SILURIAN TRILOBITES FROM SCANDINAVIA

by

Gregory James Helbert B.Sc.Hons. (London)

A thesis submitted for the degree of

Doctor of Philosophy

at the University of Keele

1985

--oOOOo--

BEST COPY

AVAILABLE

Poor quality text in the original thesis.

Page numbers cut off in original.

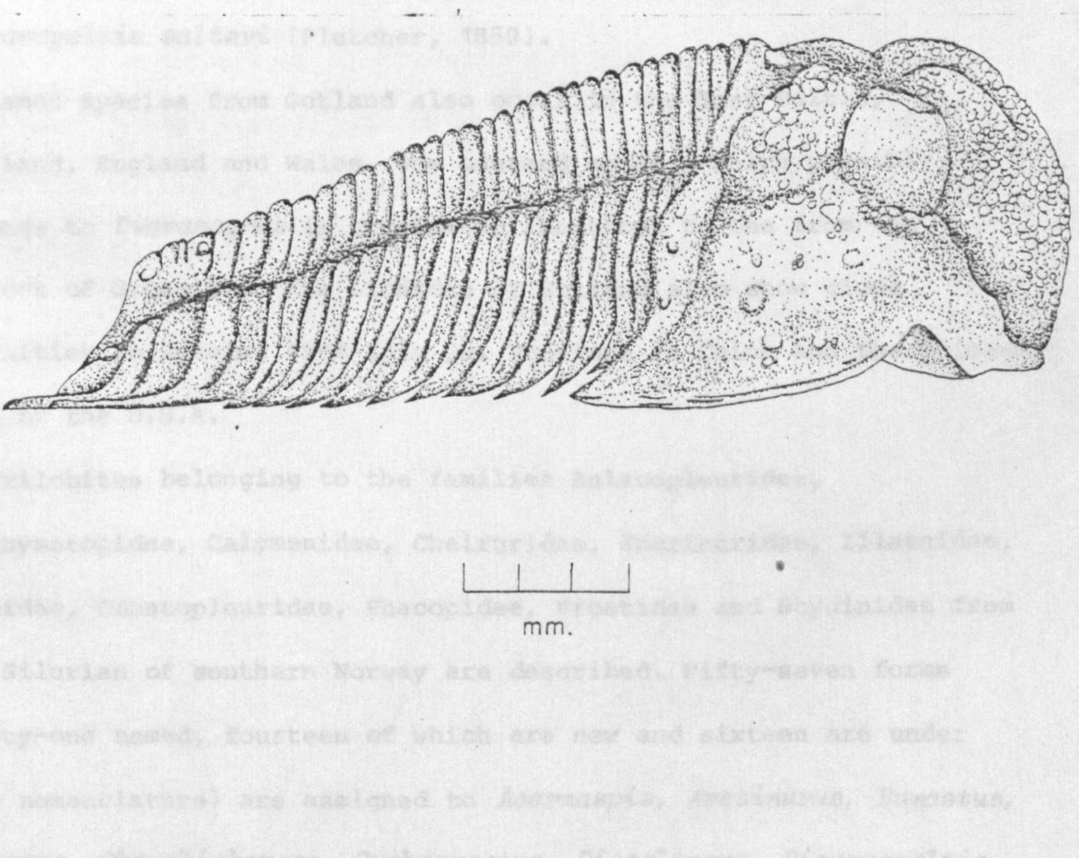
Page numbering as original.

Contains pullouts

Jherek echoed her sigh. "There's probably a knack to it," he admitted. "Where are the trilobites?" He stared absently around him at the ground.

"Pom te pom, pom pom pom, te pom pom"- wading a little further through the shallow water, pausing to raise a red and goose pimpled foot and to brush at two or three wheat-coloured trilobites which had begun to climb his leg. "Funny little beggars," he was heard to mutter, but did not seem to mind their curiosity.

(Michael Moorcock. *The dancers at the end of time*, 1976, pp. 358, 370).



Abstract

Trilobites of the family Lichidae are described from the Silurian of Gotland, Sweden. Nineteen species (fourteen of which are named, two new) are assigned to *Acanthopyge, Choneiliobarges, Craspedarges, Dicranopeltis, Lichas, Platylichas* and *Pseudotupolichas*. *Trimerolichas* Phleger, 1936 is considered to be a junior subjective synonym of *Lichas* Dalman, 1827.

L. gotlandicus Angelin, 1854 and *L. palifer* Lindström, 1885 are respectively considered to be subjective synonyms of *Lichas latifrons* Angelin, 1854 and *Lichas araneus* Lindström, 1885. *L. triquetrus* Lindström, 1885 is considered to be a juniour subjective synonym of *Dicranopeltis salteri* (Fletcher, 1850).

Named species from Gotland also occur in the East Baltic, Scotland, England and Wales. One unnamed species which possibly belongs to *Dicranogmus* is considered identical to one from the Wenlock of Greenland. The Lichidae of Gotland also show close affinities to species from Ejin Qui Province in China and the Chicago area of the U.S.A.

Trilobites belonging to the families Aulacopleuridae, Brachymetopidae, Calymenidae, Cheiruridae, Encrinuridae, Illaenidae, Lichidae, Odontopleuridae, Phacopidae, Proetidae and Styginidae from the Silurian of southern Norway are described. Fifty-seven forms (forty-one named, fourteen of which are new and sixteen are under open nomenclature) are assigned to *Acernaspis, Arctinurus, Bumastus, Calymene, Choneiliobarges, Cyphoproetus, Diacalymene, Dicranopeltis, Dudleyaspis, Eccairos* gen. nov., *Ekwanoscutellum, Encrinurus, Eophacops, Hadromeros, Harpidella, Hedstroemia, Leonaspis, Lichas, Opsypharus, Platylichas, Proetus, Pseudotupolichas*, and *Warburgella*.

Illaenus rotundus Kiær, 1908, *Illaenus sculptus* Kiær, 1908 and *Illaenus thomsoni* Salter, 1867 are considered junior subjective synonyms of *Stenopareia glaber* (Kjerulf, 1865). *Bumastus*? *phrix* Lane & Thomas, 1978 and *B. depressus* Kiær, 1908 are respectively considered to be junior subjective synonyms of *Bumastus? inflatus* (Kiær, 1908) and *Opsypharus maccallumi* (Salter, 1867). Named species from the Silurian of southern Norway occur also in Canada, the East Baltic, England, Gotland, Sweden and Wales.

Similar trilobite associations to those found in the Silurian of southern Norway have been recorded from the U.K. and the East Baltic. These associations are consistent with a shallow water environment, as shown by work on other fossil groups and by sedimentological evidence. Abundant faunas from the Llandovery and early Wenlock are dominated by associations of *Acernaspis* with species of *Encrinurus* and "illaenimorph" trilobites. An abundant fauna from the upper Wenlock has yielded an association of *Warburgella* with *Calymene* species and *Proetus (Proetus)*.

Silurian trilobites from Scandinavia

Part one

The Lichidae of Gotland, Sweden

pp.1-88, pls 1-7.

Contents

Introduction

Acknowledgements

History of research

Specimen numbers

Stratigraphy

Localities

Preservation

Terminology

Systematic descriptions

Lichidae Hawle & Corda, 1847

Lichinae Hawle & Corda, 1847

Lichas Dalman, 1827

Dicranopeltis Hawle & Corda, 1847

Pseudotupolichas Phleger, 1936

Homolichinae Phleger, 1936

Platylichas Gürich, 1901

Ceratarginae Tripp, 1957

Acanthopyge Hawle & Corda, 1847

Choneliobarges Phleger, 1936

Craspedarges Gürich, 1901

Dicranogmus? Hawle & Corda, 1847

Introduction

The purpose of the work presented in this thesis has been to study the trilobites of the family Lichidae from the Silurian of Gotland, Sweden, to provide up-to-date descriptions of the species which occur, to revise their taxonomy and to establish their stratigraphic and geographic distribution.

The generic and specific groupings used herein largely follow those of Holloway & Thomas (in prep.). The diagnoses however are those of the author unless otherwise specified.

Other trilobite forms which occur on Gotland which have recently been revised are the Cheiruridae (Ramsköld 1983) and Odontopleuridae (Ramsköld 1984); work on other trilobite groups is also being currently undertaken by other authors.

There have been studies of other fossil groups from Gotland e.g. tentaculitids (Larsson 1979), brachiopods (Bassett & Cocks 1974), chitinozoa (e.g Laufeld 1974a), ostracodes (Martinsson 1962, 1966, 1967), stromatoporoids (Mori 1968, 1970), eurypterids (Selden 1981) and epizoans (Hurst 1974).

Acknowledgements

I am deeply grateful to Dr P. D. Lane for suggesting that the Silurian trilobites of southern Norway and the Lichidae of Gotland, Sweden would be worthwhile subjects for research and for his introducing me to trilobite studies.

I thank Professor G. Kelling for the use of Keele University Geology Department facilities.

I also wish to acknowledge discussion with Drs A. T. Thomas, D. J. Holloway, Derek J. Siveter, A. W. Owen, R. M. Owens, Reet Männil, M. Bassett and Professor N. Spjeldnaes. Special thanks go to Dr B. Gudveig Baarli for introducing me to the Silurian rocks of the Oslo region in the field and for presenting several fine specimens.

I have pleasure in thanking the following for placing collections in their care at my disposal: Prof. V. Jaanusson & Mr L. Ramsköld, Naturhistoriska Riksmuseet, Stockholm. Dr R. M. Owens, National Museum of Wales, Cardiff. Dr A. W. A. Rushton, Geological Survey Museum, British Geological Survey, London. Dr S. Laufeld, Sveriges Geologiska Undersökning, Uppsala. Dr R. A. Fortey, British Museum (Natural History), London. Dr D. L. Bruton & Dr D. Worsley, Paleontology Museum, Oslo. Dr J. K. Ingham, Hunterian Museum, Glasgow University. Mr M. Dorning, Sedgwick Museum, Cambridge University.

I also thank Dr D. Worsley for the use of the Oslo Museum guest facilities and for the packaging and shipping of research material, Mr M. C. Burton for the photographing and printing of plates and diagrams; Mr M. W. Stead for electron microscope work. Mrs H. M. Tomkinson and Mrs C. A. Owen for secretarial help and the Keele Research Association for the use of its facilities.

History of research

The first descriptions of Lichidae from Gotland were made by Angelin (1854) in his work "*Palaeontologia Scandinavica*" in which he described and figured seven species; *Lichas concinnus*, *Lichas gibbus*, *Lichas gotlandicus*, *Lichas latifrons*, *Lichas ornatus*, *Lichas rotundifrons* and *Trochurus pusillus*, together with a large number of other trilobites from the Cambrian, Ordovician and Silurian of Scandinavia. Angelin also brought together and sold collections of

Swedish fossils, some of which he labelled.

Lindström (1885), following his editing of Angelin's work, redescribed and figured *L. concinnus*, *L. gotlandicus*, *L. latifrons* and *L. rotundifrons* and described and figured six new species of *Lichas*; *L. palifer*, *L. marginatus*, *L. triquetrus*, *L. araneus*, *L. plicatus* and *L. visbyensis*. In addition he described and figured a pygidium of *Trochurus salteri* (Fletcher, 1850). He furthermore stated that he believed *L. gibbus* to have been based on the cephalon of *Trochurus pusillus* and the pygidium of *T. salteri* and suggested the species *L. gibbus* be dropped.

In 1910 Westergård produced an index to Angelin's work and added notes referring to subsequent publications.

No major revision of the Gotland Lichidae has been attempted since Lindström's *"Förteckning på Gotlands siluriska crustacéer"* in 1885, although species which occur on Gotland have been described from elsewhere e.g *L. ornatus* from the East Baltic (Schmidt 1885) and *L. marginatus* from the Purple Shales of Shropshire (Whittard 1938).

Specimen numbers

Abbreviated prefixes of specimens from museums are as follows;

Ar = Naturhistoriska Riksmuseet, Stockholm.

GSM = Geological Survey Museum, London.

BM = British Museum (Natural History), London.

SM = Sedgwick Museum, Cambridge University.

Collections

The collections of the Naturhistoriska Riksmuseet, Stockholm include much of both Angelin's (1854) and Lindström's (1885) figured material and their other previously unfigured specimens. In addition there is a large quantity of material collected and prepared by Lars Ramsköld which is, in comparison to earlier collections, more precisely located geographically and stratigraphically. A few specimens collected by E. Warburg are present in the Riksmuseet collection and the Sveriges Geologiska Undersöknings Museum, Uppsala.

Stratigraphy

(emended and abridged from Laufeld (1974a: 7-13)

Text-figs 1 & 6

The Silurian succession of Gotland is about 500m thick, mainly consisting of limestones and calcareous shales overlying a thin (75-125m) Ordovician succession which in turn lies on thin Precambrian sediments. The sedimentary succession rests on older Precambrian crystalline basement. The oldest sediments that crop out are of *crenulata* Biozone age.

The Gotland Silurian sediments are believed to have been deposited in a shallow (5-200m) epicontinental sea close to the Silurian equator. Sediment input from the NW led to a shallowing of that portion of the Gotland shelf, no clastics being deposited on Gotland itself with the pattern of sedimentation being further complicated by eustatic changes in sea level. Correlation between shallow water limestones and deeper water shales and marls is hampered by the fact that floras and faunas are often entirely different from each other.

The main sources for all modern work are the geological map sheets (1:50 000) and the descriptions of them by Hede who divided the Silurian of Gotland into thirteen units (Text-fig. 6; Hede 1960, pp. 44-52) These major units have been further divided into subunits representing bodies of rock, although the fine relationship between some of the finer units remains obscure. When unnamed local units are referred to as a, b, c etc.

The aerial extent of the units is shown in Text-fig. 2.

Lower Visby Formation (Lower Visby Marl). Maximum thickness 11m.

The base of this unit has not been defined and it merges gradationally upwards into the Upper Visby Formation (Upper Visby Marl), the two units being separated on fossil content. It consists of thin lenses and irregular nodules of grey, fine grained, argillaceous limestone in a blue-grey calcareous mudstone.

Upper Visby Formation (Upper Visby Marl). Maximum thickness 16m.

This unit consists of blue-grey calcareous mudstone with embedded nodules and thin lenses of grey, fine-grained, argillaceous limestone which increase in thickness upwards with a complementary thinning of the calcareous mudstone. The appearance of bioherms also serves to distinguish this unit from the Lower Visby Formation (Lower Visby Marl).

Högklint Group. Maximum thickness 35m.

This group is divided into four units; The lowermost unit (a) (10m) consists of biohermal, grey to pink limestone, containing pelmatazoan debris and thinly-bedded argillaceous limestone. Unit (b) is (14-15m) bedded light grey, often conglomeratic, limestone. This is overlain by unit c) (4-5m) bedded, light to brownish-grey hard limestone in places rich in stromatoporoids. The uppermost unit d) is 0.5m thick (developed only in the Visby area) & consists of grey to black or reddish calcareous mudstone and limestone. In northern Gotland where unit d) does not occur this horizon is marked by a layer of silicification of the underlying strata.

Towards the south the above four divisions cannot be distinguished, and the monotonous sequence of argillaceous limestones and calcareous mudstones which occur here is referred to as the "south western facies". At some places within the main area it is also not possible to make the four-unit division.

Tofta Formation (Tofta Limestone). Maximum thickness 8m.

This consists of light to brownish grey argillaceous limestone which thins towards the north east. Hede (1960) stated that it may also thin to the southwest. In several places the base is a conglomerate 0.3m in thickness.

Slite Group. Maximum thickness 100m.

The Slite Group consists of a north-western area of stratified limestones and a south-western and southern area of mainly calcareous mudstone and argillaceous limestone; the contact between the two is gradational.

Hede (1960, p. 49) divided the limestone in the north-western area and northeastern areas into the following seven units. The lowermost unit (a) consists of 3.5m of bedded grey limestone thins to the north east and contains small bioherms. It disappears 6km north east of Visby and reappears at the southern end of Kappelshamn bay where it is 1.5m thick. It is overlain by unit (b) which consists of 3m of grey or bluish-grey to light yellowish brown argillaceous limestone; it is sometimes slightly bituminous and thins out to the north east.

Above this, unit (c) reaches thicknesses of 8m (Visby area) to 3 or 4m (Fårö island). It is also referred to as the Katrilund Limestone and is grey to yellowish or brownish grey in colour. Unit (d) is 2m thick at its maximum development and thins south west and north east. It does not appear north east of Kappelshamn Bay, but occurs on Fårö Island. Unit e) is 10m thick near Kappelshamn thinning north eastwards to 5m in Fårö and is composed of thick to thin beds of red, dense or fine-grained limestone with intercalations of calcareous mudstone. Unit f) the 2m thick *"Conchidium tenuistriatum"* Beds are highly argillaceous fine-grained limestone with thin laminae of bluish to green limestone. The uppermost unit g) is composed of 30m of mainly stratified limestone of varying character also referred to as the *P. gotlandicus* Beds. Above the *P. gotlandicus* beds is a succession of irregular nodules and lenses of light-grey, thin, argillaceous limestone.

Mulde Formation (Mulde Marl) Maximum thickness 25m.

Thinning to the north east, homogeneous thickly laminated to thinly bedded grey to bluish-grey dense or fine-grained argillaceous and slightly dolomitic limestone.

Halla Formation Maximum thickness 15m in Northeast.

Divided into three units the lowermost of which, unit a), consists of 3.4-4m of white oolitic limestone with small bioherms. Unit b) consists of grey argillaceous limestone with thin calcareous mudstone laminae and forms the top of the Halla Formation in the north east. Unit c) is 5m thick thinning south-westwards from the Horsnä-Gothemshamnar area to 2m west-north-west of Hejde church.

Farther to the south west it is not possible to refer the Halla Formation to any unit ("undifferentiated" of Text-fig. 6). On Storo Karlsö and Lilla Karlsö the Halla Formation reaches about 15m of biohermal limestone and light grey bedded limestone.

Klinteberg Formation.

Hede (1958, p. 174) divided this formation into six units. The lowermost (unit a) reaches a maximum thickness of 15m, and contains three more or less synchronous sub-units of member rank.

i) Argillaceous limestone with calcareous mudstone intercalations.

ii) Limestone rich in pelmatazoan debris

iii) Limestone intercalated with calcareous mudstone.

Unit (b) consists of 3m of dense or fine-grained limestone rich in calcareous algae. Unit (c) consists of 4m of yellowish limestone also rich in calcareous algae. Unit (d) is 10m of bluish-grey, argillaceous limestone. Unit (e) 2m of light brown argillaceous limestone, again rich in calcareous algae. The uppermost unit (f) is a white arenaceous limestone. The amount of terrigenous clastics in these units increases strongly to the southwest.

Klinteberg "Marl".

The southern development of the Klinteberg Formation is developed as a more fine-grained facies.

Hemse Group.

This group is a complex pattern of facies types. Hede (1929) divided this Group into five units; Unit (a) is a few metres of finely-bedded grey, fine-grained limestone rich in stromatoporoids and pelmatazoan debris. Unit (b) comprises 1.5m of thinly-bedded light grey argillaceous limestone with thin intercalations of calcareous mudstone. Unit (c) is 15m of thinly-bedded grey or brown fine-grained limestone with locally developed bioherms. Unit (d) is developed as 25m of thin to very thickly-bedded light grey or almost white limestone. The uppermost unit is referred to by the formal name Millklint Limestone and consists of thinly-bedded grey, yellowish-grey, reddish or nearly white limestone.

South of a line from the Linde area to Stånga the above are replaced by a calcareous mudstone- the Hemse Marl"- which is divided into a north western part and south eastern part.

Eke Formation. Maximum thickness 13.9m.

Bluish-grey argillaceous limestone with abundant calcareous algae, comprise this unit.

Burgsvik Formation (Burgsvik Sandstone & Oolite). Maximum thickness 47m.

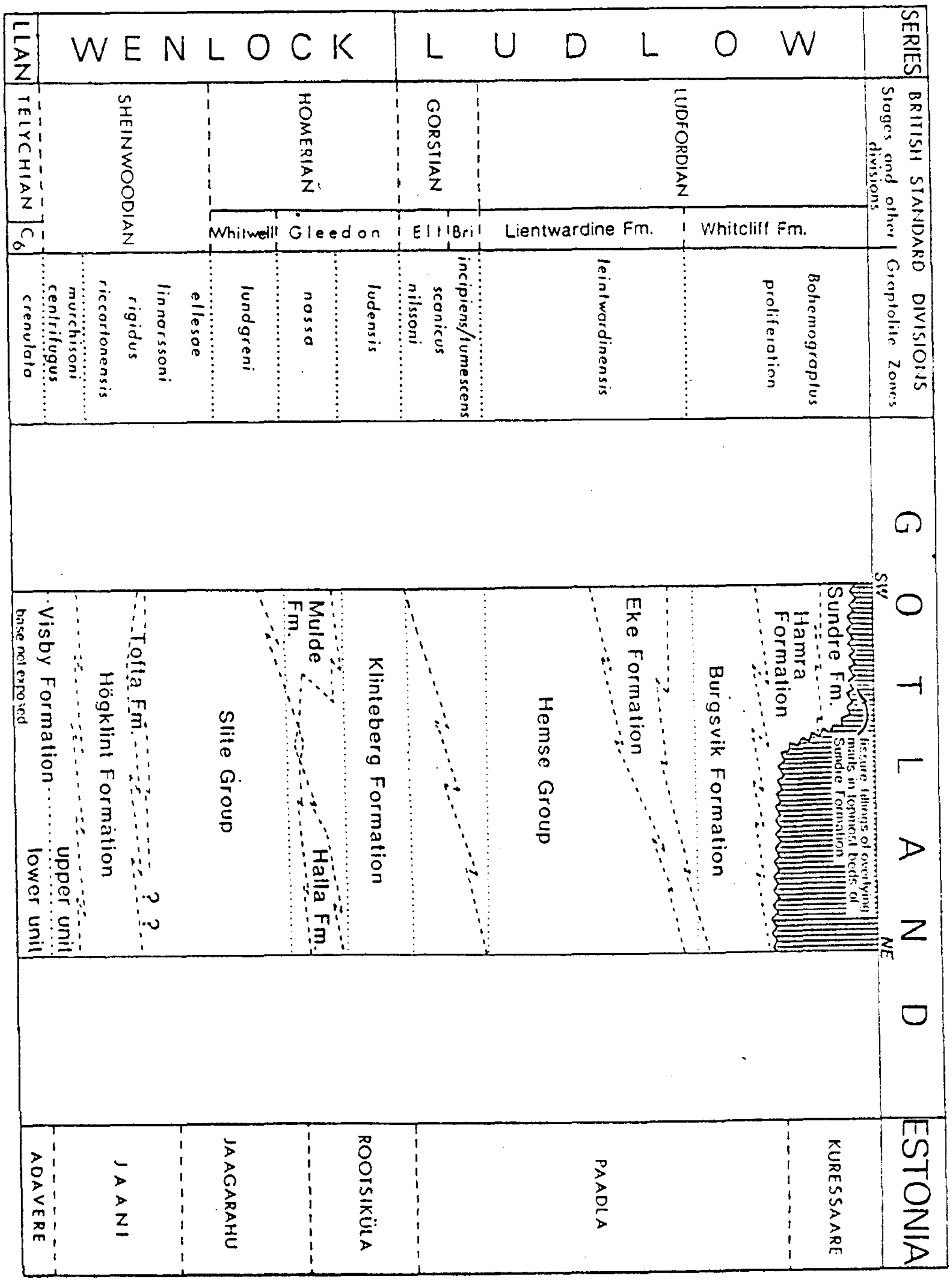
The maximum thickness was obtained in a boring at Burgsvik (Hede 1919, p. 1). It is thin to thickly bedded, light grey, fine-grained and slightly calcareous argillaceous sandstone with local intercalations of bluish-grey calcareous mudstone. Locally it is overlain by beds of oolitic sandstone.

Hamra Formation. Maximum thickness 40m.

The Hamra Formation thins to less than 10m in outliers and is divided into three units. The lowermost unit (a) comprises 0.2-1.5m of argillaceous, indistinctly-stratified algal limestone. Unit (b) consists of argillaceous limestone with intercalations of calcareous mudstone. Unit (c) is the main part of the group, composed of three facies types.

Text-figure 1

Revised correlation of stratigraphic units from Gotland [emended from Bassett 1984, unpublished].



LLAN = Llandovery

ELT = Eltonian Formation

BRI = Bringewood Formation

i) south western biohermal limestone.

ii) north east main limestone area: argillaceous limestone with intercalations calcareous mudstone.

iii) north eastern outliers of biohermal limestone equivalent to groups (a) and (b) in the southwest.

Sundre Formation (Sundre Limestone). Maximum thickness 10m.

Thickly-bedded grey or pink limestones predominate in this unit and are equivalent to, and sometimes locally replaced by, a light grey or reddish-brown biohermal limestone.

Recent revision of the stratigraphy of Gotland has revealed more of the diachronous nature of many of the Formations listed above. In general the formations become younger to the north east. Text-fig. 1 shows the time relationships as presently understood (Bassett *pers. comm.*).

Gotland Localities

(See Text-fig. 2).

The localities from which specimens have been collected are listed below in alphabetical order, as taken from Laufeld (1974a & b). The information is presented in the following order; locality, two upper case letters (see below), an eight figure map reference, topographical map sheet number, geological map sheet number, bearing and distance from nearest church, lithostratigraphic unit(s).

The two capital letters refer the locality to a 100 X 100 Km. square in the Universal Transverse Mercator (U.T.M.) grid system in which Gotland is located in zone 33-34 V.

All localities have been stratigraphically labelled using Hede (1960).

Topographic map sheets on the scale 1:50,000 referred to below are (from north to south): 7 J Fårösund SO & NO, 7 J Fårösund SV & NV, 6 J Roma NV & NO, 6 J Roma SO, 6 J Roma SV, 6 I Visby NO, 6 I Visby SO.

Geological map sheets on the scale 1:50,000 referred to below are (from north to south): Aa 180 Fårö, Aa 171 Kappelshamn, Aa 169 Slite, Aa 183 Visby & Lummelunda, Aa 170 Katthammarsvik, Aa 160 Klintehamn, Aa 164 Hemse, Aa 156 Ronehamn, Aa 152 Burgsvik.

Bjarby backe, this locality is known only from museum specimen cards and cannot therefore be located precisely. *Hamra Formation.*

Blåhäll 1, CJ 2905 5616, *c.* 2940m SW of Fröjel church. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 164 Hemse. *Mulde Formation,* lower part.

Bodudd 1, CJ 2977 2883, *c.* 6220m SW of Näs church. Topographic map sheet 5 I Hoburgen NO & 5 J Hemse NV. Geological map sheet Aa 152 Burgsvik. *Hemse & Eke Formations.*

Bondarve, this locality is known from museum specimen cards only and therefore cannot be precisely located. *Slite Group,* Slite Marl.

Bulbro, This locality is known from museum specimen cards only and therefore cannot be precisely located. *Hemse Group,* upper part.

Däpps 1, CJ 3287 6149, *c.* 3640m NE of Fröjel church. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 160 Klintehamn. *Mulde Formation,* upper part.

Djaupviksudden 1 CJ 6785 7142, *c.* 6060m NW of Östergarn church. Topographic map sheet 6 J Roma SO. Geological map sheet Aa 170 Katthammarsvik. *Hemse Group,* units b & c.

Djupvik 1, CJ 2814 5529, *c*. 4180m SW of Fröjel church. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 164 Hemse. *Mulde Formation*, lower part.

Djupviksvägen 1, CJ 5512 2873, *c*. 3950m SSW of Fröjel church. Topographic map sheet & I Visby SO. Geological map sheet Aa 164 Hemse. *Mulde Formation* undifferentiated.

Follingbo 1, CJ 4264 8617, *c*. 1200m NW of Follingbo church. Topographic map sheet 6 J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda. *Slite Group*, Slite Marl, NW part.

Galgberget 1, CJ 3971 9323, *c*. 1360m NW of Visby cathedral. Topographic map sheet 6 I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda. *Högklint & Tofta Formations*.

Gannor 3, CJ 5566 5010, *c*. 1780m NW of När church. Topographic map sheet 6 J Roma SV. Geological map sheet Aa 156 Ronehamn. *Hemse Group*, Hemse Marl, uppermost part.

Grushölmen, this locality is known from museum specimen cards only and therefore cannot be located precisely. *Högklint Formation*.

Halls Huk 1, CK 6681 2265, *c*. 4100m NNE of Hall church. Topographic map sheet 7 J Fårösund SV & NV. Geological map sheet Aa 171 Kappelshamn. *Upper Visby & Högklint Formations*, unit a.

Holmhällar 1, CJ 3508 1310, *c*. 5670m SE of Vamlingbo church. Topographic map sheet SI Hoburgen SO & 5J Hemse SV. Geological map sheet Aa 152 Burgsvik. *Sundre Formation*, middle-upper part.

Kappelshamn 2, CK 6844 1514, *c*. 5810m WSW of Fleringe church, Topographic map sheet 7 J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn. *Högklint Formation*, unit b, lower part (Hede's local bed a).

Korpklint 1, CJ 4100 9563, *c.* 5670m WSW of Väskinde church. Topographic map sheet 6 J Roma NV & NO. Geological map sheet Aa 183, Visby & Lummelunda. *Upper Visby & Högklint Formations,* unit a.

Kvarnberget 1 CJ 6956 9791, *c.* 1000m SE of Slite church. Topographic map sheet 7 J Fårösund SO & NO. Geological map sheet Aa 169 Slite. *Slite Group* Slite Marl and unit g.

Kyllaj 2, CK 7782 0302, *c.* 4070m SE of Hellvi church. Topographic map sheet 7 J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn. *Slite Group,* unit g.

Lansa 1, CK 8548 2142, *c.* 4025m W of Fårö church. Topographic map sheet 7 J Fårösund SO & NO. Geological map sheet Aa 180 Fårö. *Slite Group,* unit c.

Lau Backar 1, CJ 5775 5209, *c.* 1250m ENE of Lau church. Topographic map sheet 6 J Roma SV. Geological map Sheet Aa 156 Ronehamn. *Eke Formation, Rhizophyllum Limestone,* type locality.

Lauterhorn, CK 8788 2554, *c.* 5050m NW of Fårö church. Topographic map sheet 7 J Fårösund SO & NO. Geological map sheet Aa 180 Fårö. *Högklint Formation* lower-middle part.

Lickershamn 1, CK 5192 1262, *ca.* 4350m NNW of Stenkyrka church. Topographic map sheet 7 J Fårösund SV & NV. Geological map sheet Aa 183 Visby & Lummelunda. *Lower Visby Formation, Upper Visby Formation & Högklint Formation.*

Lickershamn 2, CK 5199 1239, *ca.* 4080m NNW of Stenkyrka church. Topographic map sheet 7 J Fårösund SV & NV. Geological map sheet Aa 183 Visby & Lummelunda. *Upper Visby Formation & Högklint Formation.*

Lindström's Grotta 1, CJ 2296 5672, *c.* 650m WNW of the triangulation point in Lilla Karlsö. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 164 Hemse. *Halla Formation & Klinteberg Formation.*

Millklint 3, CJ 6386 6458, *c.* 4275m W. of Gammelgarn church. Topographic map sheet 6 J Roma SO. Geological map sheet Aa 170 Katthammarsvik. *Hemse Group,* Millklint Limestone.

Mulde 2, CJ 3183 6102, *c.* 2770m SW of Klinte church. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 164 Hemse. *Mulde Formation,* uppermost part.

Mulde Tegelbruk 1, CJ 3127 6048, *c.* 2080m NNE of Fröjel church. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 164 Hemse. *Mulde Formation,* type locality.

Nordervik, this locality is known from museum specimen cards only and therefore cannot be located precisely. *Mulde Formation,* undifferentiated.

Samsugns 1, CK 6186 0025, *c.* 4180m ESE of Tingstäde church. Topographic map sheet 7 J Fårösund SV & NV. Geological map sheet Aa 169 Slite. *Slite Group,* unit g.

Samsugns 2, CK 6249 0015, *c.* 4790m ESE of Tingstäde church. Topographic map sheet 7 J Fårösund SV & NV. Geological map sheet Aa 169 Slite. *Slite Group,* unit g.

Samsugns 3, CK 6346 0013, *c.* 5710m ESE of Tingstäde church. Topographic map sheet 7 J Fårösund SV & NV. Geological map sheet Aa 169 Slite. *Slite Group,* unit g.

Sandarve 1, CJ 4007 5157, *ca.* 1520m NNE of Fardhem church. Topographic map sheet 6 J Roma SV. Geological map sheet Aa 164 Hemse. *Hemse Group* upper part.

Snäckgärdsbaden 1, CJ 4080 9500, *c.* 1140m WSW of Väskinde church. Topographic map sheet 6 J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda. *Upper Visby Beds & Högklint Formation,* unit a.

Snoder 2, CJ 3130 4726, *c.* 2510m WNW of Slite church. Topographic map sheet 5 I Hoburgen NO & 5 J Hemse NV. Geological map sheet Aa 164 Hemse. *Hemse Group*, Hemse Marl, north-western part.

Stave 1, CJ 4557 8203, *c.* 1630m ENE of Akebäck church. Topographic map sheet 6 J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda. *Slite Group*, Slite Marl, central part.

Storugns, CK 7042 1217, *c.* 6350m W of Rute church. Topographic map sheet 7 J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn. *Slite Group*, units e & g.

Valbytte 1, CJ 2913 6858, *c.* 1650m S. of Västergarn church. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 160 Klintehamn. *Slite Group* Slite Marl, slightly younger than the *Conchidium tenuistriatum* Beds.

Valle 2, CJ 3359 6428, *c.* 1190m N of Klinte church. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 160 Klintenhamn. *Slite Group*, Slite Marl, *Pentamerus gothlandicus* Beds.

Valve 2, CJ 7299 2859, *c.* 2800m NNW of Västergarn church. Topographic map sheet 6 I Visby SO. Geological map sheet Aa 160 Klintehamn. *Slite Group*, Slite Marl.

Väståös 1, CK 6792 1850, *c.* 6510m WNW of Fleringe church. topographical map sheet 7 J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn. *Högklint Formation*, unit b.

Vattenfallsprofilen 1, CJ 3800 9150, *c.* 1100m SW of Visby cathedral. topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda. *Upper Visby & Högklint Formations.*

Index of localities by stratigraphic order

Lower Visby Formation.

Lickershamn 1.

Upper Visby Formation.

Halls Huk 1 & 3, Lickershamn 1-2, Snäckgärdsbaden 1, Vattenfallsprofilen 1.

Högklint Formation.

Unit a.

Halls Huk 1 & 3, Korpklint 1, Lickershamn 1-3, Snäckgärdsbaden 1.

Unit b.

Kappelshamn 2, Västös 1.

Undifferentiated lower-middle part.

Lauterhorn 1.

Undifferentiated middle-upper part.

Galgberget 1.

Undifferentiated.

Vattenfallsprofilen 1.

Tofta Formation

Lower part.

Galgberget 1.

Slite Group

Unit d.

Lansa 1.

Unit e - Kalbjerga Limestone.

Storugns 1.

Unit g - Ryssnäs Limestone.

Follingbo 4, Kyllaj 1-4. Storugns 1.

Slite Marl, north-western part.

Follingbo 1-3, 5-7.

Slite Marl, undifferentiated.

Stave 1, Valbytte 1, Valve 2.

Slite Marl, Lerberget Marl - Pentamerus gotlandicus Beds.

Valle 1-2.

Slite siltstone.

Mulde 1.

Halla Formation

Undifferentiated.

Lindström's grotta 1.

Mulde Formation

Lower part.

Blåhäll 1, Djupvik 1.

Upper part.

Däpps 1-2, Fröjel 1-2, Mulde 2.

Undifferentiated.

Mulde Tegelbruk 1, Djupviksvägen 1.

Hemse Group

Unit b.

Djaupviksudden 1.

Unit c.

Djaupviksudden 1.

Unit e - Millklint Limestone.

Millklint 3.

Undifferentiated upper part.

Sandarve 1.

Hemse Marl, north-western part.

Snoder 1-2.

Hemse Marl, uppermost part.

Bodudd 1, Gannor 3.

Hemse Formation, lower-?middle part.

Bjarby Backe.

Eke Formation

Lowermost part.

Bodudd 1, Gannor 1.

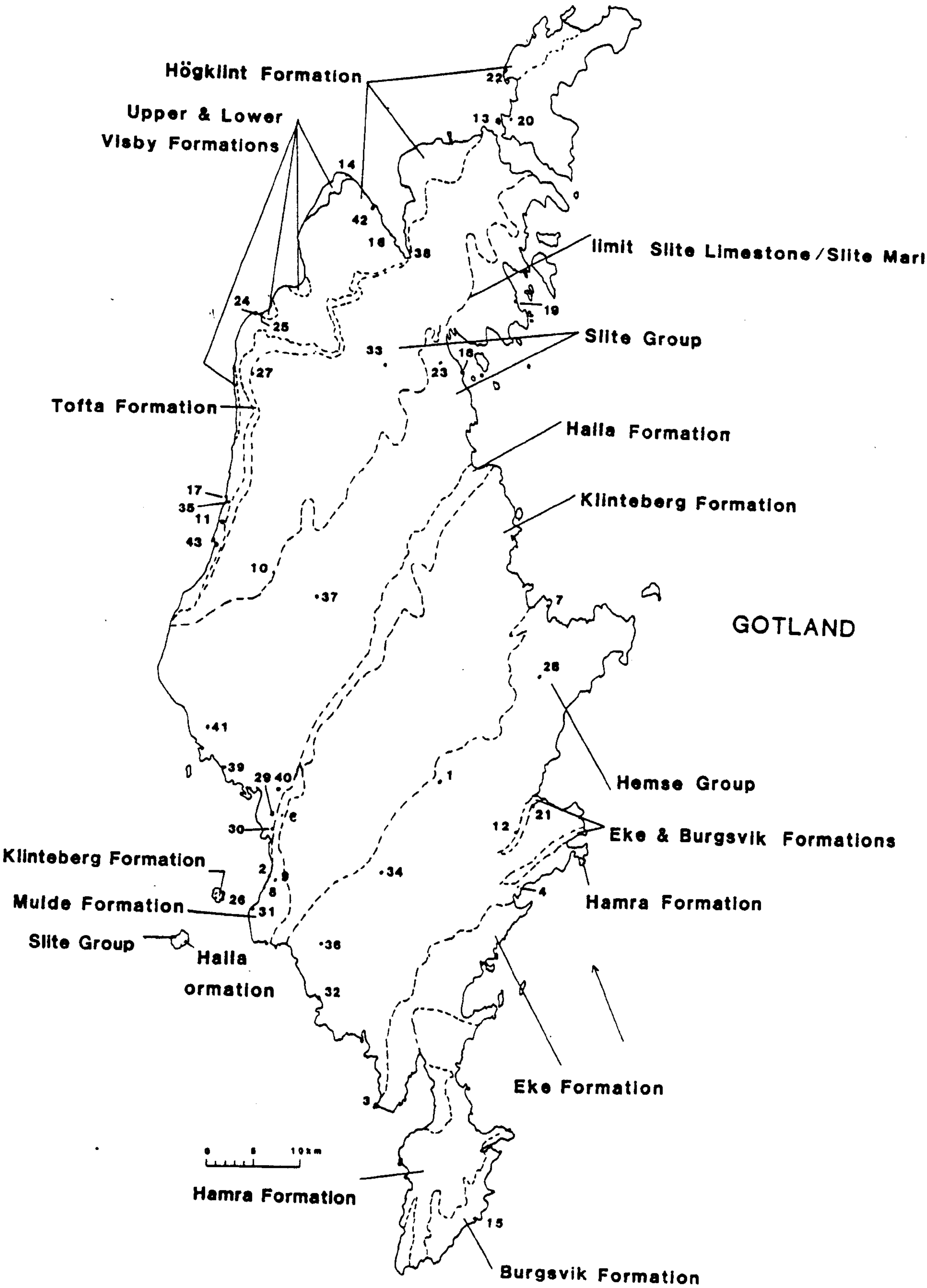
Upper part.

Lau backar 1.

Explanation Text-figure 2

Gotland localities and extent of stratigraphic units.

1) Bjarby backe
2) Blåhäll 1
3) Bodudd 1
4) Bondarve
5) Bulbro
6) Däpps 1
7) Djaupviksudden
8) Djupvik 1
9) Djaupvisvägen 1
10) Follingbo 1
11) Galgberget 1
12) Gannor 3
13) Grushölmen
14) Halls huk 1
15) Holmhällar
16) Kappelshamn 2
17) Korplklint 1
18) Kvarnberget 1
19) Kyllaj 2
20) Lansa 1
21) Lau backar 1
22) Lauterhorn
23) Laxare
24) Lickershamn 1
25) Lickershamn 2
26) Lilla Karlsö (Lindström's grotto)
27) Lummelunda
28) Millklint 3
29) Mulde 2
30) Mulde tegelbruk 1
31) Nordervik
32) Petesvik
33) Samsugns 1
34) Sandarve 1
35) Snäckgärdsbaden
36) Snoder 2
37) Stave 1
38) Storugns
39) Valbytte 1
40) Valle 2
41) Valve 2
42) Västos 1
43) Vattenfallsprofilen 1


Högklint Formation
Upper & Lower
Visby Formations
limit Slite Limestone/Slite Marl
Slite Group
Tofta Formation
Halla Formation
Klinteberg Formation
GOTLAND
Hemse Group
Eke & Burgsvik Formations
Klinteberg Formation
Hamra Formation
Mulde Formation
Slite Group
Halla
ormation
Eke Formation
0 5 10km
Hamra Formation
Burgsvik Formation

Systematic descriptions

Family Lichidae Hawle & Corda, 1847

Terminology and glabellar lobation of the Lichidae (Text-fig. 3).

The preoccipital lobation of members of the Lichinae differs from forms possessing one exsagittally elongate lobe (such as *Lyralichas* or *Amphilichas*), through forms with two pairs of lateral lobes (such as *Lichas* s.s. Text-fig. 3a), to those with three (such as *Platylichas* Text-fig 3c). The terminology applied to this lobation and the manner in which it developed has been the subject of considerable discussion. Early workers, in the absence of ontogenetic data, accepted that these pairs of glabellar lobes were homologous to the glabellar lobes of other trilobite groups.

Reed (1902, p. 64) noting the large size of the most anterior lateral lobe in forms bearing three lobes, and the weak adaxial notch or furrow at half its length, regarded this lobe as being bicomposite, formed by the fusion of L2 and L3. The lateral lobe to the posterior of this he saw as being L1 and that to the posterior of this as an occipital lobe. He also considered that in some cases L1 fused with the bicomposite lobe to form a tricomposite lobe.

Foerste (1920, p. 26) did not discuss Reed's suggestions and considered that the anterior lobe was L3 with an L2 posterior to this and L1 opposite the occipital ring. Phleger (1936, p. 593) discussed both Reed's and Foerste's views and considered there to be no occipital lobe, agreed with Foerste that the posterior lobes represented L1 and L2 but believed the anterior lobe to be composed of L3 and L4 fused together. Warburg (1939, pp. 7, 9) accepted Reed's suggestions. Vaněk (1959) saw the posterior lobe as L1, the anterior lobes as a bicomposite lobe composed of L2 and L3 and the intervening lobe to be part of the median glabellar lobe that had expanded laterally. Sdzuy (1979, p. 67) redescribed *Lichakephalus* from new material and suggested that all lateral lobes represent subdivisions of L1.

Descriptions of the ontogenetic series of species of *Lichas, Amphilichas, Hemiarges* and *Acanthopyge* (Temple 1969, 1972; Chatterton 1971, 1980; Tripp & Evitt 1981) have provided more information as to the development of the glabellar lobation.

In the early metaprotaspid stage of *Acanthopyge bifida* Edgell, 1955 (see Chatterton 1971, p. 30, pl. 6, figs 1-27, pl. 8, figs 1-7, text-figs 8-10) L1 is the first lateral lobe to form. It bears a pair of stout granules or spines; further paired spines appear on the median glabellar lobe, all of which were considered to relate to protaspid segmentation by Chatterton. The next lobe to form is the most anterior lobe, for which Temple coined the term "bulla", during ontogeny it proceeds to expand laterally and anteriorly. In the late metaprotaspid stage a swelling develops on the fixed cheek to the posterior of the bullar lobe and abaxial to L1. I agree with Holloway & Thomas (*pers. comm.*) who regard this swelling as merging with 1L and expanding abaxially to occupy the whole area between the palpebral lobe and the fixed cheek, incorporating a portion of the genal region which includes the spine A1 (Chatterton 1971, text-fig. 9c) in the process. L1a clearly remains discreet in that a posterior segmental spine or granule is clearly visible on the L1a of the holaspid cranidium (Text-fig.

In both *Amphilichas* aff. *A. aspratilis* (Bradley, 1930; see Chatterton 1980, p. 54, text-fig. 12) and *Hemiarges turneri* Chatterton & Ludvigsen, 1976 (Chatterton 1980, p. 54, text-figs 12f-k) from the middle Ordovician Esbataottine Formation of Canada, the bullar lobe is the first to form. In *Amphilichas*, a posterior as well as an anterior extension of the bullar lobe occur and form one highly elongate lateral lobe. In *H. turneri*, although similar to *Amphilichas* in the early meraspid stage, a swelling develops by the late meraspid stage situated to the posterior of the bullar lobe in a position similar to that in *A. bifida*. L1 is not developed. It is the development of this abaxial swelling which is responsible for producing the typical lichid lateral constriction of the occipital ring.

I agree with Thomas & Holloway (*pers. comm.*) that Sdzuy's terms L1a and L1b should be applied to the posterior cranidial lobes in that they are clearly glabellar in origin. There is no ontogenetic evidence for the existence of occipital lobes and the bullar lobe is derived from 2L. Where both L1a and L1b occur, it is always the circumscribed (and usually independently convex) L1a that is adjacent to the occipital ring. Thomas & Holloway (*pers. comm.*) propose the term "posterolateral cranidial lobe" for the abaxial swelling in *Acanthopyge* because unlike other genera it clearly incorporates not only L1 but also genal material including the spine A1 (Chatterton 1971, text-fig. 9c); this spine is located on the genal area of the metaprotaspid stage and incorporated into the lobe in the holaspid stage.

The production of the abaxial swelling (L1b or posterolateral cranidial lobe) would thus appear to be a crucial factor in developing the pattern of glabellar lobation. By constricting L1a against the occipital ring to produce the false occipital lobe and also often constricting the posterior growth of the bullar lobe to produce a transverse margin (in genera such as *Dicranopeltis*) as opposed to a suboval outline (in genera such as *Pseudotupolichas*).

Explanation of Text-fig. 3

A = *Lichas marginatus* Lindström, 1885, x3 (Pl. 1, fig. 2a), Paralectotype, Ar2367.

B = *Pseudotupolichas ornatus* (Angelin, 1854), x2 (Pl. 2, fig. 14), Ar2379.

