens here assigned to *P. laxatus*.

Family ODONTOPLEURIDAE Burmeister, 1843

Subfamily ODONTOPLEURINAE Burmeister, 1843

Genus *Primaspis* Richter & Richter, 1917

Type species. Original designation; *Odontopleura primordialis* Barrande, 1846, p. 29, from the Letná Formation (Caradoc) in Bohemia.

Primaspis sp.

1965 *Primaspis* sp., Bruton, p. 352, Pl. 3: 5, 6. – 1979 *Primaspis* sp.; Bruton & Owen, Fig. 6.

Material, locality and *horizon.* Bruton (1965) described a free cheek and a pygidium from the Upper Chasmops Limestone on Skjærholmen, Oslo. No other material is known.

Discussion. Primaspis is known from an earlier horizon in the Nes-Hamar district of the Oslo Region together with an hitherto undescribed trilobite fauna of Bathyurid province type. This includes specimens of *Miracybele* Whittington, 1965 (= *?Cybelurus* Levitskii, 1962; see Jaanusson *in* Ross & Ingham 1970: 406; Dean 1973: 12–13; Tripp 1976: 407), a genus common in the Table Head Formation, Newfoundland and in the Valhallfonna Formation, Spitsbergen (Fortey & Bruton 1973: 2235). This material of *Primaspis* together with specimens from the Llandeilo of Britain (see Bruton 1966: 352) is among some of the earliest in Europe though specimens of approximately equivalent age are known in North America. At least three Caradoc species of *Primaspis* are known from the Anglo-Welsh area and two from Scandinavia (Bruton 1966: 9). In the Ashgill *P. evoluta* (Törnquist, 1884) and allies are widespread, being recorded from Norway (Owen in prep.), Sweden (Warburg 1925; Bruton 1966), Latvia (Bruton 1968), Wales (Whittington 1968; Price 1973), northern England (Ingham 1966) and eastern Ireland (Dean 1974).

Subfamily MIRASPIDINAE Richter & Richter, 1917

Genus *Miraspis* Richter & Richter, 1917

Type species. Original designation; *Odontopleura mira* Barrande, 1846, p. 57, from the Liten Formation (Wenlock), St. Yvan (= Sv. Jan), near Béroun, Czechoslovakia.

Miraspis sp.

Pl. 10: 18,20.

1979 *Miraspis* sp.; Owen, Fig. 6. – 1979 *Miraspis* sp.; Bruton & Owen, Fig. 6.

Material, locality, and horizon. One incomplete cranidium from the Høgberg Member of the Solvang Formation (1.5–1.6 m below top) on Frognøya in Ringerike and an external mould of an incomplete free cheek and cranidium from the same locality and unit.

Discussion. The ratio of width to length of the cranidium (Pl. 10: 20) is slightly greater than that of *Miraspis solbergensis* Bruton (1966, p. 20, Pl. 5: 1–3) from the Boda Limestone (Ashgill) of the Siljan district, Sweden and is more like that of the much older *M. ceryx* Whittington & Bohlin (1958, p. 42, Pl. 3: 1–4) from the Lower Ordovician of Öland, Sweden. Two cranidia of *Miraspis* were described by Dean (1974, Pl. 43: 1–3, 8) as *M.* cf. *solbergensis* but these are more like *M. ceryx* in their glabellar proportions and the coarse granulation. A coarse granulation though more even in size occurs together with finer granules on the Norwegian material, including the free cheek. The free cheek shows the characteristic triangular outline, raised border with fringing spines and the posterior sutural ridge which joins with the base of the librigenal spine. Free cheeks of Ordovician species of *Miraspis* are rare and to our knowledge have not previously been figured, though Bruton (1966: 23) recorded one from the Middle Ordovician of Västergötland, Sweden.

Contrary to a comment by Ross & Shaw (1972: 29), presence or absence of occipital spines is not a reliable criterion on which to separate *Miraspis* and *Primaspis.* Cranidia of *Miraspis* are distinguished from those of *Primaspis* mainly on account of the palpebral lobe which is stalked (Bruton 1966, Pl. 5: 5; 1968a, Pl. 7: 4–6) or if broken, then the base is always far back on the fixed cheek which overhangs the border of the cranidium. While the majority of *Primaspis* species have a smooth occipital ring, that of the type species, *P. primordialis,* has paired spines (see Bruton 1968a, p. 11, Pl. 1: 11).

Subfamily APIANURINAE Whittington, 1956

Genus *Apianurus* Whittington, 1956

Type species. Original designation; *Apianurus barbatus* Whittington, 1956, pp. 254–265, Pl. 17–19; Pl. 20: 1–17; Text Figs. 19–22, from the Edinburg Limestone (Middle Ordovician) of Virginia, U.S.A.

Apianurus thorslundi Bruton, 1965

Pl. 10: 17, 19.

1956 *Apianurus* aff. *furcata* (Linnarsson); Whittington, p. 270, Pl. 20: 18, 20–25. – 1965 *Apianurus thorslundi* Bruton, p. 344, Pl. 1: 1, 2; Pl. 3: 2–4. – 1966 *Apianurus thorslundi* Bruton, p. 16, Pl. 3: 7. – 1979 *Apianurus thorslundi* Bruton; Bruton & Owen, Figs. 2–4, 6.

Holotype. An incomplete cranidium (PMO 66690) from the Upper Chasmops Limestone at Guttormsberget, Modum..

Paratypes. Two cranidia (PMO 3673; 66691a) from the Upper Chasmops Limestone on Terneholmen, Asker and one pygidium (PMO 5647) from Bygdøy, Oslo.

Other material, locality, and horizon. Three cranidia and one pygidium from the Upper Chasmops Limestone (15.5–17.2 m below top) on Raudskjer, Asker.

Discussion. The new cranidia add nothing to the description given by Bruton (1966) but the pygidium (Pl. 10: 19) is more complete than that previously figured though it does not differ in detail.

As noted by Shaw (1974: 47), *Apianurus* has a rather narrow geographical range within the Ordovician and is known from eastern North America (Whittington 1956; Shaw 1968) and northern Canada (Ludvigsen 1975; Chatterton & Ludvigsen 1976) together with typical Bathyurid province genera and from Balto-Scandinavia (Bruton 1965; 1966; 1968) with typical Asaphid province genera.

Trilobite gen. et sp. indet.

Pl. 10: 16.

Material, locality, and horizon. An hypostoma from the Høgberg Member of the Solvang Formation on Frognøya, Ringerike.

Description. Hypostoma trapezoidal in outline. Anterior border gently arched forwards, steeply inclined from the weakly incised border furrow. Anterior wings short (tr.), steep. Oval median body strongly swollen, occupying 75 % of the sagittal length of the hypostoma. Median lobe very broad (tr.), defined laterally by a pair of poorly incised longitudinal furrows which diverge rearwards slightly and extend for a distance equivalent to a little over 35 % of the sagittal length of the median body. Lateral borders narrow, steeply inclined from dorsal furrows. Posterolateral prolongations long (exsag.), too incomplete for useful description.

Discussion. The shape of the median body and the development of an albeit poorly defined median lobe suggest that this specimen is an encrinurine but the nature of the borders is more reminicent of the calymenidae.

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Plate 1

Figs. 1–4. *Trinodus* aff. *tardus* (Barrande, 1846).
Fig. 1. Dorsal view of left side of pygidium showing the reticulation of the external surface of the rachis and pleural regions, x18, PMO 100398, 2.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Figs. 2, 3. Dorsal and right lateral view of same specimen as Fig. 1, both x9.
Fig. 4. Dorsal view of internal mould of cephalon, x7, HM A11852, uppermost part of the Nerby Mbr. of the Solvang Fm., Haga near Lunner, Hadeland. Coll. A. W. Owen 1974.

Figs. 5–8. *Phorocephala* sp.
Fig. 5. Dorsal view of incomplete cranidium showing pitting and muscle scars on the external surface of the glabella, x7, PMO 9458, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. J. Kiær?
Figs. 6, 7. Dorsal and right lateral views of complete cranidium showing pitting, muscle scars on the glabella and terrace lines on the anterior border, both x6, PMO 5537, uppermost bed of the Upper Chasmops Limestone, Skjærholmen, Oslo. Coll. J. Kiær 1921.
Fig. 8. Dorsal view of small cranidium, x11, PMO 98194, 10.04 m below top of Solvang Fm., Norderhov, Ringerike. Coll. A. W. & G. Owen 1977.

Fig. 9. *Telephina?* sp.
Lateral view of incomplete eye, x7, PMO 9328, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. J. Kiær 1914.

Figs. 10–14, 16. *Stygina minor* Skjeseth, 1955.
Fig. 10. Ventral view of hypostoma showing weak anterior expansion and details of external surface sculpture, x10, PMO H242, approximately 2.0 m below top of Upper Chasmops Limestone. Terneholmen, Asker. Coll. J. Kiær 1921.
Fig. 11. Dorsal view of free cheek, x4, PMO 100589, 1.7 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. F. Nikolaisen 1967.
Fig. 12. Dorsal view of meraspid pygidium with two unreleased thoracic segments, note also the distint rachial rings and pleural ribs which are weakly developed on the external surface in holaspids, x10, PMO 81301, Solvang Fm., Norderhov, Ringerike. Coll. L. Størmer 1930.
Figs. 13, 14. Dorsal and right lateral views of internal mould of pygidium showing doublure. The slight crumpling of the right side of the doublure may be pathological, x3, PMO 100479, 2.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 16. Dorsal view of partially exfoliated incomplete cephalon, thorax and pygidium, x2, PMO 64576, Nerby Mbr. of the Solvang Formation, Nerby, Hadeland. Coll. L. Størmer & G. Henningsmoen 1943.