C = *Platylichas grayii* Fletcher, 1850, x3 (Pl. 4, fig. 11b), Ar2448.

D = *Craspedarges scutalis* (Salter, 1873), x3 (Pl. 6, fig. 5b), Ar51427.

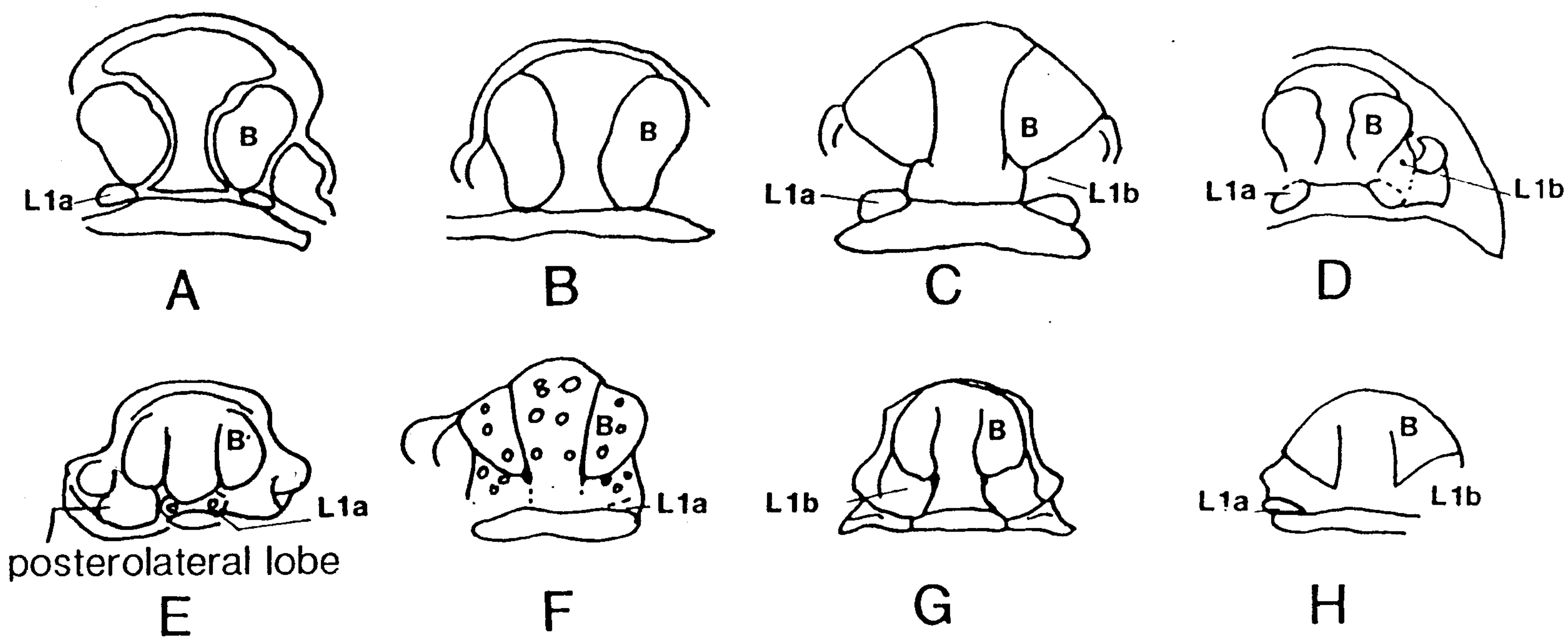
E = *Acanthopyge calcitripa* sp. nov., x5 (Pl. 7, fig. 5c), Ar5096.

F = *Dicranopeltis salterii* (Fletcher, 1850), x3 (Pl. 4, fig. 1b) Ar2447.

G = *Choneliobarges deptus* sp. nov., x3 (Pl. 5, fig. 9c), Ar51423.

H = *Dicranogmus sp.*, x3 (Pl. 3, fig 14a), Ar2358.

Text-figure 3



B = Bullar lobe

Subfamily Lichinae Hawle & Corda, 1847

[*nom. transl.* Gürich 1901 (*ex* Lichades Hawle & Corda, 1847)]

Diagnosis (from Holloway & Thomas; *pers. comm.*). Glabella as wide or wider at occipital ring than at bullar lobe and markedly constricted in between; longitudinal furrow terminating at base of bullar lobe or extending to occipital furrow; S1 incomplete abaxially or absent, except in *Dicranopeltis*; L1a may be present. Hypostome subhexagonal (excluding posterior notch) and apparently as wide as long, with widest point situated at approximately half length; middle furrow strongly oblique, bifurcating adaxially around slightly inflated maculae; posterior border commonly poorly defined. Pygidium with three pairs of pleural furrows (except in some species of *Uralichas* Delgado, 1892) and one to four pairs of axial rings. Anterior and posterior pleural bands flattened or of equal, low, convexity. Pleural margin with two to four pairs of flattened spines.

Genera included. Arctinurus Castelnau, 1843, *Lichas* Dalman, 1827; *Pseudotupolichas* Phleger, 1936; *Uralichas* Delgado, 1892.

Discussion. Pseudotupolichas Phleger, 1936 is placed in the Lichinae on the basis of its gross morphological similarity to other members of the subfamily, especially in the morphology of the hypostome and pygidium. It is however the only genus assigned to the subfamily lacking an L1a apart from *Dicranopeltis* species such as *D. salteri*. In that some species of *Dicranopeltis* do develop a L1a, the absence of this lobe in *Pseudotupolichas* is not thought sufficient to exclude it from the subfamily.

Holloway & Thomas (*pers. comm.*) prefer to retain Phleger's genus *Trimerolichas* but restrict it to *L. marginatus* Lindström (1885). For reasons given below I consider *Trimerolichas* to be a junior subjective synonym of *Lichas*.

Genus **Lichas** Dalman, 1827

[Junior objective synonym = *Autolichas* Reed, 1923.

Junior subjective synonym = *Trimerolichas* Phleger, 1936.]

Type species. By original designation; *Entomostracites laciniatus* Wahlenberg, 1818, p. 34, pl. 2, fig. 2; from the *Dalmanitina* Beds, Ashgill, Bestorp, Mosseberg, Sweden.

Diagnosis (emended from Tripp 1959, p. O496). L1a developed; L1b not developed; median lobe expanding in front of bullar lobe; occipital ring long (sag.). Pygidial axis with one ring; postaxial band expanding backwards, ending in a rounded or bluntly-pointed posterior margin; anterior two pairs of pleural bands ending in short, backwardly-directed spines; posterior pair lacking free points and continuous with posterior margin.

Discussion. For discussion of the gender of *Lichas* see *L. araneus* below.

Lichas latifrons Angelin, 1854. Pl. 1, figs 1, 4-7, 9, 11; Pl. 2, figs 1, 11, 16; Text-figs 4, 6.

v* 1854 *Lichas latifrons* n. sp., Angelin p. 71, pl. 36, fig. 9, pl. 37, fig. 6.

. 1854 *Lichas Gothlandicus* n. sp., Angelin, p. 75, pl. 38, figs 10, 10a [material not located].

. 1857 *Lichas gotlandica* Angelin; Neiszkowski, p. 368, pl. 1, fig. 12.

. 1885 *Lichas* cf. *gothlandica* Ang.; Schmidt, p. 113, pl. 6, fig. 21.

1885 Lichas latifrons Angelin; Lindström, p. 57.

. *1885 Lichas gotlandicus* Angelin; Lindström, p. 38, p. 60.

v. 1885 *Lichas* sp.; Lindström, pl. 15, figs 14, 15.

v. 1910 *Lichas* sp.; Lindström, pl. 4, figs 47, 48.

1910 Lichas latifrons Ang.; Westergård, p. 32.

. *1910 Lichas Gothlandicus* Ang.; Westergård, p. 32.

1958 L. latifrons Angelin; Tripp, p. 575.

. *1958 L.? gothlandicus* Angelin; Tripp, p. 575.

Lectotype. (selected herein) Ar2384 (pygidium); figured Angelin 1854, pl. 37, fig. 6; Pl. 1, fig. 5.

Paralectotype. (selected herein) Ar2392; Pl. 1, fig. 67 (cranidium); figured Angelin 1854, pl. 36, fig. 9, Both are from unknown localities.

Other material. Ar5065 (pygidium), locality 13. Ar2405 (cranidium), Ar2403, -04, -06, -08 (hypostome, pygidium & two cranidia), locality 17. Ar2387, Ar2489-91 (cranidia), Ar5008-12 (pygidia), Ar5037 (hypostome); figured Lindström 1885, pl. 15, fig. 4), locality 20. Ar5001-07 (pygidia & cranidia), plus several unnumbered specimens from the Sveriges Geologiska Undersöknings museum, Uppsala, locality 24 or 25. Ar2477 (pygidium), locality 42. Ar2479 (cranidium), locality 43. Ar5031 (pygidium), Högklint Formation, Kullshag canal, Hangvar parish. Ar5060 (pygidium), Högklint Formation, Lummelunda canal, Lummelunda parish. Ar5016 (pygidium), Norderstrand, Visby parish. Ar2400 (pygidium), Högklint Formation, Lummelunda parish. Ar2398 (cranidium), Hemse Group, Östergarn parish (this is queried on label). Ar5017, Slite Group, unit g, Othem parish. Ar2402 (tr.), Högklint Formation, Väskinde parish. Ar2361 (pygidium), Hamra Formation, unit a, Grötlingbo parish. Ar5066 (pygidium) locality, unknown.

Total stratigraphic range: Högklint Formation, Slite Group, unit c and g (Sheinwoodian, *riccartonensis* to *lundgreni* Biozones).

Diagnosis. A species of *Lichas* with longitudinal furrows reaching occipital furrow at adaxial corner of L1a; anterior border narrow. Pygidial axis with well-incised, broad articulating furrow; articulating ring one-twentieth pygidial length (sag.); axis with one ring anteriorly, only defined adaxially and bearing a pair of large granules; postaxial band expanding posteriorly from axis, gently at first, more rapidly near margin; first two pleurae broad with very short, backwardly-directed spines; third pleural pair merging with postaxial band close to gently-rounded posterior margin.

Description. Cranidium as wide (tr.) across palpebral lobes as long (sag.). Median lobe one-quarter cranidial width (tr.) at occipital furrow, narrowing to one-eighth cranidial width by one-quarter length, then expanding forwards to become as wide as occipital ring anteriorly. Occipital furrow well-incised. Occipital ring one-fifth cranidial length (sag.), narrowing abaxially. L1a oval, long axis in line of occipital furrow, one-third as wide (tr.) as bullar lobe. Bullar lobe oval, convex, half as wide (tr.) as long (exsag.). Fixed cheek crescentic. Axial furrow well-defined, broad, of similar form to longitudinal furrow. Palpebral lobe one-eighth cranidial length (sag.), situated at one-third cranidial length. Palpebral furrow well-incised, merging with axial furrow anteriorly.

Hypostome with small, upwardly-flexed anterior wing and gently-rounded anterior margin. Lateral border furrow well-incised. Lateral border one-sixth maximum width (tr.). Posterior margin with subangular indentation two-thirds width (tr.)of middle body.

Pygidium two-thirds as long (sag.) as wide (tr.). Pygidial axis one-third anterior width (tr.) narrowing to half this width by half pygidial length (sag.) where it merges with postaxial band. Pleural and interpleural furrows broad, well-incised. Pleural furrows almost reaching margin. Doublure one-third pygidial length (sag.) with sculpture of at least fourteen terrace ridges subparallel to margin. Entire dorsal surface of cranidium, with exception of furrows, with sculpture of coarse and fine granules of irregular distribution.

Discussion. I can find no significant morphological differences between the material listed above and Angelin's illustration of *L. gothlandicus* (1854). The name *latifrons* was chosen in preference to *gothlandicus* because original material of the former is available for comparison but not the latter.

Of the other *Lichas* species from Gotland, *L. marginatus* (Lindström, 1885) differs from the above in possessing shorter (exsag.) bullar lobes, a broader anterior cranidial margin and proportionately longer cranidium. "*Lichas*" *areneus* (Lindström, 1885) possesses a postaxial band which does not expand as greatly posteriorly and a posterior pygidial margin which is almost transverse as opposed to the curved margin of *L. latifrons*.

L. latifrons closely resembles *L. laciniatus* (Wahlenberg, 1818; see Warburg 1939, pl. 9, figs 1-7) from the Leptaena Limestone (Ashgill) of Dalarne, Sweden. The Gotland species is distinguished by the possession of one (as opposed to two) pygidial axial rings, a shorter (sag.) occipital ring and longer bullar lobes.

Zhou & Zhi-quiang (1982, pl. 1, figs 7-9, 14) figured specimens referred to *L.* cf. *laciniatus* from the Rawtheyan of Ejin Qui, Inner Mongolia, which bear a cranidial granulation more closely matching *L. latifrons* than *L. laciniatus*. The L1a of the Mongolian material is distinctly angular, and longer (exsag.) than wide (tr.); in *L. latifrons* it is suboval and wider than long & I believe this material represents a separate species of *Lichas*.

The pygidium of *Lichas affinis* Angelin, 1854 (p. 69, pl. 36, fig. 2a, pl. 38, fig. 4b) also from the Leptaena Limestone (Ashgill), Dalarne, Sweden displays a widening of the postaxial band similar to *L. latifrons* but has two axial rings defined anteriorly, in which respect it resembles *L. laciniatus*. The cranidium differs from that of *L. latifrons* in being less convex (in lateral view) and wider (tr.) between the longitudinal furrows.

Lichas sylvestris Reed, 1925 (see Howells 1982, p. 46, pl. 13, figs 1-4, 7, 8) from the Mulloch Hill Formation, Llandovery, (*cyphus* Biozone) of Girvan, Scotland and the Solvik Formation (Kiær's étage 6a, *persculptus* Biozone), of southern Norway is distinguished from *L. latifrons* by a slightly narrower (tr.) fixed cheek and shorter palpebral lobe (exsag.). The pygidium of *L. sylvestris* is narrower posteriorly, possesses one more axial ring and is carinate sagittally.

Lindström (1885, p. 56) expressed the opinion that the posterior widening of the postaxial band increased with size of specimen. A plot of the maximum sagittal length against the ratio of the narrowest to the widest points (tr.) of the postaxial band (Text-fig. 4a) shows the lowest ratios (highest degree of widening) to occur with the greatest length. A plot of greatest width (tr.) to maximum length (sag.) (Text-fig. 4b) shows a proportionate increase in these two dimensions and Lindström's statement would thus seem to be correct.

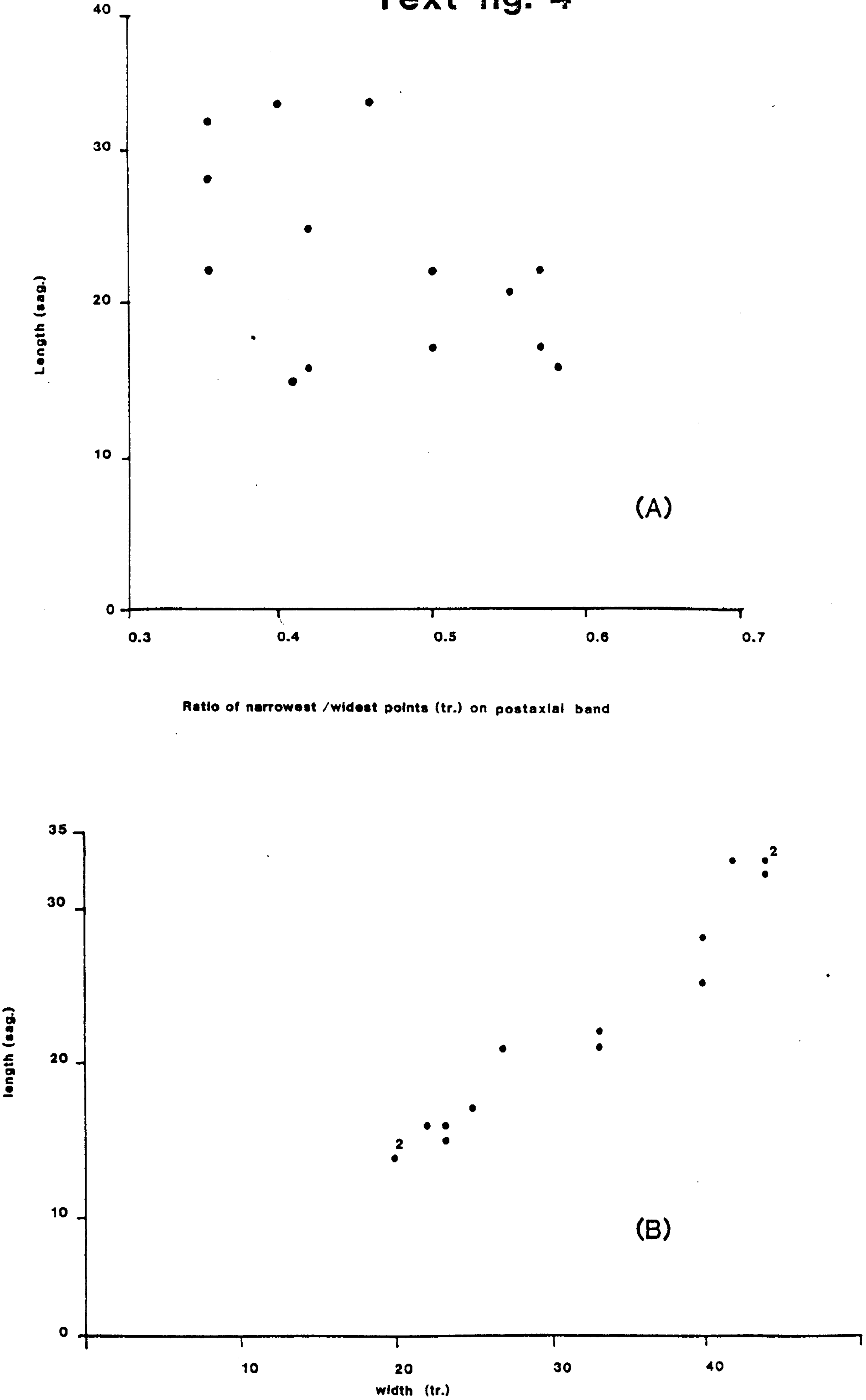
Text-figure 4

Lichas latifrons (Angelin, 1854)

A) Plot of pygidial length (sag.) against the ratio of the narrowest to widest points on the postaxial band (tr.). Lowest ratios (= greatest degree of widening) correlate with greatest length.

B) Plot of pygidial width (tr.) across tips of first pleural spines against pygidial length (sag.).

Text-fig. 4


40
30
20
10
0
Length (sag.)
0.3
0.4
0.5
0.6
0.7
Ratio of narrowest /widest points (tr.) on postaxial band
(A)
35
30
20
10
0
length (sag.)
2
2
10
20
30
40
width (tr.)
(B)

Lichas marginatus Lindström, 1885. Pl. 1, figs 2, 3, 8, 10, 12, 13; Text-figs 3, 6.

v* 1885 *Lichas marginatus* n., Lindström, p. 58, pl. 14, figs 8, 9.
1936 *Trimerolichas marginatus* Lindström; Phleger, p. 604, text-fig. 15.
v 1938 *Lichas marginatus* Lindström; Whittard, p. 114, pl. 4, fig. 4.
1957 *A. marginatus* Lindström; Tripp, p. 115.
v 1959 *A. marginatus* Lindström; Tripp, P. O496, pl. 393, figs 4a,b.

Lectotype. (selected herein); Ar2366 (cranidium), Lummelunda parish, Slite Group, Unit c (Sheinwoodian, *linnarssoni* & *ellesae* Biozones); figured Lindström 1885, pl. 14, fig. 9; Pl. 1, fig. 8. *Paralectotype.* (selected herein) Ar2367 (cranidium); locality 20; figured Lindström 1885, pl. 14, fig. 8; Pl. 1, fig. 2.

Other material (all cranidia). Ar2483, -85, locality 20. Ar2468, locality 26. Ar51747, -48, locality 37. Ar2474, -75, Högklint Formation?, drainage ditch, Hall parish. Ar2495, Slite Group, Sandsviken, Fårö parish.

Total stratigraphic range: Högklint Formation, lower to middle part, Slite Group, unit c (Sheinwoodian, *riccartonensis* to *ellesae* Biozones). Arenaceous Purple Shales (Telychian), Bog Mine outlier, Shropshire, U.K.

Diagnosis. A species of *Lichas* with longitudinal furrow extending to L1a; bullar lobe not reaching anterior margin; anterior border, flat, one-eighth cranidial length (sag.).

Description. Cranidium four-fifths as long (sag.) as wide (tr.), of constant convexity in lateral view. Occipital ring three-quarters cranidial width (tr.) and one-fifth cranidial length (sag.), narrowing abaxially. L1a oval, long axis at 10° to a transverse line. Median glabellar lobe two-fifths width (tr.) of occipital ring posteriorly, narrowing to one-tenth that width opposite palpebral lobe, widening in front of bullar lobe and separated from anterior extension of fixed cheek by an extension of axial furrow. Bullar lobe subangular, half as wide (tr.) as long (exsag.), long axis at 30° to exsagittal line, of strong independent convexity. Fixed cheek convex, crescentic, as wide (tr.) as long (exsag.). Palpebral lobe one-quarter sagittal cranidial length, situated at one-third cranidial length (sag.) from posterior margin. Palpebral furrow well-incised. Whole dorsal surface with sculpture of randomly distributed coarse and fine granules, with a large degree of variation in granulation between specimens of equal size (compare Pl. 1, figs 10 & 12a).

Discussion. *Lichas marginatus* is the type species of the genus *Trimerolichas* Phleger, 1936 (p. 604, text-fig. 15) which Tripp (1959, p. O496) declared to be a junior subjective synonym of *Arctinurus*. Although I do not believe it possible to distinguish *Arctinurus* from *Lichas* on cranidial characteristics alone, I believe this species can be placed in *Lichas* with a degree of certainty for the following reasons. Firstly it bears close similarity to the type species of *Lichas* (*L. laciniatus* Wahlenberg, 1818; see Warburg 1939, pl. 9, figs 1-7) and with *L. sylvestris* Reed, 1925 (see Howells 1982, pl. 13, figs 1-4, 7, 8) both of which have pygidia of *Lichas*-type. *L. marginatus* differs from the last two named species only in possessing a wider anterior border and longitudinal furrows that merge with the occipital furrow. Secondly the cranidia associated with

"Arctinurus"-type pygidia (*sensu* Tripp 1959) from Gotland (see *Pseudotupolichas* below) all lack L1a while *L. latifrons* and *L. marginatus* both possess this lobe. This again indicates a closer relationship between *L. marginatus* and species of *Lichas* s.s. than *"Arctinurus"* (*sensu* Tripp 1959).

A single cranidium of *L. marginatus* (GSM 55486) is known from the Arenaceous Purple Shales (Telychian, Upper Llandovery), of the Bog Mine outlier of Shropshire, U.K. (Whittard 1938, p. 114, pl. 4, fig. 4). Although comparison is hampered by a difference in preservation between the Gotland and Shropshire material (dorsal exoskeletal elements in fine grained limestone and a weathered internal mould in coarse grained sandstone respectively) I believe the English specimen to belong to this species. The Shropshire specimen occurs in older rocks than the available Swedish material.

Phleger's (1936) illustration of *L. marginatus* is based on Reed's specimen of *L. sylvestris* (see Howells pl. 13, fig 1) and may give a misleading impression. Phleger's line drawing shows the longitudinal furrows joining the occipital furrow which they do not in the Scottish specimen.

The diagnostically long (sag. & exsag.) anterior border of this species is subject to a large degree of intraspecific variation (see Pl. 1, figs 8a & 12a) but is consistently distinctive enough to separate it from other species of *Lichas*.

Lichas? araneus Lindström, 1885. Pl. 2, figs 2, 4, 6, 7, 10, 12, 13; Text-fig. 6.

v* 1885 *Lichas araneus* n., Lindström, p. 58, pl. 15, fig. 30.

v. 1885 *Lichas palifer*, n. Lindström, p. 57, pl. 14, figs 10, 11.

1958 L.? araneus Lindström; Tripp, p. 575.

. *1958 L.? palifer* Lindström; Tripp, p. 575.

Holotype. By monotypy Ar5072 (pygidium), Lansa 1, Fårö parish, Slite Group, unit c (Sheinwoodian, *ellesae* Biozone); figured Lindström 1885, pl. 15, fig. 30; Pl. 2, fig. 2.

Other material. (All pygidia): *Lectotype* of *L. palifer* (selected herein) Ar2331, locality 20; figured Lindström 1885, pl. 14, fig. 11; Pl. 2, fig. 10. *Paralectotype* of *L. palifer* (selected herein); Ar2329, locality 20; figured Lindström 1885, pl. 14, fig. 10; Pl. 2, fig. 7. Ar2360-2, -64, Ar2484, Ar5073, locality 20. Ar2470, locality 26. Ar2365, locality 42. Ar2372-74, Ar5149, locality 43. Ar2393, -94, Högklint Formation, unit d, *Pterygotus* layer.

Total stratigraphic range: Högklint Formation, south west facies, Slite Group, unit c (Sheinwoodian, *rigidus* to *ellesae* Biozones).

Diagnosis. Axis with one anterior ring, not defined abaxially and bearing two stout tubercles and a longer, inflated, posterior area bearing a stout swelling; postaxial band parallel-sided or gently expanding; third pleurae merge with postaxial band posteriorly and lack free points; posterior margin transverse.

Description. Thoracic pleurae one-quarter as long (sag.) as wide (tr.), transversely arranged for three-quarters of their length then posteriorly-directed, ending in a narrow, backwardly-directed spine. Pleural furrow well-incised running from abaxial corner of pleura almost to tip of pleural spine.

Pygidial axis convex and one-third width (tr.) posteriorly, narrowing to half this width where it merges with postaxial band, with prominent articulating ring and well-incised articulating furrow. Anterior of pygidial axis appearing flat in lateral view, sloping steeply below posterior swelling to merge with postaxial band. Anterior two pleural pairs broad, ending in short backwardly-directed spines. Anterior and posterior bands of each pleural pair of similar width at mid length of pleural furrow. Posterior pleural pair parallel to postaxial band. Doublure one-third pygidial length (sag.).

Discussion. I consider the type material of *L. palifer* and that of *L. araneus* to belong to the same species. Lindström's illustration of *L. araneus* differs from that of *L. palifer* in having pleurae which apparently extend farther posteriorly, in lacking a posterior swelling on the axis and bearing two stout granules on the anterior part of the axis. From an examination of Lindström's figured specimens of *L. palifer* it is clear that the illustration is inaccurate; a swelling does exist at the anterior of the axis and the pleural bands are not significantly longer. All the available specimens in which the axis is preserved display a pair of large tubercles anteriorly. The holotype of *L. araneus* and the paralectotype (Ar2329) of *L. palifer* are from the same locality which is in the Slite Group (unit c).

This species is placed with doubt in *Lichas* on the basis of its gross similarity to the type species *L. laciniatus* (Wahlenberg, 1818; see Warburg 1939, pl. 9 figs 1-7) and other species of *Lichas*. Like the type and other species *Lichas araneus* has broad gently curving ribs the anterior pairs of which terminate in broad points and the third pair lack free points and are fused to the postaxial band.

However it is placed with doubt in *Lichas* because of the diagnostic transverse posterior margin, which is unlike other species assigned to *Lichas* which all end in a rounded margin or blunt points. This morphology is intermediate between species placed in *Lichas* s.s. and those referred to both *Arctinurus* and *Pseudotupolichas*; with an indented posterior margin. *Arctinurus* s.s. does not occur on Gotland. The pygidium of the type species of *Pseudotupolichas* (*P. ornatus* Angelin, 1854) differs from *L. araneus* in possessing short, narrow, pleural spines, two axial rings and an indented posterior margin. The other two species of *Pseudotupolichas* from Gotland for which pygidia are known, *P. plicatus* (Lindström, 1885) and *P. visbyensis* (Lindström, 1885) both possess a coarser dorsal granulation and relatively wider (tr.) axial region.

It is possible that *L. araneus* could belong to either *L. marginatus* or *P. concinnus* both of which are known from cranidia only. In view of the great degree of variation in the sculpture of *L. marginatus* which is from the same horizon and locality as material of *L. araneus* and the poor preservation of *P. concinnus* it is not possible to determine which cranidium belongs with these pygidia.

The species of *Lichas* which most closely resembles *L. araneus* is *L. latifrons* Angelin, 1854, which differs by bearing a far more distinct posterior axial swelling, a larger posterior expansion of the postaxial band and a posterior margin which is rounded.

Lichas araneus (Lindström, 1885) was the subject of I.C.Z.N. opinion 615 (1961) which dealt with the gender of the generic name *Lichas*. Tripp (1959, p. O495) pointed out that using *araneus* as the specific name was to regard *Lichas* as masculine, possibly derived from the squire, or servant of Hercules. If however the generic name is taken as feminine, derived from the Greek noun meaning the gap between thumb and forefinger, then the specific name would be *aranea* as in *Lichas aranea* Holzapfel, 1895 (p. 32). If Holzapfel regarded the generic name as masculine then *L. aranea* would be a junior primary homonym of *L. araneus*. Holzapfel however was inconsistent in his naming of species and regarded *Lichas* as masculine in the binomen *Lichas granulosus* Röemer, 1852. In order to maintain stability of nomenclature opinion 615 ruled that *Lichas araneus* and *Lichas aranea* are not homonyms and that *Lichas* should be regarded as masculine. The name *araneus* was placed on the Official List of Specific Names in Zoology as used in the binomen *L. araneus* (name No. 1768). *aranea* Holzapfel, 1895 as published in the binomen *L. aranea* was placed on the Official List of Specific Names in Zoology (name No. 1769).

Genus **Dicranopeltis** Hawle & Corda, 1847

[Obj. Syn.= *Trachylichas* Gürich, 1901, p. 525].

[Subj. Syn.= *Dicranopeltoides* Phleger, 1936, p. 612. *Makromutis* Phleger, 1936, p. 612; *Raymondarges* Phleger, 1937a, p. 241. *Tsunylichas* Chang, 1974, p. 176].

Discussion. The above synonyms are *fide* Tripp 1959 apart from *Tsunylichas* which is *fide* Thomas 1981].

Type species. By subsequent designation of Reed 1902, p. 71; *Lichas scabra* Beyrich, 1845, p. 28, unnumbered plate, fig 16; from the Liten Formation (Wenlock) of St. Yvan (=Svaty Jan), near Beroun, Czechoslovakia.

Diagnosis (emended from Tripp 1959 p. O496). Bullar lobes fully circumscribed; L1a and L1b developed. Pygidium with three pairs of pleural bands ending in free points, posterior pair defining an indentation of the posterior margin.

Dicranopeltis salteri (Fletcher, 1850). Pl. 4, figs 1-4, 6-10, 12; Text-figs 3f, 6.

1850 *Lichas Salteri* n. sp., Fletcher, p. 237, pl. 27, figs 9, 9a, pl. 27 *bis*, fig. 4.

1854 *Lichas laticeps*, n. sp., Angelin (*pars.*), p. 70, pl. 36, fig. 8, *non* pl. 37, fig. 5 [=*Platylichas bottniensis* (Wiman, 1908); *fide* Thomas 1981, p. 68].

. 1885 *Lichas triquetrus* Lindström, p. 59, pl. 14, fig. 12.

1981 *Dicranopeltis salteri* (Fletcher); Thomas, p. 68, pl. 19, figs 4-12, text-fig. 6c. [Includes full synonymy of *D. salteri*]. .

Lectotype. By subsequent designation of Thomas 1981, p. 70, pl. 19, fig 4, SM A10261 (cranidium), Much Wenlock Limestone Formation, Dudley district, Warley, West Midlands county, U.K.. *Paralectotype*, BM 44202, same horizon and locality as lectotype, figured Thomas 1981, pl. 19, fig. 4.

Other material. Cranidia, Ar51741, -42, locality 11, Ar2446, -47, locality 24 or 25, Ar51395, Slite Group, Slite Marl, Othem parish, Ar5077, Ar5082, -83, Högklint Formation?, Visby Parish, Ar5130, Högklint Formation, unit b, dump at Visby harbour; hypostomes, Ar51467, locality 39, Ar2456, unknown locality; pygidia; Ar2455, locality 18. Ar1454, Ar2428, -29, -54, Upper Visby Formation, Visby parish.

Total stratigraphic range. Upper Visby Formation; Högklint Beds, units b & d; Slite Group, units c & g; Halla Formation, unit b (Sheinwoodian to Homerian, *centrifugus* to *nassa* Biozones). Much Wenlock Limestone Formation (Homerian *nassa* Biozone), Dudley, West Midlands County, U.K.

Diagnosis. See Thomas 1981, p. 68.

Description. Cranidium four-sevenths as long (sag.) as wide (tr.) across palpebral lobes, flat posteriorly and becoming convex forwards in lateral view. Occipital ring one-eighth length (sag.) of cranidium. Median glabellar lobe overhanging anterior margin, one-seventh maximum cranidial width (tr.) at occipital furrow, expanding slightly forwards in dorsal view. Longitudinal furrows shallow, well defined, not reaching occipital ring. L1b subquadrate, narrowing adaxially and widening slightly posteriorly. Bullar lobe convex, expanding slightly anteriorly. Axial furrow well-defined, of similar form to longitudinal furrow. Fixed cheek sloping gently downward from axial furrow, narrowing anteriorly with flattened area sloping upwards towards palpebral lobe. Palpebral lobe one-third sagittal length in plan view, half height of glabella. Free cheek unknown.

For description of hypostome see Thomas 1981, p. 69.

Pygidium two-thirds as long (sag.) as wide (tr.). Axis half width (tr.) anteriorly, narrowing gently to slight geniculation at half pygidial length (sag.) and merging with postaxial band. Postaxial band narrowing rapidly to a point by posterior margin. Pleurae gently sloping, broad, two anterior pairs with short backwardly directed spines, pleural and interpleural furrows of similar form. Posterior pleural pair triangular with less well defined pleural furrows and blunt tips which define a short, sharp, posterior notch. Sculpture of numerous, randomly distributed, coarse and fine granules.

Discussion. The Gotland material is assigned to this species largely on the overall cranidial morphology, especially on the characteristic four pairs of large granules on the glabella. *Dicranopeltis* pygidia from Gotland display no visible differences from those of *D. salteri* but are damaged anteriorly making examination of the axial region difficult.

L. triquetrus Lindström (1885, p. 59, pl. 14, fig. 12) differs from *D. salteri* only in lacking larger granules amongst the smaller, and Lindström's illustration does not display paired large tubercles on the axial rings. I do not believe these differences to be significant and consider *L. triquetrus* to be a junior subjective synonym of *D. salteri*.

I follow Lindström (1885, p.60), Warburg (1939, p. 108), Tripp (1958, p. 579) and Thomas (1981, p. 69) in placing the cranidium of *L. laticeps* Angelin, 1854 (pl. 37, fig. 5) in the synonymy of *D. salteri*.

Lindström also considered the pygidium of *L. gibbus* Angelin, 1854 (pl. 36, fig. 1 to be synonymous with this species. Thomas (1981, p. 69) stated that "the presence of numerous axial rings and a distinct pygidial border indicate that *L. gibbus* cannot be assigned to *Dicranopeltis*". I agree with Thomas that both the cranidium and pygidium illustrated by Angelin as *L. gibbus* are clearly of *Choneliobarges* type.

Thomas (1981 p. 70, pl. 19, fig. 15) figured a pygidium as *D.* cf. *salteri* from the Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone) of Dudley, U.K. which differs from the type material and that from Gotland in possessing a sharp constriction of the axis posteriorly, relatively longer pleural bands which are less strongly incurved and a less coarsely granulate dorsal surface.

He (1981, p. 71, pl. 19, fig. 16) also figured a pygidium (*Dicranopeltis* sp. 1) from the Woolhope Limestone Formation of Herefordshire which differs from *D. salteri* only in possessing a distinct flexure of the pleural and interpleural furrows close to the axis.

The pygidium of both the type species of *Dicranopeltis* (*D. scabra* Beyrich, 1845) and *D. woodwardi* Reed, 1902 (p. 9, pl. 1, figs 7, 8) of which only the pygidium is known, differ from *D. salteri* in possessing relatively longer pleural ribs and a postaxial band that does not narrow to a point near the posterior margin but is parallel sided. In addition the cranidium of *D. scabra* possesses longitudinal furrows which extend to the occipital furrow, which they do not in *D. salteri*, and the pygidium of *D. woodwardi* possesses only one axial ring, as opposed to two in *D. salteri*, and a subangular termination to the axis defining a sharp break in slope before the postaxial band, the posterior of the axis in *D. salteri* forms a continuous slope.

D. polytoma (Angelin, 1854; see Dean 1974, pl. 35, figs 4, 6, 7, 9, 12) from the Dalmanitina Beds (Ashgill) of Dalarne Sweden, the Chair of Kildare Limestone (Rawtheyan) of Ireland and the Keisley Limestone (Ashgill) of Westmorland differs from *D. salteri* in lacking the paired granules on the cranidium, possessing an L1a, longer pygidial pleural bands and broader deeper, axial furrows.

Genus **Pseudotupolichas** Phleger, 1936

[Jun. subj. synonym: *Arctinuroides* Phleger, 1936].

Type species. By original designation of Phleger; *Lichas ornatus* Angelin, 1854, p. 72, pl. 37, figs 7, 7a, from the Slite and Högklint Formations (Wenlock) of Gotland, Sweden.

Other species. P. chicagoensis (Weller, 1907), *P. plicatus* (Lindström, 1885), *P. visbyensis* (Lindström, 1885).

Diagnosis (emended from Phleger 1936, p. 602). Palpebral furrow not reaching axial furrow at γ; longitudinal furrow merging with occipital furrow; L1a and L1b not developed; no anterior process. Pygidial axis extending approximately half length (sag.), between one-half and two-fifths width (tr. at anterior margin), with one or two axial rings.

Discussion. Oncholichas was erected by Schmidt (1885, p. 109), giving as type *Lichas boltoni* (Bigsby, 1825) and including *P. ornatus* as a member of that genus. Schmidt was unaware that *L. boltoni* is the type species of *Arctinurus* Castelnau, 1843. *Oncholichas* is therefore a junior objective synonym of *Arctinurus*.

Reed (1902, p. 62) however knew that *L. boltoni* was the type species of *Arctinurus*, and believed *L. ornatus* belonged to a different genus. He proposed that *L. ornatus* be substituted for *L. boltoni* as the type species of *Oncholichas*. This is inadmissable under I.C.Z.N, articles 68b and 70a.

Gürich (1901), similarily unaware, placed *L. gothlandicus* Angelin, 1854; *L. concinnus* Angelin, 1854 and *L. marginatus* Lindström, 1885 in *Oncholichas* together with *L. ornatus* and erected *Plusiarges* with *L. boltoni* as type species. *Plusiarges* is thus another junior objective synonym of *Arctinurus*.

I consider that *L. ornatus*, *L. visbyensis* and *L. concinnus* are congeneric but separate from *A. boltoni* because they all possess a smaller palpebral lobe, a relatively longer (sag.) and broader (tr.) pygidial axis and lack an L1a. There are therefore two available generic names for these taxa (*Arctinuroides* and *Pseudotupolichas*). I choose *Pseudotupolichas* because of the better type material.

Pseudotupolichas ornatus (Angelin, 1854) Pl. 2, figs 3, 5, 8, 9, 12-15, 17; Pl. 3, figs 1-7, 12; Text-figs 3b, 6.

1854 *Lichas ornatus*. n. sp., Angelin, p. 72, pl. 37, fig. 7, 7a.

1857 *Lichas Eichwaldi*, Nieszkowski; Hoffman p. 24, pl. 1, fig. 3.

1857 *Lichas ornata* Angelin; Nieszkowski, p. 574.

v 1885 *Lichas ornatus* Angelin; Lindström, p. 58, pl. 15, fig. 13.

1885 *Oncholichas ornatus* Angelin; Schmidt, p. 109, pl. 6, figs 18-20.

1901 *O. ornatus* Ang.; Gürich, p. 527, pl. 20, fig. 13.

1902 *Oncholichas ornatus* Ang.; Reed, p. 76, Text-fig. 10.

1936 Pseudotupolichas ornatus (Angelin); Phleger, p. 602, text figs 7, 8.

1957 Arctinurus ornatus (Angelin); Tripp, text fig. 4j.

1958 A. ornatus (Angelin); Tripp, p. 575.

Type material. The whereabouts of Angelin's figured specimens (1854, pl. 37, fig. 7) is unknown. In view of the high degree of similarity between specimens in the Riksmuseet collection and that figured by Angelin specimen Ar2390 (pygidium), Lansa 1, Fårö parish, Slite Group, unit c (Sheinwoodian, *ellesae* Biozone); figured Lindström, 1885, pl. 15, fig. 13; Pl. 2, fig. 9 is herein designated neotype.

Other material; Ar50162 (cranidium), locality 16. Ar2344-46 (hypostomes), Ar2396 (pygidium), Ar2376, Ar2378-83, Ar2396, Ar2481, -82 (pygidia & hypostomes), Ar2496, Ar5030 (hypostomes), locality 20. Ar5046-47 (cranidia), locality 22. Ar2469 (cranidium), locality 27. Ar5043, (cranidium), locality 35. Ar5053, -54 (hypostome & cranidium), locality 42. Ar2479, Ar5044, (hypostomes). Ar5148 (cranidium), locality 43. Ar2471 (hypostome), Högklint Formation or Slite Group, Fleringe parish. Ar2375 (cranidium), Högklint? Formation, Hangvar parish. Ar2472 (hypostome), Högklint Formation, Kålenskvarn. Ar2395 (hypostome), Högklint Formation, Klinten vid Norderport. Ar5045 (cranidium), loose pebble, Norderstrand, Visby parish. Ar5057-59 (cranidium), Slite Group, unit g, Othem parish. Ar5032, (pygidium), Slite Group, Coast north of Storoya, Larbro parish. Ar5055 (cranidium), Visby Formation, Visby parish.

Total stratigraphic range. Högklint Formation units b, d and south west facies, Slite Group, units c, e and g (Sheinwoodian to Homerian, *riccartonensis* to *lundgreni* Biozones). Jaagarahau Stage (Sheinwoodian and Homerian, *linnarssoni* to *ludensis* Biozones), Islands of Vaika, East Baltic. Steinsfjorden Formation (Kiær's étage 9b, Sheinwoodian, *rigidus* and *linnarssoni* Biozones), Holmestrand district, southern Norway.

Diagnosis. A species of *Pseudotupolichas* of high cranidial convexity; longitudinal furrow merging with occipital furrow at one-quarter width (tr.) from mid line; anterior border narrow, convex. Pygidium with two axial rings defined anteriorly, the posterior of which does not reach sagittal line or axial furrow; anterior two pairs of pleural bands ending in short, narrow, posteriorly-directed and slightly incurved spines; posterior pair ending in short free spines in line with postaxial furrow; postaxial band parallel-sided or gently expanding posteriorly, ending in a shallow indentation; postaxial furrow reaching posterior margin.

Description. Cranidium convex (sag. & tr.) five-eighths as long (sag.) as wide (tr.). Occipital furrow broad, well-incised. Occipital ring transverse, of constant one-eighth cranidial length (sag. & exsag.). Median glabellar lobe one-quarter cranidial width (tr.) at occipital furrow, narrowing to one-eighth that width at three-fifths cranidial length (sag.) then expanding forwards, not expanding between bullar lobe and anterior border furrow. Bullar lobe subquadrate, of low independent convexity, posteriorly almost reaching occipital furrow. Longitudinal furrow angled abaxially towards anterior at 20° to exsagittal line. Axial and longitudinal furrow equally impressed. Fixed cheek convex (exsag. & tr.). Palpebral lobe half length of occipital ring (sag.) situated at one-third cranidial length (exsag.). Palpebral furrow well-incised, becoming shallower at highest point. Anterior border with sculpture of terrace ridges subparallel to margin. Rest of dorsal surface with the exception of furrows and palpebral lobe, with sculpture of predominantly large granules and interspersed smaller granules.

Hypostome two-thirds as long (sag.) as wide (tr.); anterior wing small, upwardly flexed, lateral notch a gentle curve. Lateral border furrow well-incised. Lateral border one-sixth width (tr.), convex, merging with broad rounded, posterior wing. Posterior margin with subangular indentation two-thirds width of middle body. Sculpture of terrace ridges subparallel to lateral margin on lateral border, whole remaining surface, excluding furrows with numerous punctae.

Pygidium four-fifths as long (sag.) as wide (tr.). Axis convex half width (tr.) at anterior margin, narrowing gently to half pygidial length and merging with postaxial band. Axial rings of equal length (sag.), together occupying anterior third of axis. Posterior section of axis with broad swelling. Pleurae flat, adaxial portion of first pair posteriorly directed at 10° to a transverse line, second pair at 45°, third parallel to postaxial band. Anterior pleural spines markedly constricted at base. Pleural and interpleural furrows broad and shallow, pleural furrows almost reaching lateral margin.

Discussion. Material figured as *Oncholichas ornatus* by Schmidt (1885, Pl. 6, figs 18-20) and subsequently traced from these figures by both Phleger (1936, text-figs 7, 8) and Tripp (1957, text-fig. 4) was from localities in Kerkan, Lithuania. Although cranidia of *P. ornatus* from Gotland are indistinguishable from the illustrations, Schmidt's illustration of a *L. ornatus* pygidium differs from the Gotland material in displaying only one axial ring. Other than this the figured pygidium is indistinguishable from the Gotland material. It is probable that this is an error of draughtsmanship as Schmidt described a second ring (1885, p. 3) and stated that he could not distinguish differences between his and the Gotland material. I consider specimens from the Jaagarahau Stage (Sheinwoodian to Homerian, *linnarssoni* to *lundgreni* Biozones) of the Islands of Vaika, East Baltic (pl. 3, figs 1-7) to be conspecific with the Gotland specimens. *P. ornatus* is also known from one pathological pygidium from the Steinsfjorden Formation (Kiær's ètage 9b, Sheinwoodian *rigidus* to *linnarssoni* Biozones) of Langøya, southern Norway.

This species is readily distinguished from *P. concinnus* (Angelin 1854) by being of greater convexity, possessing a narrower median lobe anteriorly and in being consistently more coarsely granulate.

P. ornatus is also comparable with *P. chicagoensis* (Weller, 1907) from the Niagaran Limestone (Wenlock) of Bridgeport, U. S. A. The American species being distinguished by possessing bullar lobes which are less angular posteriorly, a median lobe which extends farther forwards and broader pygidial pleurae with broader points which are less posteriorly deflected. The hypostome of *P. chicagoensis* is also broadly similar but from Weller's illustration appears narrower anteriorly.

Pseudotupolichas visbyensis (Lindström, 1885). Pl. 3, figs 10, 13; Text-fig. 6.

v* 1885 *Lichas visbyensis* n., Lindström, p. 58, pl. 16, fig. 11.

v *1958 A. visbyensis* (Lindström); Tripp p. 575.

Pseudotupolichas

Holotype. By monotypy Ar2392 (pygidium), Norderstrand, Visby, Lower or Upper Visby Formation (Sheinwoodian, *crenulata* to *murchisoni* Biozones); figured Lindström 1885, pl. 16, fig. 11; Pl. 3, fig. 10.

Other material. Ar2419, Visby, Lower or Upper Visby Formation; Pl. 3, fig. 13.

Diagnosis. A species of *Pseudotupolichas* with one axial ring, defined only anteromedially as a weakly-convex area; axis ends in a broad swelling, sloping steeply to postaxial band which narrows backwards then expands close to posterior margin; postaxial furrow extending two-thirds distance from posterior of axis to margin; pleural bands broad, ends in short, broad spines.

Description. Pygidium as long (sag.) as wide (tr.). Axis two-fifths anterior width (tr.), narrowing backwards and merging with postaxial band. Pleural and interpleural furrows well-incised, pleural furrows not reaching margin. Doublure extending half pygidial length (sag.) with a sculpture of terrace ridges ridges subparallel to margin. Dorsal surface, with the exclusion of furrows, with a sculpture of predominantly coarse granules. In one specimen lines of coarse granules occur along the pleurae, axis and postaxial band; these lines are without reciprocal granules on other side of the axis.

Discussion. This material is assigned to *Pseudotupolichas* on its gross similarity to the two species herein placed in that genus for which both cranidia and pygidia are known *P. ornatus* (Angelin, 1854); *P. chicagoensis* (Weller, 1907). It differs from known species of *Arctinurus* s.s. in possessing a proportionately wider and longer pygidial axis.

P. visbyensis differs from *P. ornatus* (Angelin, 1854) in possessing no well-defined axial rings posteriorly across entire width of axis, a greater axial convexity, more posteriorly-directed pleurae which end in broader points, a third pleural pair which merges with postaxial band and a coarser granulation.

P. visbyensis is differentiated from *P. plicatus* (Lindström, 1885) on the basis that the latter has two pygidial axial rings, much finer granulation and postaxial furrow which extends to the posterior margin.

The axial region of *L. araneus* (Lindström, 1885) resembles that of *P. visbyensis* but is less granulate with less posteriorly-directed pleurae, the third pleural pair do not merge with postaxial band and lacks a posterior indentation to the margin.

P. chicagoensis (Weller, 1907, p. 248, pl. 23, figs 7, 8) from the Niagaran Limestone (Wenlock) of the Chicago area, U.S.A. differs from *P. visbyensis* in possessing two well-defined rings anteriorly, a postaxial furrow which is relatively longer, pleural bands which are more strongly incurved and a narrower indentation to the posterior margin.

Pseudotupolichas plicatus (Lindström, 1885). Pl. 3, figs 8, 9; Text-figs 5, 6.

v* 1885 *Lichas plicatus* n., Lindström, p. 59, pl. 16, fig. 12.
1958 A. plicatus (Lindström); Tripp, p. 575.

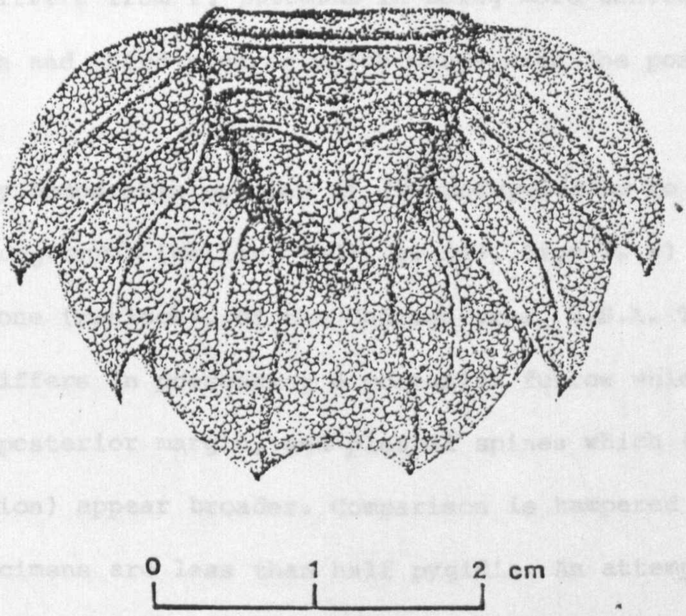
Holotype. By monotypy; Ar2424 (pygidium), Lansa 1, Slite Group, unit c (Sheinwoodian *ellesae* Biozone); figured Lindström 1885, pl. 16, fig. 11; Pl. 3, fig. 8.

Other material. Ar2425 (pygidium), from type locality; Pl. 3, fig. 9.

Stratigraphic range. This species is only known from the type locality.

Text-figure 5

Reconstruction of *Pseudotupolichas plicatus* (Lindström, 1885) based on specimens Ar2424 (Holotype) and Ar2392 (Pl. 3, figs 8 & 9 respectively).



Diagnosis. A species of *Pseudotupolichas* with two pygidial axial rings, defined anteriorly by transverse furrows which do not cross median third of width; postaxial band gently posteriorly expanding at first, rapidly expanding after two-thirds pygidial length (sag.) reaching two-thirds anterior width (tr.) of axis by posterior margin; postaxial furrow extending to margin.

Description. Pygidium three-quarters as long (sag.) as wide (tr.). Axis half pygidial width (tr.) anteriorly, of low convexity, narrowing posteriorly and merging with postaxial band. Three pairs of pleurae ending in broad spines in line with pleural furrows. Pleural and interpleural furrows well-incised, pleural furrows almost reaching tips of spines. Dorsal surface with sculpture of coarse and fine granules of irregular distribution.

Discussion. This species closely resembles *P. ornatus* (Angelin, 1854) differing from it in possessing a far greater posterior widening of the postaxial band, an anterior axial ring not defined medially and pleural spines which are broader and not as posteriorly directed.

P. visbyensis differs from *P. plicatus* in being more convex with coarser granulation and third pleurae which merge with the postaxial band.

The most closely comparable species of *Pseudotupolichas* to this material is *P. chicagoensis* (Weller, 1907, p. 248, figs 7, 8) from the Niagran Limestone (Wenlock), of the Chicago area, U.S.A. The American species differs in possessing a postaxial furrow which does not extend to the posterior margin, and pleural spines which (from Weller's illustration) appear broader. Comparison is hampered by the fact that both specimens are less than half pygidia. An attempt at reconstructing the pygidium of *P. plicatus* (Text-fig. 5) indicates a greater posterior widening of the postaxial band than in either *P. ornatus* or *P. chicagoensis*.

Pseudotupolichas? *concinnus* (Angelin, 1854). Pl. 3, fig. 11.

v* 1878 *Lichas concinnus*. n. sp., Angelin, p. 70, pl. 36, figs 6, 6a.

1885 Lichas concinnus Angelin; Lindström, p. 57.

Pseudotupolichas

1901 O. concinnus Ang.; Gürich, p. 527.

1910 Lichas concinnus Ang.; Westergård, p. 30.

1958 Arctinurus concinnus (Angelin); Tripp, p. 575.

Holotype. By monotypy; Ar2363 (cranidium), unknown locality; figured pl. 3, fig. 11.

Other material. Ar2332, unknown locality.

Diagnosis. A species of *Pseudotupolichas* with occipital ring one-sixth cranidial length (sag.) in dorsal view, its posterior margin raised above level of median lobe; bullar lobes of low independent convexity, narrowing to a blunt point anteriorly; longitudinal furrow of constant length (sag. & exsag.) and depth for entire width.

Description. Cranidium three-quarters as long (sag.) as wide (tr.). Occipital furrow broad, well-incised. Median glabellar lobe one-third cranidial width at posterior, narrowing to one-sixth by one-quarter cranidial length (sag.) then expanding in front of bullar lobe. Bullar lobe half as wide as long, long axis at 30° to an exsagittal line. Longitudinal furrow narrower than occipital furrow and of similar form to axial furrow. Fixed cheek convex. Whole cranidial dorsal surface, with exception of furrows, with sculpture of predominantly fine granules.

Discussion. This species is placed in *Pseudotupolichas*? largely on the basis of the morphology of its bullar lobes and apparent lack of L1a. It is assigned with doubt due to the poor preservation of the holotype in the abaxial region of the occipital furrow which may have obliterated a small L1a.

Pseudotupolichas

The sculpture of the dorsal surface of this cranidium is similar to that of *Pseudotupolichas plicatus* (Lindström, 1885) and the two species may be synonymous. It is impossible to state this with any certainty due to the the small number of available specimens in both cases. In addition surface sculpture amongst the Lichidae is extremely variable within single species (see *P. ornatus* above) and I do not consider it to be significantly characteristic taken in isolation as in the case of *P. concinnus*.

P. concinnus differs from *P. ornatus* (Angelin, 1854) in being less convex (sag. & tr.), in possessing bullar lobes of a lower convexity, a less coarse granulation and shallower, narrower, glabellar furrows.

L. latifrons Angelin, 1854 (see above) differs from *P. concinnus* in possessing an L1a, more subangular bullar lobes anteriorly and in being slightly less convex in longitudinal view (see Pl 1, fig. 7c; Pl. 3, fig. 11b).

Subfamily Homolichinae Phleger, 1936

Diagnosis. Lichidae with prominent L1a which indents occipital ring; L1b not independently inflated, may be fused with bullar lobe or fixigena; median glabellar lobe strongly expanding to anterior; longitudinal furrow typically extends to occipital furrow, bullar lobe (or composite lateral lobe formed by fusion of bullar lobe and L1b) invariably circumscribed. Pygidium with three pairs of spinose pleurae; anterior and posterior pleural bands of similar elevation; postaxial band tapering backwards over most of its length, widening again distally.

Genera included. *Homolichas* Schmidt, 1883, *Autoloxolichas* Phleger, 1936, *Conolichas* Dames, 1877, *Hopolichoides* Phleger, 1936, *Metalichas* Reed, 1902, *Platylichas (Platylichas)* Gürich, 1901, *Leiolichas* Schmidt, 1885.

Genus **Platylichas** Gürich, 1901

Type species. By monotypy; *Lichas margaritifer* Nieszkowski, 1857, p. 54, pl. 1, fig. 15; from the Porkuni Limestone (Ashgill), Estonia.

Platylichas grayii (Fletcher, 1850). Pl. 4, figs 5, 11; Pl. 5, figs 5, 8; Text-figs 3c, 6.

1848 *Lichas* sp. undescribed, Salter, p. 340, pl. 8, fig. 8.

1850 *Lichas Grayii*, n. sp., Fletcher, p. 237, pl. 27, fig. 8, pl. 27 *bis*, figs 3,3b.

1850 *Lichas Barrandei*, n. sp., Fletcher (*pars.*), p. 238, pl. 27 *bis*, fig. 5, *non* pl. 27, fig. 10 (= *Dicranopeltis woodwardi* Reed, 1903; *fide* Thomas, 1981).

v. 1854 *Lichas rotundifrons*, n. sp. Angelin (*pars.*), p. 70, pl. 36, figs 7-7b, *non* fig. 4 (= *Acanthopyge rotundifrons* [see Tripp (1958, p. 579, pl. 85, figs 9-11)].

non. 1865 *Lichas bulbiceps*, Huxley & Etheridge, p. 5, p. 19 (= Caradoc lichid; *fide* Thomas 1981).

1981 *Platylichas grayii* (Fletcher); Thomas, p. 78, pl. 21, figs 6, 10-20 (includes full synonymy).

Lectotype. By subsequent designation of Thomas (1981, p. 78) SM A10258 (cranidium); figured Fletcher 1850, pl. 27, fig. 8 & Thomas pl. 21, fig. 11, from Much Wenlock Limestone Formation, Dudley.

Paralectotype. (cranidium and right free cheek) figured Fletcher 1850, pl. 27 *bis*, figs 3-3b, untraced.

Material from Gotland. Ar2460, (syntype cranidium of *Lichas rotundifrons* Angelin, 1854 (selected herein)) Visby parish, Upper Visby Formation; figured Angelin, 1854, pl. 37, figs 7a-b; Pl. 4, fig. 5). Ar2417, -18, Ar2461-66; pl. 5, fig. 5 (cranidia), Visby parish, Upper Visby Formation. Ar2448; pl. 4, fig. 11 (cranidium), Visby d. Ar2422; pl. 5, fig. 8 (cranidium), Tofta parish, Upper Visby Formation.

Total stratigraphic range. Upper Visby Formation (Sheinwoodian, *centrifugus* & *murchisoni* Biozones). Coalbrookdale Formation (Sheinwoodian and Homerian, *riccartonensis* to *nassa* Biozones), Malvern district, U.K.. From beds of late Wenlock age at Penylan, Cardiff, Wales and the Lower Ludlow? of Sedgley.

Diagnosis (emended from Thomas 1981, p. 79). A species of *Platylichas* with 1S ill defined; posterior end of bullar lobe subangular; L1a twice as wide (tr.) as long (exsag.).

Description (for full description see Thomas 1981, p. 79). Cranidium flat posteriorly in lateral view, becoming convex anteriorly, two-thirds as long (sag.) in dorsal view as wide (tr.). L1a elliptical, weakly-inflated and with long axis in line of occipital furrow. L1b not circumscribed, merging with fixed cheek. Bullar lobe oval, half as long (exsag.) as cranidium, long axis at 20° to an exsagittal line. Preglabellar field very narrow and with sculpture of terrace ridges subparallel to anterior margin. Whole dorsal cranidial surface with sculpture of randomly-distributed coarse and fine granules.

Discussion. I follow Thomas (1981, p. 48) in placing the cranidium (Ar2460) figured by Angelin as *L. rotundifrons* (1854, pl. 36, figs 7-7b), in *P. grayii.* Angelin's figured pygidium (1854, pl. 36, fig. 4), Ar5145, of *L. rotundifrons* possesses a clear border which bears posteriorly-directed spines and I believe it to belong to the genus *Acanthopyge.*

The species of *Platylichas* most resembling *P. grayii* is *P. scoticus* (Reed, 1906; see Howells 1982, p. 48, pl. 13, figs 10, 12-16, 18, 20, 21, 23) from the Mulloch Hill Formation (Rhuddanian to Aeronian stages, Llandovery) of Girvan, Scotland. Thomas (1981, p. 80) and Howells (1982, p. 49) distinguish *P. scoticus* from *P. grayii* on the basis of the Scottish species relatively wider bullar lobes, which are more distinctly circumscribed posteriorly, longer (exsag.) L1b and narrower frontomedian lobe. In addition I believe the L1a of *P. scoticus* to be relatively narrower (tr.) and longer (exsag.) and the posterior end of the bullar lobe to be more gently rounded than that of *P. grayii.*

Warburg (1925, p. 286) considered *P. latus* (Törnquist, 1884), from the Lower Leptaena Limestone (Ashgill) of Dalarne, Sweden to be intermediate between *P. grayii* and *P. scoticus.* Although I have not seen the type material of *P. latus* Warburg's figures (pl. 7, figs 12-14, 16?) show the bullar lobe to be relatively wider and more angular anteriorly and the L1a to be larger and narrower adaxially than either *P. scoticus* or *P. grayii.*

P. grayii is distinguished from the type species of *Platylichas* (*P. margaritifer* (Neiskowski, 1837, pl. 1, fig. 15) in possessing a median glabellar lobe which is relatively narrower anteriorly, bullar lobes which are less angular anteriorly and a longer (sag.) more transversely arranged occipital ring.

P. cicatrosus Lovén, 1846 (see Warburg 1939, p. 115, pl. 12, figs 15a-c) also from the Leptaena Limestone (Ashgill) of Dalarne, Sweden differs from *P. grayii* in possessing a median glabellar lobe of marked independent convexity in anterior view and bullar lobes which are subangular anteriorly.

Subfamily Ceratarginae Tripp, 1957

Diagnosis. See Tripp 1959, p. O500.

Genus **Acanthopyge** Hawle & Corda, 1847

Type species. By subsequent designation of Reed 1902, p. 60. *Acanthopyge leuchtenbergi* Hawle & Corda, 1847, p. 144, pl. 1, figs 5-7. From the middle Devonian of Bohemia and Germany.

Diagnosis. Bullar lobe fully circumscribed; posterolateral lobe well defined; median glabellar lobe strongly depressed opposite posterolateral lobe; free cheek strongly constricted at base of genal spine which is long and slender. Pygidium with two pairs of well-defined pleural ribs anteriorly, posterior band of each rib more convex than anterior; posterior border may be present; margin with three pairs of spines the most posterior pair of which define a sagittal indentation.

Acanthopyge

Acanthopyge pusilla (Angelin, 1854).

1878 *Lichas pusillus*. n. sp., Angelin, p. 71, pl. 37, fig. 2.

1885 Trochurus pusillus Angelin; Lindström, p. 61.

non. 1885 Lichas gibbus Angelin; Lindström, p. 50.

non 1885 Lichas rotundifrons Angelin; Lindström, p. 50.

1959 Acanthopyge pusilla (Angelin, 1854); Tripp, p. 578.

Holotype. The whereabouts of Angelin's holotype cranidium (by monotypy) is unknown.

Discussion. Angelin's illustration of "*Lichas*" *pusillus* (1854, pl. 37, fig. 2) is of insufficient quality to allow identification of this species amongst available material. I recommend that the species *A. pusilla* be restricted to the holotype specimen.

Acanthopyge calcitripa sp.nov. Pl. 7, figs 1-6, 8, 11, 12, 16, 19; Text-figs 3e, 6.

(*Name*. Latin, "calcitripa"; a four pointed weapon placed on the ground to impede an enemy, reference to the four pygidial spines of this species).

Holotype. Ar51729 (pygidium), Nordervik, Eksta parish, Mulde Formation, undifferentiated (Homerian, *nassa* Biozone); Pl. 7, fig. 1.

Paratypes. Ar51525-29, Ar51582-86 (cranidia, hypostomes & pygidia), locality 2. Ar5090, -91, -95, -96, Ar2336 (6 cranidia), locality 8. Ar51400 (hypostome), locality 9. Ar51401-03 (pygidium & hypostomes), locality 29. Ar51721-28 (pygidia & hypostomes), locality 31. Ar51580, -81 (hypostomes), locality 41.

Acanthopyge

Total stratigraphic range: Mulde Formation, lower & upper parts (Homerian, *lundgreni* & *nassa* Biozones).

Diagnosis. A species of *Acanthopyge* with genal spine long, narrow, curved back to posterior of occipital ring. Pygidial axis with prominent spine at posterior; anterior two marginal spines of equal length; posterior border well-defined.

Description. Cranidium twice as wide (tr.) as long (sag.). Occipital ring narrowing abaxially. Occipital furrow well-incised deepening abaxially. Median glabellar lobe two-thirds width (tr.) of occipital ring at posterior, parallel-sided for most of length, expanding to same width as occipital ring in front of bullar lobe. Longitudinal furrow well-incised shallowing at anterior end of bullar lobe. 1S well-incised, at 10° to a transverse line, deepening abaxially and continued across median lobe dividing it into posterior flat and anterior convex areas. Posterolateral cranidial lobe above level of posterior area of median lobe, less convex than anterior area or bullar lobe. Bullar lobe half as wide (tr.) as long (sag.) Axial furrow well-incised. Anterior border short (sag. & exsag) convex. Lateral and posterior borders convex, well-defined. Lateral margin with deep, rounded, antennial notch opposite anterior of palpebral lobe. Palpebral lobe one-third length of bullar lobe and highly convex. Field of free cheek steeply sloping. Genal spine one-sixth as wide as long.

Hypostome as long (sag.) as wide (tr.). Anterior margin gently convex forwards. Median body two-thirds length of hypostome (sag.). Lateral furrow only impressed on abaxial eighth of width. Lateral margin a straight line angled adaxially towards posterior at 10° to an exsagittal line.

Pygidium excluding spines five-sixths as long (sag.) as wide (tr.). Axis convex, one-third width (tr.) at posterior margin, parallel-sided and extending four-fifths pygidial length (sag.). One prominent axial ring defined anteriorly, followed by ?four posterior rings (defined only abaxially by transverse furrows and rows of granules) and a terminal piece. Posterior axial spine above level of anterior axial ring. Axis steeply sloping to postaxial ridge which narrows backwards. Anterior pleural band directed transversely to margin where it is deflected back into a long slender marginal spine. Second pleural band directed posteriorly at 50° to an exsagittal line and ending in a long, slender marginal spine. Posterior pleural band broadening abaxially, ending in a spine of similar form to anterior spines and extending farther posteriorly than second spine. Pleural furrows terminating at border. Posterior border well-defined with a pair of short spines both sides of postaxial ridge which define a sharp indentation. Doublure of equal width to posterior border (sag.). Dorsal surface with sculpture of prominent granules on posterior pleural bands, clustered around axial spine and on areas both sides of postaxial ridge.

Discussion. Few named species of *Acanthopyge* are known from the Wenlock. *A. hirsuta* (Fletcher, 1850; see Thomas 1981, p. 71, pl. 20, figs 1-9, 12, 17, 21) from the Much Wenlock Limestone Formation (*ludensis* Biozone), Dudley, West Midlands, U.K. and similar unnamed specimens figured by Thomas (1981 pl. 20, figs 10, 11, 14-16) differ from *A. calcitripa* in possessing larger bullar lobes, a longer (sag.) occipital ring and shorter, broader and less posteriorly directed genal spine. In addition the hypostome is wider (tr.), there is no axial spine in the pygidium and the pygidial axial surface is far less granulate.

The hypostome and pygidium of *C. rohri* Perry & Chatterton, 1977 (p. 367, pl. 5, figs 1-4, 9-10 11-12(?), 15-17, 20) of Baillie-Hamilton Island, Canada resemble those of *A. calcitripa* The hypostome of the Canadian species is relatively shorter than the Gotland specimens, the pygidium is also relatively shorter and more granulate and lacks a posterior axial spine.

A. orientalis Wu, 1977 (p. 117, pl. 3, figs 5-8) from the upper Silurian of China has longer bullar lobes, a longer (sag.) occipital ring and a relatively longer pygidium with marginal spines that are more incurved than *A. calcitripa.*

Acanthopyge rotundifrons (Angelin 1854). Pl. 6, fig. 12.

v* 1854 *Lichas rotundifrons,* Angelin (*pars.*), p. 70, 72, pl. 37, fig. 4, *non.* pl. 36, fig. 7 (= *Platylichas grayii*).

1885 Lichas rotundifrons Angelin; Lindström, p. 59.

non 1885 *Lichas rotundifrons* Angelin; Lindström, p.50 (= *A. pusilla* Angelin, 1854).

1910 Lichas rotundifrons Angelin; Westergård, p. 32 & 33.

Holotype. By monotypy Ar2397 (pygidium), Visby?; figured Angelin pl. 37, fig. 4.

Diagnosis. A species of *Acanthopyge* with two well-defined, pygidial axial rings posteriorly followed by ?six other rings, weakly-defined by transverse furrows and alignment of granules and a terminal piece; postaxial ridge short; posterior border broad and of low convexity.

Description. Pygidium, excluding spines, four-fifths as long (sag.) as wide (tr.). Axis convex, almost half width anteriorly, parallel-sided, sloping to merge with postaxial ridge posteriorly. Two pairs of pleural ribs, anterior band as convex as posterior, pleural furrows terminating at margin. Lateral border well-defined, weakly convex. A pair of small marginal spines is present close to both sides of postaxial ridge. Whole surface, excluding furrows with sculpture of coarse and fine granules of irregular distribution.

Discussion. This pygidium is assigned to *Acanthopyge* on the basis of its three pairs of marginal spines and indentation to the posterior margin.

The pygidium of this species is differentiated from that of *A. calcitripa* sp. nov. (see above) by its lack of a posterior axial spine, its gentle slope to the posterior of the axis, the larger number of axial rings, the broader less convex posterior border and the shorter, more posteriorly directed, second marginal spine. The granulation is more randomly distributed and the large granules seen on *A. calcitripa* are lacking.

A. rotundifrons differs from *A. hirsuta* (Fletcher, 1850; see Thomas 1981, p. 71, pl. 20, figs 1-9, 12, 17, 21) from the Much Wenlock Limestone Formation of Dudley and the Coalbrookdale Formation of the Malverns in being relatively longer with a larger number of axial rings, having two well-defined axial rings anteriorly and possessing less posteriorly directed pleurae.

A. orientalis Wu, 1977 (p. 177, pl. 3, figs 5-8) from the Upper Silurian of western China is relatively longer with more backwardly directed marginal spines and pleurae than *A. rotundifrons*.

Genus **Choneliobarges** Phleger, 1936

Type species. *Corydocephalus maccullochi* Reed, 1913 (p. 28, pl. 4, figs 9, 10), from the Drummock Group, Ordovician (Cautleyan to Rawtheyan, *anceps* Biozone) of the Girvan area Scotland.

Diagnosis (emended from Phleger 1936, p. 612). L1a not developed; posterolateral cranidial lobe well-developed, subquadrate. Anterior two pairs of pygidial pleural bands with anterior and posterior pleural ribs of similar width and convexity, with well-incised pleural furrows; posterior pair without pleural furrow or independent convexity, with well-defined, convex, border; posterolateral margin with four to thirteen short spines.

Discussion. It was decided to resurrect Phleger's genus on the basis of the consistent differences between species placed in the genus (by Phleger and herein) and those also grouped under "*Hemiarges*" by Tripp (1959, p. 0503) herein placed in *Craspedarges* Phleger (1939, p. 610). *Choneliobarges* lacks an L1a and possesses a pygidial border along the margin of which are slender spines. *Craspedarges* possesses an L1a lacks a pygidial border and the marginal spines are either short, broad and blunt (*C. scutalis* Salter, 1873. See below) or not present (*C. maia* Reed, 1920. See Thomas, pl. 19, figs 1-2).

Choneliobarges bucklandii (Milne Edwards, 1840). Pl. 5, figs 1, 2, 7, 11, 12; Pl. 7, fig. 15; Text-fig. 6.

Choneiliobarges

1840 *P. Bucklandii*, Milne Edwards, p. 345, pl. 34, fig. 12; [*fide* Thomas 1981].

1981 *Hemiarges bucklandii* (Milne Edwards, 1840); Thomas, p. 74, pl. 20, figs 18-20, 22-28 [with full synonymy].

Holotype. Complete specimen (whereabouts unknown), figured Milne Edwards 1840, pl. 34, fig. 12, from the Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone), Dudley.

Other material. Ar51523 (cranidium), locality 3. Ar51426 (cranidium), locality 4. Ar51397 (hypostome), locality 6. Ar51524 (cranidium), locality 12. Ar51714, 15 (hypostomes), locality 14. Ar2427 (cranidium), locality 19. Ar51596 (hypostome), locality 21. Ar5089 (cranidium), locality 32. Ar2882 (pygidium), locality 33. Ar2333 (cranidium), locality 34. Ar51516-22, Ar51726-36 (pygidium, cranidium & hypostomes), locality 36. Ar51481, Ar51510 (hypostomes), Ar51392 (pygidium & pleurae), Ar51468-80, Ar51603-04 (cranidia), locality 39. Ar2338, -39, -52, Ar8411, (cranidia), Slite (or Högklint Formation), Fårö parish. Ar2452 (pygidium), Slite Marl, unit g, unknown locality, Fole parish. Ar2356, (cranidium), Hemse Group, Hemse Marl, top, Lau kanal, Lau parish. Ar2423 (cranidium), Slite Group, unit g, Lokrume canal, Lokrume parish. Ar5076 (pygidium), Lower Visby Formation, Norderstrand, Visby parish. Ar2437 (cranidium), Unknown locality, Stenkumla parish. Ar51711 (complete specimen), Ar51620 (complete specimen), Ar51622-24 (pygidia), Urgude 2, Sproge parish, Hemse Group, Hemse marl. Ar2411 (hypostome), Bommunds I Burgen, Hemse Group or Eke Formation.

Chonelliobarges

Total stratigraphic range: Högklint Formation, unit b; Slite Group, Marl, north western part & unit g; Hemse Group unit b, Marl north western part & marl top; Eke Formation, upper part, (Sheinwoodian to Ludfordian, ?*riccartonensis* to *linnarssoni* Biozones). Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone) of Dudley, West Midlands County and Much Wenlock, Shropshire, U.K.. Coalbrookdale Formation (Sheinwoodian and Homerian, *riccartonensis* to *ludensis* Biozones) of the Dudley and Malvern districts, U.K.

Diagnosis (see Thomas 1981, p. 74; diagnosis of *Hemiarges bucklandii*).

Description. Dorsal exoskeleton slightly longer (sag.) than wide (tr. across genal spines). Occipital ring one-seventh cephalic length (sag.) narrowing to one-third that length behind L1b. Occipital furrow broad. Median lobe half width of occipital ring posteriorly, expanding to opposite mid point of bullar lobe then narrowing to opposite anterior of bullar lobe. Bullar lobe expanding greatly at anterior margin. Longitudinal furrow broad, deepening and widening (tr.) anteriorly to mid point of bullar lobe then shallowing. Posterolateral cranidial lobe subquadrate, slightly inflated, one-third maximum cephalic width (tr.) and two-fifths sagittal length. Bullar lobe subcrescentic, half as wide (tr.) as long (sag.) and three-fifths cephalic length. Anterior border short (sag. exsag.) slightly overhung by median and bullar lobes. Posterior border convex, constricted behind L1b, becoming wider abaxially and merging with field of free cheek close to genal angle. Lateral margin with a marked notch extending from anterior margin to beneath palpebral lobe in lateral view. Palpebral lobe extending from anterior of 1S to half length of 1L. Free cheek steeply sloping beneath eye, flattening towards margin. Genal spine extending back to third thoracic segment.

Dorsal surface (excluding furrows, and palpebral lobe) with sculpture of coarse and fine granules.

Hypostome two-thirds as long (sag.) as wide (tr.). Anterior margin gently convex forwards. Lateral notch geniculate. Middle furrow only weakly impressed on abaxial quarter of width. Border furrow deep and broad. Lateral border merging with posterior border which is about as long as middle body. Posterior margin with a pair of shallow indentations opposite posterior corners of median body which define two exsagittal and one sagittal (slightly larger) lobes. Lateral and posterior margins with sculpture of terrace ridges subparallel to margin.

Thorax of eleven segments. Axis convex, well-defined, about one-third total width (tr.). Pleurae increasing in length to sixth or seventh segment then decreasing with increasing backward flexure to pygidium. Sculpture of scattered granules.

Pygidium, including spines, half as long (sag.) as wide (tr.). Axis one-third anterior width (tr.), convex, almost parallel-sided. Two distinct axial rings anteriorly followed by four others defined by weak, transverse, furrows and transverse alignment of granules. Two pairs of pleural ribs: first pair with anterior and posterior bands of equal convexity, one-sixth as long (sag.) as wide (tr.); second pair with slightly broader anterior band. Both pairs end in slender, backwardly directed spines. Two pairs of spines situated between posterior pleural spine and sagittal spine; anterior longest, similar in form to pleural spines, posterior shorter than sagittal spine. Dorsal surface with sculpture of granules of irregular distribution except for axis.

Discussion. C. bucklandii is known from the Wenlock (Much Wenlock Limestone Formation of Dudley and Much Wenlock, Shropshire and the Coalbrookdale Formation of the Dudley and Malvern districts) of Britain and from the uppermost Llandovery, Wenlock and Ludlow (Lower & Upper Visby Formations, Hemse & Slite Groups and Eke Formation) of Gotland. This indicates an upward and downward extension of the range of *C. bucklandii* on Gotland as compared to Britain. In Britain *C. bucklandii* ranges from the *lundgreni* to *ludensis* Biozones (Homerian) and on Gotland from the *riccartonensis* or *linnarssoni* to *leintwardinensis* Biozones (Sheinwoodian to Ludfordian).

Thomas (1981, p. 75) compared *C. bucklandii* with *C. mikulici* (Perry & Chatterton, 1977, p. 304, pl. 5, figs 5-8, 13-14, 18, 19, 21-25, pl. 6, figs 1-12), from the Upper Wenlock of Baillie Hamilton Island, Canada. The latter is differentiated by its anteriorly better-defined bullar lobe, smaller L1b, proportionately wider hypostomal middle body and a pygidial axis with fewer and less well defined rings.

H. deptus sp. nov. (see below) differs from *C. bucklandii* in possessing less well-incised lateral cranidial furrows which lack the distinct widening at half their length seen in *C. bucklandii,* smaller more posteriorly-situated palpebral lobes and thirteen as opposed to nine pygidial marginal spines.

C. ethnikos (Lane, 1980, p. 49, figs 4a-f), *C. bigener* (Bolton 1965, p. 16, pl. 3, figs 1-9) and *C. ptyonurus* (Hall & Clarke, 1888; see Whittington 1961, pl. 435, pl. 55, figs 1-9, 11) all differ from *C. bucklandii* in possessing a relatively shorter pygidial axis, less convex pygidial border, and broader marginal spines.

Choneiliobarges sp. nov. aff. *C. bucklandii* (Milne Edwards, 1840).

Pl. 5, fig. 13;

Text-fig. 6.

Material. Ar51743 (cranidium), Lau backar 1, Lau parish, Eke Formation (Ludfordian, *leintwardinensis* Biozone).

Description. Cranidium convex. Occipital ring one-eighth cranidial length (sag.) narrowing abaxially. Occipital furrow well incised. Median glabellar lobe half width of occipital ring posteriorly, widening anteriorly and merging with bullar lobe. Posterior portion of median lobe as convex as anterior. Posterolateral cranidial lobe convex. Bullar lobe two-thirds cranidial length. Palpebral two-thirds length of posterolateral lobe. Anterior border narrow (sag.) expanding (exsag.). Dorsal surface with overall sculpture of randomly-arranged granulation plus a large sagittal granule on occipital ring. Three large granules in a transverse row on posterior portion of median lobe. Three pairs of large granules between end of longitudinal furrow and anterior margin with a sagittal granule between the second of these pairs.

Discussion. This specimen shows clear affinities to both *C. bucklandii* (Milne Edwards, 1840; see above) and *C. deptus* sp. nov. (see below). It differs from both these species in the anterior effacement of the longitudinal furrow, the greater convexity of the posterior portion of the median lobe, the larger palpebral lobe and the regular arrangement of large granules. In overall convexity it resembles *C. bucklandii* more closely than *C. deptus* and displays the same widening of the longitudinal furrow as the former species.

Chonelliobarges

Chonelliobarges gibbus, (Angelin, 1854).

1854 *Lichas gibbus*. n. sp., Angelin, p. 71, pl. 37, fig. 1.

1885 Trochurus pusillus Angelin; Lindström, p. 61.

1885 Trochurus Salteri Fletcher; Lindström, p. 61.

1885 Lichas rotundifrons? Ang.; Lindström, p. 61.

1910 L. gibbus Ang.; Westergård, p. 32.

1958 H. gibbus (Angelin); Tripp, p. 577.

Type material. The whereabouts of Angelin's type material is unknown.

Discussion. Angelin's illustration of this Gotland species is not of sufficient quality to enable identification of it amongst material in the Riksmuseet collection. I therefore recommend restricting *C. gibbus* to Angelin's figured material.

Lindström (1885, p. 61) stated that *L. gibbus* should be dropped as a species, believing Angelin to have based his description on the cranidium of *"Trochurus" pusillus* (Angelin, 1884) and the pygidium of *"T." salteri* (Fletcher, 1850; see above). Angelin's illustration clearly depicts a pygidium of *Chonelliobarges* type possessing the flat anterior and convex posterior portions to the second pleurae seen in the available specimens. It is not at all clear why Lindström believed the pygidium to belong to *D. salteri* in that he referred to Fletcher (1850, p. 237, figs 9-9a), the only available figures of *"T." salteri* at that time, who described and figured cranidia of *"T." salteri* but did not figure a pygidium.

Choneliobarges

Choneliobarges deptus sp. nov. Pl. 5, figs 3, 4, 6, 9; Pl. 6, figs 3, 4, 6; Text-fig. 6.

(*Name*. Greek "deptus", soften by working with the hand; reference to the anterior effacement of the cranidial longitudinal furrow).

Holotype. Ar51736 (pygidium), Lau backar 1, Lau parish, Eke Formation (Ludfordian, *leintwardinensis* Biozone); Pl. 6, fig. 6.

Paratypes. Ar2426 (pygidium), locality 5. Ar 2450 (pygidium), locality 21. Ar51650 (pygidium), locality 28. Ar51423, -24 (cranidia), Ar2341, Ar2438-45 (cranidia & pygidium), Hemse Group, lower part, Grogarnshuvud 1?, Ostergarn parish.

Total stratigraphic range. Hemse Group, unit b, marl north western part & Eke Formation (Gorstian to Ludfordian, *nilssoni* to *leintwardinensis* Biozones).

Diagnosis. A species of *Choneliobarges* with longitudinal and axial furrows becoming faint anteriorly. Pygidium convex (sag. & tr.); pygidial axis three-fifths as wide (tr.) as long (sag.) with ten rings; anterior two convex, well-defined, posterior eight rings defined abaxially by furrows and adaxially by transverse rows of large granules; border well-defined; margin with thirteen short spines.

Description. Cranidium as long (sag.) as wide (tr.). Occipital ring one-tenth cranidial length (sag.) narrowing abaxially. Median lobe one-quarter cranidial width (tr.) at occipital ring, parallel sided for most of its length, expanding slightly in front of bullar lobe. Posterolateral cranidial lobe two-fifths length of bullar lobe (exsag.). Dorsal surface of cranidium, excluding furrows, with a sculpture of coarse and fine granules. Three large granules arranged transversely across posterior portion of median lobe.

Chonéliobarges

Hypostome two-thirds as long (sag.) as wide (tr.), gently convex forwards. Middle furrow weakly impressed on abaxial one-quarter of width. Lateral border furrow well incised. Lateral border merging with posterior border which is as long (sag.) as median body. Posterior margin with a pair of shallow indentations opposite posterior corners of median body, defining two exsagittal and one sagittal (slightly larger) lobes. Median body with sculpture of coarse pitting. Lateral margin with sculpture of terrace ridges parallel to margin.

Pygidium, convex (sag. & tr.), two-thirds as long (sag.) as wide (tr.) and one-quarter as high as long. Axis extends three-quarters of length (sag.). Postaxial ridge narrow, merging with well-defined posterior border, divided from axis by sharp change of slope in lateral view. Three anterior pairs of pleural bands transversely arranged. and ending in blunt backwardly-directed spines. Second pair broad, pleural furrow weakly-defined and extending to border, posterior rib ending in a spine, a spine also situated at halfway point of anterior pleural rib margin. Posterior pleural band with well-defined, convex border. Three spines equidistant along margin of third pleural band the second of which is largest. A sagittal spine is present behind the postaxial piece. Dorsal surface with sculpture of coarse granules arranged in single rows on convex parts of pleurae and on border, elsewhere also tending to fall along straight lines radiating from axis. Doublure extends three-quarters distance from margin to end of axis, with sculpture of terrace ridges subparallel to margin. Internal mould of pygidium with pronounced caecal markings on anterior pleural ribs and posterior pleural bands.

Discussion The material herein assigned to *C. deptus* resembles Angelin's illustration of *C. gibbus* in the anterior effacement of the lateral cranidial furrows and disposition of the pygidial pleural ribs. Neither of these features is considered sufficiently diagnostic however to warrant placing the above material in *C. gibbus*.

The cranidium of *C. deptus* differs from that of *C. bucklandii* by being less convex, with smaller more posteriorly-situated palpebral lobes. The pygidia of *C. bucklandii* has a shorter axis with fewer rings, nine as opposed to thirteen marginal spines and lacks the well defined border of *C. deptus*.

Choneiliobarges sp. Pl. 5, fig. 10;
Text-fig. 6.

Material. Ar5094 (cranidium), Boge parish, Slite Group, *Pentamerus gotlandicus* Beds (Homerian, *lundgreni* Biozone).

Description. Cranidium more than half as long (sag.) as wide (tr.). Occipital furrow well incised, shallowing adaxially. Median lobe three-fifths width of occipital ring (tr.), parallel-sided for most of length, expanding slightly in front of bullar lobe. Longitudinal furrow shallowing abaxial to L1b, otherwise deep and broad. L1b above level of posterior portion of median lobe, subangular. Bullar lobe half cranidial length (sag.) narrowing and less well-defined anteriorly. Axial and longitudinal furrows of similar form. Anterior border short (sag.), lengthening laterally. Palpebral lobe one-third length of bullar lobe, extending from opposite posterior of bullar lobe. Whole dorsal surface, with the exception of furrows and the palpebral lobe, with sculpture of predominantly large granules; a row of three large granules occurs on posterior portion of median lobe and four pairs of larger granules on median glabellar lobe.

Discussion. This specimen resembles *C. bucklandii* and *C. deptus* but differs in possessing a less convex bullar lobe which is better-defined anteriorly, a narrower median glabellar lobe, broader longitudinal furrow and a relatively shorter palpebral lobe.

Discussion. C. bucklandii differs from the above specimen in possessing a greater anterior convexity, larger and anteriorly less well defined bullar, smaller and adaxially better defined L1b lobe and a depression in the posterior of the median lobe.

This specimen is also comparable with *C. mikulici* (Perry & Chatterton, 1977, p. 304, pl. 5, figs 5-8, 13-14, 18, 19, 21-25; pl. 6, figs 1-12) from the Upper Wenlock of Baillie Hamilton Island, Arctic Canada, but has a shorter (exsag.) L1b and a larger bullar lobe which is less angular posteriorly.

The assignment of this specimen to *Chonelliobarges* was made on the basis of its lack of L1a which distinguishes it from *Craspedarges scutalis* (which it resembles in overall convexity). The lack of a depressed posterior area of the median glabellar lobe distinguishes this specimen from any known species of *Chonelliobarges*.

Genus **Craspedarges** Gürich, 1901

Type species. By original designation; *Craspedarges wilcanniae* Gürich, 1901 (p. 532, pl. 20, fig. 20).

Diagnosis. L1a large; L1b weakly-defined; longitudinal furrow shallowing posteriorly but reaching occipital furrow; occipital ring long (sag.) constricted greatly behind L1a; anterior border long, flat. Pygidium with three pairs pleural ribs which possess very little independent convexity; anterior two pairs of pleural ribs may end in blunt mucronations or terminate in a rounded margin; posterior pair of pleural ribs without pleural furrow; posterior margin either convex or concave backwards.

Craspedarges scutalis (Salter, 1873). Pl. 6, figs 2, 5, 7, 9, 10, 13; Pl. 7, figs 9, 10, 13, 14, 17, 18; Text-fig. 3d, 6.

1848 *Lichas verrucosus*, Eichw. sp.; Salter, p. 340, pl. 8, fig. 7.

1873 Lichas scutalis, Salter MSS., Salter p. 130.

1981 *Hemiarges scutalis* (Salter, 1873); Thomas, p. 76, pl. 21, figs 1-5, 7-9 [With full synonymy].

Lectotype. By subsequent designation of Thomas (1981, p. 76); SM A3483 (= a954 of Salter 1873), complete specimen; figured Reed 1901, pl. 1, figs 1-4; from Coalbrookdale Formation (Sheinwoodian to Homerian, *riccartonensis to nassa* Biozones), Malvern district.

Paralectotype. GSM 19528, incomplete cranidium; figured Salter 1848, pl. 8, fig. 7; from Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone), Rock Farm, May Hill.

Other material. Ar2369 (cranidium), locality 2. Ar51427-30 (cephalon, cranidium & hypostome), Ar51431-50 (free cheeks), Ar51464, -65 (free cheek & hypostome), Ar51600-02 (hypostomes & cranidium), locality 39. Ar51575-79 (pygidium & cranidium), locality 41.

Total stratigraphic range. Slite Group, Slite Marl undifferentiated; Mulde Formation, lower part (Sheinwoodian to Homerian, *rigidus* to *nassa* Biozones). Coalbrookdale Formation (Sheinwoodian & Homerian, *riccartonensis* to *ludensis* Biozones), Malvern District, U. K. Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone), May Hill, Worcestershire.

Diagnosis (emended from Thomas 1981, p. 77). A species of *Craspedarges* with median glabellar lobe narrowing between bullar lobes. Pygidium with one complete and well-defined ring, anteriorly followed by four rings defined only abaxially and each with a pair of large granules close to sagittal line; margin with three pairs of blunt mucronations.

Description. Cephalon convex, rounded anteriorly and twice as wide (tr.) as long (sag.). Occipital ring poorly defined anteriorly, one-fifth cranidial length (sag.), narrowing to one-quarter that width abaxially. Occipital furrow weakly defined adaxially, deepening abaxially. L1b only slightly convex. Median glabellar lobe expanding in front of bullar lobe. Longitudinal and axial furrows shallowing anteriorly. Bullar lobe two-thirds as wide as long (in plan view) not reaching preglabellar furrow. Preglabellar furrow shallow. Anterior border one-tenth cephalic length bearing a single row of large granules. Lateral border not defined. Posterior border only defined adaxially, convex, merging abaxially with field of free cheek. Palpebral lobe equal in length (exsag.) to L1a (exsag.), situated at half cephalic length. Free cheek broad, flattened towards margin with short, blunt, genal spine extending beyond posterior of occipital ring. Whole cephalic dorsal surface, with the exception of furrows and palpebral lobe, with sculpture of predominantly coarse granules. A region of terrace ridges exists subparallel to lateral and anterior margins.

Hypostome four-fifths as long (sag.) as wide (tr.). Middle body convex. Middle furrow only defined abaxially extending one-third width (tr.) of median body and defining small posterior lobe. Anterior margin gently rounded. Lateral border convex, with sculpture of terrace ridges subparallel to margin. Posterior border broad and weakly convex. Posterior margin with broad and shallow indentation. Sculpture of coarse pitting over most of surface, excluding furrows and lateral margin.

Thoracic axis narrowing slightly backwards. Pleurae one-tenth as long (sag.) as wide (tr.) with well-defined pleural furrows.

Pygidium two-thirds as long (sag.) as wide (tr.) and three-quarters as high as long. Axis gently convex (tr.) narrowing slightly posteriorly and merging with postaxial ridge. Postaxial ridge becoming ill-defined backwards. Anterior pleural band one-eighth as long (exsag.) as wide (tr.). Second pleural band of similar length (exsag.) to first adaxially, widening to three times that length abaxially, with pleural and interpleural furrows of similar form, pleural furrows almost reaching lateral margin. Both anterior pleural bands end in posteriorly directed mucronations. Third pleural band lacking independent convexity, ending in large mucronations defining a concave backwards posterior margin.

Discussion. C. scutalis is known in Britain from the Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone) of the May Hill and Malvern districts and from the Coalbrookdale and Much Wenlock Limestone Formations (Sheinwoodian to Homerian, *riccartonensis* to *ludensis* Biozones) of Dudley. This is a similar range to that of the

Gotland material which is from the Slite Group, Mulde and Högklint Formations, Wenlock (Sheinwoodian to Homerian, *riccartonensis* to *lundgreni* Biozones).