Fig. 15. *Phillipsinella preclara* Bruton, 1976.
Ventral view of partially exfoliated hypostoma, x12, PMO 98137, 0.57–0.67 m below top of Solvang Fm., Norderhov, Ringerike. Coll. A. W. & G. Owen 1977.

Fig. 17. *Bronteopsis* sp.
Dorsal view of incomplete internal mould of pygidium with doublure partially exposed, x3, PMO 94424, Høgberg Mbr. of the Solvang Formation, N. W. Frognøya, Ringerike. Coll. unknown.

Fig. 18. *Asaphus (Neoasaphus?)* sp.
Ventral view of hypostoma showing external sculpture, x3, PMO 100482, approximately 2.0 m below top of Upper Chasmops Limestone, Nesøy bridge, Asker. Coll. J. F. Bockelie 1967.

Fig. 19. *Illaenus (Parillaenus) roemeri* Volborth, 1864. Detail of axe-shaped rostral flange and connective sutures, x2, Sveriges Geologiska Undersökning unnumbered, Boda Limestone, Kallholn, Siljan district, Sweden. Coll. von Schmalensée 1909. Original of Warburg 1925, Pl. 1: 26, 27.

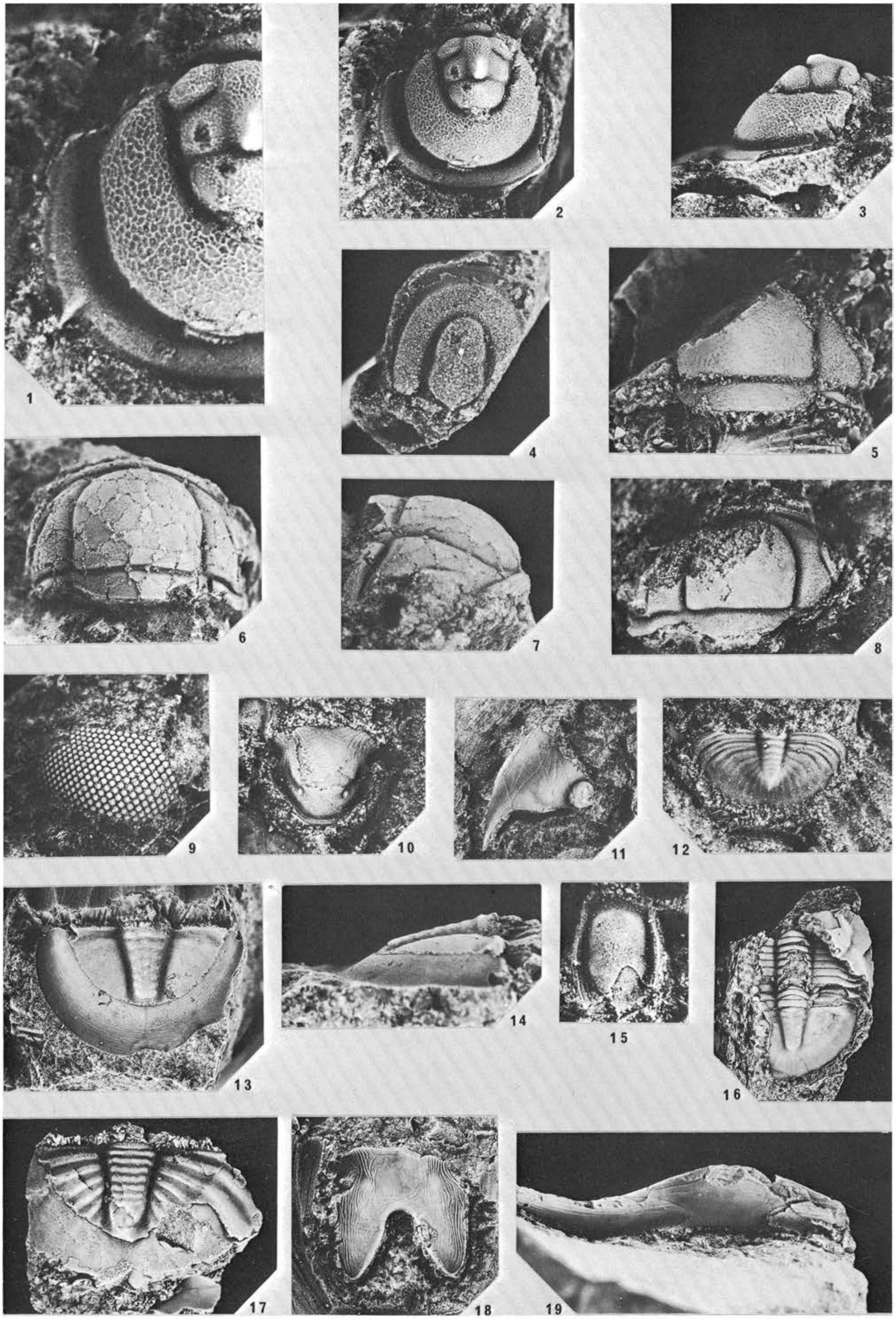
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Plate 2

Figs. 1–8. *Illaenus (Parillaenus)* aff. *fallax* Holm, 1882.

Fig. 1. Palpebral view of internal mould of cranidium of incomplete exoskeleton, x1½, PMO 100571, 1.15–1.95 m below top of Upper Chasmops Limestone, West Raudskjer, Asker. Coll. J. F. Bockelie 1967.

Figs. 2, 3. Frontal view and dorsal view of free cheek showing pitted surface and terrace lines, x4, PMO 9324, Høgberg Mbr. of the Solvang Fm., Frognøya, Ringerike. Coll. J. Kiær 1914.

Figs. 4–6. Right lateral, palpebral and anterior views of partly exfoliated cranidium, x2, PMO 100569, same horizon and locality as Fig. 1. Coll. J. F. Bockelie 1973.

Fig. 7. Oblique left lateral view of internal mould of pygidium prepared to show inner margin of doublure, x2, PMO 100570, same horizon and locality as Fig. 1. Coll. J. F. Bockelie 1973.

Fig. 8. Dorsal view of internal mould of pygidium prepared to show inner margin of doublure, x1½. PMO 100568, same horizon and locality as Fig. 1. Coll. J. F. Bockelie 1973.

Figs. 9, 10, 17–19. *Stenopareia oviformis* (Warburg, 1925).

Fig. 9. Dorsal view of partly exfoliated pygidium showing pitted surface, x2, RM Ar 10130, Boda Limestone, Östbjörka, Siljan district, Sweden. Coll. unknown. Original of Holm 1882, Pl. 4: 23, 24.

Fig. 10. Dorsal view of internal mould of pygidium, x1½, UM D16, Boda Limestone, Osmundsberget, Siljan district, Sweden. Coll. unknown. Original of Holm 1882, Pl. 4: 25, 26.

Figs. 17–19. Lectotype. Dorsal, right lateral and anterior views of internal mould of complete enroled specimen, note muscle scar pattern on cranidium and profile of pygidium, Figs. 17, 18 x2, Fig. 19 x1½, UM D14, Boda Limestone, Kallholn, Siljan district, Sweden. Coll. E. Warburg. Original of Warburg 1925, Pl. 2: 19, 20.

Figs. 11, 12, 15, 16. *Stenopareia linnarssoni* (Holm, 1882).

Fig. 11. Palpebral view of cephalon showing pitted surface, x1½, RM Ar 45601, Boda Limestone, Osmundsberget, Siljan district, Sweden. Coll. unknown.

Fig. 12. Palpebral view of internal mould of cranidium showing muscle scars, x1, RM Ar 10334, Boda Limestone, Kallholn, Siljan district, Sweden. Coll. unknown.

Figs. 15, 16. Dorsal and anterior views of internal mould of pygidium prepared to show tongue-like projection of inner margin of doublure, x1, RM Ar 46759c, Boda Limestone, Osmundsberget, Siljan district, Sweden. Coll. unknown.

Figs. 13, 14. *Stenopareia glaber* (Kjerulf, 1865). Palpebral view of internal mould of 'short' cephalon and dorsal view of partly exfoliated pygidium of enroled specimen, x2½, UM D, Kullsberg Limestone, Kullsberg, Siljan district, Sweden. Coll. G. Weström 1930.