Thomas (1981, p. 77) stated that the only comparable species of *Hemiarges* (*sensu* Tripp, 1959) to *C. scutalis* was *C. serus* (Reed, 1935; see Howells 1982, p. 49, pl. 14, figs 1-4, 7) from the Mulloch Hill Formation (Rhuddanian and Aeronian *atavus* to *argenteus* Biozones), Mulloch Hill, Girvan, Scotland, differentiating the latter on the basis of the better definition of its occipital ring adaxially, smaller L1a, better defined pygidial postaxial ridge and its distinct marginal spines as opposed to blunt mucronations. I am satisfied that the Gotland material differs from *C. serus* in these respects.

The pygidial mucronations developed on the available Gotland material vary from short and bluntly rounded to subtriangular. They are always sufficiently pronounced to differentiate *C. scutalis* from *Craspedarges* aff. *C. maia* (Reed, 1920; see below) which has a rounded margin with very small mucronations on the second pleural band only. There appears to be a complete gradation from the bluntly rounded to subtriangular type of mucronations in the available material and I believe this represents intraspecific variation.

Craspedarges sp. nov. aff. *C. maia* (Reed, 1920). Pl. 7, figs 7, 14; Text-fig. 6.

Material. Ar5087 (cephalon), Visby c, Visby parish, Högklint Formation (unit c?), Ar2349, -50 (pygidium), locality 20. Ar51718, Kappelshamn 1, Högklint Formation, unit b, Hangvar parish. (Ludfordian, *leintwardinensis* Biozone).

Craspedarges

Total stratigraphic range: Högklint Formation and Slite Group (Sheinwoodian & Homerian *riccartonensis* to *lundgreni* Biozones).

Description. Cephalon half as long (sag.) as wide (tr.). Occipital ring one-tenth cephalic length (sag.), narrowing abaxially. Occipital furrow well-defined. Median glabellar lobe parallel-sided, one-third width (tr.) of occipital ring posteriorly, not expanding greatly in front of bullar lobe. Longitudinal furrow well-incised along bullar lobe, weakly-incised adaxial to L1b. Bullar lobe three-fifths cephalic length, subsemicircular in dorsal view. Axial furrow of similar form to longitudinal. Palpebral lobe one-third length of bullar lobe, extending posteriorly from opposite posterior of bullar lobe. Preglabellar furrow well-incised. Anterior border narrow (sag.), overhung by median lobe, lengthening abaxially. Lateral margin with deep antennial notch, anterior half of which is parallel to facial suture. Free cheek steep beneath eye, rapidly flattening towards genal angle. Dorsal surface, excluding furrows and palpebral lobe, with sculpture of predominantly coarse granules. Antennial notch with terrace ridges subparallel to margin.

Pygidium two-thirds as long (sag.) as wide (tr.). Axis convex (sag. & tr.), three-sevenths anterior pygidial width with two well-defined rings anteriorly followed by three other rings which are defined only abaxially by transverse furrows, and a terminal piece. Anterior pleural band with posterior and anterior ribs of similar width and convexity. Second pleural band with flat, broad, anterior rib and convex, narrow, posterior rib ending in a weak mucronation. Pleural and interpleural furrows extending nearly to margin. Margin, apart from weak mucronation on second pleural band, without spines. Dorsal surface, with the exclusion of furrows, with sculpture of randomly-distributed coarse and fine granules.

Discussion. These specimens are assigned to *Craspedarges* with question on the basis of their overall morphological similarity to other species assigned to that genus. The Gotland material differs from those species of *Craspedarges* for which the cranidium is known (*C. scutalis* (Salter, 1873; see above), *C. serus* (Reed, 1935; see Howells 1982, p. 49, pl. 14, figs 1-4, 7), *C. wilcanniae* Gürich, 1901 (p. 532, pl. 20, fig. 20) in possessing a median glabellar lobe that is not expanded greatly anteriorly and in lacking an L1a.

The Gotland specimens are closest morphologically to one from the Dolyhir and Nash Scar Limestone (Sheinwoodian) figured by Thomas (1981, p. 76, pl. 19, fig. 3) which is from a similar horizon to that of the Gotland material. The Gotland specimen differs in possessing an axis which is wider anteriorly and less well-defined posteriorly and better abaxially defined posterior axial rings. Both specimens are incomplete which makes comparison difficult.

H. maia is morphologically the most similar named species but has six? ill defined axial rings as opposed to three in the Gotland specimens. *C. maia* is known from the type material only, (two pygidia; see Thomas 1981, p. 75, pl. 19, figs 1, 2), and occurs in the Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone), of Hobbs Ridge, Gloucestershire and is therefore stratigraphically younger than the Gotland material.

Genus **Dicranogmus** Hawle & Corda, 1847.

[Jun. Obj. synonym; *Liparges* Gürich, 1901, p. 529, pl. 20, fig. 7; *fide* Tripp, 1959].

Dicranogmus

Type species. By original designation; *Dicranogmus pustulatus* Hawle & Corda, 1847 (=*Lichas simplex* Barrande, 1846a) from the Budnay Limestone (Late Silurian) of Czechoslovakia.

Diagnosis. See Tripp 1959, p. O503.

Dicranogmus? sp. Pl. 3, fig. 14; Pl. 7, figs 20, 21; Text-figs 3h, 6.

Material. Ar2353 (cranidium), locality 1. Ar2458 (hypostome), locality 15. Ar29807-09 (cranidia), locality 34. Ar2358, (cranidium), Hamra Formation, unit a, Grötlingbo parish. Ar29885 (cranidium), Visby b.

Total stratigraphic range: ?Hemse Group, upper part; Hamra Formation, unit a; Sundre Formation, undifferentiated middle to upper part (Ludfordian, ?*leintwardinensis* & *Bohemograptus* Biozones). Drommebjerg Limestone (Wenlock), Kronprins Christian Land, eastern North Greenland.

Description. Cranidium two-thirds as long (sag.) as wide (tr.). Occipital ring one-sixth cranidial length (sag.). L1b well-defined abaxially, not defined adaxially, minimum length (exsag.) twice that of occipital ring. Occipital furrow well-incised and of constant depth. Occipital ring transversely arranged, of low convexity and one-ninth cranidial length (sag.). Median lobe less than one-third maximum cranidial width (tr.) between bullar lobes. Longitudinal furrow well-incised at posterior of bullar lobe, following an exsagittal line not reaching occipital furrow and disappearing anteriorly. Preglabellar furrow well-defined. Palpebral lobe extending posteriorly from abaxial end of 1L. Dorsal surface with sculpture of coarse and fine granules of irregular distribution.

Dicranogmus

Hypostome two-thirds as long (sag.) as wide (tr.). Median body subangular, half maximum sagittal length and two-thirds width. Middle furrow very weakly-incised extending one-quarter width (tr.) of median body. Lateral border furrow deep, well-incised, confluent with posterior border furrow. Anterior wing strongly upwardly flexed. Posterior margin gently convex towards anterior.

Discussion. The morphologically closest form to that described above is the material which Lane (1972, p. 360, pl. 64, figs 5, 8) assigned with doubt to *Dicranopeltis*; it is from the Drommebjerg Limestone (Wenlock) of Kronprins Christian Land, eastern North Greenland. I believe these specimens should be possibly assigned to *Dicranogmus*. The Greenland material differs from the Swedish material in possessing a slightly longer (exsag.) L1b and wider (tr.) median glabellar lobe. These differences may be because the Greenland form is slightly larger and I consider that both sets of material belong to the same species.

Material from the latest Llandovery or earliest Wenlock of Washington Land, eastern North Greenland assigned with doubt to *Dicranogmus* by Lane (1982, p 56, pl. 5, figs 4, 6, 7) closely resembles the Gotland and Kronprins Christian Land specimens. The Washington Land specimens possess less well defined glabellar furrows and probably represent a separate species.

The type species of *Dicranogmus* (*D. simplex* Barrande, 1846a, p. 55; 1852, p. 608, pl. 28, figs, 14, 15) from the Silurian of Bohemia differs from the Swedish material in being less convex anteriorly in lateral view, in possessing an occipital ring of strong independent convexity, two strong granules on a depressed posterior portion of the median lobe, L1a situated much closer to the median line and a longitudinal furrow which extends to the occipital furrow.

PAGE

NUMBERING

AS ORIGINAL

Silurian trilobites from Scandinavia

Part two

Silurian trilobites from southern Norway

pp. 89-302, pls 8-42.

Contents

Introduction

History of research

Specimen numbers

Stratigraphy

Geographical nomenclature

Localities

Preservation

Systematic descriptions

Illaenidae Hawle & Corda, 1847

Stenopareia Holm, 1886

Styginidae Vogdes, 1890

Bumastus Murchison, 1839

Eccairos gen. nov.

Ekwanoscutellum Přibyl & Vaněk, 1971

Opsypharus Howells, 1982

Proetidae Hawle & Corda, 1847

Proetinae Hawle & Corda, 1847

Proetus (Proetus) Steininger, 1831

Proetus (Lacunoporaspis) Yolkin, 1966

Cyphoproetus Kegel, 1927

?Crassiproetinae Osmólska, 1970

Hedstroemia Přibyl & Vaněk, 1978

Aulacopleuridae Angelin, 1854

Aulacopleurinae Angelin, 1854

Harpidella McCoy, 1849

Brachymetopidae Prantl & Přibyl, 1951

Warburgellinae Owens, 1973

Warburgella (Warburgella) Reed, 1931

Cheiruridae Hawle & Corda, 1847

Cheirurinae Hawle & Corda, 1847

Hadromeros Lane, 1971

Youngia Lindström, 1885

Encrinuridae Angelin, 1854

Encrinurinae Angelin, 1854

Encrinurus Emmrich, 1844

Calymenidae Milne Edwards, 1840

Calymeninae Milne Edwards, 1840

Calymene Brongniart, 1822

Diacalymene Kegel, 1927

Phacopidae Hawle & Corda, 1847

Phacopinae Hawle & Corda, 1847

Acernaspis Campbell, 1967

Eophacops Delo, 1935

Lichidae Hawle & Corda, 1847

Lichinae Hawle & Corda, 1847

Lichas Dalman, 1827

Arctinurus Castelnau, 1843

Dicranopeltis Hawle & Corda, 1847

Pseudotupolichas Phleger, 1936

Homolichinae Phleger, 1936

Platylichas Gürich 1901

Ceratarginae Tripp, 1957

Choneliobarges Phleger, 1936

Odontopleuridae Burmeister, 1843

Odontopleurinae Burmeister, 1843

Leonaspis Richter & Richter, 1917

Dudleyaspis Prantl & Přibyl, 1949

Correlation & trilobite associations

Introduction

The purpose of the work presented in the second section of this thesis is the study of the Silurian trilobite faunas of southern Norway in order to provide up-to-date systematic descriptions of the species which occur, to revise their taxonomy and establish their stratigraphical and geographical distribution.

Other fossil groups have been the subject of much recent study e.g. algae (Lauritzen & Worsley 1974), bioherms (Hanken, Olaussen & Worsley 1970), brachiopods (Worsley & Broadhurst 1975; Johnson & Worsley 1982; Cocks & Baarli 1982; Thomson & Baarli 1982), bryozoa (Spjeldnæs 1982), conodonts (Aldridge & Mohamed 1982), corals (Aarhus 1982; Neuman 1982), gastropods (Peel & Yochelson 1976), graptolites (Howe 1982), ostracodes (David. Siveter 1982), palynomorphs (Dorning & Aldridge 1982) and stromatoporoids (Mori 1978).

History of Research

The Silurian trilobites of southern Norway, although common and diverse, have never been the subject of a comprehensive study. The Styginidae and Illaenidae were looked at by Whittard (1940) but a degree of confusion exists between his study and a previous discussion of the same material by Kiær (1908) who collected it.

The first description of a Silurian trilobite from southern Norway was made by Esmark (1833) who described and figured *"Phacops" (=Acernaspis) elliptifrons* from the Solvik Formation of Malmøykalven.

In 1838, Kielhau brought out the first part of his *Gæa Norvegica* including a map of the "Uebergangs-Territorium" (Transitional Formation) taken directly from Werner's classical "Ubergangsgebirge" (essentially meaning, Lower Palaeozoic Strata). In a brief section appended to this, Boeck described a large number of the Lower Palaeozoic (mainly Cambrian and Ordovician) trilobites.

It was the Rev. William Bilton, a friend of Murchison, who, in a "piscatorial guide" bearing the title "*Two Summers In Norway*" (1840, vol. 2, p. 180), made the first printed reference to the Silurian System of Norway:

"The numerous fossils contained in these deposits prove that they belong to the ancient group of rocks, lately named and admirably described by Mr Murchison, as Silurian"

Following Murchison's 1844 visit to Oslo the term Silurian took on a much more restricted meaning the Cambrian and Ordovician occupying what had previously been Murchison's "Lower Silurian" the Silurian system becoming restricted to Murchison's "Upper Silurian". In 1845 (p. 481, table 2) he published the names of four trilobite species from the "Upper Silurian" of Norway; *Calymene Blumenbachii, Calymene Blumenbachii "var." pulchella, Calymene punctata, Phacops macropthalmus*. It was of rocks in the southern Norway that Murchison (1859, p. 370) first in print used the stratigraphical term "Llandovery rocks".

In his work *Paleontologica Scandinavica* Angelin (1854) figured and described seven Silurian Norwegian trilobite species together with a large number of others from the Cambrian and Ordovician, and from other parts of Scandinavia.

Kjerulf (1857) initiated an independent stratigraphic system of numbered "étages"; he produced extensive lists of fossils and a lithological description for each "étage" and provided a geological map which included the islands of the Oslo fjord. Additionally he attempted a correlation, based largely on lithology, with the Silurian of Gotland and Britain. His correlations were largely consistent with those of Murchison (1845) who in 1858 produced his own correlation for the Silurian rocks of Norway and Great Britain.

Brøgger (1900) divided Kjerulf's "étage" 5 into two separate "étages" the lower of which became the new "étage 5" (uppermost Ordovician) the upper "étage 6" (earliest Llandovery). This required adjustment of the other subdivisions in southern Norway so that, for example, Kjerulf's "étage 6" (*Pentamerus* limestone) became "étage" 7a.

Kiær (1908), in *"Das Obersilur Im Kristianiagebiete"*, divided "étages" 6 to 9 into subunits identified by Roman and Greek letters. He referred to some of his basic units as zones; on Malmøya for instance étage 6c was "the zone with *Stricklandia lens*". In different areas however the zone name often varied and étage 6c in the Ringerike district was "the zone with *Rhynchonella 10-plicata*". In this work he diagnosed five new species of *"Illaenus"* and six new species and one new variety of "*Bumastus*" from southern Norway, in addition to listing a large number of other Silurian trilobites. His original intention was to produce an amply-illustrated monograph; however his attention was diverted to Devonian vertebrates and the fossiliferous Cambrian rocks of Tømten with the result that he never finished his work. In a later paper Kiær (1922) abandoned the system of "étage" numbers and Greek and Roman letters for a simplified system of series and groups. Although promising in the same paper to later publish a reason for this decision, that paper was never written.

Whittard (1940) in an attempt to trace the type material of Kiær's taxa from the Oslo museum collection, described and figured four of Kiær's species of "*Illaenus*", two of "*Bumastus*", and added a new species of "*Illaenus*" and a new variety of "*Bumastus*" *sulcatus*. Whittard believed that in several cases Kiær had described as belonging together pygidia and cranidia that did not belong to the same species.

Warburg (1937) following work by Brøgger (1882) corrected a mistake in the locality from which *Arctinurus norvegicus* was said to have been collected, which now placed the species as Silurian (it having first been described as from the Ordovician); she also redescribed the species.

A specimen of *Calymene* from the Wenlock of Norway was briefly discussed by Whittington (1971) who compared it to species from the United States and Sweden.

In 1982 the third field meeting of the I.U.G.S. Subcommission on Silurian Stratigraphy took place in Oslo. It was concerned with the definition of the first Series of the Silurian. A new lithostratigraphic scheme for the Oslo Silurian was introduced in the field meeting volume (Worsley 1982) who divided the marine Silurian sequence into the Baerum and Hole Groups which contain eight and three Formations respectively (Text-fig. 7). An attempt at a brief review of the Silurian trilobites of the southern Norway was also made in the I.U.G.S. volume (Helbert *et. al.* 1982). This paper is of limited scope because the short time in which it had to be prepared, by the fact that much of the Museum material was unavailable for study and the systematic part was restricted to diagnoses and discussions without descriptions.

Specimen numbers

Abbreviated prefixes of specimens from museums are as follows;

Ar = Naturhistoriska Riksmuseet, Stockholm, Sweden.

BM = British Museum (Natural History), London, England.

GSM = Geological Survey Museum, British Geological Survey. England.

NMP = National Museum of Prague, Czechoslovakia.

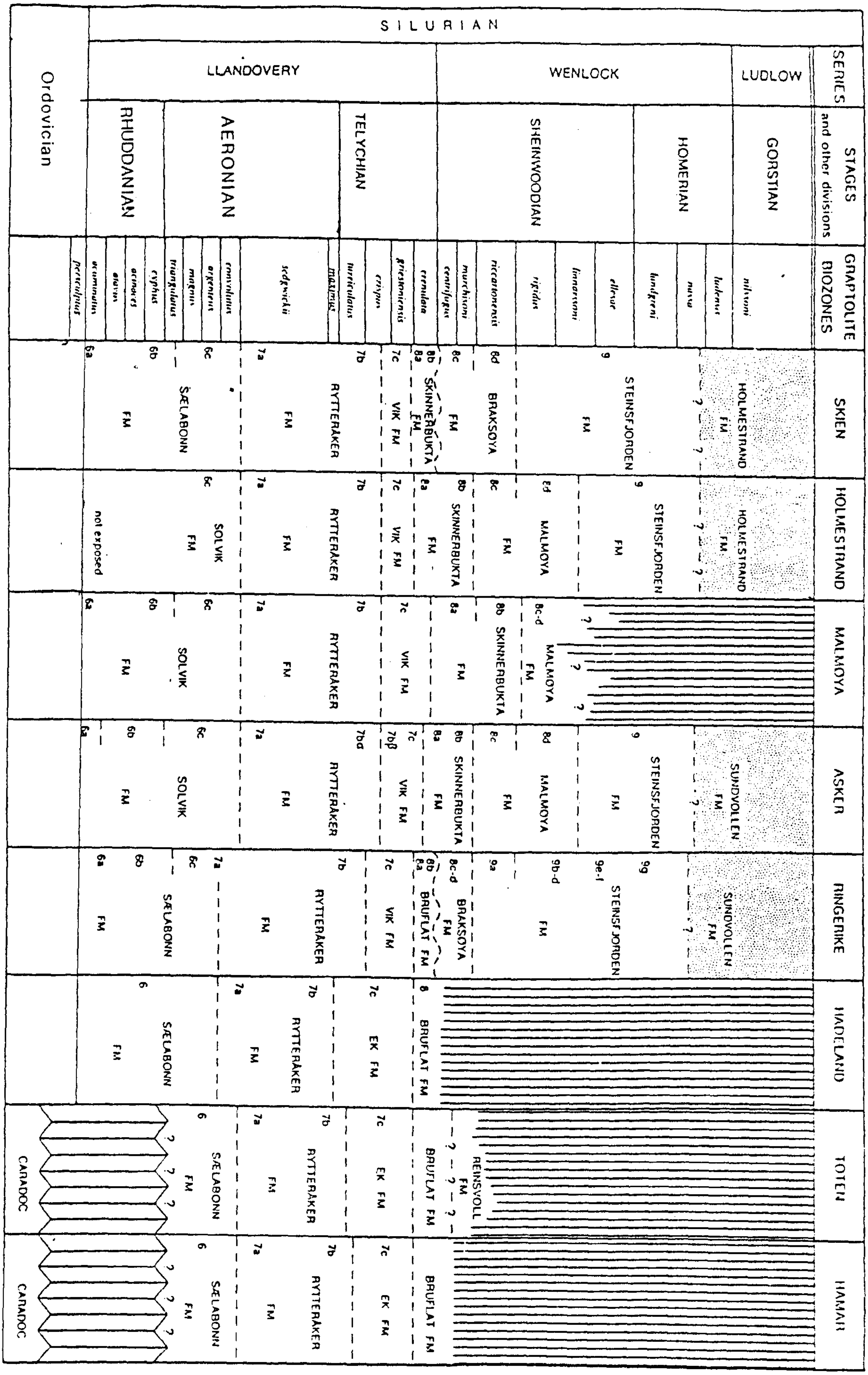
NMW = National Museum of Wales, Cardiff, Wales.

SM = Sedgwick Museum, Cambridge, England.

Stratigraphy

Text-figure 7

The lithostratigraphic units referred to are those of Worsley *et al.* 1983. Many of Kiær's numerical stratigraphic units and subunits have been shown to be diachronous (Bassett & Rickards 1971; Worsley 1982; Worsley *et al.* 1983) and are used here only as local and informal descriptive terms having no significance in correlating between regions.



Text-fig. 7. Correlation of Silurian units in the various districts of the Oslo Region showing relationships to previously used étage units (modified from Worsley *et al.* 1983).

Geographical nomenclature

Text-figure 8

The districts of the southern Norway referred to herein are those of Størmer, 1953 as modified by Worsley *et al.* 1983.

Localities

Text-figures 9-11

All localities referred to are within European Datum Transverse Mercator Projection (U.T.M.) grid zone 32. Localities are referred to the Norges Geografiske Oppmåling (N.G.O.) 1:50,000 sheets and references are given in the form;

(**Biliås Quarry**, 1815 III, 699618, Ringerike, CA).

The locality name being followed by four figures and roman numeral referring to the appropriate map sheet number, followed by a six figure reference and the district as for Text-figure 8. The letters CA after a locality reference indicate the collection of material by the author, the letter M indicating that the locality is known from museum specimens; many localities are known only from museum specimens. Some localities which for various reasons are no longer accessible are indicated by the letters NA. In some cases stratigraphic units present, previous references to the locality and synonymous locality names are appended.

1) **Biliås Quarry** 1815 III, 699618, Ringerike, CA.
Saelabonn & Rytteråker Formations (Kiær's étages 6c & 7a), locality 4 of Whittaker 1977.

2) **Billingstad** 1814 I, 826387, Asker, M.
Solvik & Rytteråker Formations (Kiær's étages 6 & 7).

3) **Bjerkøya** 1814 III, 764990, Holmestrand, M.
Solvik & Rytteråker Formations (Kiær's étages 6 & 7).

4) **Christian Skredsvik Veien** 1814 I, 864420, Asker, M.
Solvik Formation (Kiær's étage 6), M.

5) **Feikarodden** 1815 III, 711592, Ringerike, M.
Bruflat & Braksøya Formations (Kiær's étages 8a to 8c), otherwise referred to as Feikar, Feikaraas or Fiekjartangen.

6) **Garntangen** 1815 III, 717609, Ringerike, CA, M.
Bruflat Formation (Kiær's étage 8a), locality 7 of Whittaker 1977.

7) **Gjettum Bus Stop** 1814 I, 873448, Asker, CA.
Malmøya Formation (Kiær's étage 8c).

8) **Gjettum Locality** 2 1814 I, 874449, Asker, CA.
Malmøya Formation (Kiær's étage 8).

9) **Gjettum Station** 1814 I, 853421, Asker, M, NA.
Rytteråker Formation (Kiær's étage 7b), temporary exposure in garden of house opposite station; collected by Dr. P. D. Lane.

10) **Gulleråsen** 1814 I, 940480, Oslo, M.
Solvik Formation (Kiær's étage 6b).

11) **Herøya** 1815 III, 734635, Ringerike, M.
Braksøya Formation (Kiær's étage 8c).

12) **Honefoss Road** 1815 III, 699619, Ringerike, CA.

Saelabonn Formation (Kiær's étage 6c), locality 3 of Whittaker 1977.

13) **Hoyerholmen** 1814 I, 870350 & 870560, Asker, M.

Solvik Formation (Kiær's étage 6).

14) **Hvalsbakken** 1814 I, 838355, Asker, M.

Solvik Formation (Kiær's étage 6).

15) **Kampbråten** 1814 I, 850400, Asker, M.

Solvik Formation (Kiær's étage 6)

16) **Kommersøya** 1814 III, 745995, Holmestrand, M.

Malmøya & Steinsfjorden Formations (Kiær's étages 8 & 9).

17) **Kunglungen** 1814 I, 846357, Asker, M, CA.

Solvik Formation (Kiær's étage 6a).

18) **Langåra** 1814 I, 865360, Asker, M.

Solvik Formation? (Kiær's étage 6?).

19) **Langøya** 1814 III, 1813 I, 780950, CA, M.

Steinsfjorden Formation (Kiær's étage 9).

20) **Leangbukta (=Blakstad)** 1814 I, 825342, Asker, CA, M.

Solvik Formation (Kiær's étage 6c) Rytteråker Formation (Kiær's étage 7).

21) **Limovnstangen** 1815 III, 692589, Ringerike, CA, M.

Saelabonn Formation (Kiær's étage 6c).

22) **Malmøykalven** 1914 IV, 978378, Oslo, CA, M.

Solvik Formation (Kiær's étages 6b to 6c).

23) **Nesbru** 1814 I, 840370, Asker, M.

Solvik Formation (Kiær's étage 6).

24) **Porsgrund** 1713 III, Skien.

Insufficient information is available to locate these specimens more accurately.

25) **Purkøya** 1815 III, 688570, M.

Bruflat Formation (Kiær's étages 8a & 8b).

26) **Rambergøya** 1814 IV, 962395, Oslo, M.

Solvang Formation (Kiær's étage 5b), Ordovician.

27) **Semsvatnet** 1814 I, 804365, Asker, M.

Solvik Formation (Kiær's étage 6c), road to lake,

Courtesy of Dr. R. Owens, National Museum of Wales collection.

28) **Sjursøya** 1914 IV, 985,404, Oslo, M, NA.

Solvik Formation (Kiær's étage 6a), locality now covered by an industrial complex.

29) **Skinnerbukta** 1914 IV, 984381, Oslo, CA, M.

Vik Formation (Kiær's étage 7c).

30) **Skien** 1713 III, Skien, M.

Steinsfjorden Formation (Kiær's étage 9). Insufficient information is available to allow more accurate location of these specimens.

31) **Skytterveien** 1814 I, 818327, Asker, CA, M.

Solvik Formation (Kiær's étage 6cb).

32) **Solvik** 1914 IV, 981378, Oslo, CA, M.

Solvik Formation (Kiær's étages 6a to 6c).

33) **Spirodden** 1814 I, 840337, Asker, M, CA.

Solvik Formation (Kiær's étages 6b to 6c).

34) **Storøya** 1815 III, 700580, Ringerike, M.

Bruflat Formation (Kiær's étages 8a & 8b).

35) **Top of Malmøya** 1914 III, 985383, Oslo, CA, M.

Malmøya Formation (Kiær's étage 8b).

36) **Ulvøya** 1914 IV, 993385, Oslo, M.

Solvik & Rytteråker Formations (Kiær's étages 6 & 7).

37) **Utøya** 1815 III, 697549, Ringerike, M.

Steinsfjorden Formation (Kiær's étage 9).

38) **Våkas** 1814 I, 823357, Asker, M.

Solvik Formation (Kiær's étage 6b).

Index of localities by stratigraphic order

Solvik Formation

Billingstad, Bjerkøya, Christian Skredsvik Veien, Gulleråsen, Hoyerholmen, Hvalsbakken, Kampbråten, Kunglungen, Langara, Leangbukta, Malmøykalven, Nesbru, Semsvatnet, Sjursøya, Skytterveien, Solvik, Spirodden, Storøya, Ulvøya, Våkas.

Saelabonn Formation

Biliås Quarry, Honeföss road, Limovnstangen.

Rytteråker Formation

Biliås Quarry, Billingstad, Bjerkøya, Ulvøya, Gjettum Station, Leangbukta.

Vik Formation

Skinnerbukta.

Bruflat Formation

Feikarodden, Storøya, Purkøya.

Braksøya Formation

Feikarodden, Garntangen, Herøya.

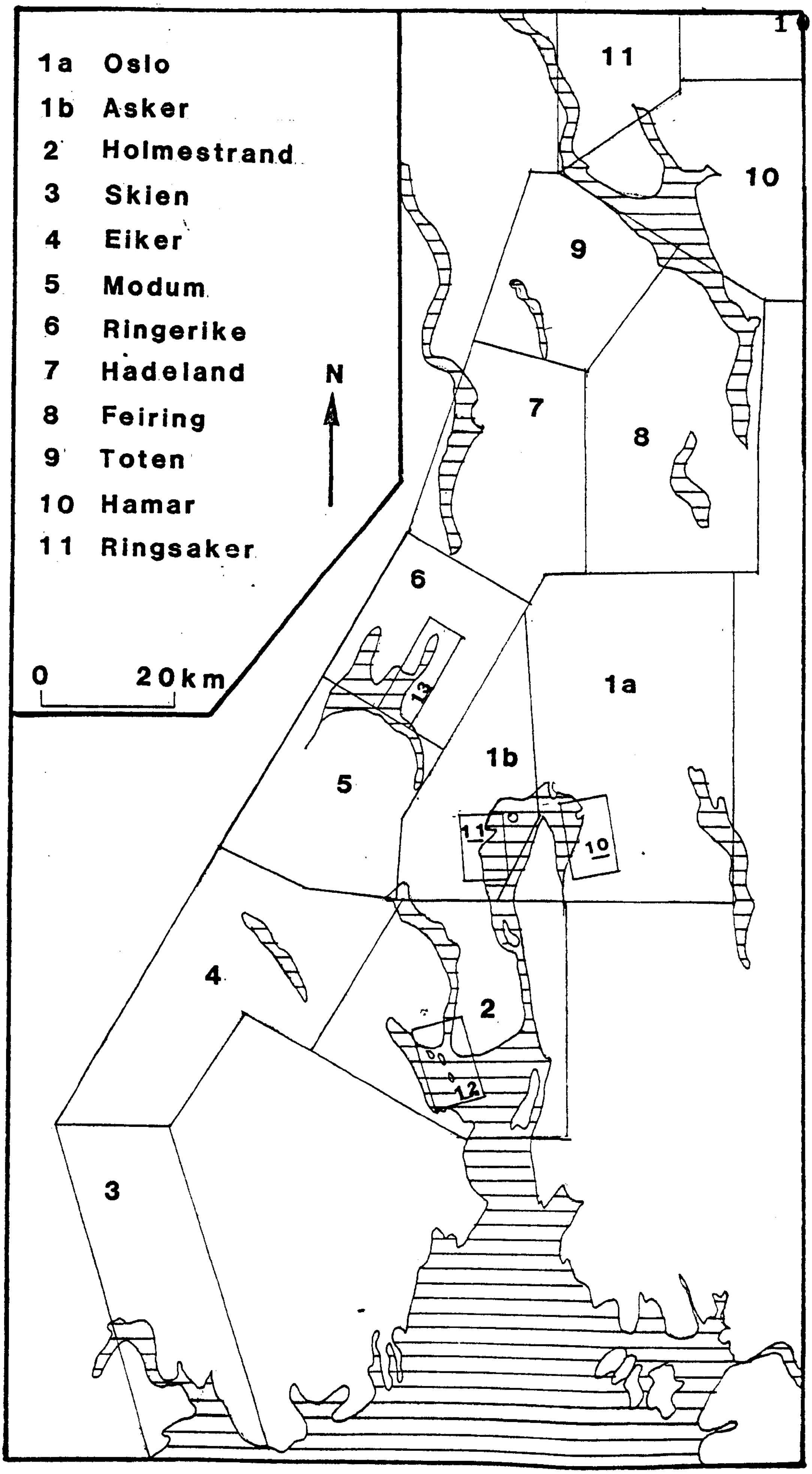
Malmøya Formation

Gjettum Bus Stop, Gjettum Locality 2, Kommersøya, Top of Malmøya.

Steinsfjorden Formation

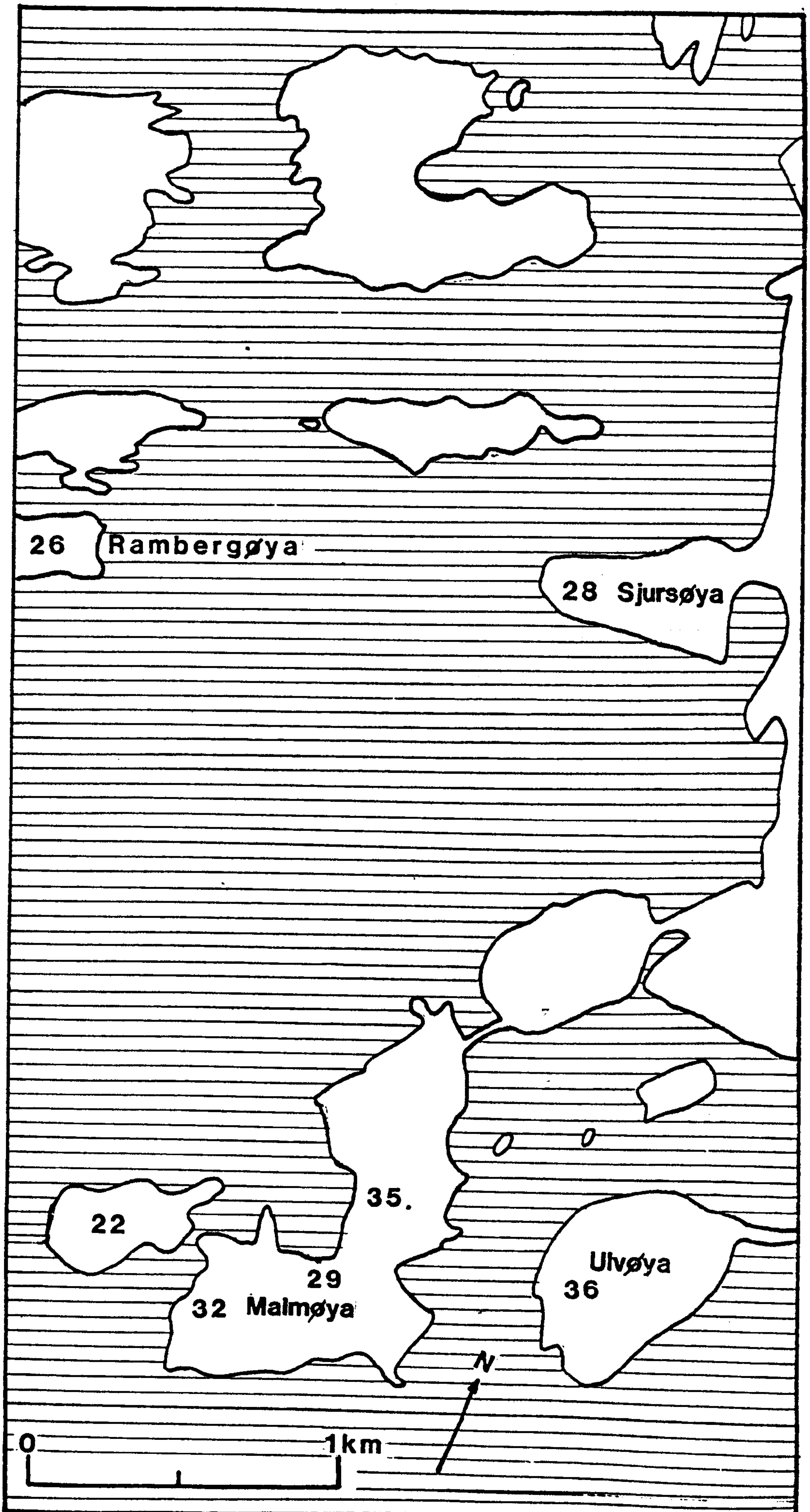
Kommersøya, Langøya.

Text-fig. 8. Map of the Oslo Region showing the districts referred to (after Worsley *et al.* 1983) and the areas covered by Text-figs 9–12.



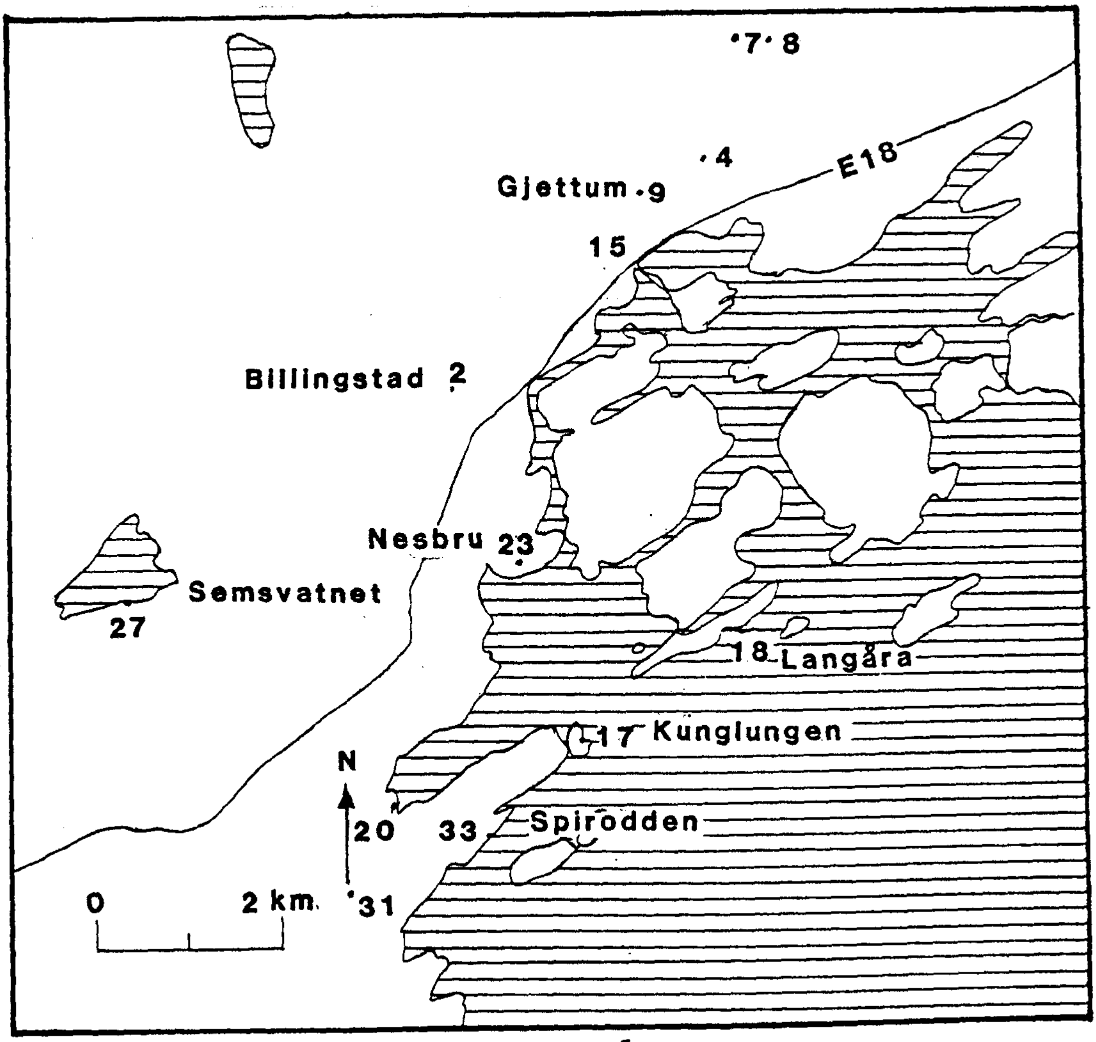
Text-fig. 9

Localities in the Oslo district (district 1a).



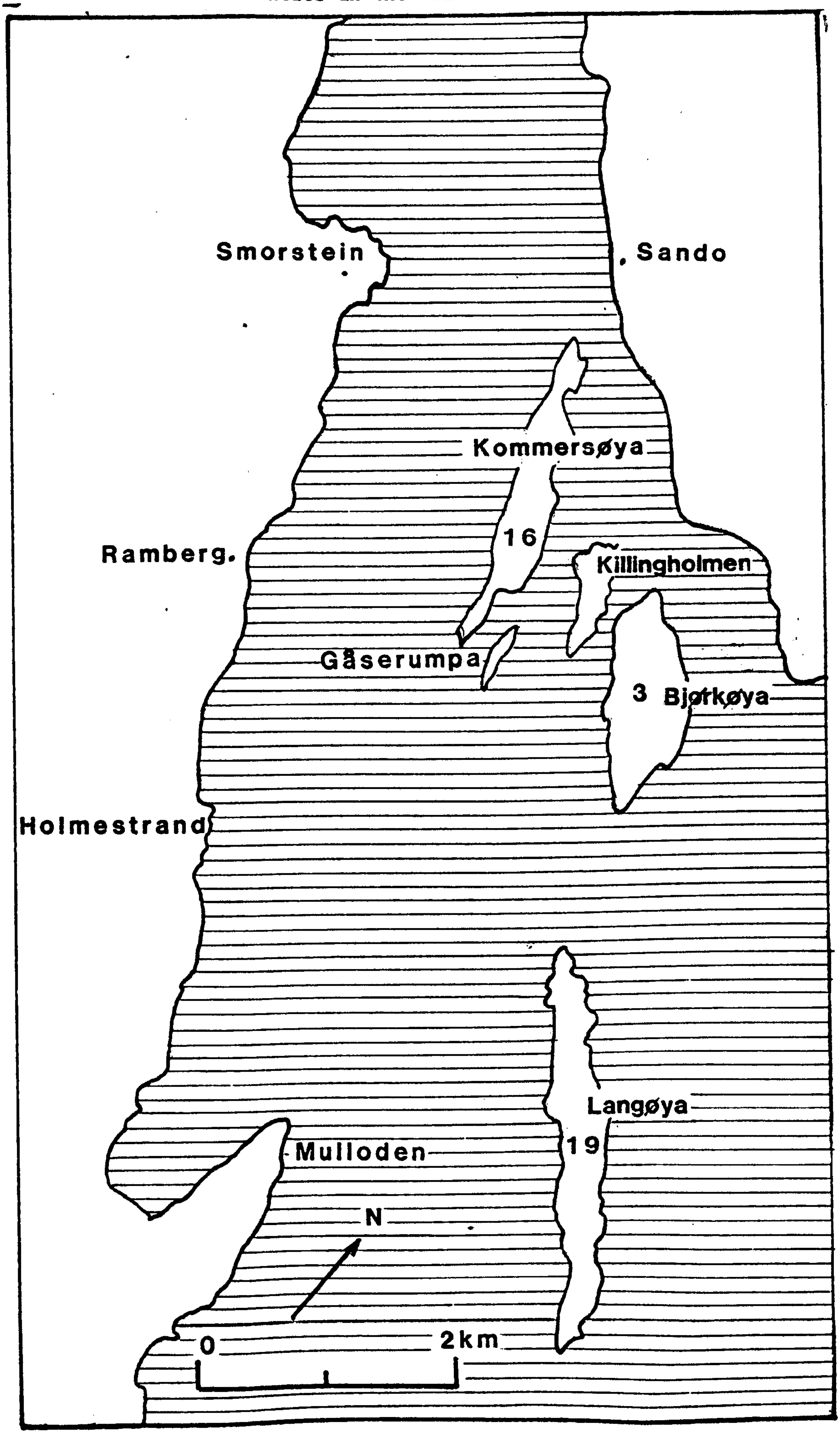
Text-fig. 10

Localities in the Asker district (district 1b).



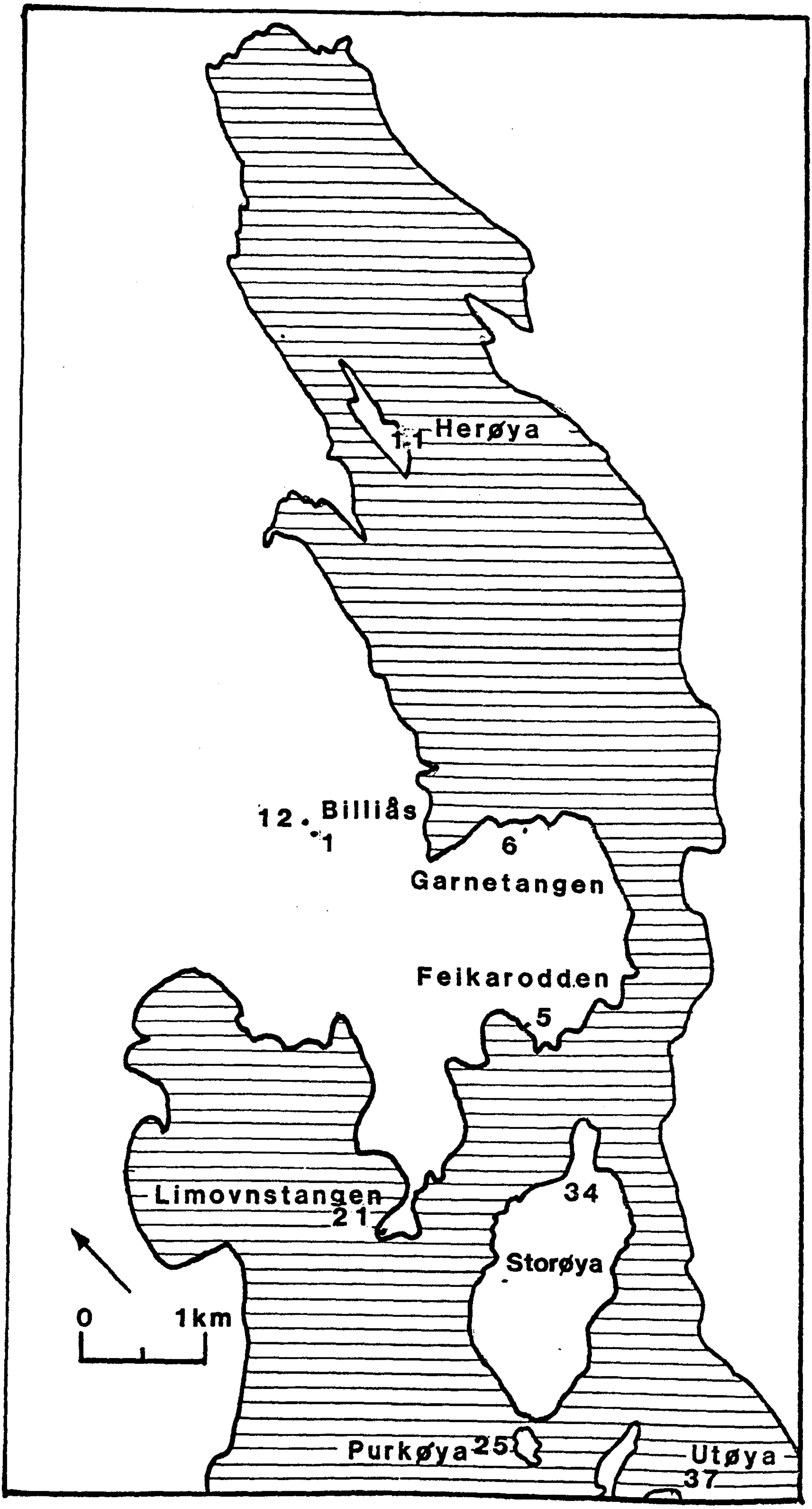
Text-fig. 11

Localities in the Holmestrand district (district 2).



Text-fig. 12

Localities in the Ringerike district (district 6).



Collections

The collections of the Paleontologisk Museum, Oslo include specimens figured by Angelin (1854), Campbell (1967), Esmark (1833), Warburg (1937) and Whittard (1940). In addition there is a large quantity of previously unfigured material collected by Kiær and other workers. The authors own collections, also to be housed in the Paleontologisk Museum, include approximately 1,830 specimens. A small number of specimens is also present in the collections of the National Museum of Wales.

Preservation

The trilobites of southern Norway are most commonly preserved in impure limestones they also occur in shales, although in these the larger specimens are generally not recoverable due to cleavage. There is a pronounced tendency for preserved cuticle to remain on the external moulds and thus internal moulds are more common than external. Garntangen and Gjettum Station have yielded, from decalcified horizons, many excellent specimens mainly of internal moulds; latex casts of external moulds may also be taken.

Suborder Scutelluina Hupé, 1953 (emended Hupé 1955)

[*nom. transl.* Lane & Thomas, 1984, p. 155, *ex.* Superfamily

Scutelloidae Hupé, 1953]

Family Illaenidae Hawle & Corda, 1847

Diagnosis. See Lane & Thomas 1984, p. 156.

Genus **Stenopareia** Holm, 1886

Type species. Original designation; *Illaenus Linnarssoni* Holm, 1882, from the Boda Limestone (Ashgill, Rawtheyan & Hirnantian), Siljan District, Sweden.

Diagnosis. See Howells 1982, p. 12.

Stenopareia glaber (Kjerulf, 1865). Pl. 8, figs 1-11; Pl. 9, figs 1-5; Pl. 10, figs 1-4; Pl. 11, figs 1, 2, 4, 5; Pl. 12, figs 9, 10; Text-figs 12, 13, 44, 45.

1865 *Illaenus glaber,* Kjerulf, p. 14, fig. 28 [*fide* Owen & Bruton 1980].

1867 *Illaenus (Dysplanus) thomsoni,* Salter; Salter, p. 188, pl. 28, figs 2, 3; *non* fig. 4 [= brachiopod]; pl. 30, figs 8, 10, *non* fig. 9 [= *Stenopareia* sp. indet.].

v. *1908 Illaenus rotundus* nov. sp., Kiær, p. 572.

v. *1908 Illaenus sculptus* nov. sp., Kiær, p. 572.

v. *1908 Illaenus cf. Thomsoni* Salt., Kiær, p. 571.

v. 1940 *Illaenus norvegicus* new species, Whittard, p. 284, pl. 2, figs 1-3.

v. 1940 *Illaenus rotundus* Kiær; Whittard, p. 278, (*pars*), pl. 1, figs 1-5, 7, 8; *non* fig. 6. [=*Stenopareia* sp. indet.].

v. 1940 *Illaenus sculptus* Kiær; Whittard, p. 280, pl. 1, figs 9-12.

1980 *Stenopareia glaber* (Kjerulf, 1865); Owen & Bruton, p. 15, pl. 2, fig. 13, 14, pls 3-5, figs 1-3, text-fig. 3. [Includes full synonymy of *S. glaber*].

v. *1982 Stenopareia norvegicus* [*sic.*] (Whittard 1940); Helbert, p. 131.

v. *1982 Stenopareia rotunda* (Kiær 1908); Helbert, p. 130.

v. *1982 Stenopareia sculpta* (Kiær 1908); Helbert, p. 132.

v. *1982 Stenopareia thomsoni* (Salter, 1867), Howells; p. 12, pl. 3, figs 1-8, [Includes full synonymy of *S. thomsoni*].

Lectotype. Designated by Størmer (1943, p. 47); PMO 63891, a complete exoskeleton, probably from the Upper Chasmops Limestone, Bygdøy, Oslo; figured Owen & Bruton, pl. 3, figs 1, 2.

Paralectotypes. Three specimens on the same block, only two of which have numbers; PMO 101.536 (pygidium), 101.535 & an unnumbered specimen (cranidia).

Other material. Complete specimens, PMO 19262 (paralectotype of *S. rotunda*; figured Whittard 1940, pl. 1, fig. 7; Pl. 8, fig 11), locality 2, PMO 19280 (paralectotype of *S. sculpta*; Pl. 11, fig. 4), Locality 18; cephala, PMO 110.194, locality 2. PMO 19135 (lectotype of *S. sculpta*; figured Whittard 1940, pl. 1, figs 9-11; Pl. 9, fig. 2), locality 33, cranidia, PMO 19247 (paralectotype of *S. rotunda*; figured Whittard 1940, pl. 1, fig. 4; Pl. 9, fig. 2), PMO 19421 (paralectotype of *S. rotunda*; figured Whittard 1940, pl. 1, figs 2, 3; Pl. 8, fig. 9), PMO 19422 (lectotype of *S. rotunda*; figured Whittard 1940, pl. 1, fig. 1; Pl. 8, fig. 3), PMO 19423-424, -426-428, PMO 110.164, PMO 110.165, -166, -194, -270, locality 2, PMO 19143, locality 3. PMO 65530, -548, locality 10, PMO 109.915, locality 12, PMO 52312, -314, -317, locality 13, PMO 53328, -329, -369, PMO 110.271, locality 17, PMO 19139, -140, PMO 19164 (lectotype of *S. norvegica*; figured Whittard 1940, pl. 2, figs 3, 4; Pl. 10, fig. 4), PMO 19174 (figured Whittard 1940, as *I. norvegica*, pl. 2, fig. 2; Pl. 11, fig. 5), PMO 52517, -518, -520, -549, PMO 109.497, PMO 110.160, -161, 110.168-170, -175, 110.178-80, -183, -186, -187, -273, locality 32, PMO 43427, -431, PMO 88724, -725, locality and horizon unknown; free cheeks, PMO 110.163, locality 2, PMO 110.186, locality 17, PMO 52521, locality 32, PMO 19136 (paralectotype of *S. sculpta*; figured Whittard 1940, pl. 1, fig. 12; Pl. 12, fig. 9), locality 33; rostral plates, PMO 19411 (figured Whittard 1940, as *I. norvegica*, pl. 2, fig. 1, Pl. 10, fig. 1), locality 3, PMO 110.272, -274, locality 32, PMO 43011-013, locality 35; pygidia, PMO 19255, PMO 19425 (paralectotype of *S. rotunda*; figured Whittard 1940, pl. 1, fig. 8; Pl. 8, fig. 4), locality 2, PMO 19410, -412, PMO 88726, locality 3, PMO 525., -515, locality 13, PMO 19139, PMO 88733, PMO 110.166, -184, -185, -189, -277, locality 33.

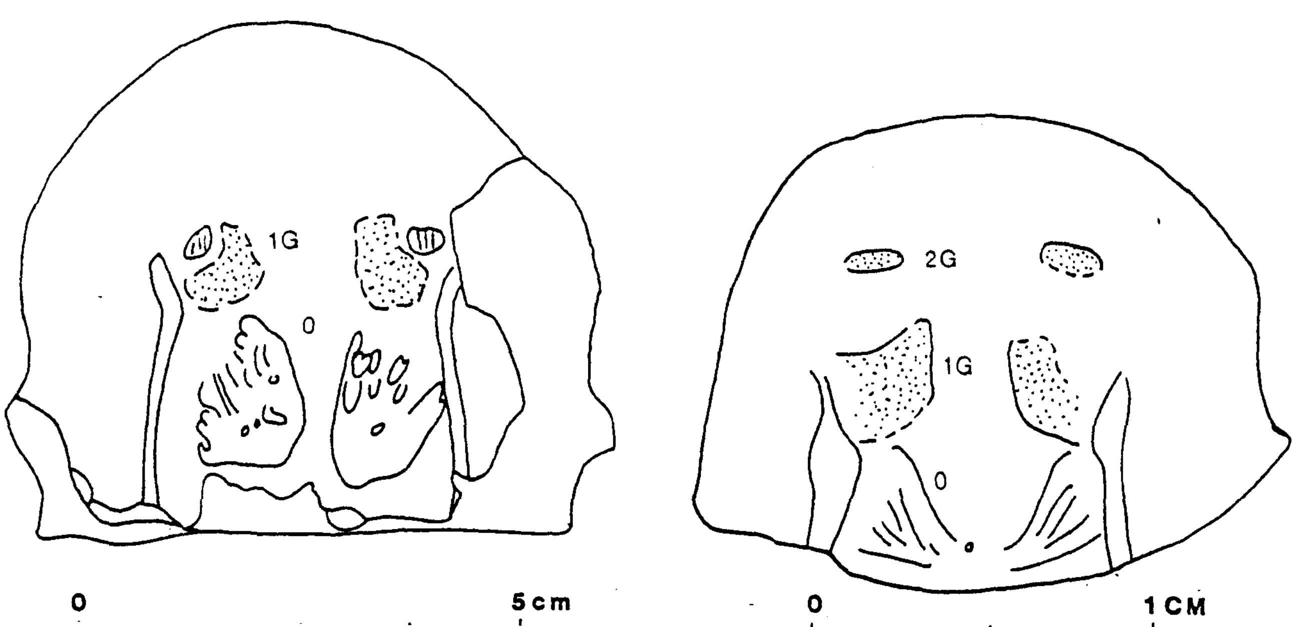
Stratigraphic range. "Upper Chasmops Limestone" and Solvang Formation, Solvik, Saelabonn and Rytteråker Formations of the Holmestrand, Oslo, Asker and Ringerike districts, Ashgill to Llandovery (Vasagardian (=Onnian) to Aeronian, *linearis* to *sedgwickii* Biozones). Mulloch Hill Formation (Aeronian, *atavus* to *cyphus*

Biozones), Girvan, Scotland.

Diagnosis (amended from Helbert 1982, p. 130). A species of *Stenopareia* with axial furrows extending half cranidial length in dorsal view; three pairs of cranidial axial muscle impressions visible on internal mould: impression 0 consisting of radiating striae in a subtriangular area, originating from near median tubercle and extending to opposite posterior end of lateral muscle impression; 1G (Text-fig. 13a) consists of a double area a posterior very weakly-defined subcrescentic portion curves away from the lateral muscle impression separate from and enclosing on the posterior and adaxial sides a subcircular and well-incised area of longitudinally arranged striae; 2G an oval area as broad (tr.) as 1G, situated halfway between anterior of lateral muscle impression and anterior margin. Pygidial axis weakly defined on external mould and clearly delimited on internal mould, extending half length of pygidium, with eight axial rings defined by weakly-impressed furrows; pygidial doublure extending almost to posterior of axis, bearing two short, triangular projections.

Text-fig. 13

Diagram showing the distribution of cranidial axial muscle impressions, in dorsal view, of *Stenopareia glaber* Kjerulf, 1865 (PMO 19164 is holotype of *S. norvegica*, Whittard, 1940; PMO 19421 is paralectotype of *S. rotunda* (Kiær, 1908)).



Description. Glabella with slight independent posterior convexity. Axial furrows parallel-sided or converging slightly, not extending beyond lateral muscle impression anteriorly. Palpebral lobe about one-sixth combined length of axial furrow and lateral muscle impression. Lateral muscle impression one-third wider (tr.) and better incised than axial furrow and three-quarters as long (exsag.) on internal mould, shallowing and deflected abaxially anteriorly. On external mould lateral muscle impression an expanded oval area of equal depth to axial furrow. Small median tubercle situated opposite posterior end of palpebral lobe. Fixed cheek without independent convexity, half width (tr.) of area between axial furrows at posterior margin. Free cheek subtriangular, posterior margin two-thirds length of lateral margin. Subocular depression well-incised. Dorsal surface with sculpture of fine punctae of irregular distribution with terrace ridges subparallel to margin anteriorly, becoming transverse posteriorly and ill-defined near suture.

Rostral plate one-third as long (sag.) as wide (tr.) at anterior margin, suture at 40° to an exsagittal line. Sculpture of twelve terrace ridges subparallel to anterior margin, posterior face of each ridge more gently sloping then anterior, ventral surface of plate lacking punctae.

Hypostome unknown from the Silurian of Norway (for description see Owen & Bruton, 1980, p. 17).

Thorax of nine segments. Axis about half total width anteriorly narrowing slightly posteriorly. Surface sculpture as for cranidium, with terrace ridges confined to articulating facets.

Pygidium with median arch of over half anterior width; axis occupies half this width. A pair of apodemes are developed between lateral furrows and axis, close to anterior margin and varying from being well-incised on some specimens to barely visible on others. Pleural fields lacking sculpture apart from punctae. Pygidial doublure with sculpture of terrace ridges subparallel to margins, becoming fainter towards sagittal line with a well-incised sulcus present on dorsal surface.

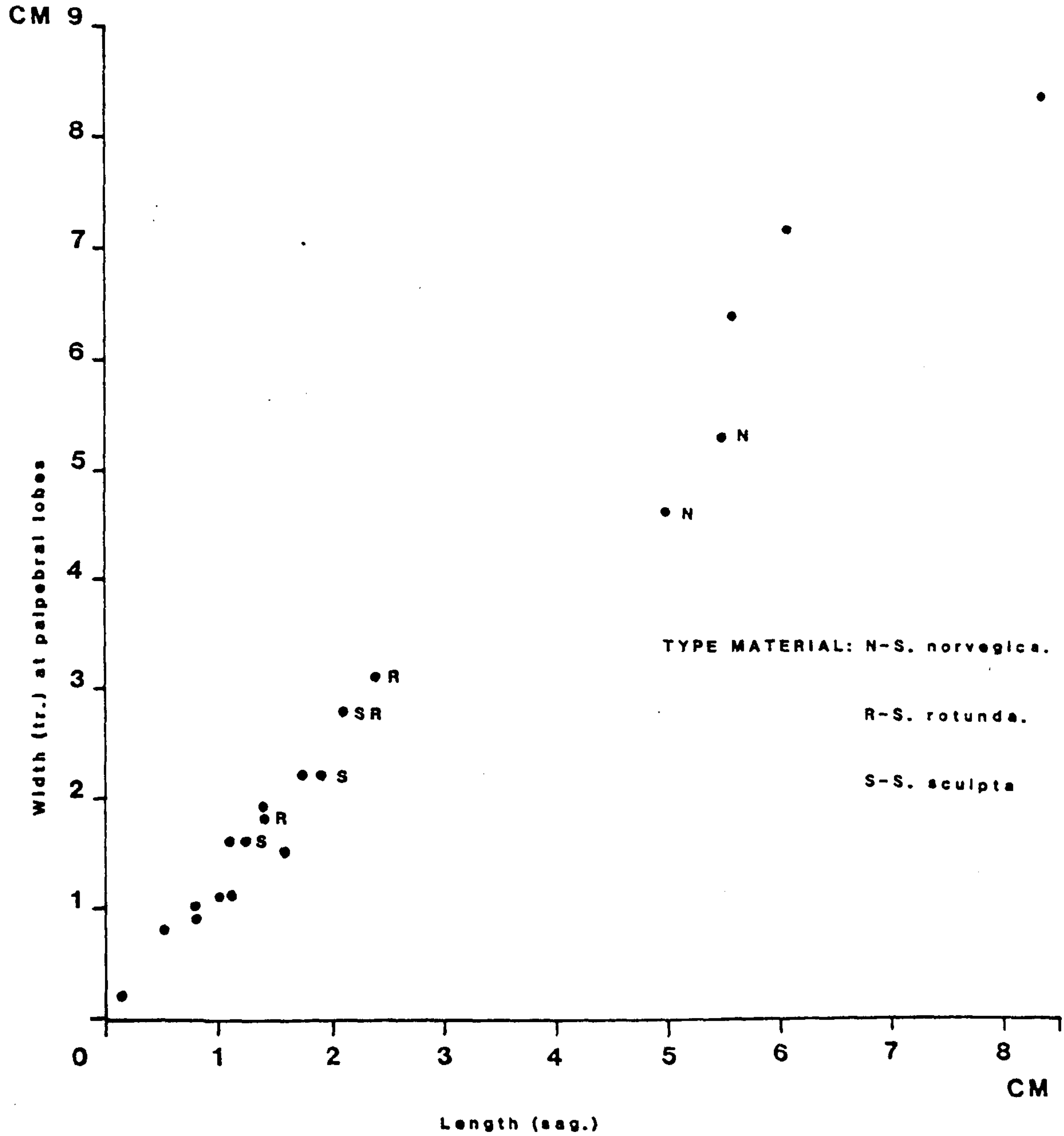
Ontogeny. A cranidium of *S. glaber* with a sagittal length of 1.5mm (Pl. 9, fig. 1) from Spirodden, Asker (PMO 110.161) is believed to represent the small holaspid stage of *S. glaber*, the only species of *Stenopareia* which occurs at that locality. In this specimen, the glabella is defined by axial furrows extending from the anterior to posterior margins and is of marked independent convexity. Medium size specimens of *S. glaber* with a cranidial sagittal length of 20-30mm (Pl. 9, figs 2, 4) display no independent anterior glabellar convexity and the axial furrows are restricted to the area behind the lateral muscle impressions. The largest cranidia of *S. glaber* possess a sagittal length of 10cm (Pl. 11, figs 3, 4) and have a relatively elongate cranidium which is flattened posteriorly in lateral view. Chatterton & Ludvigsen (1976, pl. 6) figure juvenile specimens of *Failleana calva* which display a similar effacement of the axial furrow although the loss of independent glabellar convexity is not as marked as in *S. glaber*.

Discussion. A full discussion of the species name *glaber* is given in Owen & Bruton (1980, p. 17). *Illaenus rotundus* Kiær (1908), *Illaenus sculptus* Kiær (1908), *Illaenus norvegicus* Whittard (1940) and *Illaenus thomsoni* Salter (1867) are considered to be junior subjective synonyms of *Stenopareia glaber* (Kjerulf, 1865) on the basis of the following observations:

The type material of *S. sculpta* is from the same stratigraphic horizon as that of *S. rotunda* and the only detectable difference is that *S. rotunda* is more convex. I have collected topotype specimens of *S. sculpta* which show variability in convexity between that of the most convex specimens of *S. glaber* (PMO 110.164, pl. 8, fig. 5) and that of *S. sculpta*.

Material of *S. glaber* figured by Owen & Bruton (1980) does appear in some cases to be more convex than some of the Silurian specimens but in view of the degree of variation observed in the convexity of the latter this is not considered significant. They also (*ibid.* 1982, p. 16) described two "morphs" of *S. glaber*, one sagittally shorter and more convex, and one longer and less convex. Owen (1982, *pers. comm.*) on the basis of an unpublished biometric study now believes the two "morphs" to represent end-members of a continuous variation in convexity.

Stenopareia norvegica is considered to represent the mature holaspid stage of *S. glaber* for the following reasons. Firstly only large specimens have been referred to *S. norvegica* and no immature cranidia are known that more closely resemble this species by possessing an elongate cranidium which is flattened posteriorly in lateral view. Secondly I follow Lane (1979, p. 16) in considering the morphology of the anterior margin of the pygidial doublure to be a useful specific indicator. The pygidial doublure of *S. norvegica* has a pair of anterior projections identical to those of *S. glaber*, the topotype material of *S. sculpta* and the type material of *S. rotunda*. Thirdly *S. norvegica* is known from the same localities and horizons as *S. rotunda* and *S. sculpta*. Fourthly a plot of sagittal length against transverse width across palpebral lobes for specimens of *S. glaber* from southern Norway shows the type specimens of *S. norvegica* *S. rotunda* and *S. sculpta* to follow the same trend (Text-fig. 14).



Text-figure 14

Plot of sagittal length against transverse width across palpebral lobes for specimens of *S. glaber* from the Silurian of southern Norway.

A comparison of *S. thomsoni* (Salter, 1867; see Howells 1982 pl. 3, figs 1-8) from the Llandovery (Aeronian, *atavus* to *cyphus* Biozones) of the Girvan area, Scotland with large specimens of *S. glaber* (as represented by *S. norvegica*) reveals no differences which I consider of specific importance. Accordingly I consider *S. thomsoni* to be a junior subjective synonym of *S. glaber*.

Three other species of *Stenopareia* described by Reed (1935) also possess twin projections on the pygidial doublure. From an examination of the type material of these species the following differences from *S. glaber* were observed. Firstly *S. fluvialis* (Reed, 1935; p. 13, pl. 2, figs 1-3) from the Drummock Group, Starfish Bed (Cautleyan to Rawtheyan), of the Girvan area, Scotland, possesses a far shorter (sag.) cranidium than comparably sized specimens of *S. glaber* and the projections and median sulcus on the pygidial doublure are less well-defined. Pygidia of *S. fluvialis* (Reed, 1935) and those of *S. longicapitata* (Reed, 1934; p. 17, pl. 2, figs 1-7) are from the same locality and horizon and appear to be identical; I believe them all to belong to the same species.

The cranidium of *S. longicapitata* var. *subcarinata* (Reed, 1940; p. 19, pl. 2, figs 8, 8a) also from the same horizon and locality is relatively longer than that of comparable sized specimens of *S. glaber* and possesses a larger 1G cranidial muscle impression and lateral muscle impression and a relatively longer (sag.) pygidium which has a less well defined axial region.

S. craigensis (Reed, 1935; p. 20, pl. 2, figs 10-12) from the Craighead Limestone (*Dicranograptus clingani* Biozone, Caradoc), is similar in overall pygidial morphology and development of the projections on the pygidial doublure but comparison is hampered by preservation and the small number of available specimens.

S. bowmanni (Salter, 1848; see Price 1974, p. 842, pl. 112, figs 1-8,?9) from the Sholeshook Limestone (Cautleyan, Ashgill) of Dyfed, Wales also possesses twin projections on the pygidial doublure but differs from *S. glaber* in that the doublure is relatively far longer, extending sagittally for two-thirds the pygidial length, as opposed to one-third in the Norwegian species.

It is possible that the well incised lateral pygidial furrows in *S. glaber* are not axial furrows in the sense of defining the pygidial axis. The segmented area seen in some specimens (PMO 19425, Pl. 8, fig. 4) only occupies two-thirds of the area between the furrows and if this is taken as representing the axis then the furrows are not axial. The segmented area may represent areas of muscle attachment however, and if this is the case may not reflect the true extent of the axis.

Stenopareia longispinosa (Kiær, 1908). Pl. 12, figs 1-8; Pl. 13, figs 1-3, 5-7; Text-figs 15, 44.

v* *1908 Illaenus longispinosus* nov. sp., Kiær, p. 573.

v 1940 *Illaenus longispinosus*, Kiær; Whittard, p. 282, pl. 1, figs 13-17.

v. 1940 *Pygidium* Type A, Whittard, p. 292, pl. 3, figs 15, 16.

v. 1940 *Pygidium* Type B, Whittard, p. 292, pl. 4, figs 1-4.

v *1982 Stenopareia longispinosa*, (Kiær 1908); Helbert, p. 132.

v. *1982 Stenopareia* sp. nov., Helbert, p. 132.

Type material. As no holotype was selected by Kiær, Whittard's statement that PMO 19483 (external mould cranidium) is holotype is groundless. Whittard (1940, p. 283) stated that "the specific name was proposed by Kiær in order to direct attention to the presence of a long spine on the caudal fascia of the pygidium. There is no specimen in the collection showing a pygidium associated with a cranidium". On this basis he retained the name *longispinosus* for a cranidium identified by Kiær. However (*ibid.*, p. 292) he stated that the specimen he assigned to *Pygidium* Type A was "an isolated specimen associated with with the holotype of *I. longispinosus*" and furthermore that this pygidium may belong to *I. longispinosa*. It is clear from the specific name chosen by Kiær that the long anterior process on the pygidial doublure is the major diagnostic character of this species as there is no other spine elsewhere on the exoskeleton. Thus the pygidium PMO 19483 (figured Whittard 1940, pl. 1, figs 13-15; Pl. 13, fig. 3), from the Rytteråker Formation (Kiær's ếtage 7a), Bjerkøya, Holmestrand district was designated lectotype by Helbert 1982, p. 131.

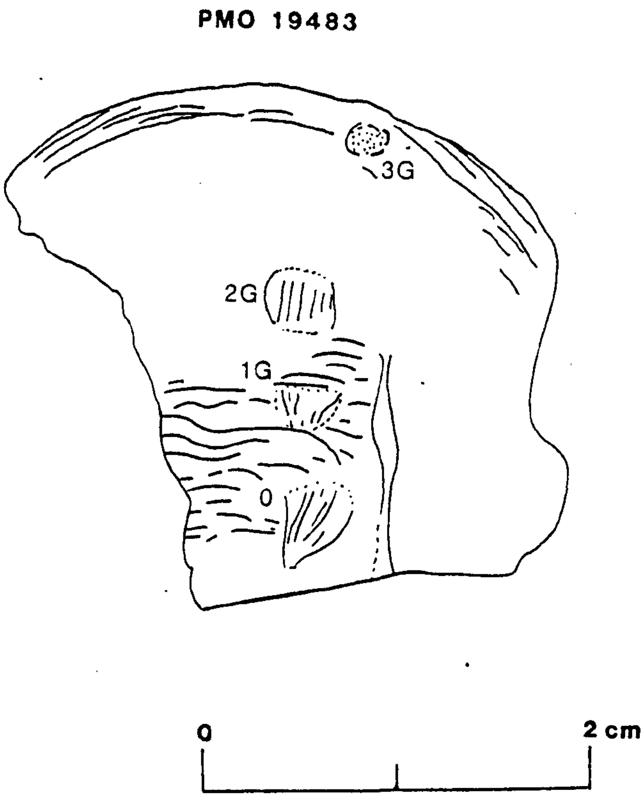
Paralectotypes; PMO 21306 (internal mould free cheek; figured Whittard 1940, pl. 1, fig. 17; Pl. 13, fig. 6) and PMO 21307 (poorly preserved internal mould cranidium; figured Whittard 1940, pl. 1, fig. 16; Pl. 13, fig. 2), locality 35.

Other material. Cranidia, PMO 54589, locality 3, PMO 110.256, locality 9, PMO 43566, locality 29, PMO 21309, -345, locality 36; pygidia, PMO 19434-437, -439, -445, -446, PMO 54588, -990, locality 3, PMO 19546 (figured as *Pygidium* Type B by Whittard 1940, pl. 4, fig. 1; Pl. 12, fig. 1), PMO 19547 (figured as *Pygidium* Type B by Whittard 1940, pl. 4, figs 2-3; Pl. 12, fig. 3), 19632 (figured as *Pygidium* Type B Whittard 1940, pl. 4, fig. 4; Pl. 13, fig. 7), locality 29, PMO 43603, locality and horizon unknown.

Stratigraphic range. Rytteråker Formation (Kiær's étages 7a & 7b), Oslo, Asker and Holmestrand districts (Aeronian & Telychian, *sedgwickii* to *crispus* Biozones).

Text-fig. 15

Diagram showing distribution of cranidial axial muscle impressions, in dorsal view, of *S. longispinosa* (Kiær, 1908) (PMO 19483; lectotype).



Diagnosis. A species of *Stenopareia* with cranidium two-thirds as long (sag.) as wide (tr.); palpebral lobe large and prominent, convex, and half its own length from the posterior margin; four pairs of cranidial axial muscle impressions visible on internal mould (Text-fig. 15): impression 0 an area of radiating striae extending from opposite median granule to opposite posterior end of lateral muscle impression; 1G an area of exsagittally arranged striae one-quarter as long and extending anteriorly from opposite half length of lateral muscle impression; 2G slightly larger than 1G, situated at half cranidial length; 3G small, close to anterior margin. Pygidial length (sag.) about two-thirds width (tr.) at anterior margin and with strong median arch one-third its width. Weakly-defined axial region narrowing slightly backwards, extending for half pygidial length and with at least six weakly-defined axial rings; anterior margin of doublure produced into a long, narrow median projection (a median groove running its length) extending about half pygidial length (sag.).

Description. Cranidium highly convex; glabella over one-third cranidial width (tr.) at posterior. Axial furrow well-incised, broad and extending to mid point of palpebral lobe. Lateral impression as long as axial furrow, confluent with it, curving adaxially for the posterior half of length and abaxially for the anterior half. Fixed cheek and glabella almost horizontal posteriorly, sloping sharply anterior to lateral impressions. Free cheek with gently convex field, posterior and lateral margins of approximately equal length and with a rounded genal angle. Cranidial sculpture consists of a zone of terrace ridges anteriorly extending about one-third sagittal length with a second set between the axial furrows, leaving the fixed cheeks and median part of the glabella without sculpture. The free cheek, known only from internal mould, has a sculpture of coarse granules near the suture, becoming smooth posterolaterally.

Pygidium less convex than cranidium. Pygidial doublure close to dorsal exoskeleton anteriorly, separated from it posteriorly to leave a cavity running parallel to the posterior margin. Doublure, excluding projection, about one-third pygidial length. Sculpture of dorsal surface includes at least four weakly-defined ribs which are posteriorly directed, originate from the weakly-defined axial rings and cross the axial furrows. The doublure, on internal mould, has twelve to thirteen terrace ridges subparallel to the posterior margin.

Discussion. Helbert (1982, p. 132) assigned Whittard's *Pygidium* Type B to *Stenopareia* sp. nov. The only difference I have detected between the type material of *S. longispinosa* and *Pygidium* Type B is surface sculpture. This varies from specimen to specimen amongst the type specimens of *S. longispinosa* and is not considered significant as a specific character as other specimens of that species have *Pygidium* Type B sculpture. Both sets of material are from the same horizon and one paralectotype of *S. longispinosa* is from the same locality as the specimens of *Pygidium* Type B. I therefore consider *Pygidium* Type B to belong to *S. longispinosa.*

S. catathema Howells, 1982 from the Aeronian of Girvan, Scotland resembles *S. longispinosa* in cranidial and overall pygidial morphology but possesses a shorter projection to the pygidial doublure.

S. somnifer Lane (1979, p. 14, pl. 1, figs 17-25, pl. 2, figs 1-14, pl. 3, figs 1-2, pl. 5, fig 3) from the Llandovery (Aeronian) of Washington Land, North Greenland also resembles *S. longispinosa* but differs in possessing a shorter projection to the pygidial doublure and, in addition, a less convex palpebral lobe.

Whittard (1940, p. 283) compared *S. longispinosa* to *S. imperator* (Hall, 1861) stating that in the latter the palpebral lobe is smaller and nearer the posterior border. I agree that this is so and in addition to this the cranidium of *I. imperator* is narrower anteriorly with less well-defined lateral impressions and the pygidial axis is better defined and more distinct posteriorly than in *S. longispinosa.*

S. longispinosa also resembles *S. aemula* (Salter, 1867; see Howells 1982, pl. 5, fig. 3) from the Pentamerus Beds (Aeronian, *triangulatus* to *convolutus* Biozones) of Norbury?, Shropshire, in overall pygidial shape but the latter lacks the long anterior process on the doublure.

Stenopareia postrema (Kiær, 1908). Pl. 11, fig. 3; Text-figs 16, 44.

v* *1908 Illaenus postremus* nov. sp., Kiær, p. 573.

v 1940 *Illaenus postremus* Kiær; Whittard, p. 283, pl. 1, figs 18-20.

v *1982 Stenopareia postrema* (Kiær 1908); Helbert, p. 131.

Lectotype. Designated by Helbert (1982, p. 132) PMO 21757 (external mould, cranidium), Braksøya Formation (Kiær's êtage 8c), Ringerike. Only available specimen (see discussion).

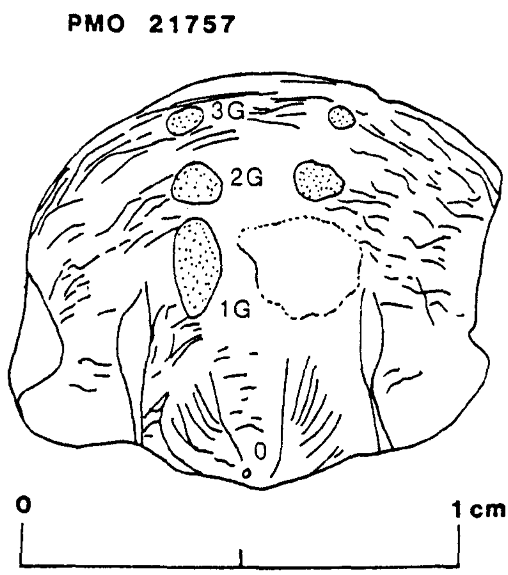
Stratigraphic range. Braksøya Formation (Kiær's êtage 8c), Ringerike district (Sheinwoodian, *centrifugus* & *murchisoni* Biozones).

Diagnosis. Highly convex species of *Stenopareia* with lateral cranidial impressions well-defined, shallow lateral furrows extending to opposite one-third length (exsag.) of palpebral lobe; glabella of marked independent convexity posteriorly in anterior view; palpebral lobe small, less than its own length from posterior margin; four pairs of cranidial axial muscle impressions clearly defined on external and internal moulds (Text-fig. 16); impression 0 an area of radiating striae originating from median granule, extending to opposite anterior end of lateral impressions; 1G adaxial and largely anterior to lateral impressions, is a circular area devoid of terrace ridges and as long (exsag.) as 0; 2G one-third length (exsag.) of 1G, is a subcircular area situated one-third the distance from 1G to anterior margin; 3G half size of 2G situated two-thirds distance from 2G to anterior margin.

Description. Cranidium as wide (tr.) across palpebral lobes as long (sag.). Axial furrows parallel. Median granule small, situated opposite posterior of palpebral lobe. Fixed cheek of lower convexity than glabella. Sculpture of terrace ridges over whole dorsal surface (excluding axial furrows, lateral impressions and axial muscle impressions) transversely arranged, becoming more deeply incised anteriorly.

Text-figure. 16

Diagram showing the distribution of cranidial axial muscle impressions, in dorsal view, of *S. postrema* (Kiær, 1908) (PMO 21757; lectotype).



Discussion. Only one cranidium of this species (that figured by Whittard 1940) is present in the collection. Kiær, although not giving any indication of the numbers of specimens available to him, describes the pygidium of *S. postrema*. The cranidium was therefore designated lectotype by Helbert (1982, p. 132) because the species was clearly originally described from more material than is now available. Kiær's other (lost) specimens are subsequently designated paralectotypes.

The features distinguishing *S. postrema* from *S. glaber* Kjerulf, 1865 are its greater convexity, shorter palpebral lobe, relatively greater width anteriorly and the sculpture of terrace ridges which in *S. glaber* are confined to the anterior and posterior borders.

S. postrema differs from *S. longispinosa* (Kiær, 1908) in possessing a more convex glabella posteriorly (in anterior view) and shorter lateral muscle impressions.

S. catathema Howells (1982, p. 15, pl. 4, figs 14-18, pl. 5, figs 1, 2, 4, 5) from the Llandovery (*sedgwickii* to *crispus* Biozones) of Girvan, Scotland, differs from *S. postrema* by being of lower cranidial convexity and less rounded anteriorly in dorsal view.

S. somnifer Lane (1979, p. 14, pl. 1, figs 17-25, pl. 2, figs 1-14, pl. 3, figs 1, 2) from the Llandovery (Aeronian) of Washington Land, North Greenland differs from *S. postrema* in possessing axial furrows and lateral muscle impressions which diverge anteriorly and in being more triangular in dorsal view.

Stenopareia sp. Pl. 10, fig. 2;
Text-figs 17, 44.

v. *1908 Illaenus rotundus*, Kiær, p. 573.

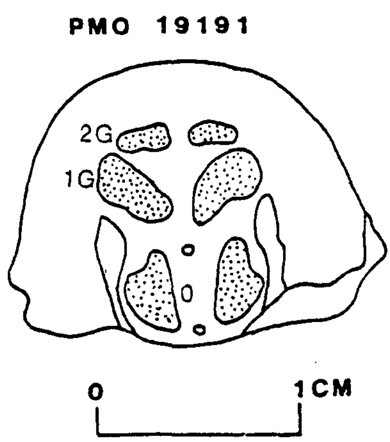
v. 1940 *Illaenus rotundus* Kiær; Whittard, p. 278 (*pars*) pl. 1, fig. 6, *non*. figs 1-5, 7, 8 (= *S. glaber* Kjerulf, 1865).

Material. PMO 19191 (internal mould cranidium), Upper Chasmops Limestone (Kiær's étage 5b), Rambergøya, Oslo district (Arenig).

Description. Cranidium slightly as long (sag. in dorsal view) as wide (tr.); axial furrow extending to opposite mid length of palpebral lobe. Lateral cranidial impression one-third longer (exsag.) than axial furrow, well-incised. Two median tubercles; one situated opposite mid point of lateral cranidial impression the other opposite anterior of palpebral lobe. Three pairs of well-defined cranidial axial impressions visible on internal mould (see Text-fig. 17); impression 0 an exsagittally elongate area extending from opposite posterior sagittal tubercle to opposite anterior sagittal tubercle; 1G the same size and shape as 0, with long axis diverging forwards from opposite anterior end of palpebral lobe at 45°; 2G less than one-quarter size of 1G, oval with long axis transversely arranged, situated at three-quarters cranidial length (exsag.) from posterior margin.

Text-fig. 17

Diagram showing the distribution of cranidial axial muscle impressions, in dorsal view, of *Stenopareia* sp.



Discussion. This Ordovician specimen figured by Whittard as *I. rotundus* differs from that species in possessing a smaller palpebral lobe, longer 1G impression and two cranidial tubercles.

S. postrema (Kiær, 1908) differs from this specimen in being far shorter (sag.) in dorsal view and in having a more posteriorly placed 1G, only one median tubercle, and a more convex glabella in anterior view.

This specimen is placed in *Stenopareia* on the basis of its high convexity, disposition of cranidial axial muscle impressions and small palpebral lobe. It differs from all known species of *Stenopareia* in possessing two median tubercles, a feature more commonly associated with the genus *Nileus*. *Nileus* possesses a far less convex cranidium with larger palpebral lobes than *Stenopareia* and the anterior tubercle is typically more anteriorly placed than in the above specimen. Fortey & Clarkson (1976, p. 101) discussed the possible function of the glabellar tubercle in *Nileus* as a light-sensitive organ. The position of the more anterior tubercle on the Oslo specimen corresponds closely to that of *Nileus*. Fortey & Clarkson (*ibid.*) indicated that such tubercles in species of the Illaenidae are of a similar structure to that of *Nileus*, representing a marked thinning of the cuticle not reflected on the dorsal surface. As the present specimen is an internal mould, more material is required in order to confirm the structure of the tubercles. The possession of two median tubercles distinguishes this specimen from all other species of *Stenopareia* and *Nileus*. The more posterior tubercle is in a position which indicates it to be occipital in nature.

Family Styginidae Vogdes, 1890 [Emended Lane & Thomas, 1984]

Diagnosis. See Lane & Thomas 1984, p. 156.

Terminology. The term "holcos" (derived from the Greek for furrow) was introduced by Helbert & Lane (1982, p. 132) for the concave zone parallel to and generally near to the lateral and posterior margins of some scutelluid (=styginid) pygidia; the "holcos" may be complete parallel to the whole margin or restricted in development.

Diagnosis See Lane & Thomas 1983, p. 156.

Genus **Bumastus** Murchison, 1839.

Type species. By monotypy; *Bumastus Barriensis* Murchison, 1839; originally described from the Barr Limestone Member of Coalbrookdale Formation, Hay Head lime works, Great Barr, West Midlands Metropolitan County, U.K.

Diagnosis. See Lane & Thomas 1978b, p. 11.

Bumastus bouchardi (Barrande, 1846a). Pl. 14, figs 1-4, 6; Pl. 15, fig. 5; Text-figs 18, 44, 45.

1846a *Asaphus (Nileus) Bouchardi*, Barrande, p. 49.

1847 *Nileus Bouchardi*, Hawle & Corda, p. 53.

1847 *Nileus cyclurus*, Hawle & Corda, p. 52.

1847 *Illaenus minutus*, Hawle & Corda, p. 55.

1852 *Illaenus bouchardi* (Barrande); p. 689, pl. 2b, fig. 19; pl.

34, figs 26-38.

v. *1908* *Bumastus praeruptus*, Kiær, p. 576.

v. 1940 *Pygidium* Type C; Whittard, p. 293, pl. 4, figs 5-7.

v 1940 *Bumastus bouchardi*, (Barrande); Whittard, p. 287, pl. 2, figs 11-14.

1953 *Bumastus bouchardi* (Barrande); Pribyl, p. 29.

1957 *Bumastus bouchardi* (Barrande, 1846); Snajdr, p. 109, pl. 10, figs 1-9, pl. 11, figs 1-13, text-figs 31-34.

1970 *Bumastus bouchardi*, (Barrande); Horny & Bastl, pp. 82-83, 203.

v *1982* *Bumastus bouchardi Barrande*; Lane & Helbert, p. 133.

Lectotype. By designation of Snajdr (1957, p. 238) NMP IT623 (incomplete specimen), Liteň Formation (Wenlock) of Luzce, Czechoslovakia. *Paralectotypes*. NMP 655:66 (cephalon), NMP 655:66 (cranidium), NMP 652:66 (rostral plate), NMP 654:66 (free cheek), NMP IT625 (pygidium), Liteň Formation, Listice, Near Beroun, Czechoslovakia. NMP 36397 (pygidium), Lodenice, near road to Bobovice. NMP IT626 (rostral plate), Liteň Formation, Svatý Jan Pod Skalou, Czechoslovakia. NMP IT626b (cranidium), NMP 626a (incomplete enrolled specimen), NMP IT627 (pygidium), Liteň Formation, Luzce, Czechoslovakia.

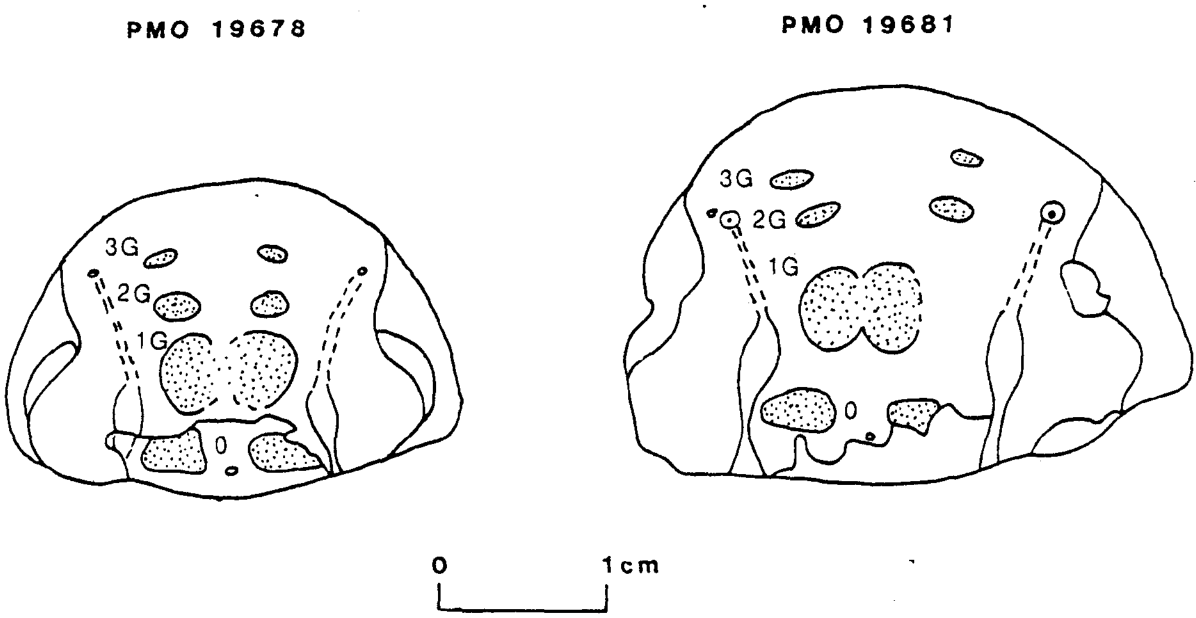
Norwegian material. Cephala, PMO 19681 (lectotype of *B. praeruptus* Kiær (1908) selected herein; figured Whittard 1940, pl. 2, figs 11-14; Pl. 14, fig 2) PMO 19682 (paralectotype of *B. praeruptus* Kiær 1908; figured Whittard 1940, pl. 3, figs 1-3; Pl. 14, fig. 1); free cheeks, PMO 19678 (& unnumbered internal mould pygidium, paralectotypes *B. praeruptus* Kiær, 1908; free cheek figured Whittard 1940, pl. 3, fig. 4; Pl. 14, fig 6); pygidia, PMO 19679-680 (figured as *Pygidium* Type C by Whittard 1940, pl. 4, figs 5-7); Pl. 15, fig. 5

& Pl. 14, fig. 3 respectively); all specimens are from locality 35.

Stratigraphic range. Malmøya Formation (Kiær's étage 8c), Oslo district (Sheinwoodian, *rigidus* & *linnarssoni* Biozones). Liten Formation (Wenlock), Luzce, Czechoslovakia.

Text-fig. 18

Diagram showing the distribution of cranidial axial muscle impressions, in dorsal view, of *Bumastus bouchardi* from the Oslo Region (PMO 19681 is lectotype of *B. praeruptus* Kiær, 1908).



Diagnosis A species of *Bumastus* with anterior pit containing granule on internal but not external mould and with another granule just abaxial and anterior to it; lateral cranidial impressions well-incised, opposite mid point and half length of palpebral lobe; three pairs of cranidial axial muscle impressions visible on available material (Text-fig. 18); impression 0 oval, long axis transversely arranged, extending exsagittally from just anterior of sagittal tubercle to opposite one-third length of lateral muscle impression, twice as wide (tr.) as long; 1G oval, half length of and extending from opposite mid length of palpebral lobe; 2G oval, one-eighth size of 1G, long axis transversely arranged, situated at half distance from lateral muscle impression to anterior margin; 3G smaller than 2G, oval situated halfway between 2G and anterior margin. Rostral plate one-quarter cephalic length (sag.) with rounded posterior flange sagittally, connective sutures at 50° to an exsagittal line and with a sculpture of terrace ridges parallel to anterior margin, deflected posteriorly onto flange. Pygidium with weakly defined holcos and small articulating facet; dorsal surface with median sulcus on holcos, changing to a weak carina anteriorly which extends to half pygidial length (sag.).

Description. Cephalon two-thirds as long (sag.) as wide (tr.) at posterior margin and highly convex. Lateral furrows shallow, extending to anterior pit. Lateral muscle impression well-incised, opposite and as long as palpebral lobe. Median tubercle pronounced, opposite posterior of palpebral lobe. Palpebral lobe of low independent convexity, half cranidial length (sag.), less than half its own length from posterior margin. Visual surface vertical, socle very well-defined. Subocular depression weak on external, and stronger on internal mould. Field of free cheek gently convex, posterior margin two-thirds length of lateral margin. Surface of cephalon excluding cranidial axial and lateral impressions and visual surface with sculpture of terrace ridges which are transverse on cranidium and parallel to lateral margin on most of free cheek but transverse on subocular depression. Cephalon covered with densely-packed, minute punctae of different sizes.