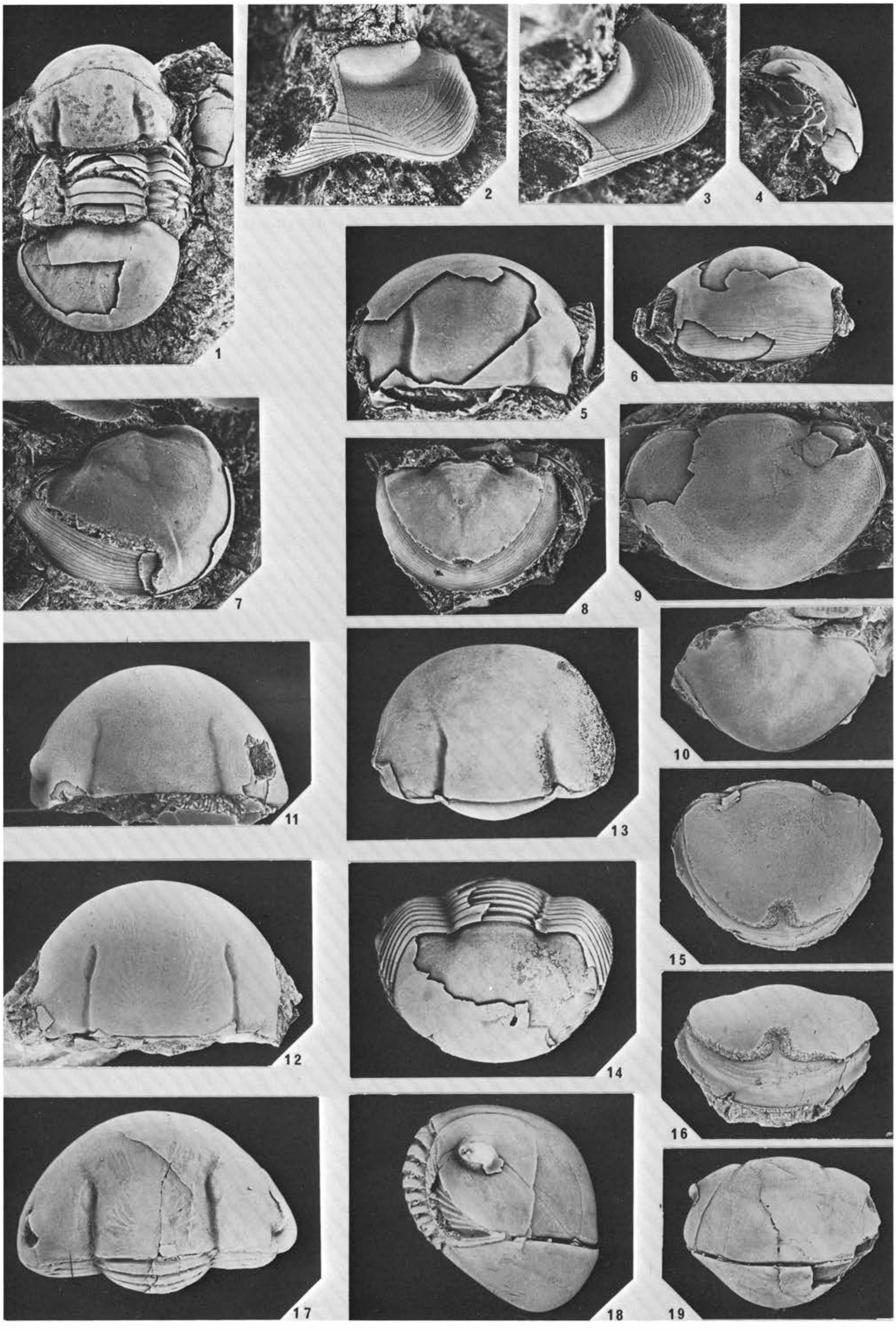
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Plate 3

Figs. 1–20. *Stenopareia glaber* (Kjerulf, 1865).

Figs. 1, 2. Lectotype. Dorsal and right lateral views of internal mould of complete individual, x3, PMO 63891, Upper Chasmops Limestone, Bygdøy, Oslo. Coll. unknown. Original of Kjerulf 1865, Fig. 28 (see Størmer 1943: 49).

Fig. 3. Dorsal view of partly exfoliated complete individual, x1½, PMO 100505, 6.0 m below top of Upper Chasmops Limestone, Terneholmen, Asker. Coll. D. L. Bruton, G. Hamar & F. Nikolaisen 1967.

Fig. 4. Dorsal view of 'long' cranidium, x2, UM D, Kullsberg Limestone, Amtjärn, Siljan district, Sweden, Coll. Excursion 1935.

Figs. 5–7. Left lateral, dorsal and anterior views of small individual showing terrace line pattern on cranidium, Fig. 5 x5, Fig. 6 x4, Fig. 7 x6½, PMO 100503, 7.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. D. L. Bruton 1967.

Fig. 8. Palpebral view of 'short' cranidium, x2½, UM D20, Kullsberg Limestone, Kullsberg, Siljan district, Sweden. Coll. E. Warburg. Original of Warburg 1925, Pl. 2: 34, 35.

Figs. 9–11. Anterior, palpebral and right lateral views of internal mould of 'long' cranidium, x1½, PMO 100574, Upper Chasmops Limestone, Ostøya, Bærum. Coll. P. von Weymann 1934.

Figs. 12, 13. Palpebral and right lateral views of internal mould of 'short' cranidium, x2, PMO 100504, same horizon, locality and collection as Figs. 9–11.

Figs. 14, 15. Paralectotype. Palpebral and anterior views of 'long' cranidium, x2, PMO 101535, Upper Chasmops Limestone, Bygdøy, Oslo. Coll. unknown.

Figs. 16, 17. Dorsal and right lateral views of internal mould of 'long' pygidium prepared to show doublure, x2, PMO 101378, 6.0 m below top of Upper Chasmops Limestone, Persteilen, Oslo. Coll. D. L. Bruton 1967.

Figs. 18, 19. Palpebral view of internal mould of cranidium and posterior view of cranidium and thorax of complete individual, x2, PMO 100583, Upper Chasmops Limestone, Fornebu, Bærum. Coll. F. Nikolaisen 1952.

Fig. 20. Dorsal view of free cheek and eye, x4, PMO 100582, Upper Chasmops Limestone, Ostøya, Bærum. Coll. P. von Weymann 1934.

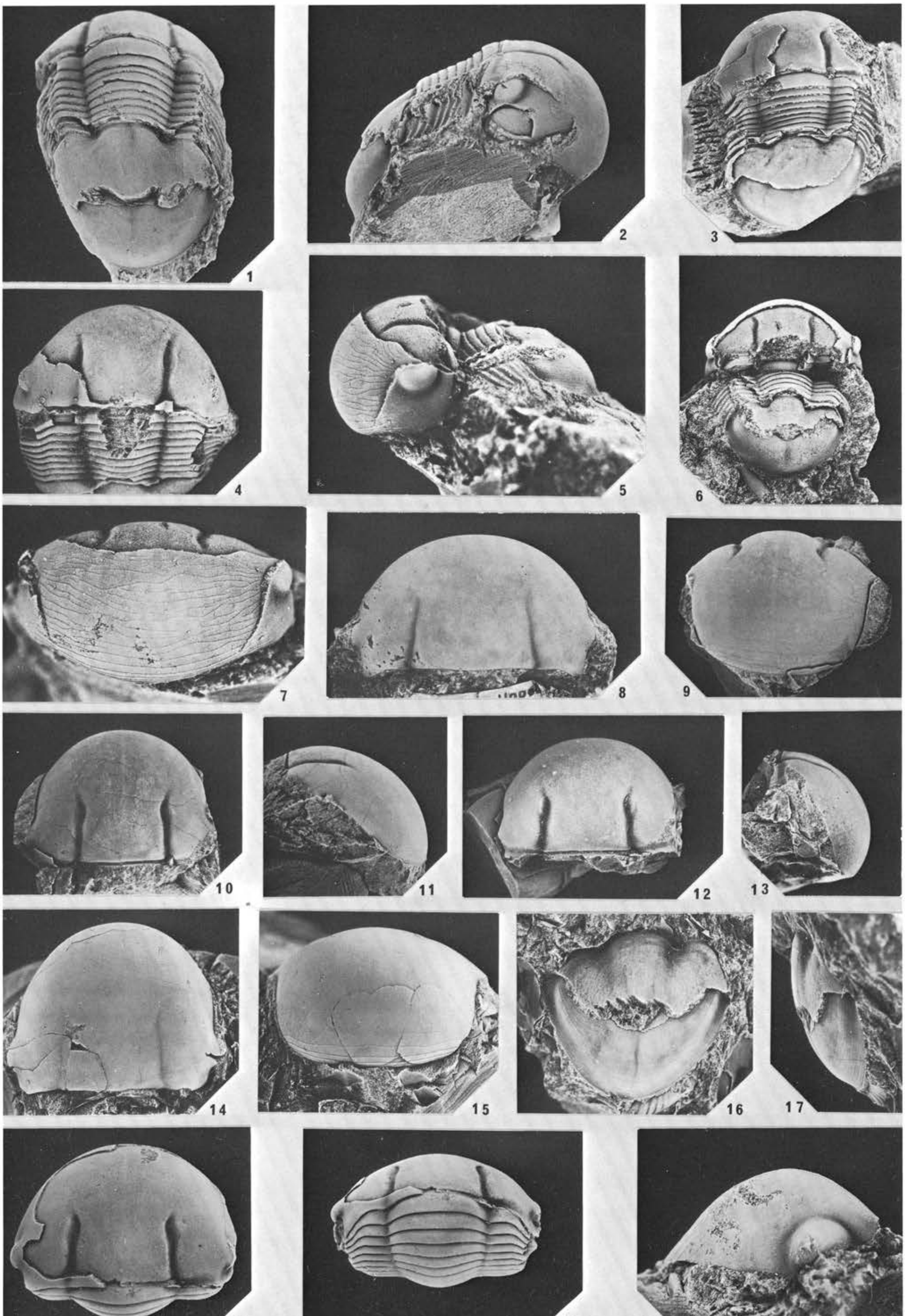
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Plate 4

Figs. 1–17. *Stenopareia glaber* (Kjerulf, 1865).

Fig. 1. Left lateral view of enroled specimen showing detail of cheek doublure and tips of plaurae lying in vincular groove, x4, PMO 100583, Upper Chasmops Limestone, Fornebu, Bærum. Coll. F. Nikolaisen 1952.