Pygidium, in dorsal view, four-fifths as long (sag.) as wide (tr.) at anterior margin. Doublure one-third pygidial length (sag.). Articulating facet less than one-fifth pygidial width, articulating groove, one-tenth pygidial length (sag.)nd two-thirds width.

Discussion. The Norwegian material is placed in this species on the basis of comparison with topotype material from Czechoslovakia in the Sedgwick Museum, Cambridge (specimen No's SM A10422-423, SM A49246-249, A49347, SM A49984-986). The type pygidia of *B. praeruptus* Kiær (1908) are identical to Whittard's *Pygidium* Type C and the specimens are from the same locality and horizon.

Snajdr (1957, p. 113, text-figs E & F) figured the cranidial axial impressions 2G and 3G and pygidial auxilliary impressions of the type material of *B. bouchardi* which are identical to those observed on the Norwegian material.

Kiær (1908, p. 577) described both the pygidium and cranidium of *B. praeruptus*. The specimens assigned to *Pygidium* Type C by Whittard are accompanied by cards attributing them to *B. praeruptus* and may therefore represent Kiær's material. Kiær (1908, p. 577) compared *B. praeruptus* to *B. inflatus* (Kiær) and *B. barriensis* Murchison, 1839 (see Lane & Thomas 1982, p. 11, pl. 1, figs 1-6, pl. 2, figs 1-9.). He differentiated *B. inflatus* on the basis of its greater convexity, less pronounced palpebral lobe and narrower free cheek with fewer, coarser, terrace ridges. In addition the anterior pit of *B. inflatus* is shallower and the sculpture of terrace ridges is confined to the anterior and posterior margins. *B. barriensis* differs from *B. bouchardi* principally in its lower cranidial convexity, less pronounced anterior pit, better defined eye socle, longer (sag.) rostral plate and more convex pygidium.

Bumastus? inflatus Kiær, 1908.   Pl. 14, fig. 5,
Pl. 15, figs 1, 2;
Text-figs 19, 44, 45.

v* *1906 Bumastus inflatus* nov. sp., Kiær, p. 577.

v 1940 *Bumastus inflatus*, Kiær; Whittard, p. 289, pl. 3, figs 5-8.

v. 1978 *Bumastus? phrix* Lane & Thomas sp. nov., Thomas, p. 14, pl. 3, figs 1-22.

Lectotype. Here selected PMO 21399 (external mould cranidium; figured Whittard 1940, pl. 3, figs 5-7; Pl. 14, fig. 5) Malmøya Formation (Kiær's étage 8c), Top of Malmøya, Oslo district (Sheinwoodian, *rigidus* & *linnarssoni* Biozones).

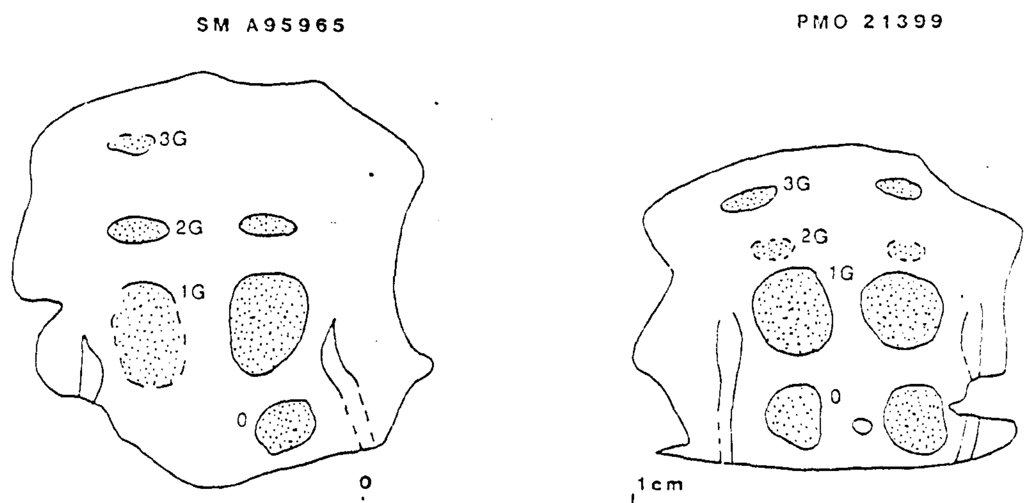
Paralectotype. PMO 21400 (internal mould free cheek; figured Whittard 1940, pl. 3, fig. 8; Pl. 15, fig. 1), locality 35.

Other material. PMO 109.477 (free cheek), locality 35.

Stratigraphic range. Malmøya Formation (Kiær's étage 8c), Oslo district (Sheinwoodian, *rigidus* & *linnarssoni* Biozones). Dolyhir and Nash Scar Limestone (Sheinwoodian, *centrifugus* & *murchisoni* Biozones), Wales.

Text-fig. 19

Diagram showing the distribution of cranidial axial muscle impressions, in dorsal view, of *Bumastus? inflatus* (Kiær, 1908) from the Oslo Region and Wales (SM A95965 is holotype of *B.? phrix* Lane & Thomas 1978; PMO 21399 is lectotype of *B.? inflatus* (Kiær, 1908).



Diagnosis. See *B.? phrix* Lane & Thomas (1978, p. 15).

Description. Cranidium highly convex, twice as wide (tr.) across palpebral lobes as long (sag.). Lateral cranidial impression two-thirds length of palpebral lobe, width between impressions (tr.) half maximum cranidial width. Lateral furrows very weakly impressed. Four pairs of cranidial axial impressions defined on internal and external mould (Text-fig. 19). Surface sculpture two regions of "terrace ridges"; one at posterior margin extending to mid point of palpebral lobe another extending for an equal sagittal length from the anterior margin. Dorsal surface with numerous densely packed minute punctae of different sizes. Socle well developed, one-quarter height of visual surface. Subocular depression weak. Field of free cheek gently convex, posterior margin three-quarters length of lateral, genal angle rounded. Sculpture of coarse terrace ridges describing a whorl centred near genal angle, parallel to lateral margin and becoming transverse beneath socle.

Thorax rostral plate and pygidium unknown from Norway, for description see Lane & Thomas (1982, p. 15).

Discussion. The synonymy of *B.? phrix* and *B. inflatus* is most strongly supported by the identical cranidial axial impressions developed in both sets of material (Text-fig. 19). The species occurs at different horizons in Norway and the U.K., in Britain it occurs in the Dolyhir and Nash Scar Limestone (*centrifugus* & *murchisoni* Biozones) whereas the Norwegian material is from the younger Malmøya Formation (Kiær's êtage 8c, *rigidus* & *linnarssoni* Biozones). Lane & Thomas (1978, p. 16) express doubts as to whether *B.? phrix* should be placed in *Bumastus* on the basis of differences between the auxilliary impressions of that species and those of *B.? barriensis* (see Lane & Thomas *ibid.*, p. 11, pl. 1, figs. 1-7; pl. 2, figs 1-12; pl. 4, fig 6); they concluded that they were probably derived from different non-effaced ancestors. In *B. barriensis* the 0 and 1G impressions are confluent and situated opposite the lateral impressions, in *B. inflatus* these two impressions are discrete. Little work has been done on the taxonomic value of cranidial axial muscle impressions, I believe them to be a useful specific indicator but not of much value in the majority of cases for diagnosing genera because of large differences in the impressions between otherwise similar species.

Genus **Eccairos** gen. nov.

Name. Greek, masculine; "out of date, antiquated"; referring to the primitive morphology of this genus.

Type species. *Eccairos dolabratus* gen. et sp. nov.

Diagnosis. Styginid of low convexity. Glabella with strong median ridge posteriorly; 1G and 2G circular and close to axial furrow; 3S oval; cranidium less than half as long (sag.) as wide (tr.) across anterior margin; frontal area absent; anterior cranidial margin broad, almost a transverse line medially. Pygidium with convex, elongate, almost parallel-sided axis, extending one-quarter length (sag.); three ring furrows defined only abaxially; seven pairs of lateral ribs; rib furrows narrow, well-incised; median rib without sagittal furrow. Terrace ridges clearly defined on anterior margin, occipital ring, rostral plate and pygidium.

Eccairos dolabratus sp. nov. Pl. 15, figs 3, 7-9; Text-figs 20a, 44.

Name. Latin, "shaped like an axe"; referring to shape of glabella.

Holotype. PMO 54753 (internal mould, cranidium; Pl. 15, fig. 3), Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand district (Aeronian, lower *sedgwickii* Biozone).

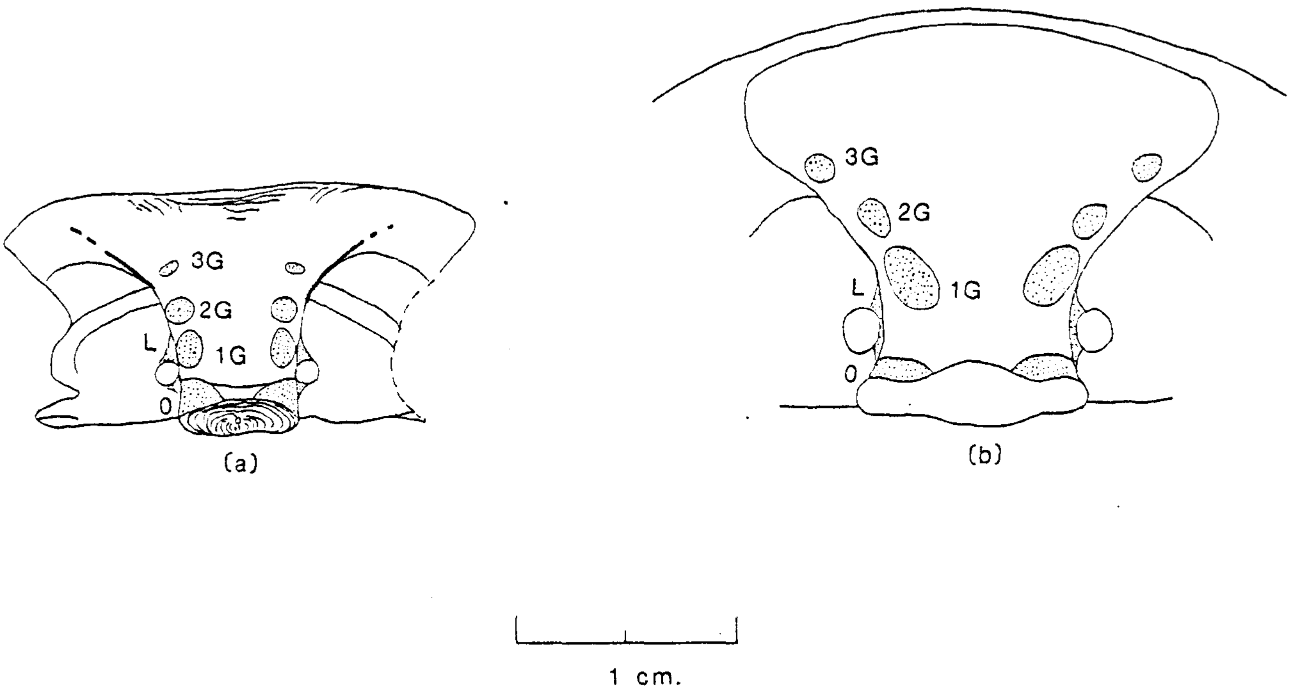
Paratypes. From type locality: PMO 110.285 (internal mould, free cheek; Pl. 15, fig. 9), PMO 110.261 (internal mould pygidium; Pl. 15, fig. 8), PMO 110.284 (internal mould, pygidium; Pl. 15, fig. 7).

Stratigraphic range. This species is only known from the type locality.

Diagnosis. As for genus.

Text-fig. 20

Diagram comparing the distribution of cranidial axial muscle impressions in a) *Eccairos dolabratus* gen. et sp. nov. and b) *Ekwanoscutellum platyactin* (Angelin, 1854) (PMO 54753 is holotype of *Eccairos dolabratus*).



Description. Glabella sloping gently and continuously to anterior margin, parallel-sided between 1G and 2G, expanding gently to anterior of 2G and expanding greatly in front of fixed cheek. Glabella lower than fixed cheek posteriorly. Occipital ring one-third as long (sag.) as wide (tr.), narrowing abaxially. Occipital furrow broad, well-incised, deepening and broadening abaxially. Axial furrow broad, well-defined posteriorly, becoming faint in front of fixed cheek. Fixed cheek convex (exsag. & tr.) with well-defined, circular, paraglabellar area opposite posterior of palpebral lobe. Palpebral lobe semicircular, one-fifth cranidial length (exsag.) with weakly defined ridge along rim. anteriorly. Anterior portion of facial suture at 45° to an exsagittal line, posterior portion only slightly posteriorly directed for most of its length, sharply deflected close to posterior margin. Free cheek steeply sloping beneath eye, with genal angle produced into narrow spine; lateral border flattened.

Pygidial axis well-defined, half as wide (tr.) as long (sag.). Lateral ribs weakly convex, furrows becoming faint close to margin. Sculpture of subtransverse terrace ridges on pleural ribs and median rib. Sagittal furrow extending one-fifth pygidial length. Doublure less than half pygidial length (sag.).

Discussion. Šnajdr (1960, p. 230) considered several features to be characteristic of "primitive scutelluids" (= styginids). Many of these features are present in *Eccairos*. Firstly in Ordovician species such as *Eobronteus* (e.g. *E. laticaudatus* (Wahlenberg, 1818) from the Leptaena Limestone Formation (Rawtheyan), of Dalarne, Sweden; see Šnajdr 1960, fig. 16) all three pairs of lateral glabellar muscle impressions are simple in shape and close to the axial furrow. In stratigraphically younger forms such as *Bojoscutellum* (e.g. *B. paliferum paliferum* (Beyrich, 1845) from the Koneprusy Limestone (earliest Devonian) of Czechoslovakia; see Šnajdr 1960, fig. 32) and *Ekwanoscutellum* (see below & Text-fig. 20b) the impressions are distinct from the axial furrow and tend to become more complex in shape. Secondly, the frontal glabellar lobe of *Eccairos* is broad which is a feature it shares with *Kosovopeltis* Snajdr, 1958 (e.g. *K. svobodai* Šnajdr, 1958, from the Kopanina Formation (earliest), of Czechoslovakia; see Snajdr 1960, fig. 21). Šnajdr considered more advanced forms to display a narrower anterior glabellar lobe such as that of *Scabriscutellum* (e.g. *S. caelebs caelebs* (Barrande, 1852) from the Suchomasty Limestone (Eifelian), of Czechoslovakia; see Šnajdr 1960, fig. 46). The anterior cranidial lobe of *Ekwanoscutellum* (see Text-fig. 20b), which also occurs in southern Norway (see below), is of intermediate width.

The median pygidial rib in primitive genera such as *Bronteus* is either not bifurcate or very weakly so and the pygidial sagittal furrow becomes progressively better defined in more advanced genera such as *Ekwanoscutellum* (Pl. 16, fig. 6), *Thysanopeltis* (Šnajdr 1960, pl. 24, fig. 6) and *Scabriscutellum* (Šnajdr 1960, pl. 25, fig. 12)

Šnajdr also considered the possession of six or eight pygidial pleural ribs as being a primitive feature and believed those genera with seven ribs to represent a separate, advanced, evolutionary lineage beginning with *Planiscutellum* R. & E. Richter, 1956 in the Wenlock and continuing into the Devonian. *Eccairos* from the Llandovery (Aeronian; see Pl. 15, fig. 8) and species of *Heptabronteus* Webby, 1974, (pl. 28, fig. 17; pl. 29, fig. 5 = *Kosovopeltis*) from the Ordovician of New South Wales, Australia both possess seven pleural ribs and Šnajdr's concept of a separate advanced lineage would therefore seem to be incorrect.

Eobronteus differs from *Eccairos* in possessing a preglabellar field, more widely spaced 1G and 2G a pygidium with six pleural ribs and a relatively short, broad and unsegmented, axis.

Kosovopeltis (Nicholson & Etheridge, 1879) is differentiated from *Eccairos* by its cranidial axial furrows which extend almost to the anterior margin, widely spaced 1G and 2G and a relatively short less convex pygidial axis.

The cranidium of *Eccairos dolabratus* resembles *Bronteopsis concentrica* (Linnarsson, 1869) from the Beyrichia Limestone (Caradoc), Alleberg, Vestergotland, Sweden, the Balclatchie Beds (Caradoc, Harnagian & Soudleyan), Girvan, Scotland and the Ampyx Limestone (lowermost Caradoc, Kiær's êtage 4ab) of Asker. *Eccairos* differs in possessing a broader occipital ring, better defined paraglabellar area and a less curved anterior margin. The pygidium of *Bronteopsis* in general has a far longer and more clearly segmented axis and eight lateral ribs.

Genus **Ekwanoscutellum** Přibyl & Vaněk, 1971

Type species. *Bronteus ekwanensis* Whiteaves, 1904; from the latest Llandovery or early Wenlock Attawapiskat Formation of Ekwan River, Ontario, Canada. Original designation of Přibyl & Vaněk (1971, p. 383).

Diagnosis. See Lane 1982, p. 134.

Ekwanoscutellum platyactin (Angelin, 1854). Pl. 15, figs 4, 6, 10, 11; Pl. 16, 1–10, 12; Text-figs 20b, 44, 45.

v* 1854 *Bronteus platyactin*, Angelin, p. 57, pl. 33, fig. 3.

v 1885 *Bronteus platyactin* Angelin; Lindström, p. 86, pl. 14, figs 1–3.

1908 *Bronteus platyactin*, Ang.; Kiær, p. 594.

v *1982* *Ekwanoscutellum platyactin* (Angelin 1885); Lane, p. 135.

v. *1982* *Kosovopeltis* cf. *K. umbonatus* (Lindström 1885); Helbert & Lane, p. 135.

Holotype. By monotypy Rm Ar29470 (pygidium and eleven thoracic segments; figured Angelin 1854, pl. 33, fig. 3; figured Lindström 1885, pl. 14, fig. 3; Pl. 16, fig. 9), Lower Visby Formation (*crenulata* Biozone), Norderstrand, Gotland, Sweden.

Swedish material. Ar29469 (whole individual lacking free cheek plus two pygidia with thoracic segments; figured Lindström 1885, pl. 14, fig. 1; Pl. 16, fig. 1), Ar29519 (free cheek), Ar29520 (two cranidia, one thorax and pygidium), Ar29521 (pygidium); all Swedish material is from the type locality.

Norwegian material. Cranidia, PMO 89038, locality 7; PMO 110.260, locality unknown (Kiær's étage 6), PMO 45570, locality unknown (Kiær's étage 7); pygidia, PMO 45597, -681, -684, -714, -715, locality 25, PMO 19507, locality, 36, PMO 110.263, -265, locality unknown (Kiær's étage 6).

Stratigraphic range. Solvik, Rytteråker and Malmøya Formations (Kiær's étages 6, 7a & 7b, 8c respectively), (Aeronian to Sheinwoodian, *cyphus*? or *sedgwickii* to *murchisoni* Biozones), Oslo, Asker and Ringerike districts. Lower Visby Formation (*crenulata* Biozone), Norderstrand, Visby parish, Gotland, Sweden.

Diagnosis (emended from Helbert & Lane 1982, p. 134). Glabella slightly inflated independent of cranidial convexity; lateral impressions very clearly delimited (Text-fig. 20b); occipital ring lacking median tubercle. Pygidium four-fifths as long (sag.) as wide (tr.) and gently convex. Terrace ridges clearly developed on anterior of frontal glabellar lobe and particularly on thorax and pygidium.

Description. Cranidium five-sixths as long (sag.) as wide (tr.). Convex anteriorly in lateral view, becoming flat posteriorly. Occipital ring one-sixth cranidial length (sag.), narrowing abaxially and a little wider than posterior of glabella. Occipital furrow well-defined, broad adaxially. Glabella one-third total cranidial width posteriorly, expanding anteriorly to two and a half times this width. Axial furrows well-defined, merging anteriorly with shallow, broad, anterior border furrow. Fixed cheek wide, gently convex with pronounced circular paraglabellar area. Palpebral lobe subsemicircular one-quarter length of glabella extending anteriorly from opposite occipital furrow. Anterior border furrow broadening adaxially. Posterior border not defined near axial furrow. Free cheek with long slender genal spine and sculpture of subtransversely-arranged terrace ridges. Rostral plate flat, broad medially, narrowing abaxially. Connective sutures at 45° to an exsagittal line.

Thorax of ten segments. Axis convex, one-third width (tr.). Thoracic segments flat for adaxial half of width, gently downwardly flexed for abaxial half. Sculpture of terrace ridges gently curved towards anterior on axis, exsagittally arranged on adaxial region of pleurae becoming transverse abaxially.

Pygidial axis convex anteriorly, less so posteriorly. Articulating half ring convex, well-defined posteriorly by deeply-incised furrow. Pleural fields with seven backwardly-directed, abaxially widening and gently convex ribs. Median rib is half maximum axial width (tr.) anteriorly, widening to equal axial width by posterior margin. Dorsal surface of pygidium with sculpture of transverse terrace ridges.

Discussion. A pygidium (PMO 43221; Pl. 16, fig. 6) was referred to *Kosovopeltis* cf. *K. umbonatus* (Lindström, 1885) by Helbert & Lane (1982, p. 135); it possesses a bifid pleural rib unlike the majority of other species referred to that genus. It would therefore be better referred to *Ekwanoscutellum*; in any case it is from the same locality and horizon as specimens of *Ekwanoscutellum platyactin* from which I am unable to distinguish it. Helbert & Lane (1982, p. 134) distinguished *E. platyactin* from the type species (*E. ekwanensis*; see Norford 1982, p. 5, pl. 2, figs 1-12, pl. 3, figs 1-10, pl. 4, figs 1-7) by the slight independent convexity of the glabella, the shorter almost parallel-sided posterior portion of the glabella, the more clearly delimited lateral and 1G cranidial impressions, the wider posterior border of the hypostome, the maximum width of the pygidium being farther back and the overall sculpture of terrace ridges being more pronounced. In addition, in dorsal view, the anterior margin of *E. ekwanensis* is more strongly curved than that of *E. platyactin*; the pygidial axis is proportionatly longer and the pygidial interpleural furrows disappear at a far greater distance from the margin.

In comparing the Swedish and Norwegian material of *E. platyactin* Helbert & Lane (1982, p. 135) stated that the Gotland material possessed a more bluntly-rounded pygidial axis and that the seventh pygidial pleural rib was proximally more constricted than in the Norwegian specimens. I am now unable to support these differences. They also stated that the 2G and 3G in the Norwegian material were shallower and less well-defined than those in Gotland specimens. On examination of external moulds from Norway not then available to us I now believe that in both sets of material the impressions are of equivalent size and depth.

The Gotland material, as compared with that from southern Norway, does possess a less strongly curved anterior cranidial margin and a posteriorly more convex pygidial axis. When the slight differences are set against the significant similarities in the two sets of material, it is necessary to recognize that the species occurs in the two areas. There is a stratigraphic difference between the two occurrences, the Swedish material occurs in the *crenulata* Biozone the Norwegian in the younger *crispus* and *griestoniensis* Biozones. One cranidium bearing a card assigning it to the Solvik Formation but without further data is assigned to this species and this Norwegian specimen therefore probably represents an extension of the range of *E. platyactin*.

Genus **Opsypharus** Howells, 1982

Type species. *Illaenus (Bumastus) Maccallumi* Salter, 1867, p. 210, pl. 28, fig. 1, pl. 30 figs 2 & 3; from the Mulloch Hill Formation, Girvan.

Diagnosis. See Howells 1982, p. 11.

Opsypharus maccallumi (Salter, 1867). Pl. 16, fig. 11;
Pl. 17, figs 1-6;
Pl. 18, figs 3-5;
8, 11, 12, 14, 15;
Pl. 19, figs 1-3, 6.
Text-figs 21, 44, 45.

1867 *Illaenus (Bumastus) Maccallumi*, Salter, p. 210, pl. 28, fig. 1; pl. 30, figs 2, 3.

v. *1908 Bumastus depressus*, nov. sp., Kiær, p. 575.

v. 1940 *Bumastus depressus* Kiær; Whittard, p. 285, pl. 2, figs 5-10.

v. 1940 *Pygidium* Type E, Whittard, p. 294, pl. 4, figs. 10-11.

v. 1940 *Pygidium* Type F, Whittard, p. 294, pl. 4, figs 12-13.

1982 *Opsypharus maccallumi*, (Salter, 1867); Howells, p. 11, pl. 2, figs 8-20 [Includes full synonymy of *O. maccallumi*].

v 1982 *"Bumastus" maccallumi*, (Salter 1867); Helbert & Lane, p. 132.

Lectotype. Designated by Howells (1982, p. 11) OUM C5 (internal mould of disarticulated complete specimen), Mulloch Hill Formation, Mulloch Hill (Rhuddanian & Aeronian, *atavus* to *argenteus* Biozones), Girvan; figured Howells 1982, pl. 2, fig. 17.

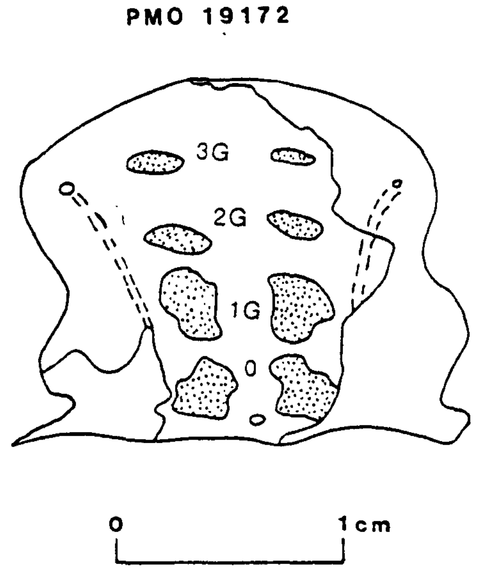
Paralectotypes. from type locality OUM C4, GSM 35906 (pygidia); figured Howells, 1982, pl. 2, figs 14 & 11 respectively.

Norwegian material. Cranidia, PMO 19369 (paralectotype of *B. depressus*; figured Whittard 1940, pl. 2, fig. 8; Pl. 17, fig. 1), PMO 19415, locality 3, PMO 60618 (paralectotype of *B. depressus* figured Whittard 1940, pl. 2, figs 6, 7; Pl. 17, fig 3), PMO 110.192, -193, -197, -200, -287, -295, locality 22, PMO 110.240, -241-243, -267, -422, locality 31, PMO 4374, -376, PMO 110.194, -196, -201, -288, locality 32, PMO 19172, PMO 21526, PMO 52586, -587, PMO 110.224, -233, locality 33, PMO 19365 (lectotype of *B. depressus*; figured Whittard 1940, pl. 2, fig 5; Pl. 19, fig. 3), PMO 42968, PMO 43058, locality 36; free cheeks, PMO 19231 (paralectotype of *B. depressus* figured Whittard 1940, pl. 2, fig. 9; Pl. 19, fig 6), PMO 19481 (paralectotype of *B. depressus*; figured Whittard 1940, pl. 2, fig. 10; Pl. 18, fig. 12), locality 3, PMO 110.119, locality 22, PMO 110.245, -252, locality 31, PMO 110.215, locality 32; rostral plates, PMO 19479, locality 3, PMO 110.191, locality 22, PMO 110.214, locality 32, PMO 110.223, -237, locality 33; hypostomes, PMO 109.537, locality 33; thoracic segment; PMO 110.297 (paralectotype of *B. depressus*; Pl. 17, fig. 5), locality 3; pygidia, PMO 19480, PMO 110.289, -515-517, -519, -520, locality 3, PMO 43474, -476, PMO 110.194, -196, -201, -288, locality 22, PMO 110.231, -244, -246, 110.253-255, -268, -269, locality 32, PMO 19143, PMO 19180 (*Pygidium* type F of Whittard 1940, pl. 4, fig. 14; Pl. 17, fig. 6), PMO 110.090, -092, -226, -229, 110.232-234, -238, -292, -298, locality 33, PMO 19508, PMO 42956, 42958-60, -969, PMO 43329, locality 36.

Stratigraphic range. Solvik Formation (Kiær's êtages 6b & 6c), Oslo & Asker districts; Rytteråker Formation (Kiær's êtage 7a), Oslo & Holmestrand districts (Rhuddanian & Aeronian, *cyphus* to lower *sedgwickii* Biozones). Mulloch Hill Formation (Rhuddanian & Aeronian, *atavus* to *argenteus* Biozones) and Newlands Formation (*triangulatus* to *argenteus* Biozones), Girvan, Scotland.

Text-fig. 21

Diagram showing the distribution of cranidial axial muscle impressions, in dorsal view, of *Opsypharus maccallumi* (Salter, 1867) from the Oslo Region.



Diagnosis (emended from Helbert & Lane 1982, p. 133 & Howells 1982, p. 10). Weak sagittal carina extending from large granule near posterior margin to two-thirds cranidial length in dorsal view; a deep pit is present halfway (exsag.) between the anterior margin and anterior end of palpebral lobe, seen on internal and external moulds but containing a granule on internal mould only; between pit and anterior margin is a pronounced granule; a narrow, well-defined ridge is present subparallel to the posterior margin between the end of suture and glabella; four pairs of cranidial axial muscle impressions visible on internal mould; impression 0 an area of irregular shape extending from opposite sagittal tubercle to opposite mid point of palpebral lobe and as long (exsag.) as wide (tr;). 1G same size as 0 and of a similar shape, extending from opposite anterior of to opposite mid point of palpebral lobe. 2G oval, transversely arranged, one-quarter as long (exsag.) as 1G and half as long as wide (tr.) situated at two-thirds cranidial length; 3G same size and shape as 2G situated at half distance from 2G to anterior margin. Pygidium with sagittal carina extending from a shallow posterior pit to half pygidial length on internal mould; articulating facet triangular, one-fifth anterior width (tr.); holcos one-eighth length of pygidium (sag.).

Description. Cranidium as long (sag.) as wide (tr.) across palpebral lobes, gently convex of even convexity (in lateral view) from posterior to anterior margin. Lateral furrows broad and shallow ending at anterior pit. Lateral cranidial impressions oval, opposite mid point and half length of palpebral lobe. Median granule, halfway between posterior margin and posterior of palpebral lobe. Palpebral lobe half its own length from posterior margin, lacking independent convexity, approximately one-quarter sagittal cranidial length. Surface sculpture of numerous, densely-packed, minute punctae of different sizes. Terrace ridges confined to area between anterior margin and anterior of palpebral lobe. Posterior margin of free cheek three-quarters length of lateral margin; field gently convex with broad, shallow subocular depression. Genal angle rounded. Sculpture of terrace ridges parallel to margins, with punctae restricted to ridge crests. Hypostome four-fifths as long (sag.) as wide (tr.); middle body subtriangular, convex; middle furrow very weakly-defined situated at two-thirds length from anterior margin. Anterior wing large, continuing curve of lateral margin. Lateral furrow weakly-defined; posterior margin rounded with narrow border defined by shallow furrow.

Pygidium four-fifths as wide (tr.) as long (sag. in plan view) gently convex, anterior margin extending in front of articulating facet, which laterally is one-quarter pygidial length (sag.). Surface sculpture of terrace ridges arranged transversely becoming medially deflected anteriorly on holcos. Punctae restricted to ridge crests.

Discussion. Howells (1982, p. 12) stated that *O. maccallumi* differed from *B. depressus* in being less convex, with less well-pronounced terrace ridges especially in the pygidium. The major problem with comparison of the Norwegian and Scottish material is the difference in preservation; the Scottish material occurs as internal moulds in fine sandstone, the Norwegian specimens are superbly preserved in carbonate as specimens with cuticle and as internal moulds. I consider that the different preservations probably account for the slight differences noted by Howells and therefore I can find no significant differences between *O. maccallumi* and *B. depressus*.

The Scottish material is recorded from the Mulloch Hill Formation (Rhuddanian & Aeronian, *atavus* to *argenteus* Biozones) and the Newlands Formation (*triangulatus* to *argenteus* Biozones). The Norwegian material is recorded both from the equivalent Solvik Formation (Kiær's étage 6) and the younger Rytteråker Formation (Kiær's étage 7a).

O. sulcatus (Kiær, 1908) from the Steinsfjorden Formation (Kiær's étage 9d), of Langøya, Holmestrand most resembles *O. maccallumi*, but differs in having a more convex cranidium, and a relatively broader pygidium with narrower articulating facet and more pronounced punctae.

Opsypharus longicaudatus (Kiær, 1908). Pl. 18, figs 1, 7, 9, 10, 13; Pl. 19, figs 5, 7; Text-fig. 44.

v* *1908 Bumastus longicaudatus*, nov. sp., Kiær, p. 576.

v. 1940 *Pygidium* Type D (=*Bumastus longicaudatus*, Kiær), Whittard, p. 293, pl. 4, figs 8 & 9.

v *1982 "Bumastus" longicaudatus*, Kiær 1908; Helbert & Lane, p. 134.

Lectotype. By designation of Helbert & Lane (1982, p. 134) PMO 19606 (external mould, pygidium); and PMO 19578 (the counterpart, figured as *Pygidium* type D by Whittard 1940, pl. 4, figs 8, 9; Pl. 18, fig. 9), Rytteråker Formation (Kiær's étage 7), Leanghagda, Asker.

Paralectotypes. As the counterpart of Whittard's figured specimen was found associated with other material in a separate box it seems reasonable to assume that the other material was part of Kiær's collection and represent paralectotypes. Free cheek, PMO 110.282 (Pl. 19, fig. 5). Rostral plate, PMO 19577 (Pl. 8, fig. 1). Pygidium, PMO 19571, PMO 19580 (pl. 19, fig. 7), PMO 19581, PMO 110.281.

Other material. Cranidium, PMO 19741, locality 19; pygidia, PMO 19739, PMO 110.280, locality 19, PMO 19543, locality, 29.

Stratigraphic range. Rytteråker Formation (Kiær's étage 7a), Oslo district; Steinsfjorden Formation (Kiær's étage 9), Holmestrand district, (Aeronian to Sheinwoodian, lower *sedgwickii* to *rigidus*? Biozones).

Diagnosis. Species of *Opsypharus* with very well-incised and broad (tr.) cranidial axial furrow. Rostral plate with posterior indentation. Pygidium as long (sag.) as wide (tr.) at anterior margin; strong sagittal carina running half length (sag.) in dorsal view from shallow pit on posterior margin; holcos weakly defined anteriorly, disappearing posteriorly; articulating facet narrow.

Description. Cranidium of very low convexity. Anterior pit twice as wide and deep as axial furrow. Dorsal surface with sculpture of terrace ridges near anterior margin becoming fainter posteriorly. Field of free cheek gently convex with well-developed subocular depression and rounded genal angle. Rostral plate with eleven or twelve terrace ridges, connective sutures at 50° to an exsagittal line.

Pygidium elongate, of low convexity. Flat anteriorly in lateral view sloping gently posteriorly. Articulating facet steeply sloping towards anterior one-quarter pygidial width (tr.). Sculpture of terrace ridges over entire dorsal surface deflected posteriorly close to sagittal carina.

Discussion. I follow Howells (1982, p. 11) in placing this material in *Opsypharus*. A cranidium associated with pygidia of *O. longicaudatus*, which was not available to Howells, confirms this assignment.

The relatively greater length and low convexity of this species serves to distinguish it from all other species of *Opsypharus*.

Opsypharus convexus (Kiær, 1908). Pl. 18, figs 2, 6;
Pl. 19, figs 4, 8;
Text-figs 22, 44.

v* 1906 *Bumastus sulcatus*, Ldm., var. *convexus*, nov. var., Kiær, p. 577.

v. 1940 *Bumastus sulcatus*, Lindström, var. *Kiæri*, new variety, Whittard, p. 290, pl. 3, figs 9-14. pl. 3, figs 9-14.

v 1982 "*Bumastus*" *sulcatus convexus*, Kiær 1908; Helbert & Lane, p. 133.

Lectotype. By designation of Helbert & Lane 1982, p. 133, PMO 60616 (external mould cephalon; figured Whittard 1940, pl. 3, figs 9-11; Pl. 19, fig. 4), Steinsfjorden Formation (Kiær's étage 9d), Langøya, Holmestrand district.

Paralectotypes; PMO 19754 (figured Whittard 1940, pl. 3, fig. 12; Pl. 18, fig. 2), PMO 60617 (figured Whittard 1940, pl. 3, figs 13, 14; Pl. 18, fig. 6); both internal moulds of pygidia from type locality and horizon.

Other material. Pygidium, PMO 19754, locality 19.

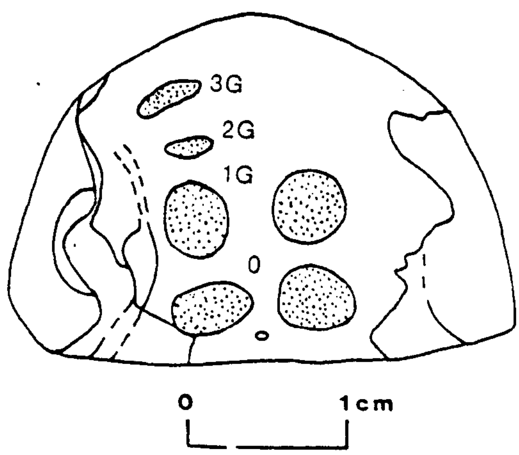
Stratigraphic range. Steinsfjorden Formation (Kiær's étage 9d), Holmestrand district (Homerian, *lundgreni* and *nassa* Biozones).

Diagnosis. Species of *Opsypharus* with pronouncedly triangular cephalic outline; lateral furrows well-incised on internal mould; four pairs of cranidial axial muscle impressions (Text-fig. 22): Impression 0 circular extending from opposite sagittal tubercle to opposite one-third length of palpebral lobe; 1G of similar size and shape to impression 0, extending from opposite half length of to opposite anterior of palpebral lobe; 2G oval one-third as long as wide (tr.), situated one-third distance from 1G to anterior margin; 3G slightly larger than 2G, oval, situated two-thirds distance from 1G to anterior margin. Rostral plate one-quarter cephalic length (sag.) with six terrace ridges and a sagittal indentation, extending one-fifth cephalic length (sag.); connective sutures at 80° to an exsagittal line. Pygidium of low convexity with small articulating facet. Pygidial terrace ridges confined to articulating facet.

Text-fig. 22

Diagram showing the distribution of cranidial axial muscle impressions in dorsal view, of *Opsypharus convexus* (Kiaer, 1908).

PMO 60616



Description. Cephalon two-thirds as long (sag.) as wide (tr.) at posterior margin. Convex anteriorly in lateral view less so towards posterior. Lateral impressions twice width (tr.) of lateral cranidial furrows, extending from posteror of palpebral lobe to two-thirds its length. Weak sagittal carina discernable on internal mould, extending three-quarters of cephalic length from a weak median tubercle which is situated halfway between posterior margin and posterior of palpebral lobe. Visual surface sloping forwards at 5° to horizontal with well-incised subocular depression widening posteriorly, socle absent. Field of free cheek gently-convex, genal angle sharply angular. Dorsal surface with a sculpture of numerous densely-packed, minute punctae of varying sizes and a zone of terrace ridges which on internal mould extends one-quarter cephalic length. Field of free cheek with terrace ridges in a zone parallel to margins, not present on subocular depression. Terrace ridges on rostral plate follow lateral margin becoming deflected posteriorly close to indentation.

Discussion. The Norwegian material is placed in *Opsypharus* on the basis of the low cephalic convexity and the axial furrow which extends to the anterior pit.

Whittard (1940, p. 290) in his synonymy for this species mistakenly quoted Kiær (1908) as attributing this material to *B. sulcatus* Lindström, 1885. Kiær in fact attributed it to a new "variety" of *B. sulcatus* Lindström, *B. s. convexus*. Whittard, on the basis of this material from Kiær's collection, subsequently erected *B. sulcatus* var. *kiæri* which is thus a junior objective synonym of *B. sulcatus* Lindström var. *convexus*.

Compared to *B. sulcatus* from the Slite Group (*linnarssoni to lundgreni* Biozones) of Gotland, Sweden, the Norwegian form is far less triangular in dorsal view with a shallower axial furrow and anterior pit. The Swedish species possesses a very pronounced subocular depression not seen in *O. convexus*.

O. convexus is distinguished from *O. maccallumi* (Salter, 1867) by its more convex cranidium with deeper axial furrows, deeper indentation to the rostral plate and broader pygidium with narrower articulating facets. Cranidial axial muscle impressions 1G and 2G in *O. maccallumi* are of similar size and disposition to those in *O. convexus* but differ in that in the former 1G is oval rather than circular in shape.

Family Proetidae Hawle & Corda, 1847

Diagnosis. See Owens 1973, p. 6.

Subfamily Proetinae Hawle & Corda, 1847

Diagnosis. See Owens 1973, p. 8.

Dimensions. The nomenclature herein applied to dimensions of proetid trilobites (Apendices 3-14) is that of Owens (1973, p. 4).

Genus *Proetus* Steininger, 1831

Type species. By original designation; *Calymmene concinna* Dalman, 1827, p. 234, pl. 1, figs 5a-c; from Mulde Formation (Silurian, Wenlock Series, *lundgreni* & *nassa* Biozones (Homerian), Djupvik, Gotland, Sweden.

Diagnosis. See Owens 1982, p. 135

Subgenus *Proetus* Steininger, 1831

Type species. As for genus.

Diagnosis. See Owens 1982, p. 135.

Proetus (Proetus) concinnus Dalman, 1827. Pl. 19, figs 9, 10;
Pl. 20, figs 1-5, 7-16;
Text-figs 23, 44, 46.

1827 *Calymmene concinna*, Dalman, p. 234, pl. 1, figs 5a-c.

1873 Proetus Fletcheri, Salter, p. 134; [*fide* Owens 1973].

1946 *Proetus (Proetus) morinensis*, nov. sp. (*nomen nudum*); Pribyl, pl. 2, fig. 12 [*fide* Šnajdr 1978].

. 1960 *Proetus (Proetus) morinensis* nov. spec., Přibyl, p. 178, pl. 2, figs 1-5.

. *1969 Proetus (Proetus) morinensis* Přibyl; Alberti, p. 74.

. *1970 Proetus (Proetus) morinensis* Přibyl; Horny & Bastl, p. 209.

. *1973 Proetus (Proetus) morinensis* Přibyl, 1946; Owens, p. 15.

1973 *Proetus (Proetus) concinnus* (Dalman, 1827); Owens, p. 12, pl. 2, figs 14, 15; Pl. 3, figs 1-9 [Includes full synonymy].

. 1980 *Proetus (Proetus) morinensis* Přibyl, 1960; Šnajdr, p. 42, pl. 1, figs 1-10, text-fig. 11.

v *1982 Proetus (Proetus) concinnus* Dalman, 1827; Owens, p. 135.

Holotype. UM G733 (complete, partially enrolled specimen) Mulde Formation (Wenlock, Homerian), Gotland, Sweden. Specimen figured Dalman 1827, pl. 1, figs 5a-c; Owens 1973, pl. 3, figs 5a-c.

Material from Norway. Cranidia, PMO 21401, PMO 44668, -672, -716, -721, -723, -725, -797, -802, PMO 110.299-301; free cheeks, PMO 44669, -720, -736, -792, -809, PMO 109.543, PMO 110.302, -303, -305; hypostome PMO 110.307; pygidia, PMO 21402, PMO 44666, -667, -671, 44678-682, -687, -714, -719, -722, -724, 796, -805, -808, PMO 110.306-313; all specimens are from locality 35.

Stratigraphic range. Malmøya Formation (Kiær's étage 8c), Oslo district, Sheinwoodian (*centrifugus* & *murchisoni* Biozones). Mulde Formation, Homerian (*lundgreni* to *nassa* Biozones), Gotland, Sweden. Woolhope Limestone, Much Wenlock Limestone Formation and Lower Elton Formation (Sheinwoodian to Gorstian, *centrifugus* to *nilssoni*

Biozones), U.K. Kopanina Formation, horizon with *Cromus beaumonti* (Ludlow), Karlstein (Quarry) "Amerika" field 18, Czechoslovakia.

Diagnosis. See Owens 1973, p. 13

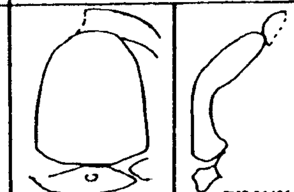
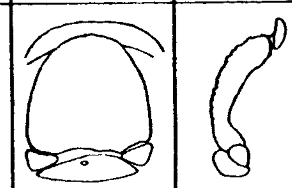
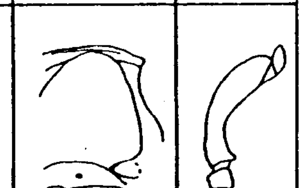
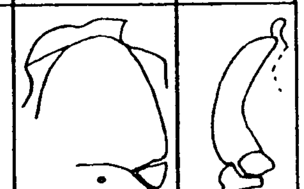
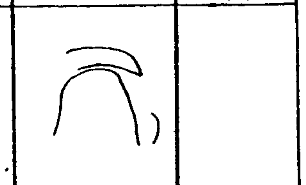
Description. See Owens 1973, p. 13.

Dimensions of holotype & Norwegian specimens. See Appendix 3.

Discussion. Owens (1973, p. 15) stated that *P. (P.) concinnus* is one in a complex of closely-related species of Wenlock and early Ludlow age which includes *P. (P.) foculus* Campbell, 1967, *P. (P.) morinensis* Přibyl, 1946, *P. (P.) osiliensis* Schmidt, 1894 and *P. (P.) pluteus* Whittington & Campbell, 1967. He did not discuss differences between these species however. The genal spine of *P. (P.) morinensis* as figured by Snajdr is shorter than that of many Norwegian or British specimens of *P. (P.) concinnus.* This is a feature however which can vary within members of the same population (see Owens 1973, pl. 2, fig. 14; pl. 2, fig. 1. Pl. 20, figs 4 & 15) and this is not thought to be of specific significance. No other consistent differences were observed and subsequently *P. (P.) morinensis* is considered to be a junior subjective synonym of *P. (P.) concinnus.*

P. (P.) foculus Campbell, 1967 (p. 15, pl. 4, figs 1-2) from the Henryhouse Formation (late Wenlock or Ludlow) of Oklahoma, U.S.A. differs from *P. (P.) concinnus* in possessing an occipital lobe which is very-poorly defined posteriorly, less well-incised inter-ring furrows on the pygidium which define less inflated axial rings and a series of terrace ridges parallel to the pygidial pleural ribs along the lateral margin.

P. (P.) pluteus differs from *P. (P.) concinnus* Whittington & Campbell, 1967 (p. 451, pl. 1, figs 1-31; pl. 2; pl. 3, figs 6-8, 10, 13-16; text-figs 1-5, 6c) from the Hardwood Mountain Formation (upper Wenlock or Ludlow) of Maine, U.S.A. in possessing a less convex cranidium (sag. & tr.), in possessing a constriction of the glabella

	Genal spine		Glabella		Preglabellar field		Paradoublural area		No. of axial rings	Sculpture		
	short	long	tapering	parallel	present	absent	present	absent				
concinnus		X		nearly		X		X	7–8	Smooth & pitting on cheeks		PMO 21401
baarlii		X	X		X		X		7–8	Strong granulation on glabella cheek pitted		PMO 53893
conctoratus	X		X			X	X		7–8	Fine granulation & incurved pyg. terrace ridges.		PMO 110.334
confossus	X		X			X	X		7–8	Fine granulation & pitting on cheeks		PMO 5001C
sp.		X	X		X		X		7–8	Strong granulation on glab. incurved pyg. terrace ridges		PMO 60618

Text figure 23. Summary of diagnostic characters of *Proetus* species described herein at γ and granulation on the dorsal surface.

P. (P.) osiliensis Schmidt, 1894 (p. 41, pl. 4, figs 1-9) from the Wenlock (Jaani or Jaagarahau Stages, = Sheinwoodian to Homerian, *centrifugus* to *lundgreni* Biozones), of Kerkan, Lithuania very closely resembles *P. (P.) concinnus* differing only in possessing a slightly broader glabella. This difference alone is not considered to be of specific importance and the two species may be synonymous. Schmidt's figures are not of sufficient quality however to allow any conclusion to be drawn with certainty.

Many of the Norwegian specimens of *P. (P.) concinnus* display coarser pitting on the field of the free cheek than the Gotland or British specimens (see Owens 1973, pl. 3, figs 1, 3-9; Pl. 20, figs 4, 5, 15). There is however a large degree of variation in the nature of the pitting amongst the Norwegian material and it is thus not considered of specific importance.

P. (P.) concinnus is known from the Much Wenlock Limestone Formation and Lower Elton Formations of the British Isles (Wenlock to Ludlow, *centrifugus* to *nilssoni* Biozones); from the Upper Visby Formation (Wenlock, *centrifugus* & *murchisoni* Biozones) to Hamra Formation (Ludlow, *Bohemograptus* Biozone) of Gotland, Sweden. *P. (P.) morinensis* Přibyl (1946) is known from the Kopanina Formation, horizon with *Cromus beaumonti* (Ludlow) of Karlstein (Quarry) "Amerika" field 18, Czechoslovakia (see Šnajdr 1980, pl. 1, figs 1-10; text-fig. 11).

Subgenus **Lacunoporaspis** Yolkin, 1966

(=*Khalfinella* Yolkin, 1968; *Ganinella* Yolkin, 1968) [*fide* Owens 1973, p. 15].

Type species. By original designation *Lacunoporaspis contermina* Yolkin, 1966, p. 28, figs 1-5; from middle Devonian, early Eifelian, S.W. Siberia, U.S.S.R.

Diagnosis. See Owens 1982, p. 136.

Proetus (Lacunoporaspis) confossus Owens, 1973. Pl. 20, fig. 6; Pl. 21, figs 1-3, 5, 15-17; Text-figs 23, 44, 46.

1973 *Proetus (Lacunoporaspis) confossus* sp. nov., Owens, p. 15, pl. 4, figs 1-8, text-fig. 4.

v *1982 Proetus (Lacunoporaspis) confossus* Owens 1973; Owens, p. 136.

Holotype. By original designation; NMW 71.6G.502 (cranidium), Much Wenlock Limestone Formation, Nodular Beds, (Silurian, Wenlock Series, *ludensis* Biozone), Wrens Nest, Dudley, West Midlands; figured Owens 1973, pl. 4, fig 1.

Paratypes. NMW 72.18G.34 (free cheek); figured Owens 1973, pl. 4, fig. 4, NMW 71.6G.244 (pygidium); figured Owens 1973, pl. 4, fig. 7; from type locality.

Material from Norway. Cranidia, PMO 44721, PMO 50007, -009, -010, -210, PMO 89319, PMO 110.332, 110.778-780; free cheek, PMO 110.781; pygidia, PMO 49989, PMO 49996, PMO 50008, PMO 50170, PMO 89318, PMO 110.342; all specimens are from from locality 19.

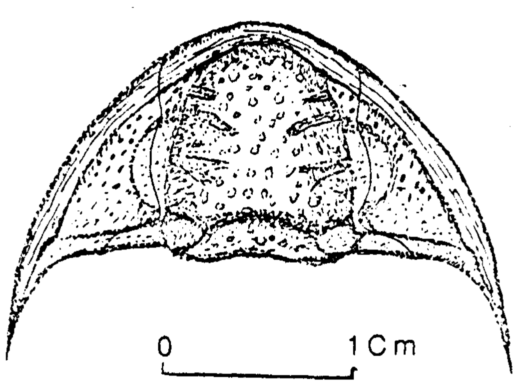
Stratigraphic range. Steinsfjorden Formation (Kiær's êtages 9c to 9g), Holmestrand district, Sheinwoodian to Homerian (*rigidus* to *lundgreni* Biozones). Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone), W. Midlands, U.K.

Diagnosis (emended from Owens, 1973, p. 15). Glabella conical, a little shorter than long (sag.); no preglabellar field; palpebral lobe and eye small; genal spine very short. Pygidial axis with seven or eight rings; paradoublural area well-developed to posterior of first two pleural ribs. Sculpture of fine granules with randomly distributed larger granules on cranidium and pygidium; distinct pitting on cheeks.

Description. See Owens 1973, p. 16.

Dimensions of type and Norwegian material. See Appendix 4.

Discussion (For comparison with other forms of the subgenus see *P. (L.)* sp. below). Although Owens (1973, p. 15) in his diagnosis stated that the pygidial axis had six rings, the paratype pygidium possesses at least seven. This is the case with the majority of the Norwegian specimens although some have eight. In any case the paratype pygidium is damaged posteriorly and could have had more rings.



Text-figure 24. Reconstruction of the cephalon of *Proetus (Lacunoporaspis) baarlii* sp. nov. (based on PMO 49319, free cheek, Pl. 21, fig. 7 & PMO 49320, cranidium, Pl. 21, fig. 8).

(See overleaf)

Proetus (Lacunoporaspis) baarlii sp. nov. Pl. 21, figs 4, 7, 8, 11-14; Text-figs 23, 24, 44.

(Name; in recognition of the help given to the author by B. Gudveig Baarli of the Paleontologisk Museum, Oslo).

1979 Proetus (Lacunoporaspis) n. sp. a (aff. *signatus* Lindström), Owens, p. 117, fig. 33.

v. *1982 Proetus (Lacunoporaspis)* sp. nov., Owens, p. 136.

Holotype. PMO 49320 (Cranidium), Steinsfjorden Formation, Kiær's étage 9 (Sheinwoodian, *linnarssoni* to *nassa* Biozones), Kommersøya, Holmestrand district; Pl. 21, fig. 8.

Paratypes. Cranidia, PMO 49294, locality 16; PMO 53893, locality unknown, Malmøya Formation, Asker district; free cheek, PMO 49319, locality 16; pygidia, PMO 19659, PMO 49327, PMO 89318, locality 16;

Stratigraphic range. Steinsfjorden & Malmøya Formations (Kiær's étages 8d & 9), Asker and Holmestrand districts, Sheinwoodian (*rigidus* to *nassa* Biozones).

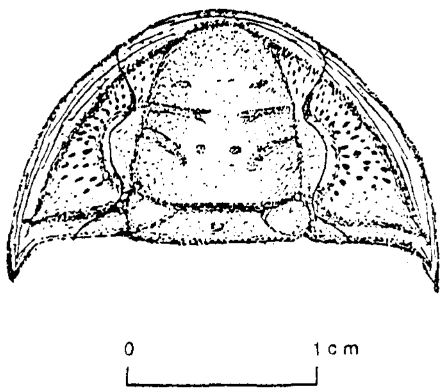
Diagnosis. Glabella highly convex, as wide (tr.) as long (sag.), conical not laterally constricted; preglabellar field very short (sag.) lateral parts pitted; genal spine long; occipital lobes prominent. Pygidial paradoublural area well-defined for whole length of lateral margin; pygidial axis with seven rings; six pairs of pleural ribs. Exoskeleton with coarse granulation on glabella, occipital ring and occipital lobes.

Description. Cephalon with wide, convex border defined by well-incised furrows. Three pairs of well-impressed glabellar furrows; 1S opposite mid point of palpebral lobe running backwards at 5° to a transverse line for one-quarter of glabellar width, then deflected posteriorly at 45° terminating away from occipital furrow at one-third glabellar width (tr.). Small oval auxiliary impression located close to point of deflection of 1S. 2S a little anterior of γ parallel to abaxial portion of 1S, narrow for abaxial half of length expanding into an oval area adaxially and extending one-third glabellar width. 3S an isolated, oval, transversely arranged area situated at one-quarter glabellar width (tr.). Occipital furrow deep and wide narrowing slightly in front of lateral occipital lobe. Occipital ring longer (sag.) than anterior border, constricted behind occipital lobe. Lateral occipital lobe subtriangular, convex, completly isolated. Pronounced median tubercle present. Section β-γ of anterior branch of facial suture diverging anteriorly at 5°. Posterior branch with ϵ and ζ very widely separated with intervening stretch parallel to axial furrow. Palpebral lobe weakly convex. Eye half length of glabella. Eye socle of low convexity, not defined by furrow at lower margin which is parallel to upper. Field of free cheek gently convex with pitting defined by a network of fine granules. Posterior border furrow broader than lateral.

Pygidium three-fifths as long (sag.) as wide (tr.). Paradoublural area narrowing anteriorly with weak holcos posteriorly. Axis anteriorly one-third width (tr.) of pygidium. First four ring furrows well incised; posterior three ring furrows progressively less well incised. Pleural areas weakly convex. Pleural ribs parallel sided, not extending onto paradoublural area and scalloped in longitudinal section. Pleural and interpleural furrows are equally well-incised. Dorsal surface of pygidium finely granulated.

Dimensions of holotype & paratypes. See Appendix 5.

Discussion (for comparison with other forms of the subgenus see *P. (L.)* sp. below).



Text-fig. 25

Text-figure 25. Reconstruction of *Proetus (Lacunoporaspis) conctoratus* sp. nov. (based on PMO 110.336, cranidium, Pl. 22, fig. 6 & PMO 110.337, free cheek, Pl. 22, fig. 16).

Proetus (Lacunoporaspis) conctoratus sp. nov. Pl. 22, figs 4, 6, 7, 10, 11, 14, 16; Text-figs 23, 25, 44.

(Name; Latin, "conctoratus"; to tarry, referring to the collection of this species at a locality near a bus stop).

Holotype. PMO 110.335 (cranidium), Malmøya Formation, Kiær's étage 8c (Sheinwoodian, *centrifugus* & *murchisoni* Biozone), Gjettum Bus Stop, Asker district; Pl. 22, fig. 11.

Paratypes. Cranidia, PMO 110.334, PMO 110.336; free cheeks PMO 110.337, -338; pygidia, PMO 110.339-341; all specimens are from locality 7.

Stratigraphic range. This species is only known from the type locality.

Diagnosis. A species of *Lacunoporaspis* with glabella three-quarters as wide (tr.) as long (sag.), tapering forwards, not laterally constricted; no preglabellar field; palpebral lobe less than its own length from posterior margin; free cheek with strongly convex border, field with sculpture of coarse pitting, genal spine very short; glabella with sculpture of fine granules with isolated randomly distributed larger granules. Pygidial axis with eight rings and a terminal piece, each ring with three pairs of granules; pygidial sculpture of fine granulation especially on axis.

Description. Similar in overall morphology to *P. (L.) confossus*, but 2p extends to opposite 1p auxiliary impression and is bifurcate adaxially. Occipital lobe large, oval, fully circumscribed. Section β-γ of anterior branch of facial suture diverges anteriorly at 10° to an exsagittal line through γ which is close to axial furrow. Posterior branch with ϵ and ζ closely spaced, intervening stretch diverging slightly backwards. Dorsal surface of glabella with sculpture of coarse, widely-spaced granules.

Pygidial axial rings with three pairs of prominent granules. A shallow pit is present on posterior six rings between most abaxial granule and axial furrow. Pleural areas with seven pairs of pleural ribs curving backwards abaxially, with a scalloped profile and narrowing progressively posteriorly.

Discussion (for comparison with other forms of the subgenus see *P. (L.)* sp. below.

Proetus (Lacunoporaspis) sp. Pl. 21, figs 6, 9, 10; Pl. 22, figs 1-3; Text-figs 23, 44.

Material. Cranidia, PMO 110.133, -331; free cheeks PMO 110.327, -328, -330; pygidia, PMO 110.314, 110.316-325, -331, -347; all specimens are from locality 8.

Stratigraphic range. Malmøya Formation (Kiær's étage 8b?), Asker district, Telychian & Sheinwoodian (*crenulata* & *centrifugus* Biozones).

Description. Similar to *P. (L.) confossus* but differs in the following ways: glabella has short (sag.) preglabellar field, which is bluntly rounded anteriorly. Palpebral lobe crescentic, half length of glabella, extending from near posterolateral corner of glabella. Genal spine long, lateral and posterior border furrows merging posteriorly and continued for two-thirds of its length. Glabella with coarse, widely-spaced granulation of irregular distribution.

Pygidial axis with seven or eight rings. Ring furrows widening abaxially. Terminal piece short, bluntly rounded. Seven pairs of pleural ribs.

Dimensions. See Appendix 7.

Discussion. *P. (L.) confossus* most closely resembles *P. (L.) conctoratus* but possesses a longer anterior border (sag.), a less convex glabella anteriorly and no incurved terrace ridges on the pygidial margin. *P. (L.) confossus* is distinguished from *P. (L.) obconicus* Lindström, 1885 (see Owens 1973, p. 73, pl. 4, figs 11-19; pl. 5, fig. 1) from the Eke Formation (Ludfordian, *leintwardinensis*

Biozone) of Gotland, Sweden and the Upper Bringewood and Leintwardine Formations (Gorstian to Ludfordian, *incipiens:tumescens* & *leintwardinensis* Biozones) of Shropshire by its relatively narrower glabella, shorter genal spine and pronounced pitting on the free cheek. *P. (L.) conctoratus* differs from *P. (L.) obconicus* in possessing a longer and narrower cephalon, a longer genal spine and a less well-defined paradoublural area which is narrower anterolaterally. *P. (L.).* sp. differs from *P. (L.) obconicus* in possessing a more coarsely granulate glabella and more strongly defined paradoublural area.

P. (L.) baarlii most closely resembles *P. (P.) signatus* Lindström, 1885 (p. 80, pl. 15, figs 16, 17) from the Halla or Klinteberg Formations, Homerian (*nassa* to *nilssoni* Biozones) of Gotland, Sweden. *P. (L.) baarlii* differs in possessing a glabella which tapers far less anteriorly and is wider posteriorly, a shorter anterior border (sag.) and a facial suture which diverges less strongly anteriorly. *P. (L.) baarlii* differs from *P. (s.l) granulatus* Lindström, 1885 (see Owens 1973, p. 22, pl. 2, fig. 3) from the Tofta Formation or Slite Group (Sheinwoodian & Homerian, *rigidus* to *lundgreni* Biozones) of Kyrkberget, Visby, Gotland, Sweden in possessing a glabella of greater convexity which is less coarsely granulate.

I consider P. (s.1) *simus* Lane, 1984 (p. 55, pl. 2, figs 1-7) from the Wenlock of Hall land, western North Greenland to belong to *Proetus (Lacunoporaspis)* on the basis of its similarity to species of the subgenus described herein. The Greenland species is of a similar convexity to *P. (L.) baarlii* but differs in possessing a granulate field of the free cheek, a shorter genal spine and a relatively shorter pygidial axis, which does not narrow posteriorly to the extent seen in *P. (P.) baarlii.*

I agree with Owens (1973, table 1) who considered the length of genal spine, shape of glabella (in dorsal view), presence of a preglabellar area, presence of a pygidial border (paradoublural area) and the number of pygidial axial rings to be of particular value in differentiating species of *Proetus*. Text-fig. 23 includes the information published by Owens for species which were described by him and which occur in the southern Norway and is intended for comparison with Owens table 1. Of the new species described herein *P. (L.) baarlii* is the most easlily recognized, the relatively broad and convex glabella which is strongly granulate serving to distinguish it from all other species of *P. (Lacunoporaspis)*.

P. (L.) sp. possesses a less granulate glabella which is narrower anteriorly and a longer anterior border than *P. (L.) baarlii*. The strong glabellar granulation, preglabellar field and incurved terrace ridges on the pygidial margin serve to distinguish *P. (L.)* sp. from all other species of *Proetus* from southern Norway. Few specimens are available and therefore I have declined to erect a new species for this material until more specimens can be collected.

Subfamily Crassiproetinae Osmólska, 1970

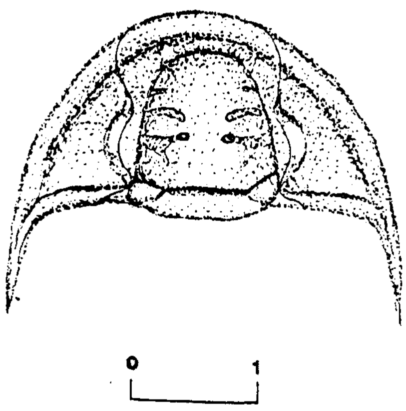
Diagnosis. See Osmólska 1970, p. 156.

Genus **Hedstroemia** Pribyl & Vanek, 1978

Type species. By original designation; *Proetus delicatus* Hedström, 1923; from the Halla Formation (Wenlock, *nassa* Biozone), Horsne Canal, Gotland, Sweden; see Pribyl & Vanek 1978, p. 163, pl. 1, figs 1-5.

Diagnosis. See Owens 1982, p. 138.

Discussion. Owens (*ibid.*) has given reasons for placing *Hedstroemia* in the Crassiproetinae with which I agree.



Text-figure 26. Reconstruction of the cephalon of *Hedstroemia simpulum* sp. nov. (based on PMO 110.756, Pl. 25, fig. 5 & PMO 110.766, free cheek, Pl. 25, fig. 10).

Hedstroemia simpulum sp. nov. Pl. 25, figs 2-8, 10-12, 14, 15; Text-figs 26, 27.

(*Name*. Latin "simpulum", a small ladle; referring to the shape of the glabella).

v. *1982 Hedstroemia?* sp. cf. *delicatus*, (Hedström 1923); Owens, p. 132.

Holotype. PMO 54838 (cranidium), locality 3; Pl. 25, fig. 11.

Paratypes. Cranidia, PMO 54845, -849, locality 3, PMO 41905, -915, PMO 43612, PMO 70610, PMO 93816, localities 22 & 32, PMO 110.756-761, -766, locality 31, PMO 110.777, locality 33, PMO 43111, locality 36, Ar31482, Lower Visby Formation (*centrifugus* Biozone), Norderstrand, Gotland, Sweden; free cheeks, PMO 54844, locality 3, PMO 110.766-775, locality 31, PMO 41917, locality 32; pygidia, PMO 54837, -848, -850, locality 3, PMO 41598, -908, PMO 43239, -246, -414, -577, -611, -636, PMO 93820, -826, -828, localities 22 & 32, PMO 42954, -999, PMO 43954, locality 36, Ar21439, Ar29438, -440, Ar31482, Lower Visby Formation (*centrifugus* Biozone), Norderstrand, Gotland, Sweden.

Stratigraphic range. Solvik and Rytteråker Formations, (Kiær's étages 6c to 7b), Oslo, Asker and Holmestrand districts, Aeronian to Telychian (*triangulatus* to *crispus* Biozones). Lower Visby Formation (Telychian, *crenulata* Biozone), Norderstrand, Gotland, Sweden.

Diagnosis. A species of *Hedstroemia* with short preglabellar field (sag.); anterior border long (sag.) and flat, lengthening slightly medially; free cheek with pronounced eye socle; genal spine long with deep furrow along length. Pygidium with eight to ten axial rings and a terminal piece; six to seven pleural ribs lacking pleural furrows; interpleural furrows not extending to margin. Dorsal exoskeleton with sculpture of fine granulation on glabella and five or six terrace ridges parallel and close to lateral margin.

Description. Glabella parallel sided as wide (tr.) as long (sag.), weakly inflated. Three pairs of very weakly incised furrows; 1p opposite anterior end of palpebral lobe, gently curving and extending one-third glabella width (tr.), terminating opposite posterior corner of palpebral lobe. 2p opposite γ deflected posteriorly at about 10° to a transverse line, extending one-third glabella width (tr.) and slightly expanded at adaxial end. 3p parallel to and two-thirds length of 2p. Occipital furrow well-incised, broad, shallowing and deflected anteriorly around occipital lobes. Occipital ring narrower than anterior border (sag.) constricted to half sagittal width behind occipital lobe, slightly wider than glabella. Occipital lobes of low convexity, widening abaxially, defined posteriorly by a shallow furrow. Preglabellar area one-quarter length (sag.) of anterior border and lacking independent convexity. Section β-γ of facial suture diverging anteriorly from y at 30-40°. ϵ and ζ independent angles the former being situated opposite halfway point of occipital lobe Stretch ϵ-ζ close to and parallel to axial furrow. Palpebral lobe about half length of glabella lacking independent convexity. Field of free cheek with eye inclined at 35-40° to horizontal. Posterior border furrow narrow and deep both sides sloping at a similar angle. Posterior border convex, parallel sided. Lateral border furrow well defined shallower than posterior. Lateral border weakly, convex posteriorly flattening towards anterior.

Pygidial axis convex narrowing to half its anterior width by last axial ring. Axial rings better defined on internal than external mould, of constant width (sag & exsag.).

Dimensions. See Appendix 14.

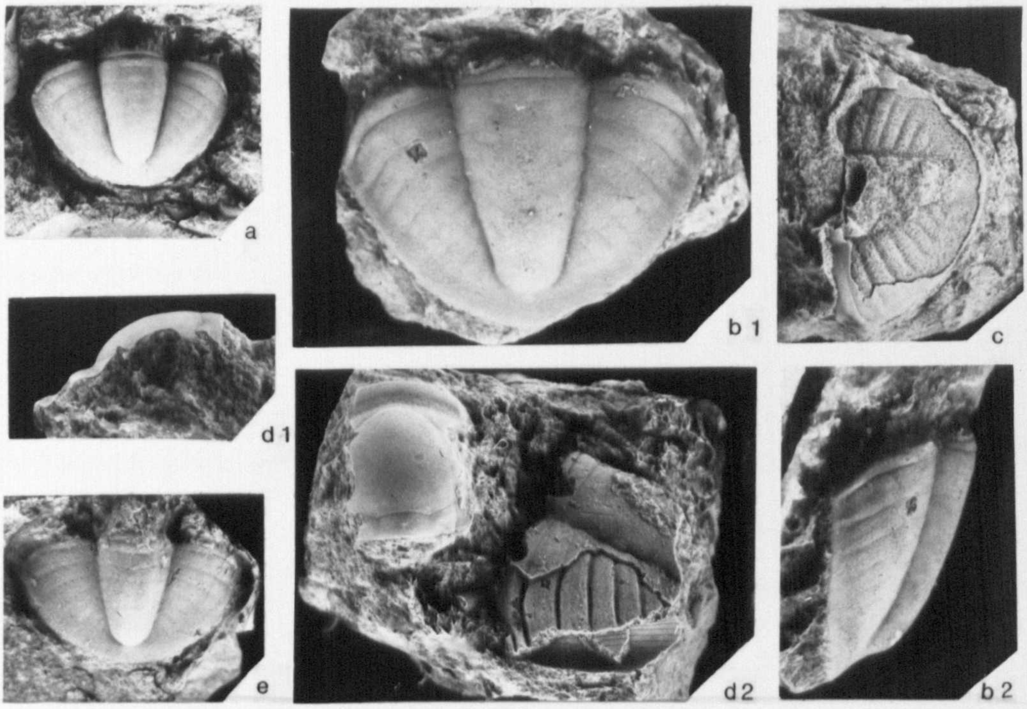
Discussion. This species is placed in *Hedstroemia* on the gross morphological similarity of the glabella and pygidium to those of the type species *Hedstroemia delicatus* (Hedström, 1923; see Přibyl & Vaněk 1978, pl. 1, figs 1-5). The Norwegian species differs from *H. delicatus* in possessing a 1p that is narrower and less oval in outline, a larger 3p, narrower preglabellar area, wider anterior border and shorter pygidial pleural furrows. *H. delicatus* also possesses a series of pits on the pygidial axial furrows and pleural furrows not seen in *H. simpulum*.

Another species which belongs in *Hedstroemia* is *Proetus planedorsatus* Schmidt, 1894 (p. 49, pl. 4, figs 21, 22) from the Juuru Stage (G1, =Rhuddanian, *persculptus* to *vesiculosus* Biozones) of the East Baltic. The cranidium of this species very closely resembles that of *H. simpulum* differing in possessing a posteriorly less well-defined occipital lobe, a glabella which tapers more anteriorly and a narrower anterior border bearing terrace ridges. The pygidium of *H. planedorsatus* differs from that of the Norwegian species in possessing a series of pits on the pygidial axis which is broader anteriorly, eight or nine pleural ribs and better defined pleural furrows.

Owens 1982 (p. 138) believed there to possibly be two species belonging to this genus represented in the collection available to him. From an examination of that material and specimens collected by myself I am unable to differentiate two species from southern Norway.

This species is also known from the Lower Visby Formation (Telychian, *crenulata* Biozone) of Gotland, Sweden (Text-fig. 27) and therefore from a similar stratigraphic level to its occurrence in Norway.

Text-fig. 27



Text-fig. 27

Paratype specimens of *Hedstroemia simpulum* sp. nov. from the Lower Visby Formation of Norderstrand, Visby Parish, Gotland, Sweden:

a	Pygidium, dorsal view, Ar29440, x3.
b1,2	Pygidium, dorsal & lateral views, Ar31481, x3.
c	Pygidium, partially exfoliated, dorsal view, Ar29438, x3.
d1,2	Cranidium, lateral & dorsal views, Ar31482, x3. (& unnumbered pygidium, partially exfoliated).
e	Pygidium, dorsal view, Ar21439, x3.

Genus **Cyphoproetus** Kegel, 1927

Type species. Subsequently designated by Pribyl 1946, p. 15; *Cyphaspis depressa* Barrande, 1846a, p. 60; from Liteň Formation (Wenlock Series), Listice near Beroun, Prague district, Czechoslovakia.

Diagnosis. See Owens 1981, p. 136.

Cyphoproetus externus (Reed, 1935). Pl. 22, figs 5, 8, 9, 12, 13, 15; Pl. 23, figs 1, 4, 5, 7, 11; Text-figs 28, 44, 46.

1935 *Proetus (Cyphoproetus) externus*, Reed, p. 42, pl. 2, fig. 15.

1982 *Cyphoproetus externus* (Reed, 1935); Lane, p. 18, pl. 3, figs 4-6, 8, 10, 14; pl. 4, figs 5, 10, 11, 15, 16.

v *1982* *Cyphoproetus externus* (Reed, 1935); Owens, p. 136. [includes full synonymy].

1982 *Cyphoproetus externus* (Reed, 1935); Howells, p. 17, pl. 5, figs 6, 8, 9, 11-13.

Holotype. By monotypy; HM A1032; internal mould cranidium; figured Reed, 1935, pl. 2, fig. 15; from Saugh Hill Sandstones (Llandovery Series, Aeronian Stage), Newlands, Girvan, Scotland; figured Owens, 1973, pl. 6, fig. 6.

Material from Norway. Cranidia, PMO 110.465, -468, locality 31, PMO 52509, -576, PMO 88684, -689, -759, -824, -826, PMO 88841, -916, -917, -920, -972, -974, -982, -983, 88987-989, -996, PMO 89010, PMO 93801, 93809-11, -818, -819, -822, PMO 109.466, -469, -470, -481, -484, -487, -489, PMO 110.349-352, 110.354-400, -404, -407, -435, 110.465-467, -476, -496, locality 33; free cheeks, PMO 110.472-474, locality 12, PMO 110.469-471, locality 31, PMO 88682, -743, -746, -750, -768, -831, -962, -997, PMO 93812, -815, PMO 109.465-466, -472, -486, -488, -491, -538, PMO 110.353, -402, -403, -405, -406, 110.408-434, 110.436-440, -446, -448, -477, -482, -489, -499, locality 33; hypostomes, PMO 88751, -860, -984, PMO 109.483, PMO 110.462, -463, -475, -479, -594; thoracic segment 110.464, locality 33; pygidia, PMO 52762, -770, -772, -774, PMO 88686, -687, -753, -778, -832, -855, locality 31, PMO 89007, -011, PMO 93814, -820, -821, PMO 109.467, -471, -473, -475, -476, -484, -485, 487, -488, -490, -534, PMO 110.401, 110.442-445, -447, 110.449-461, -478, locality 33.

Stratigraphic range. Solvik & Saelabonn Formations (Kiær's étages 6b & 6c), Asker and Ringerike Districts, Rhuddanian & Aeronian (*atavus* to *convolutus* Biozones). Saugh Hill Sandstone (Llandovery, Aeronian), Newlands, Girvan area, Scotland. Kap Schuchert Formation (Aeronian, *triangulatus* Biozone), Washington Land, North Greenland.

Diagnosis. See Owens 1982, p. 136.

Description. See Owens 1973, p. 32.

Hypostome (described here for the first time) half as wide (tr.) across anterior wings as long (sag.). Median body highly convex, elongate, anterior slope almost vertical, posteriorly sloping gently to margin. Anterior lobe of median body oval. Posterior lobe of lower convexity than anterior rounded or bluntly pointed posteriorly. Median furrow defined for abaxial quarter of width directed posteriorly at 45°. Anterior wing broad, triangular, strongly downwardly flexed close to median body, less so abaxially. Posterior wing smaller and rounded. Anterior border furrow deep, broad. Lateral border furrow deep, narrow, shallowing posteriorly and merging with poorly-defined posterior border furrow. Median notch shallow, gently curved, situated opposite abaxial end of median furrow. Lateral border narrow. Posterior border narrow and flat, margin gently curved towards anterior. Ventral surface with sculpture of exsagittally arranged terrace ridges on anterior wings, lateral border and abaxial part of median body becoming transverse posteriorly and medially. Posterior lobe of median body without sculpture.

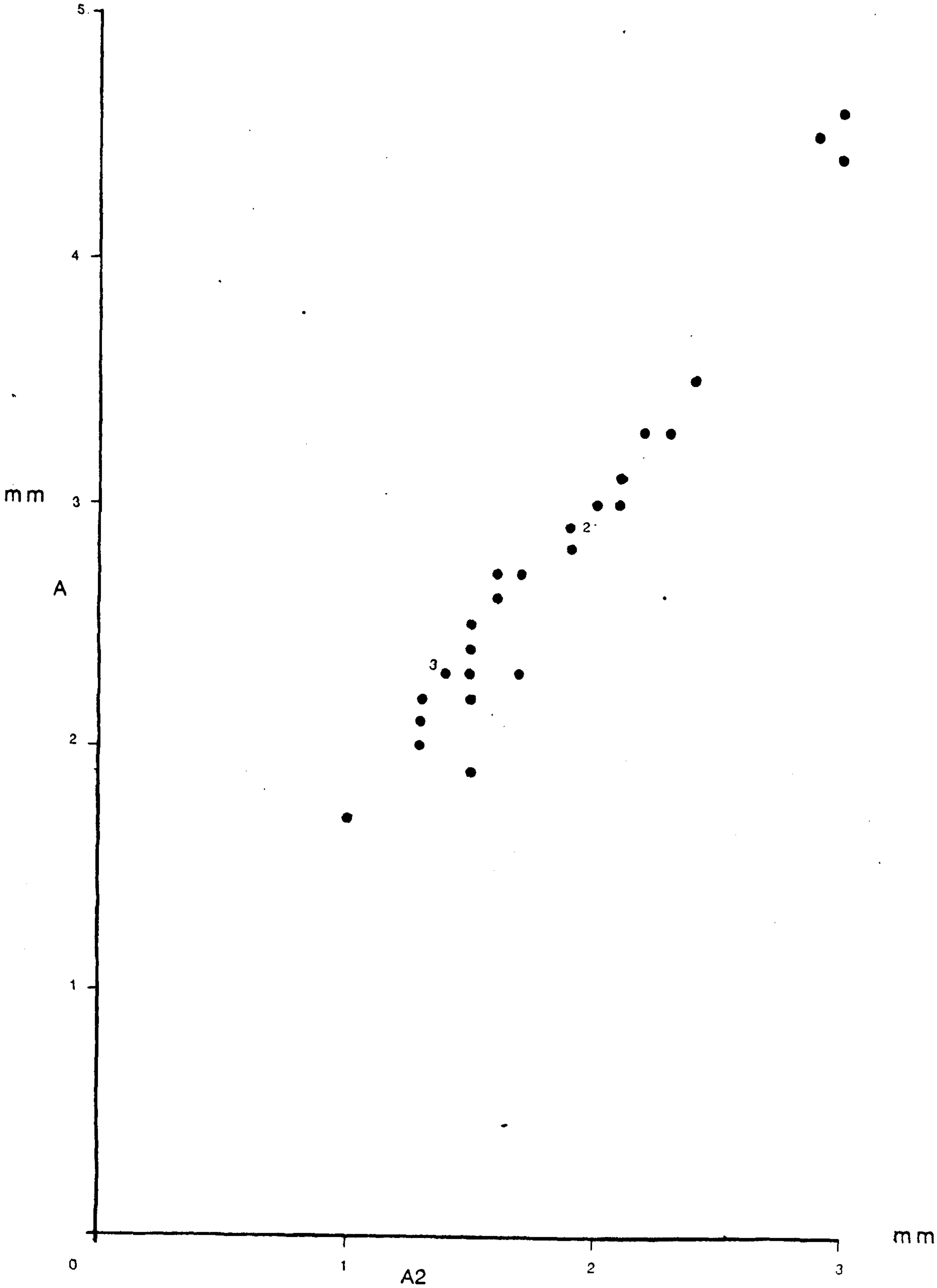
Dimensions. See Appendix 8 & Text-figure 26.

Discussion. *C. externus* is a very distinctive species which, in addition to the type area and Norway, has also been collected from a similar horizon of the Kap Schuchert Formation (Aeronian, *triangulatus* Biozone) of Washington Land, North Greenland (see Lane 1979, p. 18, pl. 3, figs 4-6, 8, 10, 11, 15, 16).

There is little intraspecific variation amongst specimens of *C. externus* from the Oslo Region. A plot of glabellar length (A1) against cranidial length (A2) (Text-fig. 26) showing a close grouping of points.

The type species of *Cyphoproetus*, *C. depressus* (Barrande, 1846a; see Owens 1973, p. 32, pl. 6, figs 6-8), differs from *C. externus* in possessing a granular surface sculpture, shorter (sag. & exsag.) preglabellar field and better defined occipital lobes.

C. externus is differentiated from *C. strabismus* Owens, 1973 (p. 35, pl. 6, figs 13-15; pl. 7, figs 1, 2; text-fig. 5) from Trewern Brook Mudstone Formation (Homerian, *lundgreni* Biozone), Long Mountain, Powys, Wales, by its less well-defined occipital lobe, narrower preglabellar field and four (as opposed to eight) pygidial axial rings. In addition the Welsh species lacks the furrow along the genal spine typical of *C. externus*.



Text-figure 28. Variation of glabellar length (A2) to cranidial length (A) in specimens of *Cyphoproetus externus* (Reed, 1935) from the Solvik Formation of Spirodden Asker.

Family Aulacopleuridae Angelin, 1854

Diagnosis. See Thomas & Owens (1978, p. 55).

Discussion. Thomas & Owens (1978, p. 67) have given reasons for considering the Aulacopleuridae and Otarionidae to be synonymous, with which I agree.

Subfamily Aulacopleurinae Angelin, 1854

Genus **Harpidella** McCoy, 1849

Diagnosis. See Thomas & Owens 1978, p. 62.

Type species. By monotypy; *Harpes? megalops* McCoy, 1846, p. 54, pl. 4, fig 5; from Upper Llandovery, Galway, Eire.

Diagnosis. See Owens 1982, p. 137

Subgenus **Harpidella (Harpidella)** McCoy, 1849

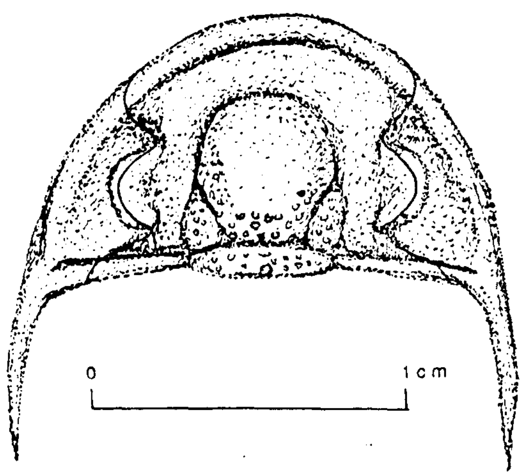
Type species. As for genus.

Diagnosis. Harpidella with no median spine on anterior cephalic border. Rostral plate triangular.

Harpidella (Harpidella) chermasera sp. nov. Pl. 23, figs 2, 3, 9, 12, 13, 18; Text-figs 29, 31, 44.

(*Name.* Greek "cherm"; pebble and "aseros"; irksome).

v. *1982 Harpidella (Harpidella)* aff. *newlandensis*, Owens, p. 137.



Text-figure 29. Reconstruction of the cephalon of *Harpidella (Harpidella) chermasera* sp. nov. (based on PMO 110.508, holotype cranidium, Pl. 23, fig. 2 & PMO 110.491, free cheek, Pl. 23, fig. 18).

Holotype. PMO 88904 (cranidium), locality 33; Pl. 23, fig. 2.

Paratypes. Cranidia, PMO 52540, -545, -546, -560, PMO 88756, -786, -788, -856, -878, -886, PMO 88900, -905, -915, -918, -964, -965, PMO 88973, -995, PMO 91368, -375, PMO 110.480, -483, -492, -494, -495, 110.501-504, 110.509-511, -518, -522, -529, -531, 110.538-540, -788; free cheeks, PMO 110.491, -505-508, -519, -530, -532, -541, -542; hypostome PMO 110.682; all specimens are from locality 33.

Stratigraphic range. Solvik Formation (Kiær's êtages 6b & 6c), Asker district, Rhuddanian to Aeronian (*atavus* to *convolutus* Biozones).

Diagnosis. A species of *Harpidella (Harpidella)* with glabella just under half length of cranidium (sag.); anterior border as long sagittally as exsagittally, slightly upturned; 1L slightly less than half length of glabella; occipital ring two-fifths as long (sag.) as wide (tr.); posterior border of free cheek more convex than lateral. Sculpture of coarse granulation restricted to posterior of glabella and occipital ring; a few smaller very widely spaced granules on field of free cheek.

Description. Cranidium as wide (tr. across palpebral lobes) as long (sag.). Median lobe of glabella expanding slightly forwards and gently rounded anteriorly. 1L as wide (tr.) as long (exsag.) triangular. 1S deep, isolating 1L, widening and shallowing greatly opposite posterolateral corner of glabella. Occipital ring convex (sag. & tr.) median granule only slightly larger than other granulation. Occipital furrow shallow and wide. Axial furrow similar but narrower. Preglabellar furrow wide, well-incised not as deep as 1S. Preglabellar area convex, one-eighth cranidial length (sag.). Anterior border convex, same length (sag.) as preglabellar area. Palpebral lobe approximately one-quarter sagittal length of cranidium, extending from midway between 1S and preglabellar furrow to midway between 1S and occipital furrow. Free cheek with weakly-convex lateral border. Lateral border furrow broad, shallow, deepening anteriorly. Posterior border furrow very deeply incised. Lateral margin incurved at base of genal spine. Genal spine as long as rest of free cheek and lacking median furrow. Field of free cheek gently convex, steepening beneath eye. Lateral border with two or three very weakly defined terrace ridges parallel, and very close, to margin.

Hypostome two-thirds as wide (tr.) as long (sag.). Middle body gently convex, divided into large, oval, anterior and smaller, crescentic, posterior lobes by well-incised median furrow which extends across entire width. Anterior wing large, slightly dorsally flexed. Lateral border broader than anterior. Lateral border furrow well incised. Posterior wing small, rounded. Posterior border narrow, poorly defined.

Dimensions. See Appendix 9 & Text-fig. 29.

Discussion. This species most closely resembles *H. (H.) newlandensis* (Begg, 1950; see Howells 1982, p. 22, pl. 6, figs 12-14) from the Newlands Formation (Aeronian, *triangulatus* to *argenteus* Biozones) of the Craighead Inlier, Girvan, Scotland and therefore is of similar stratigraphic age. The Norwegian species possesses a glabella which is less angular anteriorly, a longer (sag.) occipital ring and shallower preglabellar furrow. Comparison is hampered by the difference in preservation between the Scottish and Norwegian material (internal moulds in sandstone and external moulds in fine-grained limestone respectively). Howells 1982 (pl. 5, fig. 11) figured a free cheek from the type locality of *H. (H.) newlandensis* which she labelled as *Cyphoproetus externus*. The genal spine of this specimen is deflected outwards and lacks a median furrow and I believe it to represent a free cheek of *H. (H.) newlandensis* (Howells did not describe a free cheek for this species). The free cheek of the Scottish species therefore possesses a better defined lateral border and shorter genal spine than *H. (H.) chermasera*.

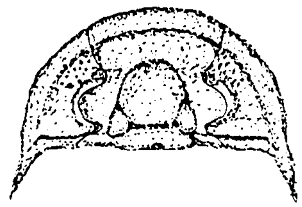
Harpidella (Harpidella?) helenae Lane, 1979 (p. 23, pl. 4, figs 7-9, 12-14, 17) from the Llandovery (Aeronian, *triangulatus* & *magnus* biozones or a little older) of Washington Land, North Greenland, differs from *H. (H.) chermasera* in possessing a shorter (sag.) glabella, a deeper preglabellar furrow and a granulation which is coarser and extends onto the preglabellar area.

H. (H.) christyi (Hall, 1882, p. 333, pl. 34, figs 5-7) from the Waldron Shale (Wenlock) of Waldron, Indiana, U.S.A. differs from *H. (H.) chermasera* in possessing a broader glabella anteriorly, a more posteriorly placed palpebral lobe and a longer genal spine.

Hypostomes are known for only a few species of *Harpidella (Harpidella)*. The hypostome of *H. (H.) aitholix* Thomas, 1978 (p. 32, pl. 8, figs 1-10) from the Coalbrookdale Formation (Homerian, *nassa* Biozone), Wenlock Edge, Shropshire, possesses a more deeply incised lateral border furrow than the Norwegian specimen but is otherwise indistinguishable, The cranidium of the British species possesses a granulation over more of the dorsal surface than does that of the Norwegian and a median glabella lobe which is more angular anteriorly and broader posteriorly.

The hypostome of *H. (H.) plautum* (Whittington & Campbell, 1967, p. 463, pl. 7, figs 1-9, 11-15, 17-19, 23-15; text-fig. 6b) from the Hardwood Mountain Formation (near the Wenlock:Ludlow boundary) of Maine, U.S.A., possesses a broader, less convex, middle body and less convex lateral border than that of *H. (H.) chermasera*. The cranidium of the American species has a strong granulation over most of the dorsal surface and a more angular median lobe than the Norwegian species.

Harpidella (Harpidella) sp. Pl. 23, figs 6, 15; Text-figs 30, 31, 44.



Text-figure 30. Reconstruction of *Harpidella (Harpidella)* sp. (based on PMO 112.878, cranidium, Pl. 23, fig. 15 & PMO 112.922, free cheek, Pl. 23, fig. 6).

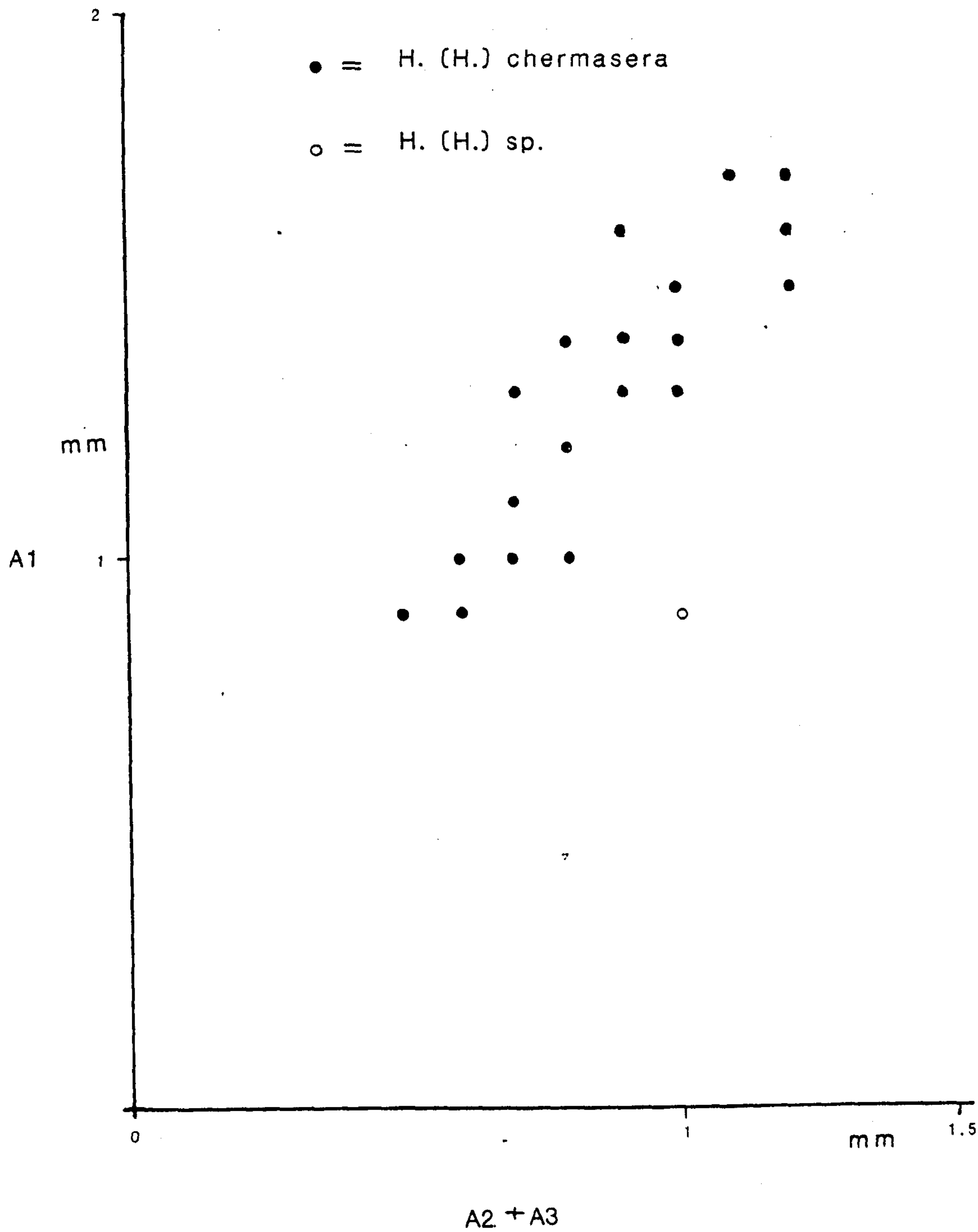
Material. Cranidium, PMO 112.878; free cheek, PMO 112.922; locality 28.