Fig. 2. Ventral view of pygidium showing terrace lines on doublure, flattened platform area beneath facet and granules on inner surface of dorsal exoskeleton, x5, PMO 100576, Upper Chasmops Limestone, Gåsøya, Bærum. Coll. N. Spjeldnæs 1951.

Fig. 3. Ventral view of cheek doublure showing pattern of terrace lines in the vincular groove, x7, PMO 100582, Upper Chasmops Limestone, Ostøya, Bærum. Coll. P. von Weymann 1934.

Fig. 4. Ventral view of cephalon showing rostral plate and hypostoma, x2½, 100565, Upper Chasmops Limestone, Raudskjer, Asker. Coll. N. Spjeldnæs 1953.

Fig. 5. Oblique posterior view of pygidium prepared to show inner cuspate margin of doublure, x3, PMO 100579, Solvang Fm., Rud, Røysetangen, Ringerike. Coll. L. Størmer, N. Spjeldnæs & F. Hagemann 1955.

Figs. 6, 14. Paralectotype. Dorsal view of internal mould of pygidium prepared and enlarged to show mould of external surface of doublure and cuspate margin, inner surface of doublure bearing granules and mould of inner surface of dorsal exoskeleton showing pits which are impressions of the granules, Fig. 6 x5, Fig. 14, x2, PMO 101536, Upper Chasmops Limestone, Bygdøy, Oslo. Coll. unknown.

Fig. 7. Lateral view of free cheek showing border notch and terrace lines forming marginal rim, x4, PMO 100581, Upper Chasmops Limestone, Ostøya, Bærum. Coll. P. von Weymann 1934.

Figs. 8, 9. Rostral plate and ventral view showing connective sutures and triangular rostral flange, Fig. 8 x5, Fig. 9 x3, PMO 100504, same horizon, locality and collection as Fig. 7.

Figs. 10–12. Left lateral, dorsal and anterior views of hypostoma, Figs. 10, 12 x7, Fig. 11 x4, PMO 100572, same horizon, locality and collection as Fig. 7.

Fig. 13. Ventral view of cephalon showing rostral plate and rostral and connecting sutures, x3, same specimen as Pl. 3: 18.

Figs. 15, 16. Dorsal and right lateral view of internal mould of pygidium, x2, PMO 100577, same horizon, locality and collection as Fig. 7.

Fig. 17. Dorsal view of pygidium, x3, PMO 100578, same horizon, locality and collection as Fig. 7.

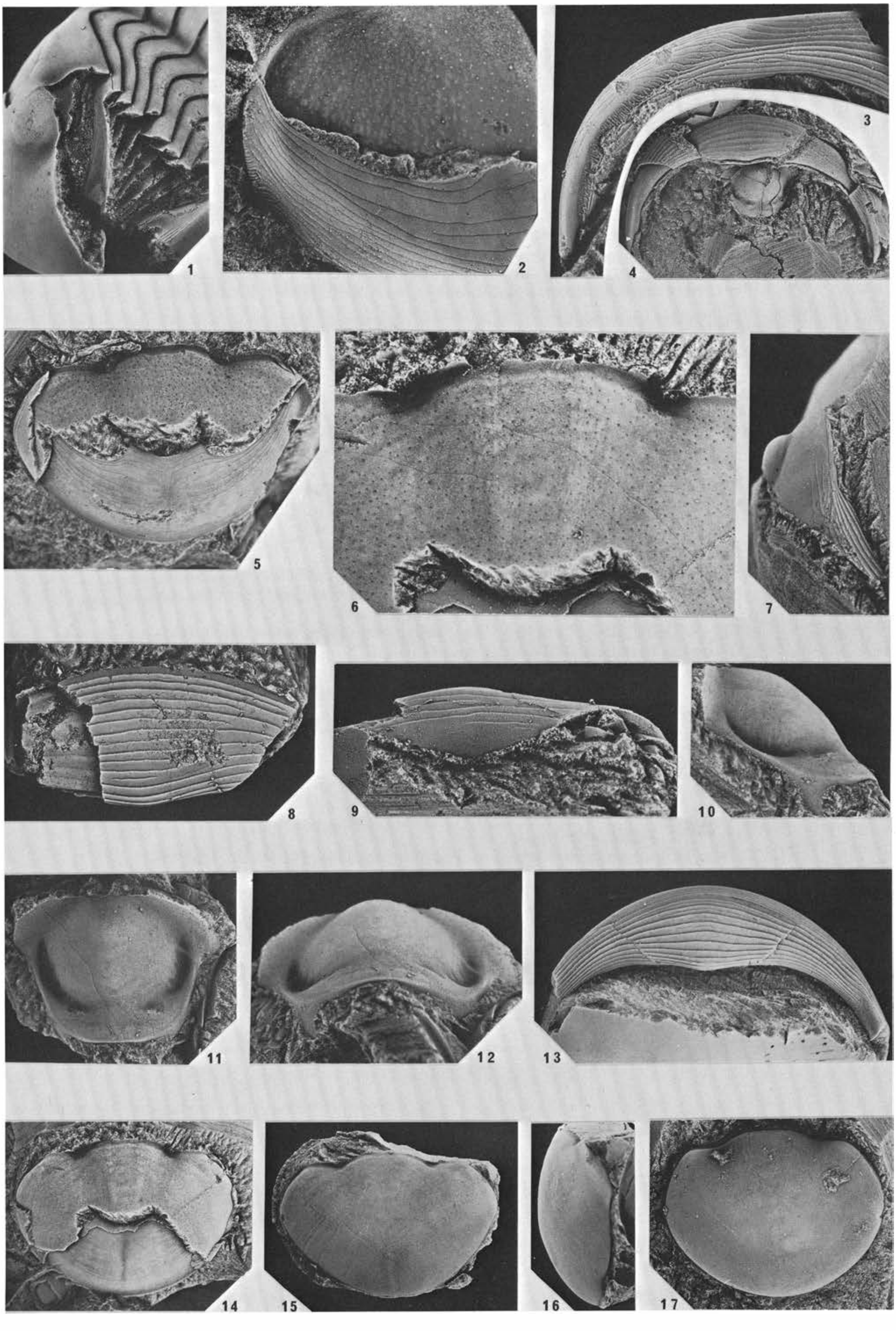
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Plate 5

Figs. 1–3. *Illaenus (Parillaenus) roemeri* Volborth, 1864.
Dorsal, ventral and oblique left lateral views of enroled individual, note steep inner margin of pygidial doublure, x2, Sveriges Geologiska Undersökning unnumbered, Boda Limestone, Kallholn, Siljan district, Sweden. Coll. von Schmalensée 1909. Original of Warburg 1925, Pl. 1: 28, 29.

Figs. 4, 5. *Decoroproetus* sp. A.
Fig. 4. Slightly oblique dorsal view of silicone rubber cast of external surface of free cheek showing large eye socle, x8, PMO 100593, 11.8–12.2 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 5. Dorsal view of slightly exfoliated free cheek, x6, PMO 100383, 12. 2 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. & T. Bockelie 1968.

Fig. 6. *Decoroproetus* sp. B.
Ventral view of external mould of free cheek, x14, HM A14528/1a, 2.35–2.52 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. D. L. Bruton, J. K. Ingham & A. W. Owen 1975.

Figs. 7, 8, 11. *Mesotaphraspis bockeliei* n. sp.
Figs. 7, 11. Dorsal and right lateral views of holotype cranidium, x18, PMO 100388, 10.0–11.0 m below top of Upper Chasmops Limestone, Bygdøy, Oslo. Coll. D. L. Bruton & J. F. Bockelie 1972.
Fig. 8. Dorsal view of internal mould of paratype cranidium showing pitting, specimen slightly flattened, x16, PMO 100381, 18.10–18.25 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.

Figs. 9, 10, 12–15, 18. *Harpidella (s. l.)* sp. A.
Figs. 9, 10. Dorsal and oplique left anterolateral views of cranidium with an unusually blunt-ended glabella, both x9, PMO 100478, 2.25 m below top op Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 12. Dorsal view of cranidium, x6, PMO 100498, 2.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Figs. 13, 14. Dorsal and anterior views of cranidium, Fig. 13 x8, Fig. 14 x9, PMO 100397, 8.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1969.
Fig. 15. Dorsal view of cranidium showing palpebral lobe, x9, PMO 100396, 15.3 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 18. Lateral view of free cheek, x12, PMO 100828, 3.55–3.90 m below top of Solvang Fm., Norderhov, Ringerike. Coll. J. F. Bockelie 1978.

Figs. 16, 17. *Harpidella (s. l.)* sp. B.
Dorsal and anterior views of cranidium, Fig. 16 x8, Fig. 17 x9, PMO 94436, 1.5–1.6 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. D. L. Bruton & G. Hamar 1966.

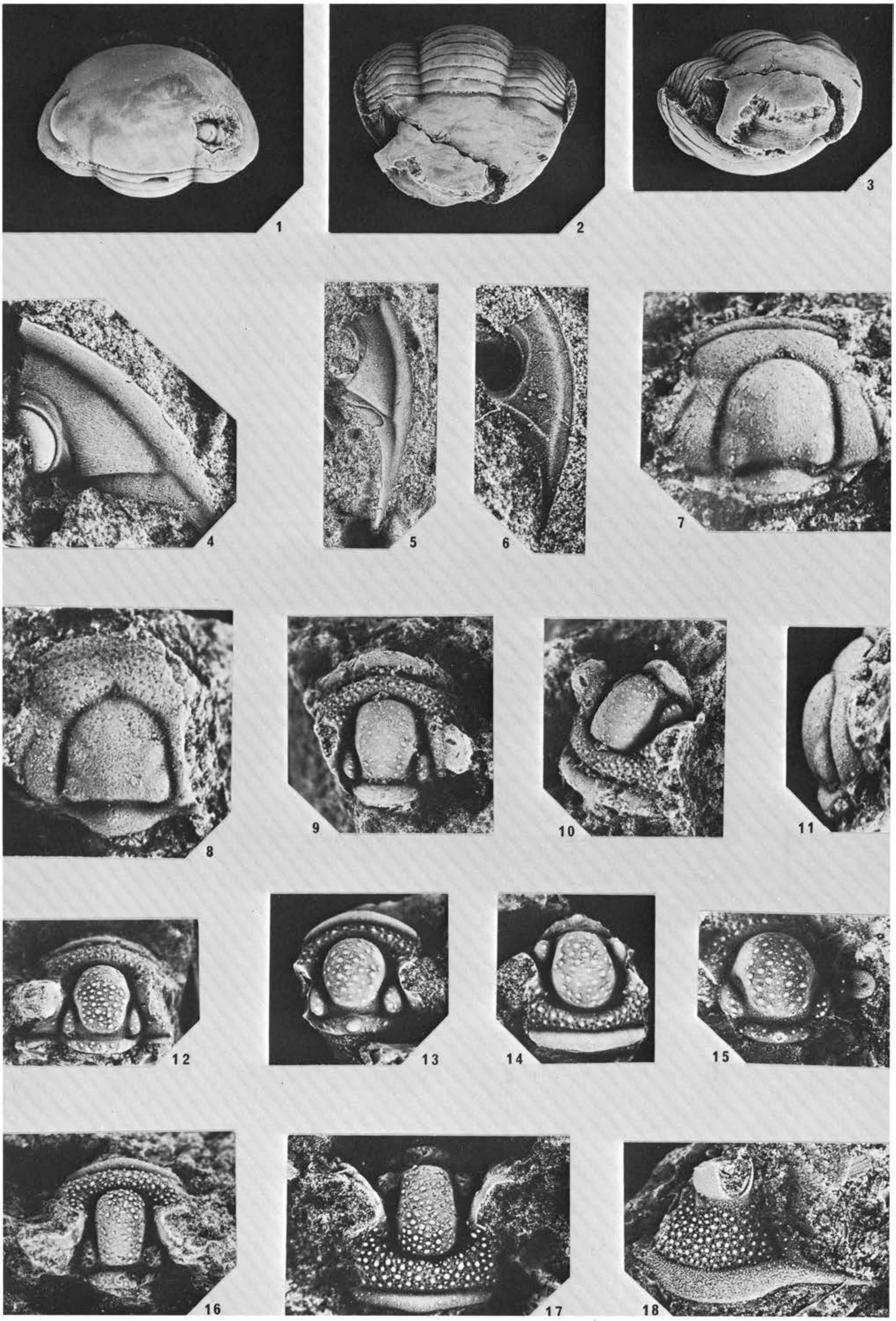
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Plate 6

Figs. 1–7. *Dionide magnifica* n. sp.

Figs. 1, 3. Dorsal views of holotype cephalon with attached thoracic segments. Fig. 1 silicone rubber cast of external mould, x4, PMO 6527. Fig. 3 upper lamella broken off on left side revealing lower lamella, x2½, PMO 6528/1a, upper part of Upper Chasmops Limestone (probably 2.0 m below top), Terneholmen, Asker. Coll. J. Kiær 1922.

Fig. 2. Dorsal view of latex peel of paratype pygidium, x2½, PMO 6528/2b, same horizon, locality and collection as Fig. 1. Fig. 4. Dorsal view of exfoliated cephalon with much of the upper lamella missing, x2½, PMO 5653, same horizon, locality and collection as Fig. 1.

Fig. 5. Ventral view of paratype hypostoma lacking most of the exoskeleton, x6, PMO 81151, uppermost part of Upper Chasmops Limestonme, Terneholmen, Asker. Coll. N. Spjeldnæs 1951.

Figs. 6, 7. Dorsal and oblique left anterolateral views of internal mould of cephalon showing the two median glabellar tubercles, Fig. 6 x4, Fig. 7 x3½, PMO 81209, 2.0 m below top of Upper Chasmops Limestone, Terneholmen, Asker. Coll. J. F. Bockelie 1968.

Figs. 8, 9, 11–17. *Ampyxella aculeata* Angelin, 1854.

Figs. 8, 12. Dorsal and left lateral views of incomplete, partly exfoliated pygidium showing the very steep border bearing a large number of terrace lines, both x3, PMO 93709, 2.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. F. Nikolaisen 1968.

Figs. 9, 11. Dorsal and right lateral views of almost complete specimen retaining most of the exoskeleton, the occipital spine and surrounding matrix were removed to enable the dorsal view to be photographed, Fig. 9 x3, Fig. 11 x2½, PMO 63443, uppermost part of Upper Chasmops Limestone, Rambergøya, Oslo. Coll. Excursion 1921.

Fig. 13. Dorsal view of internal mould of pygidium with thoracic segments attached, x5, PMO 100386, 3.6–3.8 m below top of Upper Chasmops Limestone, West Raudskjer, Asker. Coll. J. F. Bockelie 1967.

Figs. 14, 16. Dorsal and slightly oblique left anterolateral views of cephalon showing course of facial suture and long genal spine, Fig. 14 x1½, Fig. 16 x2, PMO 93712, Upper Chasmops Limestone, East Raudskjer, Asker. Coll. D. L. Bruton 1968.

Fig. 15. Oblique right anterolateral view of lectotype cranidium, x6, RM Ar 36892, Upper Chasmops Limestone, probably from Gåsøya, Bærum. Coll. unknown. Original of Angelin 1854, Pl. 40: 5, 5a, 5c, 5d.

Fig. 17. Dorsal view of silicone rubber cast of paralectotype pygidium, x8, RM Ar 36891, same horizon and locality as Fig. 15. Coll. unknown. Original of Angelin 1854, Pl. 40: 5b.

Fig. 10. Harpid gen. et sp. indet.

Dorsal view of silicone rubber cast of the anterior part of cranidium, x2½, PMO 9385, 2.35–2.52 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. J. Kiær 1914.

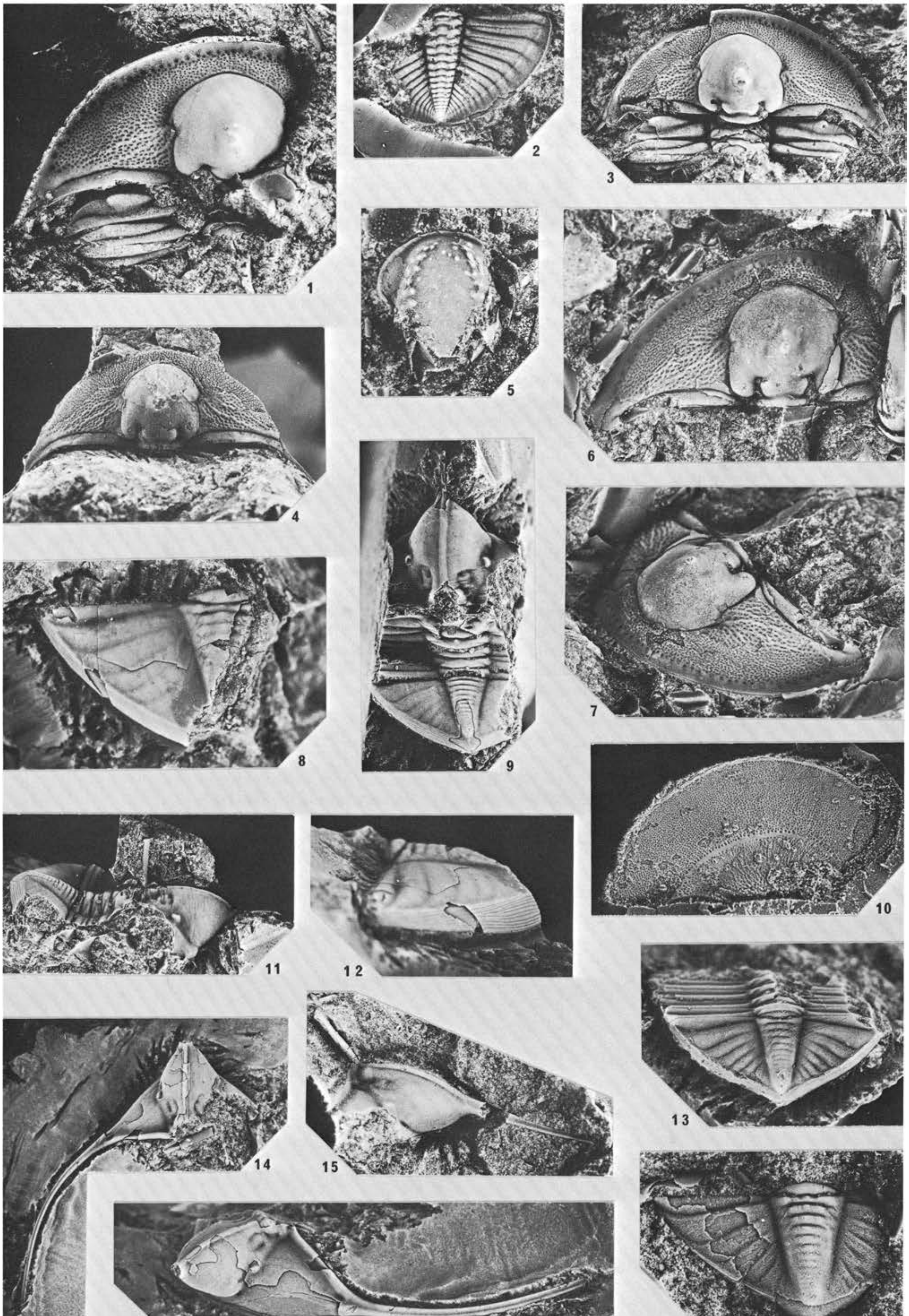
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Plate 7

Figs. 1–13. *Lonchodomas* aff. *pennatus* (LaTouche, 1884).
Fig. 1. Dorsal view of cranidium bearing a very dense, coarse pitting on the external surface, internal mould bears a dense, fine pitting, x6, PMO 100588, 8.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. F. F. Bockelie 1968.
Fig. 2. Dorsal view of partially exfoliated, almost complete specimen, x2, PMO 100491, same horizon and locality as Fig. 1. Coll. D. L. Bruton 1970.
Figs. 3, 13. Dorsal and oblique lateral views of partly exfoliated complete specimen and cephalon of an enroled individual, Fig. 3 x1½, Fig. 13 x1, PMO 100488, same horizon and locality as Fig. 1. Coll. D. L. Bruton 1970.
Figs. 4–6. Dorsal, slightly oblique posterior and lateral views of partially exfoliated pygidium showing muscle scars on the rachis and terrace lines on the border, all x3, PMO 100490, same locality and horizon as Fig. 1. Coll. D. L. Bruton 1970.
Fig. 7. Ventral view of internal mould of hypostoma, x6½, PMO 31030, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. L. Størmer.
Fig. 8. Dorsal view of small pygidium showing pitting on pleural areas, x18, PMO 100384, same horizon, locality and collection as Fig. 1.
Figs. 9–11. Detail of facial suture, dorsal view of partially exfoliated cephalon with attached thorax and pygidium and ventral view of cephalic doublure, Fig. 9 x3, Fig. 10 x1½, Fig. 11 x3, PMO 100489, same horizon and locality as Fig. 1. Coll. D. L. Bruton 1970.
Fig. 12. Detail of proximal part of genal spine showing terrace lines, x4½, PMO 100493, same horizon and locality as Fig. 1. Coll. D. L. Bruton 1970.

Figs. 14–18. *Ampyxina?* sp.
Figs. 14, 15. Dorsal and oblique left lateral views of slightly exfoliated cranidium with smooth exoskeleton, both x12, HM A14565, uppermost bed of Upper Chasmops Limestone, N. E. Nakholmen, Oslo. Coll. A. W. Owen 1975.
Figs. 16, 18. Left lateral and dorsal views of cranidium showing shallow pitting in the external surface of the fixed cheeks, both x9, PMO 100487, 8.6 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 17. Dorsal view of cranidium with smooth external surface, x8, PMO 5395, uppermost bed of Upper Chasmops Limestone, Rambergøya, Oslo. Coll. J. Kiær 1921.

Figs. 19–21. *Raymondella* sp.
Fig. 19. Dorsal view of pygidium retaining exoskeleton, x16, PMO 100379, 2.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 20. Dorsal view of cranidium showing ornament on external surface of fixed cheeks, x13, HM A14556, 1.5–1.6 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. A. W. Owen 1974.
Fig. 21. Dorsal view of slightly exfoliated cranidium, x9, PMO 81082, same horizon and locality as Fig. 19. Coll. F. Nikolaisen 1968.

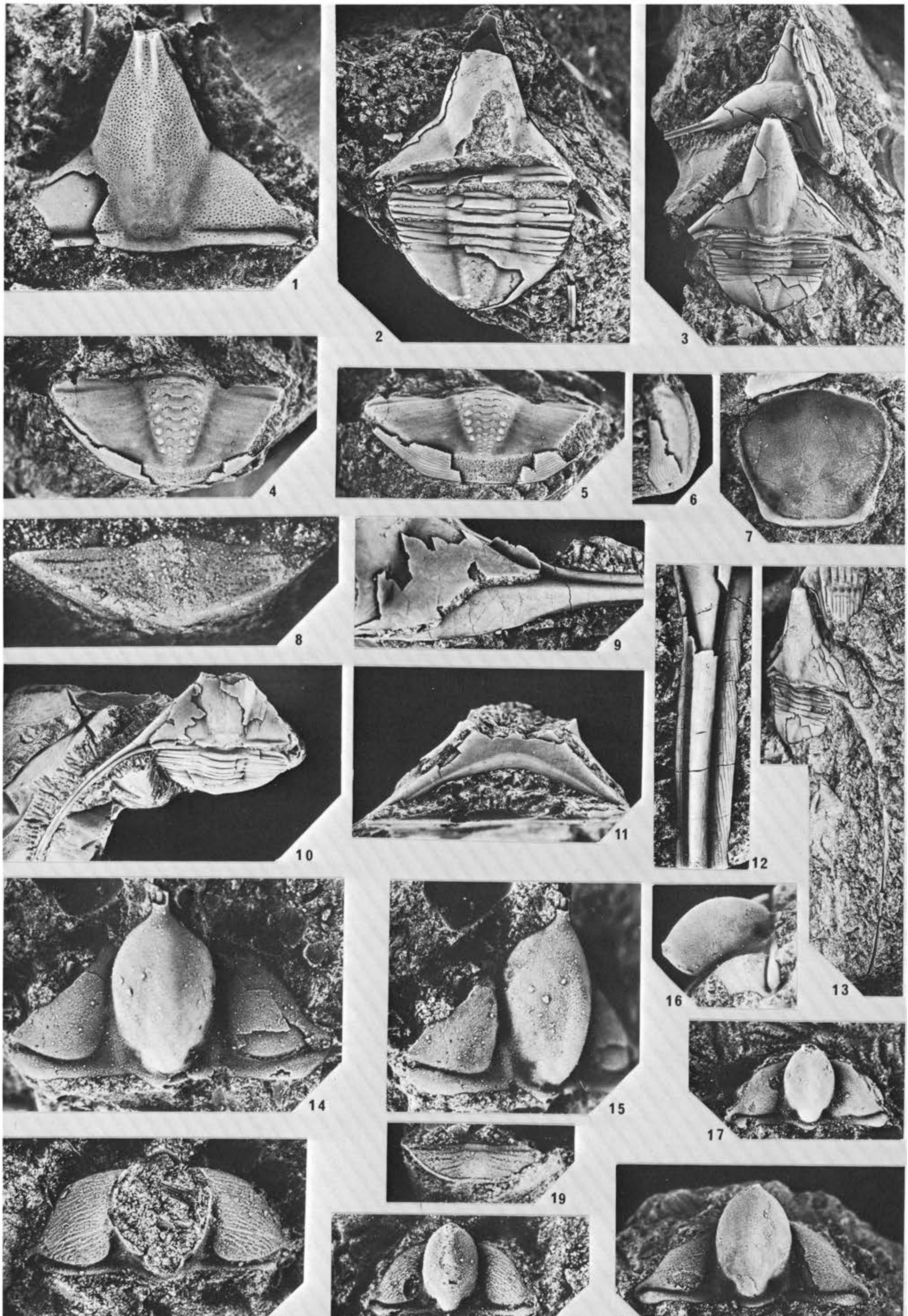
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Plate 8

Figs. 1–3, 10. *Pseudosphaerexochus bulbosus* Nikolaisen, 1965.

Figs. 1–3. Dorsal and left lateral views and detail of surface sculpture of partially exfoliated glabella, Figs. 1, 2 x2, Fig. 3 x4, PMO 100378, 15.6 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.

Fig. 10. Ventral view of free cheek, x4, PMO 100393, 11.25 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.

Figs. 4–9. *Pseudosphaerexochus densigranulatus* Nikolaisen, 1965.

Figs. 4–7. Dorsal, left lateral, left anterolateral and anterior views of internal mould of cranidium, all x3, PMO 94425, 1.5–1.6 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. D. L. Bruton & G. Hamar 1966.

Fig. 8. Dorsal view of partially exfoliated pygidium showing pitting on the internal mould of the rachis, x4½, PMO 94434, same horizon, locality and collection as Figs, 4–7.

Fig. 9. Dorsal view of partially exfoliated pygidium showing pitting on the internal mould of the pleural spines, x3, PMO 9455, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. J. Kiær?

Figs. 11–13. *Sphaerocoryphe* n. sp.?

Dorsal, anterolateral and lateral views of cranidium, Figs. 11, 12 x3, Fig. 13 x5½, PMO 100399, 2.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.

Figs. 14–17. *Deacybele gracilis* (Nikolaisen, 1961).

Fig. 14. Oblique dorsal view of partially exfoliated cranidium showing course of posterior branch of facial suture, x3½, PMO 93715, Upper Chasmops Limestone, Raudskjer, Asker. Coll. D. L. Bruton 1968.

Figs. 15, 16. Oblique anterolateral and dorsal views of internal mould of cranidium showing tubercle-like anterior border, x4½, PMO 81070, 1.7 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. F. Nikolaisen 1967.

Fig. 17. Lateral view of internal mould of free cheek, x4½, PMO 81081, 2.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. F. Nikolaisen 1968.

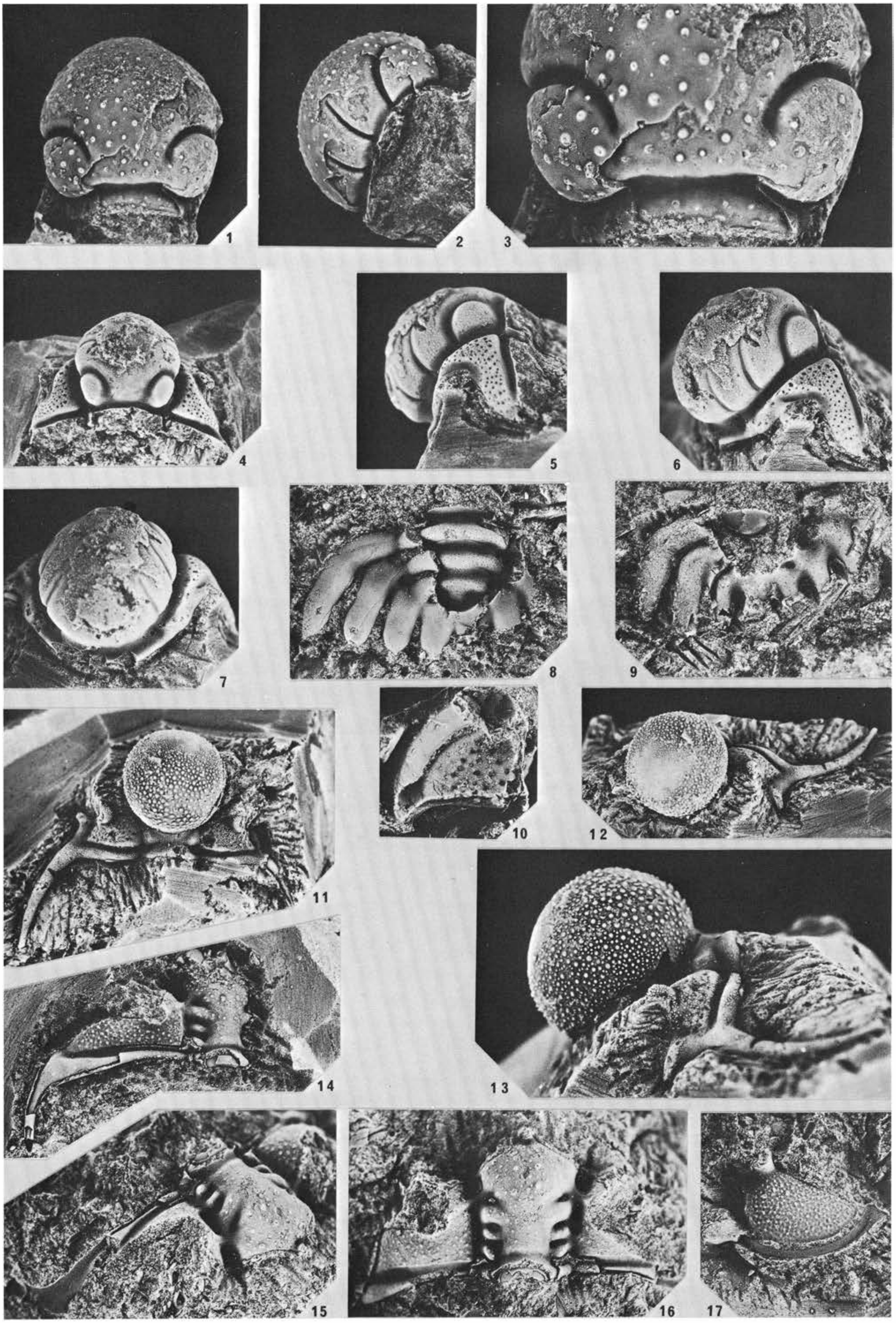
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Plate 9

Figs. 1–7. *Staurocephalus pilafrons* n. sp.
Figs. 1, 2. Dorsal and slightly oblique anterolateral views of silicone rubber cast of external surface of cranidium showing the stump-like occipital spine, both x12, HM A14411/1, upper part of Lieker Mbr. of the Solvang Fm., Lunner, Hadeland. Coll. A. W. Owen & J. K. Ingham 1975.
Fig. 3. Dorsal view of incomplete cranidium showing external surface sculpture, x10, PMO 94427, 1.5–1.6 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. D. L. Bruton & G. Hamar 1966.
Fig. 4. Dorsal view of holotype cranidium showing glabellar lobation and shape of fixed cheeks, x8, PMO 67044, Upper Chasmops Limestone (almost certainly uppermost part), Terneholmen, Asker. Coll. V. Jaanusson. Original of Kielan 1957, Pl. 4: 3; Text Fig. 4.
Fig. 5. Dorsal view of incomplete cranidium showing external surface sculpture, x9, PMO 100477, 1.7 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. D. L. Bruton, G. Hamar & F. Nikolaisen 1967.
Fig. 6. Dorsal view of paratype pygidium, note tubercles on pleural ribs, x17, PMO 100829, 2.60–2.65 m below top of Solvang Fm., Norderhov, Ringerike. Coll. D. L. Bruton 1978.
Fig. 7. Dorsal view of very small pygidium, x25, HM A11517/1, 15.54 m below top of Lieker Mbr. of the Solvang Fm., Railway section, Lunner, Hadeland. Coll. A. W. Owen 1974.

Figs. 8, 9. *Flexicalymene* sp.
Fig. 8. Dorsal view of internal mould of cranidium, x2, HM A11613/3, uppermost bed of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. A. W. Owen 1974.
Fig. 9. Dorsal view of internal mould of pygidium, x3½, PMO 94429, 1.5–1.6 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. D. L. Bruton & G. Hamar 1966.

Figs. 10, 11, 13–15. *Prionocheilus* aff. *obtusus* (McCoy, 1846).
Fig. 10. Dorsal view of internal mould of pygidium, x4½, PMO 100391, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. L. Størmer & P. E. Raymond ?1935.
Fig. 11. Dorsal view of partially exfoliated cranidium showing external surface sculpture of glabella, x9, PMO 98156, 4.47–4.57 m below top op Solvang Fm., Norderhov, Ringerike. Coll. A. W. & G. Owen 1977.
Fig. 13, 14. Dorsal and left lateral views of internal mould of cranidium showing spine bases on anterior border, both x4, PMO 61130, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. L. Størmer & P. E. Raymond ?1935.
Fig. 15. Dorsal view of internal mould of cranidium showing spine bases on anterior border and fine pitting on the preglabellar area and fixed cheeks, x5, HM A14528/1a, 2.35–2.52 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. D. L. Bruton, J. K. Ingham & A. W. Owen 1975.

Fig. 12. *Prionocheilus narinosus* (Siveter, 1977).
Dorsal view of internal mould of cranidium, x2, PMO 100484, 4.0 m below top of Upper Chasmops Limestone, near Strøm Farm, Snarøya, Bærum. Coll. J. F. Bockelie

Figs. 16–22. *Calyptaulax* aff. *norvegicus* Størmer, 1945.
Figs. 16–18. Dorsal, oblique left anterolateral and anterior views of partially exfoliated cephalon, all x4, PMO 100374, 8.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 19. Dorsal view of internal mould of cranidium showing fine pitting, x3, PMO 100380, 8.2 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Figs. 20, 21. Dorsal and oblique left anterolateral views of internal mould of cranidium showing pitting and shape of fixed cheek, both x3½, PMO 100392, 4.25 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 22. Dorsal view of internal mould of pygidium, x3, PMO 100592, Upper Chasmops Limestone, islet between Nesøya and the mainland (probably S. Kuholmen), Asker. Coll. N. Spjeldnæs 1950.

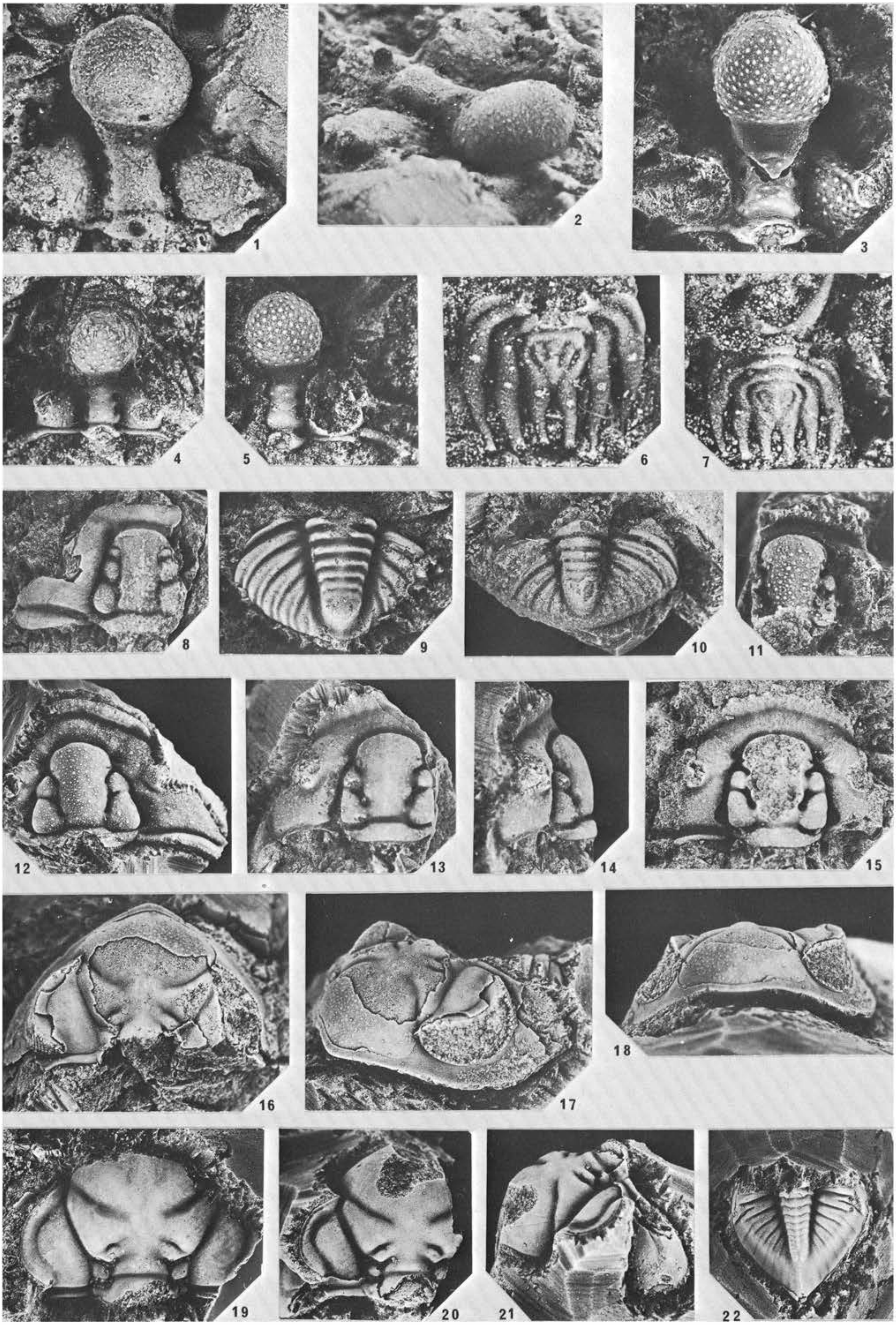
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Plate 10

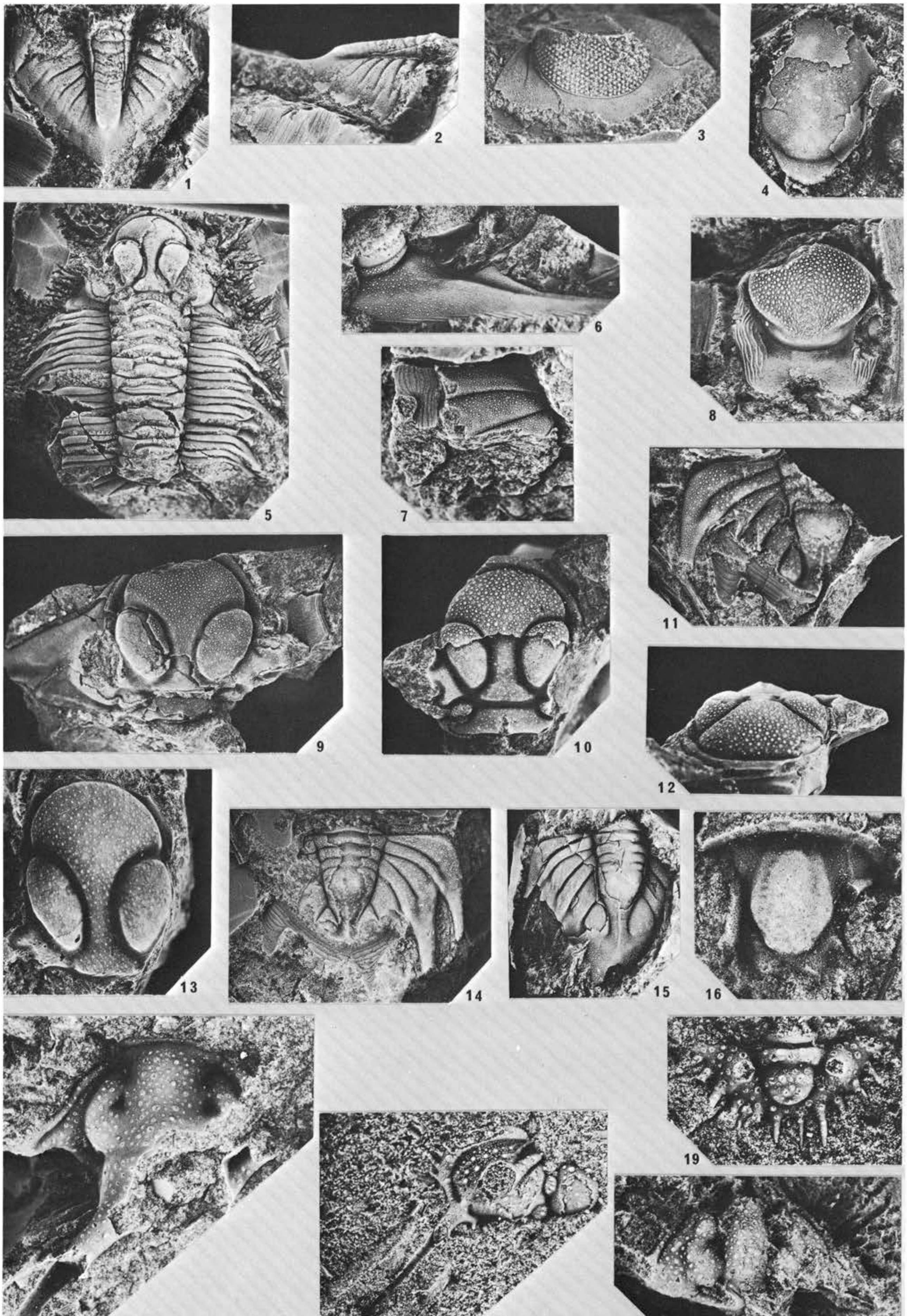
Figs. 1–4. *Calyptaulax* aff. *norvegicus* Størmer, 1945.
Figs. 1, 2. Dorsal and right lateral views of almost completely exfoliated pygidium, both x3, PMO 100400, 8.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1969.
Fig. 3. Lateral view of silicone rubber cast of free cheek (external mould of specimen on Pl. 9: 16–18) showing eye surface, x4, PMO 100375, same horizon and locality as Figs. 1, 2. Coll. J. F. Bockelie 1968.
Fig. 4. Ventral view of partially exfoliated hypostoma, x6, PMO 100869, 5.3 m below top of Upper Chasmops Limestone, Ostøya, Bærum. Coll. D. L. Bruton 1978.

Figs. 5–15. *Platylichas laxatus* (McCoy, 1846).
Figs. 5, 7. Dorsal view of partially exfoliated cranidium, thorax and left anterior part of pygidium. Fig. 7 shows a panderian notch from the anterolateral corner of the pygidium. Fig. 5 x1½, Fig. 7 x3½, PMO 100395, 1.15–1.95 m below top of Upper Chasmops Limestone, West Raudskjer, Asker. Coll. J. F. Bockelie 1967.
Fig. 6. Lateral view of silicone rubber cast of external mould of free cheek, x2, PMO 100591, Upper Chasmops Limestone, Bjørkøya, Asker. Coll. J. F. Bockelie 1967.
Fig. 8. Ventral view of internal mould of hypostoma, x3½, PMO 100385, 3.6–3.8 m below top of Upper Chasmops Limestone, West Raudskjer, Asker. Coll. J. F. Bockelie 1967.
Fig. 9. Dorsal view of partially exfoliated cephalon with a broad glabella, x1½, PMO H2568, Upper Chasmops Limestone Terneholmen, Asker. Coll. J. Kiær 1921.
Figs. 10, 12. Dorsal and anterior views of partially exfoliated cranidium with a 'broad' glabella, both x3, PMO H2562, Lake Slepene (probably S. Kuholmen), Asker. Coll. unknown. Original of *Lichas sexspinus* Angelin (1854, Pl. 38: 7), also figured by Warburg (1939, Pl. 12: 10).
Fig. 11. Dorsal view of partially exfoliated incomplete pygidium showing doublure, x2, PMO 100382, 8.0 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 13. Dorsal view of internal mould of 'narrow' glabella, x3, PMO 63535, Upper Chasmops Limestone, Bygdøy, Oslo. Coll. T. Ørvig 1941.
Fig. 14. Dorsal view of partially exfoliated pygidium showing external surface ornament, shape of pleural ribs and doublure, x2, PMO H2563, same horizon and locality as Figs. 10, 12. Coll. unknown. Original of *Lichas sexspinus* Angelin (1854, Pl. 38: 8a), also figured by Warburg (1939, Pl. 10: 11).
Fig. 15. Dorsal view of silicone rubber cast of external mould of incomplete pygidium, x1½, PMO 5432, uppermost bed of Upper Chasmops Limestone, Nakholmen, Oslo. Coll. J. Kiær 1921.

Fig. 16. Trilobite gen. et sp. indet.
Ventral view of internal mould of hypostoma, x10, PMO H216, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. J. Kiær 1921.

Figs. 17, 19. *Apianurus thorslundi* Bruton, 1965.
Fig. 17. Dorsal view of incomplete cranidium, x8, PMO 100500, 15.8 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.
Fig. 19. Dorsal view of pygidium, x14, PMO 100501, 16.5 m below top of Upper Chasmops Limestone, East Raudskjer, Asker. Coll. J. F. Bockelie 1968.

Figs. 18, 20. *Miraspis* sp.
Fig. 18. Dorsal view of silicone rubber cast of external mould of incomplete cephalon, x8, PMO 9328, Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. J. Kiær 1914. Fig. 20. Dorsal view of incomplete cranidium, x6½, PMO 94431, 1.5–1.6 m below top of Høgberg Mbr. of the Solvang Fm., N. W. Frognøya, Ringerike. Coll. D. L. Bruton & G. Hamar 1966.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