Stratigraphic range. Solvik Formation (Kiær's étage 6a), Oslo district, Rhuddanian (*persculptus* to *atavus* Biozones).

Description. Similar in overall morphology to *H. (H.) chermasera,* but with glabella one-third cranidial length (sag.), broadest just in front of 1L, narrows slightly and bluntly-rounded anteriorly. 1L triangular of very low convexity. Preglabellar area almost as long as glabella. Dorsal surface without sculpture. Lateral margin of free cheek becomes poorly defined posteriorly. Field of free cheek with distinct pitting.

Dimensions. See Appendix 10 & Text-fig. 29.

Discussion. The species most resembling the Norwegian material is *H. (H.) thomasi* Clarkson & Howells, 1981 (p. 515, pl. 79, figs 1, 2, 16) from the Upper Reservoir Formation (?mid Telychian), of the Pentland Hills, Scotland. The Scottish species possesses a relatively



Text-figure 31. Comparison of *Harpidella (Harpidella) chermasera* sp. nov. and *Harpidella (Harpidella)* sp. showing sagittal length of anterior border + preglabellar area (A2+A3) against sagittal length of glabella (A1).

shorter, broader median glabellar lobe, better incised 1S and a lateral border-furrow that is better incised than the Norwegian species.

This material represents the earliest occurring species of *Harpidella (Harpidella)* from southern Norway and probably represents a new species. The locality from which it was collected however is no longer accessible and the quantity of available material is small. Subsequently I have declined to erect a new species until more specimens can been identified.

Family Brachymetopidae Prantl & Pribyl, 1951

Diagnosis. See Campbell 1977, p. 18.

Discussion. See Thomas 1978, p. 46.

Subfamily Warburgellinae Owens, 1973

Diagnosis. See Thomas 1978, p. 49.

Discussion. See Thomas 1978, p. 49.

Genus **Warburgella** Reed, 1931

(=*Podolites* Balashova, 1968; *?Waigatchella* Maksimova, 1970.

fide Owens 1973, p. 65).

Type species. By original designation *Asaphus stokesii* Murchison, 1839, from Much Wenlock Limestone Formation (Wenlock) of Dudley, West Midlands, U.K.

Diagnosis. See Owens 1982, p. 137.

Subgenus **Warburgella (Warburgella)** Reed, 1931

Type species. As for genus.

Diagnosis. See Owens 1982, p. 137.

	Anterior border furrow	2P & 3P	Preglabellar ridge	Pygidial holcos	No.pygidial axial rings
W. (W.) baltica	Broad	Well defined	Weak	Strong	7-8
W. (W.) brutoni	Broad	Poorly defined	Weak	Weak	7
W. (W.) gongrus	Narrow	V. well defined	Strong	Weak	7?

Text-figure 32. Summary of dia ostic characters of *Warburgella* species

Warburgella (Warburgella) baltica Alberti, 1963. Pl. 23, figs 8, 10, 14, 16, 17, 19; Pl. 24, figs, 2, 3, 5, 6, 8, 11-14, 18, 19; Text-figs 32-34, 44, 46.

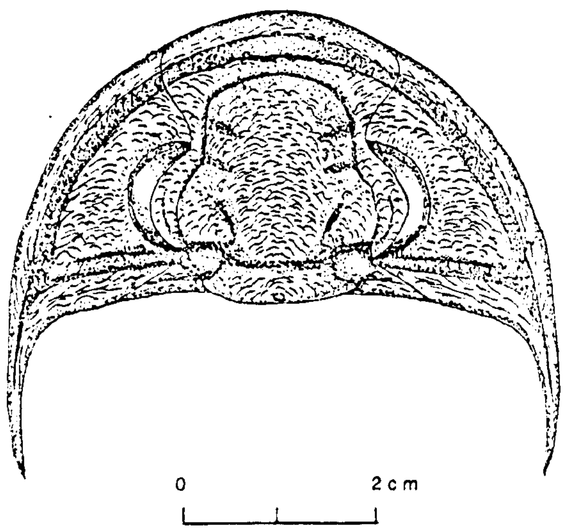
v* 1885 *Phaetonides rugulosus*, Lindström, p. 75, pl. 16, fig. 13.

1963 Warburgella baltica, Alberti, p. 155.

1973 *Warburgella (Warburgella) baltica* Alberti; Owens, p. 69. pl. 14, fig. 3.

. 1979 *Warburgella (W.) estonica*, Männil, p. 103, pl. 1, figs 6-13; Pl. 2, figs 1-3, 8.

v *1982 Warburgella (Warburgella) baltica* Alberti; Owens (*pars*), p. 137.



Text-figure 33. Reconstruction of the cephalon of *Warburgella (Warburgella) baltica* Alberti, 1963 (based on PMO 110.676, cranidium, Pl. 24, fig. 2 & PMO 110.639, Pl. 24, fig. 13).

Holotype. By monotypy; RM Ar28751, cranidium, from the Visby Formation (Telychian to Sheinwoodian, *crenulata* to *murchisoni* Biozones) of Lummelunde, Gotland, Sweden; figured Owens 1973, pl. 14, fig. 3. For a discussion of the species name *baltica* and the holotype of this species see Owens (1973, p. 69).

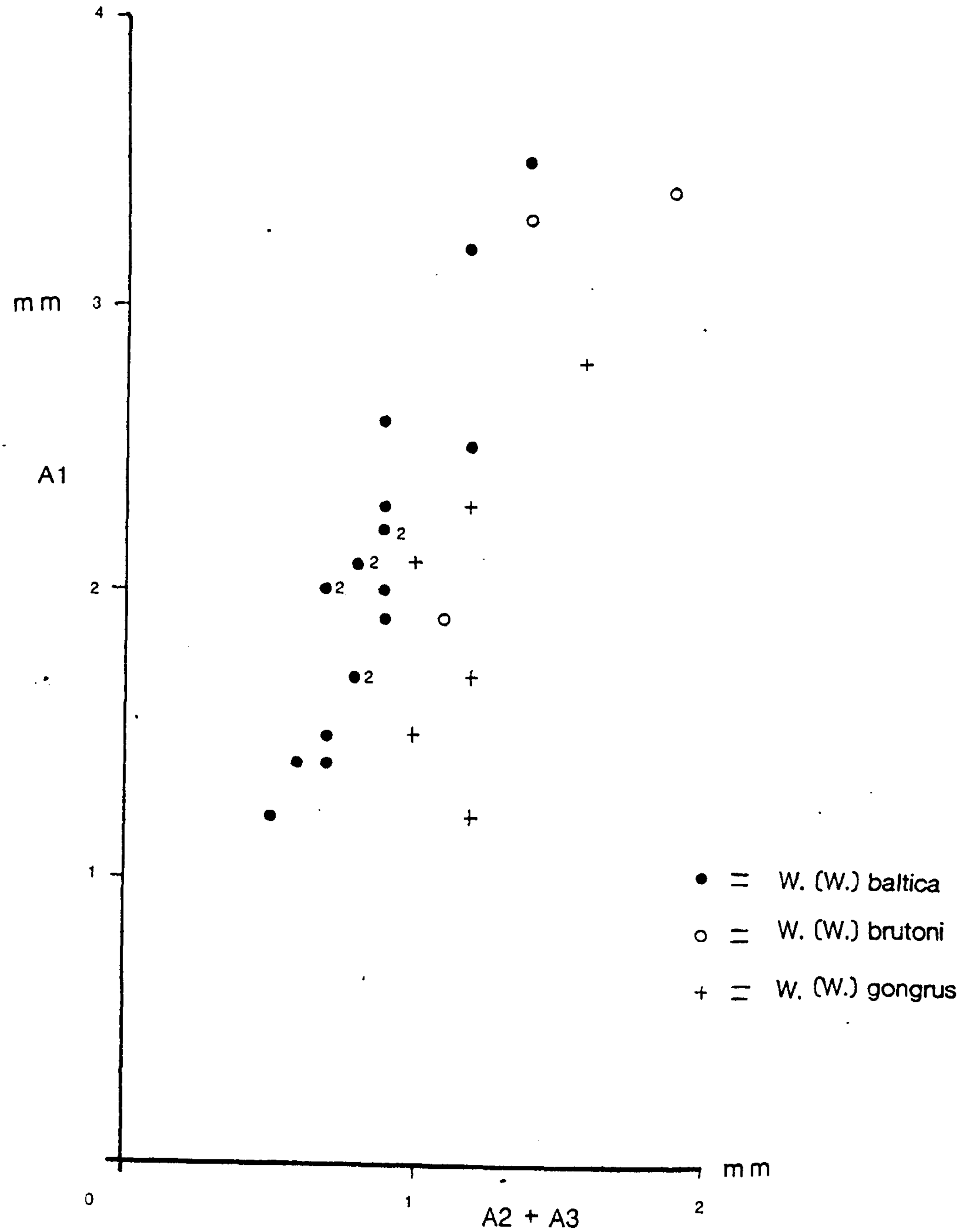
Material from Norway. Cranidia, PMO 5034, locality 16, PMO 21461, -462, PMO S3734, PMO 5016, PMO 110.544-604, 110.673-678, -741, locality 19; free cheeks, PMO 5011, -012, PMO 49970, PMO 110.605-672, 110.684-687, -782; hypostomes, PMO 110.681-684, -689, -742, locality 19; pygidia PMO 48654, locality 16, PMO 49869, -873, -979, PMO 50150, -183, -234, PMO 89283, PMO 110.680, 110.688-740, -744, -745, locality 19.

Stratigraphic range. Steinsfjorden Formation (Kiær's êtages 9a to 9g), Holmestrand district, Sheinwoodian to Homerian (*rigidus* to *nassa* Biozones). Visby Formation (Telychian to Sheinwoodian, *crenulata* to *murchisoni* Biozones) of Gotland, Sweden. Upper Wenlock, Jaagarahau Stage (J_2) (*linnarssoni* & *ellesae* Biozones) of Saarema Island, East Baltic.

Diagnosis. A species of *Warburgella* with well defined tropidium; preglabellar ridge very weakly defined or absent; A2 and A3 of equal length; occipital lobe large, circumscribed; furrow defining abaxial margin of occipital lobe confluent with 1S. Pygidium with seven to eight axial rings plus a terminal piece; weak postaxial ridge; holcos wide and flat; pleural furrows defined only abaxially. Dorsal exoskeleton with sculpture of fine continuous terrace ridges.

Description. Cranidium four-fifths as wide (tr.) as long (sag.). Glabella as wide (tr.) as long (sag.), two-thirds cranidial length, convex, bluntly rounded anteriorly. Three pairs of lateral cranidial furrows; 1S narrow and very deep opposite mid point of palpebral lobe, shallower and broader anteriorly and posteriorly reaching occipital and axial furrows. Abaxial end of 2S opposite γ, which is close to axial furrow, directed posteriorly at 20° to a transverse line, extending to opposite posterior end of 1S. 3S directed posteriorly at 5° to a transverse line less well-incised than and two-thirds length of 2S. Occipital furrow transverse medially deflected anteriorly around occipital lobe. Occipital ring one-fifth length of glabella, median granule close to posterior margin. Preglabellar area as long (sag.) as occipital ring. A2 and A3 of equal length (sag.). Section β-γ of facial suture diverging anteriorly at 10° to an exsagittal line through γ. Posterior branch of facial suture with ε and ζ as a single angle. Palpebral lobe half length of glabella (sag.), sloping steeply upwards from axial furrow. Field of free cheek flat with steeply-sloping tropidium and broad lateral border furrow. Lateral border highly convex. Posterior border furrow of similar form to lateral. Posterior border longer (exsag.) and less convex than the lateral. Genal spine long and slender, gently divergent; median furrow extending half its length.

Hypostome half as wide (tr.) as long (sag.). Median body highly convex, separated from anterior margin by broad, flat anterior border. Median furrow broad, shallow, directed posteriorly at 20° to a transverse line extending two-thirds width of median body. Anterior wing large, slightly upwardly flexed. Lateral border convex, narrow. Lateral border furrow deeply incised at mid length, shallowing anteriorly and posteriorly. Anterior and posterior border furrows very weakly defined. Posterior wing broad and flat. Posterior margin with a pair of triangular processes. Ventral surface with sculpture of terrace ridges.



Text-figure 34. Comparison of *Warburgella (Warburgella) baltica* Alberti, 1963, *Warburgella (Warburgella) brutoni* sp. nov. and *Warburgella (Warburgella) gongrus* sp. nov. showing sagittal length of anterior border + preglabellar area (A2 + A3) against sagittal length of glabella (A1).

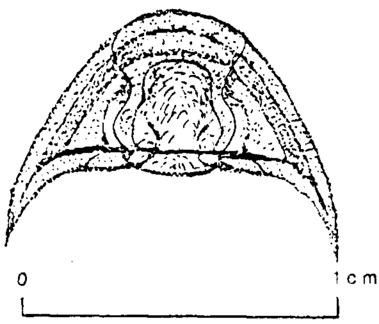
Pygidium twice as wide (tr.) as long (sag.). Axis extending four-fifths pygidial length (sag.) and less than one-third width (tr.) at anterior margin. Axial rings of constant length (sag. & exsag.). Five pairs of pleural ribs expanding slightly abaxially extending half length of pleural ribs. Pleural and interpleural furrows of similar depth and not crossing holcos.

Dimensions. See Appendix 11 & Text-fig. 34.

Discussion. I believe *W. (W.) estonica* Männil, 1979 from the Upper Wenlock, Jaagarahau Stage (J_2) (*linnarssoni* to *ellesae* Biozones) of Saarema Island, East Baltic to be a junio r subjective synonym of *W. (W.) baltica.* The East Baltic specimens figured by Männil are slightly less convex and possess slightly smaller occipital lobes than the Norwegian material but in view of the degree of variation observed between Oslo specimens I do not consider these differences significant.

W. (W.) rugulosa (Alth, 1874) from the early Devonian of Podolia, differs from *W. (W.) baltica* in possessing a very strongly developed preglabellar ridge, wider preglabellar furrow, a narrower and more elongate glabella, a pygidium with up to twelve axial rings and a less pronounced holcos.

Owens (1973, p. 69) stated that both *W. (W.) stokesii* (Murchison, 1839; see Owens 1973, p. 73, pl. 13 figs 5-13; pl. 14, fig. 2) from the topmost Coalbrookdale Formation and the Much Wenlock Limestone Formation, Homerian (*lundgreni* & *ludensis* Biozones) of Dudley, West Midlands, U.K. and specimens figured by Alberti (1963, p. 150, pl. 15, figs 10, 11) from Wenlock erratics from Hiddensee Island, north of Straslund, D.D.R. which he assigned to *W. (W.) stokesii,* differ from the type of *W. (W.) baltica* in possessing a transverse preglabellar ridge. An examination of material from Gotland (including the holotype) shows that *W. (W.) baltica* possesses a very weakly defined preglabellar ridge which is often not visible until the specimen has been prepared for photography and which is of variable development (compare Pl. 23, fig. 16 & Pl. 24, fig. 2). *W. (W.) baltica* differs from *W. (W.) stokesii* in possessing a 1S which is less deeply incised anteriorly and posteriorly, a longer preglabellar field and a glabella that is more rounded anteriorly. The two sets of material are from a similar stratigraphic horizon.



Text-figure 35. Reconstruction of the cephalon of *Warburgella (Warburgella) brutoni* sp. nov. (based on PMO 89294, Pl. 24, fig. 17 & PMO 44415, Pl. 24, fig. 4).

P.T.O.

Warburgella (Warburgella) brutoni sp. nov. Pl. 24, figs 1, 4, 7, 9, 10, 16, 17, 20; Text-figs 32, 34, 35, 44.

(Name; in recognition of the help given to the author by Dr. D. L. Bruton of the Paleontologisk Museum, Oslo).

v. 1982 *Warburgella (Warburgella)* sp. nov. (Howells 1982); Owens, p. 138.

Holotype. PMO 89288 (cranidium), locality 35; Pl. 24, fig. 16.

Paratypes. Cranidia, PMO 44387, -707, PMO 89291, -294, -296, -304, 89306-310; free cheek, PMO 44415; pygidia, PMO 44651, -652, PMO 89317; all specimens are from locality 35.

Stratigraphic range. Malmøya Formation (Kiær's êtage 8c), Asker District (Sheinwoodian, *centrifugus* & *murchisoni* Biozones).

Diagnosis. A species of *Warburgella (Warburgella)* with cranidium lacking preglabellar ridge; tropidium well-defined; A2+A3 as long as A1; anterior and lateral border furrows very broad and shallow, deepening slightly posteriorly, making field of free cheek very narrow. Pygidial axis with at least seven axial rings and a terminal piece; pleural areas with at least six pairs of pleural ribs; holcos very weakly defined.

Description. Glabella as wide (tr.) as long (sag.), half cranidial length, weakly convex and bluntly rounded anteriorly. Three pairs of cranidial furrows; 1S poorly defined anteriorly, well-incised opposite mid point of palpebral lobe, becoming shallower posteriorly. 2p very weakly defined, abaxial end opposite γ, which is close to axial furrow, directed posteriorly at 30° to a transverse line and extending to opposite posterior end of 1S. 3S situated close to 2S, very poorly-defined, directed posteriorly at 5° to a transverse line. Occipital furrow transverse in front of occipital lobe. Occipital ring one-fifth length of glabella, sagittal granule close to posterior margin. A2 twice as long (sag.) as A3. Anterior border of constant length (sag. & exsag.). Section β-γ of facial suture diverging anteriorly at 10° to an exsagittal line through γ. Posterior branch of facial suture with ϵ and ζ as a single angle. Palpebral lobe half length of glabella (sag.) of low independent convexity. Genal spine long with well-defined median groove. Posterior border of free cheek highly convex, lateral border of low convexity.

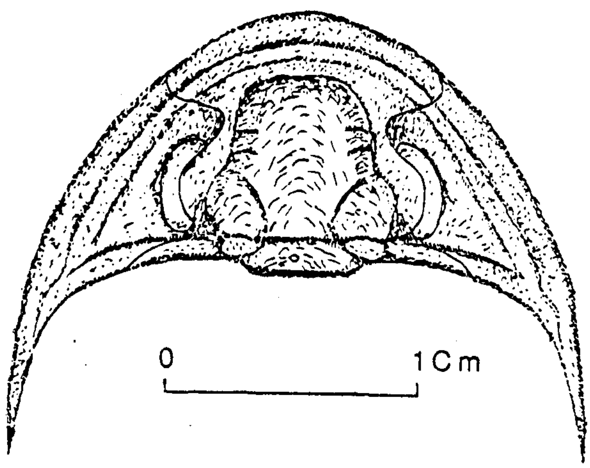
Pygidium as long (sag.) as wide (tr.). Axis extending three-quarters of length (sag.). Axial rings of constant length (sag.) becoming less well-defined posteriorly, last two rings defined only medially. Pleural ribs expanding abaxially. Pleural furrows less well-incised than interpleural, neither furrow crosses holcos.

Dimensions of holotype and paratypes. See Appendix 11 & Text-fig. 34.

Discussion. The chief diagnostic character of this species is the extremely wide and shallow lateral and anterior cephalic border furrows which reduce the field of the free cheek to a thin strip beneath the eye and define a very narrow preglabellar area (see Pl. 24, figs 4, 20); this serves to distinguish this species from all other known species of *Warburgella (Warburgella)*.

Owens (1982, p. 138) referred these specimens to a then undescribed species subsequently described by Howells (1982, p. 21, pl. 6, figs 2, 5-7, 10) as *Warburgella (W.) capetos* from the Deerhope Formation (Telychian), Ree Burn Formation (Telychian or early Sheinwoodian) and Knockgardiner Formation (early Sheinwoodian) of the Pentland Hills and Girvan area, Scotland. *W. (W.) brutoni* differs from *W. (W.) capetos* in possessing a broader anterior border furrow, a median glabellar lobe which does not narrow anteriorly, larger occipital lobes and a pygidial axis which does not taper as strongly posteriorly.

The pygidium of this species is readily distinguished from that of *W. (W.) baltica* Alberti, 1963 by its lack of a pronounced holcos and from that of *W. (W.) stokesii* (Murchison, 1839) by its more pointed axis.



Text-figure 36. Reconstruction of the cephalon of *Warburgella (Warburgella) gongrus* sp. nov. (based on PMO 51777, holotype cranidium, Pl. 25, fig. 1 & PMO 49099, free cheek, Pl. 24, fig. 17).

Warburgella (Warburgella) gongros sp. nov. Pl. 24, fig. 15; Pl. 25, figs 1, 17; Text-figs 30, 34, 36, 44.

(Name; Gr. "gongros", a swelling; referring to the shape of the median glabellar lobe).

v. *1982 Warburgella (Warburgella) baltica* Alberti; Owens, (*pars*), p. 137.

Holotype. PMO 51777 (cranidium), locality, 24; Pl. 25, fig. 1.

Paratypes. Cranidia, PMO 48615, -616, PMO 49095, -096, locality 5, PMO 47945, locality 11; free cheeks, PMO 48853, PMO 49098, locality 5; pygidium PMO 44651, locality 11.

Stratigraphic range. Steinsfjorden Formation (Kiær's étage 9), Ringerike and Skien districts, Sheinwoodian to Homerian (*centrifugus* to *nassa* Biozones).

Diagnosis. A species of *Warburgella (Warburgella)* with narrow, very deeply incised anterior border furrow; glabella tapering forwards from 1S; 2S and 3S deeply incised; occipital furrow transverse in front of occipital lobes; pygidial axis with seven rings; holcos weakly defined.

Description. Glabella slightly wider (tr.) than long (sag.). Three pairs of well-defined glabellar furrows; 1S very deeply incised at mid length, shallowing slightly posteriorly and effaced anteriorly, arranged at 30-40° to an exsagittal line. 2S well-incised with abaxial end opposite γ, extending one-third glabellar width (tr.) directed posteriorly at 30° to a transverse line. 3S of similar form to, parallel to, and two-thirds as long as 2S. Occipital furrow narrow well-defined. Occipital ring of low convexity, less than one-quarter length of glabella, sagittally narrowing to half this length behind occipital lobes. Occipital lobes oval, inflated, well-defined posteriorly by a deep furrow. No preglabellar ridge. Tropidium very well-defined. Preglabellar area of slight independent convexity undercut by anterior border furrow. Anterior border broad, slightly upturned. Preocular part of facial suture diverging at 45° to an exsagittal line. Field of free cheek narrow. Genal spine long, weakly constricted at base, with well-defined median furrow. Lateral border broad, of low convexity. Posterior border broad, of high convexity. Dorsal surface with sculpture of terrace ridges.

Pygidium twice as wide (tr.) as long (sag.). Axis narrowing slightly posteriorly. Axial rings narrowing and becoming less well-defined posteriorly, posterior four rings defined only medially; terminal piece poorly-defined posteriorly. Five pairs of pleural ribs; pleural furrows less well-incised than interpleural. Pleural and interpleural furrows not crossing holcos.

Discussion. This species occurs at a similar horizon to *W. (W.) baltica* from which it differs by possessing a deeper anterior border furrow, slightly inflated preglabellar area and glabella which narrows more sharply towards the anterior. The pygidium of *W. (W.) gongros* possesses a far less well-defined holcos than that of *W. (W.) baltica* and less deeply incised axial furrows.

The lack of a preglabellar ridge and the undercutting of the preglabellar area by the preglabellar furrow serves to distinguish this species from *W. (W.) stokesii* (Murchison, 1839; see Owens 1973, p. 67, pl. 13, figs 5-13; pl. 14, fig. 2).

Family Calymenidae Milne Edwards, 1840

Subfamily Calymeninae Milne Edwards, 1840

Genus **Calymene** Brongniart, 1822

Type species. By original designation *Calymene Blumenbachii* Brongniart, 1822, p. 11, pl. 1, figs 1a-d, from the Much Wenlock Limestone Formation (Homerian, *ludensis* Biozone), West Midlands, U. K.

Terminology. Furrows in the fixed cheek opposite glabellar furows are herein referred to by the letter F and a number relating to the corresponding glabellar furrow i.e. 2F opposite 2S.

Calymene frontosa Lindström, 1885. Pl. 29, figs 3, 5-7, 9, 10, 12, 13; Text-figs 38, 44, 48.

1885 *Calymmene frontosa* n. , Lindström, p. 69, pl. 15, figs 1-4.

[1973 *Calymene frontosa* Lindström, 1885; Siveter, p. 189, pl. 4, figs 1-9].

1981 *Calymene frontosa* Lindström, 1885; Clarkson & Howells, p. 523, pl. 79, figs 3-11 [Includes full synonymy].

1982 *Calymene* (s.l.) *frontosa* Lindström, 1885; Howells, p. 39, pl. 10, figs 8-13.

v *1982 Calymene frontosa* Lindström; Siveter, p. 140.

v. *1982 Calymene* cf. *frontosa*, Siveter, p. 140.

Lectotype. By designation of Clarkson & Howells 1981, p. 523, RM Ar6210, complete specimen; figured Lindström 1885, pl. 15, figs 1-3 from Lower Visby Formation (*crenulata* Biozone), Visby, Gotland, Sweden.

Paralectotypes. By designation of Clarkson & Howells 1981, p. 523, RM Ar6211-2, enrolled specimens, from type locality, the former figured Lindström 1885, pl. 15, fig 4.

Material from Norway. Cranidia, PMO S2683, locality 5, PMO 51360, locality 6, PMO 44618, -660, PMO 44419, -420, locality 35, PMO 42726, locality 36, PMO 48627, -644, -645, locality 37; pygidia, PMO 48838, locality 5, PMO 44654, -657, -658, locality 35, PMO 48646, locality 37.

Stratigraphic range. Rytteråker?, Malmøya and Braksøya Formations (Kiær's étages 8a to 8c), Oslo and Ringerike districts (Telychian & Sheinwoodian, *crenulata-rigidus* Biozones). Lower Visby Formation (*crenulata* Biozone), Visby, Gotland. Knockgardner Formation (early Wenlock) of Girvan, Scotland. Ree Burn Formation (Telychian or early Sheinwoodian), Hagshaw Hils, Scotlland. Wether Law Lynn Formation (Telychian & early Sheinwoodian), Pentland Hills, Scotland.

Diagnosis. A species of *Calymene* with broad deep preglabellar furrow; anterior border of cranidium narrow and rolled, one-third length of glabella (sag.); intermediate lobe small; glabella weakly constricted at 1S; axial furrow broad and deeply incised in front of 2L; anterior corner of fixed cheek pointed and projecting; 2F narrow well-defined; palpebral lobe small. Pygidium with six axial rings and five broad pleural ribs with pleural furrows extending entire length. Dorsal surface with a sculpture of granules of irregular size and distribution, predominantly large on glabella.

Description. Cephalon twice as wide (tr.) as long (sag.). Glabella weakly bell-shaped, longer than wide. Occipital ring one-quarter as long (sag.) as wide (tr.) narrowing to one-third this width by axial furrow. Occipital furrow transverse and of constant depth medially, deepening broadening and deflected posteriorly behind 1L, which is slightly elongate exsagittally. 2L oval, half size of 1L. 3L half size of 2L. Median glabellar lobe bluntly rounded. 1S broad, backwardly directed, very deep with rounded adaxial termination not extending between 1L and median glabellar lobe. 2S shallower than 1S, opposite anterior corner of palpebral lobe. 3S half length of and parallel to 2S. Axial furrow deep, widest opposite 2S. Anterior border of constant length (sag. & exsag). Preocular fixed cheek one-third glabellar width (tr.). Posterior border furrow of constant depth, confluent with axial furrow, terminating abruptly at abaxial end. Preocular facial suture exsagittally directed. Postocular facial suture transverse for adaxial half of length then deflected backwards at 45°, finally directed exsagittally.

Discussion. Clarkson & Howells (1981, p. 516) stated that material from the Wether Law Lynn and Deerhope Burn Formations of the Pentland Hills was conspecific with *C. frontosa* on the basis of "the deep, wide preglabellar furow, deep and wide axial furrow in front of 2L, the pointed anterior corner of the fixed cheek, small palpebral lobe and the cranidial ornamentation". They did not however include any of these characters in their diagnosis. I agree with Clarkson & Howells that these features are important and in addition believe the size of the intermediate lobe and degree to which the glabella is constricted at 1S to be useful specific indicators. I have consequently emended the diagnosis.

Calymene frontosa is known from the Lower and Upper Visby Formation (Telychian & Sheinwoodian, *crenulata* to *murchisoni* Biozones) of Gotland Sweden, from the Knockgardner Formation (early Wenlock) of Girvan, Scotland, the Ree Burn Formation (Telychian or early Sheinwoodian) of the Hagshaw Hills, Scotland, the Wether Law Lynn Formation, (Telychian & early Sheinwoodian) of the Pentland Hills, Scotland and from the Adavere Stage (Telychian, *sedgwickii* to *crenulata* Biozones), of the East Baltic. The majority of the

Norwegian material is from the Malmøya and Braksøya Formations (Kiær's étages 8a to 8c, *crenulata* to *murchisoni* Biozones) and one specimen (PMO 42726) also considered conspecific with *C. frontosa* (*C.* cf. *frontosa* of Siveter 1982, p. 140) bears a label stating it to be from the Rytteråker Formation (Kiær's étage 7a, *sedgwickii* Biozone) which would indicate that *C. frontosa* possesses a similar stratigraphic range in southern Norway and elsewhere.

Calymene aff. *Calymene frontosa* Lindström, 1885. Pl. 32, figs 1, 2; Text-figs 38, 44.

Material. Cranidia, PMO 44419, -420, locality 35.

Stratigraphic range. Malmøya Formation (Kiær's étage 8c), Oslo district (Sheinwoodian, *centrifugus* & *murchisoni* Biozones).

Description. Cranidium twice as wide (tr.) as long (sag.). Occipital ring one-quarter length of glabella (sag.) narrowing to half that length behind 1L. Glabella weakly bell-shaped, almost as long (sag.) as wide (tr.), well above level of fixed cheek. Anterior border furrow broad, deep. Anterior border broad, convex, not rolled. 1L one-quarter width of glabella (tr.) well-defined adaxially. 2L one-quarter size of 1L, well-defined adaxially. Intermediate lobe very small with glabella not constricted behind. 3L very small, well-defined adaxially. 4L not developed. Median lobe bluntly-rounded. 1S well-incised narrow, of constant width along entire length, shallowing adaxially and well-defined between 1L and median glabellar lobe. 2S less well-incised than 1S. 3S very poorly-incised. Axial furrow well-incised, widest opposite posterior of 1L, narrowing towards buttress and of constant width in front of

2L. Posterior border furrow well-incised, narrowing very slightly abaxially, anterior face more gently sloping than posterior. Preocular fixed cheek half width of frontal lobe, adaxial corner projecting. 2F shallow. Preocular facial suture exsagittally directed. Postocular facial suture transverse for adaxial third of length then deflected to 45°, finally exsagittally arranged on posterior border. Dorsal surface with a sculpture of randomly distributed coarse and fine granules, predominantly fine on posterior border and occipital ring.

Discussion. These cranidia resemble *C. frontosa* in the possession of a deep, broad anterior border furrow and type of surface granulation but possess a broader anterior border and a less well-defined intermediate lobe.

This material is from the same locality and horizon as that of *C. tetartos* sp. nov. (see below) but differs from it in possessing a wider anterior border furrow, smaller intermediate lobe, projecting adaxial corner of the fixed cheek, better incised axial furrow and in lacking a 4L.

Calymene pholeteros sp. nov. Pl. 30, figs 2, 6, 7; Text-figs 38, 44.

(Name. Greek: One who lives in a hole; reference to the type locality, an island (Langøya) the centre of which has been quarried away).

v. 1971 *Calymene* sp., Whittington, p. 461, pl. 84, figs 1, 4-6.

Holotype. Cranidium, PMO 49987, Steinsfjorden Formation (Kiær's étage 9c), Holmestrand district (Homerian, *lundgreni* & *nassa* Biozones); figured Whittington 1971, p. 461, pl. 84, figs 1, 4-6; Pl. 30, fig. 2.

Paratypes. Cranidia, PMO 50590, -596, -597, locality 19.

Stratigraphic range. This species is only known from the type locality.

Diagnosis. A species of *Calymene* with bell-shaped glabella which is longer (sag.) than wide (tr.); 1L very large; 4L not present; anterior border furrow narrow, slightly undercutting median glabellar lobe; anterior border almost transversely arranged; anterior margin of fixed cheek almost transversely arranged; 2F deep, broad; 3F shallower than 2F; dorsal surface sculpture of predominantly fine granulation with larger granules on cheeks and glabellar lobes.

Description. Cephalon two-fifths as long (sag.) as wide (tr.). Occipital furrow transverse and broad medially, narrowing and deepening abaxially. Occipital ring one-quarter length of glabella (sag.) narrowing to one-third median length behind 1L. 1L subangular one-third as wide (tr.) as occipital ring (tr.). 2L half size of 1L. Intermediate lobe between 1L and 2L of low convexity not defined adaxially. 3L well-defined half length of 2L (exsag.), oval, elongate transversely. 1S broad, deep, bifurcating behind intermediate lobe with a broad rounded posterior termination, which markedly constricts the glabella opposite anterior corner of 1L, and with a narrow branch continuing between 1L and glabella. 2S deep, half length (exsag.) of 2L, defined adaxial to 2L and confluent with 1S. 3S half length (exsag.) of and shallower than 2S, very weakly-defined adaxial to 3L and confluent with 2S. Axial furrow deep, widest opposite 3L. Anterior furrow deep, narrow, undercutting anterior margin of glabella. Anterior slope very steep. Anterior border one-tenth glabellar length (sag.) widening slightly abaxially. Preocular fixed cheek one-third width of glabella, anterior corner rounded. Posterior border, adjacent to axial furrow, as long (exsag.) as abaxial part of occipital ring, widening abaxially. Posterior border furrow broad (exsag.), posterior slope steeper than anterior, narrowing (exsag.) adaxially and abaxially. Preocular facial suture exsagittally directed. Postocular branch of facial suture transverse for adaxial half of length, then running backwards at 30° to a transverse line, finally deflected onto an exsagittal line. Free cheek subtriangular, lateral border of constant width. Lateral border furrow shallow and broad. Surface of cranidium, excluding furrows with a sculpture of coarse and fine granules with a number of larger granules adjacent to axial furrow.

Discussion. See *Calymene* sp. (below).

Calymene aff. *Calymene pholeteros* sp. nov.

Pl. 31, fig. 4;
Text-figs 38, 44.

Material. Cranidium, PMO 109.917, locality 19.

Stratigraphic range. Steinsfjorden Formation (Kiær's étage 9c), Holmestrand district (Homerian, *murchisoni* & *riccartonensis* Biozones).

Description. Similar to *C. pholeteros* but with anterior border gently curved, 1L and 2L smaller, a broader occipital furrow and 2F is less well-developed.

Discussion. See *Calymene* sp. (below).

Calymene sp. Pl. 29, figs 1, 2; Pl. 31, figs 1-3, 5-12; Text-figs 38, 44.

Material. Cranidia, PMO 49667, -919, PMO 50023, -190, -194, PMO 89321, -324, PMO 109.914, -916, -922, -924, -926, -932, -934, 109.936-938; free cheeks, PMO 109.923, -925, -935; pygidia, PMO 49664, PMO 50193, -232, PMO 109.927, -939, -961; all material from locality 19.

Stratigraphic range. Steinsfjorden Formation (Kiærs êtages 9b & 9c), Holmestrand district (Homerian, *centrifugus* to *riccartonensis* Biozones).

Description. Cranidium as for *C. pholeteros* apart from; anterior border narrow, gently curved in dorsal view. Anterior border furrow narrow in smaller specimens generally becoming broader with increasing size of individual. Anterior adaxial corner of fixed cheek projects.

Pygidium with axis one-third width (tr.) anteriorly, narrows to half this width by terminal piece and extends to close to posterior margin. Axial rings narrowing slightly abaxially. Anterior 5 ring furrows end in shallow abaxial pits on internal mould, progressively less well-defined posteriorly. Axial furrow deep well-incised, very shallow to posterior of terminal piece. Five pleural ribs last pair slightly more convex than others. Pleural furrows shallow adaxially.

Discussion. Material herein assigned to *C. pholeteros*, *C.* aff *pholeteros* and *C.* sp. are all from the Steinsfjorden Formation (Kiær's êtages 9b & 9c) of Langøya in the Holmestrand district. The material has been separated into these three groups largely on the basis of differences in the morphology of the anterior cranidial border and anterior border furrow. The pygidia assigned to *C.* sp. are placed there on the basis of the author's own collection which has yielded cranidia and pygidia from the same sample. It is possible that these groups represent variation within a population in that they all share certain features. In particular the type of surface sculpture (compare Pl. 30, fig. 2a; Pl. 31, fig. 11); size of intermediate lobe (compare Pl. 30, figs 3a, 4) and depth of 2F (compare Pl. 30, fig. 2a; Pl. 31, figs 3a, 5a, 4). However the number of available specimens, especially those of equivalent size, are small and I consider it more useful to separate the groups until more material can be collected.

A number of species of *Calymene* possess the distinctive transverse anterior margin displayed by *C. pholeteros*. *C. minimarginata* Schrank, 1970 (p. 129, pl. 5, figs 1-7; Pl. 6, figs 1-4) from the Jaani Stage, (J1, *centrifugus* to *rigidus* Biozones) of the East Baltic and *C. latvica* Männil, 1983 (p. 77, pl. 3, figs 7-10) from the Kuressaare Stage, Downtonian ($K_3$2, *lochkovensis* to *bouceki* Biozones) of the East Baltic are both differentiated from *C. pholeteros* by their coarser surface granulation, smaller 1L, less well-defined 3L and lack of 2F or 3F. *C. minimarginata* possesses a relatively longer glabella, shallower anterior border furrow and smaller 1L than *C. latvica.*

C. aff. *C. lawsoni* Shirley, 1962 (Siveter 1973, p. 288, pl. 37, figs 1-5) from the Upper Leintwardine Beds, Ludlow (*tumescens* & *leintwardinensis* Biozones), of the Welsh Borderland, U.K, differs from *C. pholeteros* in possessing a shallower and wider, anterior border furrow, shallower 1S, less well-defined intermediate lobe, shallower 2F and coarser granulation.

Calymene interjecta (Hawle & Corda, 1847) from the Pridoli Series, Svaty Jan, Czechoslovakia possesses a 4L, a coarser granulation, proportionately smaller and more angular 1L and less prominent intermediate lobe than does the Norwegian species.

C. aff. *C. pholeteros* resembles *C. livonica* Männil, 1977b(p. 247, pl. 4, figs 1-5) from the upper Wenlock, Jaani Stage (J1, *centrifugus* to *rigidus* Biozones) of the East Baltic from which it is differentiated by its better defined 2F, larger intermediate lobe, relatively shorter and broader glabella and smaller 1L. Specimens assigned to *C.* aff. *mimaspera* Schrank, 1970 and *C.* cf. *mimaspera* Schrank, 1970 by Siveter 1973 (pl. 23, figs 4-6 and figs 2,3, 7-9 respectively) from Harley Brook (latest Llandovery or early Wenlock), the Welsh Borderland and the Much Wenlock Limestone Formation (*ludensis* Biozone) of Shropshire respectively differ from *C.* aff. *pholeteros* in possessing a smaller 1L, lacking a 2F and being of an overall lower convexity.

The narrow anterior border and well-incised border furrow of *C.* sp. resembles that of *C. frontosa,* the latter species being distinguished by its coarser surface granulation, lack of 2F, smaller intermediate lobe and 1L and an anterior border that is not rolled.

Calymene planicurvata Shirley, 1936. Pl. 29, fig. 8; Pl. 30, fig. 1; Pl. 32, figs 3-9; Text-figs 38, 44, 48.

1865 *Calymene Blumenbachii,* Brongniart, var. a, *auctorum* Salter, pl. 9, figs 1a,b. *non* figs 2a,b [*fide* Siveter 1973].

1936 *Calymene planicurvata* sp. nov. , Shirley, p. 412, pl. 30, figs 6, 7.

1938 Calymene planicurvata Shirley; Whittard, p. 88.

1970 Calymene planicurvata Shirley; Schrank, p. 116.

Holotype. By original designation GSM 19642, cranidium, internal mould, Bog Quartzite, Aeronian (*fide* Ziegler, Cocks & McKerrow, 1968), Hope Quarry, Shelve area, Shropshire, U.K.; figured Shirley 1936, pl. 30, figs 6, 7.

Material from Norway. Whole specimens, PMO 20987, -989, PMO 41538, -540, -614, -615, -727, PMO 41961, -965, -972, PMO 43460, localities 29 & 32; cranidium and partial thorax, PMO 41606, locality 32; cranidia, 41690, locality 32.

Stratigraphic range. Solvik and Rytteråker Formations (Kiær's étages 6c & 7a), Oslo district (Aeronian, *magnus* to *sedgwickii* Biozones). Bog Quartzite (Aeronian), Shropshire, U.K.

Diagnosis. A species of *Calymene* with broad, shallow anterior border furrow and broad flat slightly upturned anterior border which is gently curved in dorsal view; anterior margin of fixed cheek of moderate convexity with slightly projecting abaxial corner; 2F absent; palpebral lobe large; intermediate lobe poorly-defined behind which the glabella is distinctly constricted. Pygidium with six axial rings and a terminal piece; pygidial pleural furrows extending whole length of pleural ribs; posterior margin strongly indented. Dorsal surface with sculpture of very fine granulation.

Description. Cranidium twice as long (sag.) as wide (tr.) glabella four-fifths as long (sag.) as wide (tr.), bell-shaped. Occipital ring one-quarter as long (sag.) as wide (tr.), narrowing to half this length behind 1L. Occipital furrow deep and broad medially, narrowing abaxially with steeper anterior than posterior slope. 1L about one-quarter width of glabella. 2L very small, well-defined adaxially. 3L half size of 2L poorly defined adaxially. 1S deep, widening and shallowing adaxially. 2S broad, short. 3S narrow, well-incised, not extending between 3L and median glabellar lobe which is bluntly rounded anteriorly. Axial furrow well-incised, widest opposite 1L, widening forwards from 2L. Axial pit variably developed, situated to anterior of 3S. Posterior border of cranidium highly convex adaxially, becoming less convex abaxially. Posterior border furrow deep and broad, anterior slope more gently inclined than posterior, both slopes becoming more gently inclined abaxially with narrowing of furrow. Anterior portion of facial suture diverging at 5° to an exsagittal line. Posterior branch of facial suture with adaxial half of length posteriorly directed at 5° to a transverse line then deflected to 45°, finally deflected to 70° on posterior border. Preocular fixed cheek one-third width of median glabellar lobe (tr.). Palpebral lobe of low convexity, extending from opposite posterior of 3L to just opposite anterior margin of 1L. Free cheek with well-incised lateral border furrow, slightly undercutting field. Lateral border with flattened dorsal surface, widening slightly posteriorly. Field of free cheek steeply sloping anteriorly, progressively less so posteriorly. Thorax narrowing slightly posteriorly. Axis one-third width with twelve transversely arranged rings each of constant length, convex in lateral view. Posterior branch of each pleura more convex than anterior. Pleural furrows narrow well-incised.

Pygidial axis gently convex, one-third width (tr.) anteriorly, narrowing to half this width by terminal piece. Axial rings well-defined convex anteriorly, becoming less so posteriorly. Terminal piece rounded, slightly shorter (sag.) than wide (tr.). Ring furrows shallowing medially Axial furrow well-incised along entire length, extending around terminal piece. Six pairs of pleural ribs. Pleural field without distinct point of flexure. Anterior and posterior pleural bands of anterior five ribs of equal convexity.

Pleural furrows deepening and broadening abaxially. Sixth pleural rib more convex than anterior ribs and defining a short postaxial ridge.

Discussiion. *C. planicurvata* is known from the Bog Mine Quartzite, Llandovery (Aeronian) of the Shelve area, Shropshire, U.K. The Norwegian museum material is labelled as coming from Kiær's étages 6, 6c and 7a. My own collection from Malmøya has yielded this species from the Padda Member of the Solvik Formation only (Kiær's étage 6c) and I thus believe that the museum material labelled as being from "étage 6" may all belong to Kiær's étage 6c. The range of this species is thus Kiær's étages 6c & 7a (*centrifugus* & *murchisoni* Biozones) indicating an upward extension of stratigraphic range of *C. planicurvata* in southern Norway.

C. planicurvata is differentiated from *C. orthomarginata* Schrank, 1970 (p. 126, pl. 4, figs 2-7; Männil 1977, pl. 3, figs 1-5) of the J1, Jaani stage (*centrifugus* & *murchisoni* Biozones) from Wenlock erratics from the D.D.R. and the East Baltic, by its less well developed anterior border furrow and its finer granulation of the dorsal surface.

C. puellaris Reed, 1920 (see Shirley 1933, pl. 1, fig. 15) from the Eke Formation, Ludlow (*leintwardinensis* Biozone), of Gotland Sweden, possesses a similar flattened anterior border but differs from *C. planicurvata* by having a relatively shorter glabella, smaller 1L and coarser surface granulation.

C. staycii Schmidt, 1894 (p. 23, pl. 2, figs 9-11) from the uppermost Ordovician (F1 Stage) of Gdansk, Poland, possesses a broader anterior portion to the fixed cheek and coarser granulation. However Schmidt's illustrations are not sufficiently clear to allow a closer comparison of the two species.

Calymene tetartos sp. nov. Pl. 29, figs 4, 11; Pl. 33, figs 4-7, 11; Text-figs 38, 44.

(Name. Greek, fourth; referring to the well-developed 4L).

Holotype. Cranidium, PMO 44655, Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo district (Sheinwoodian, *rigidus* & *linnarssoni* Biozones); Pl. 33, fig. 7.

Paratypes. Cranidia, PMO 44654, -656, -660, -812, PMO 109.920, locality 7, PMO 109.968, -500, -504, PMO 110.834, locality 35; free cheeks, PMO 109.503, PMO 110.835, -836, locality 7, PMO 109.499, -919, locality 35; pygidia, PMO 109,502, PMO 110.837, locality 7, PMO 44625, -626, -630, locality 35.

Stratigraphic range. Malmøya Formation (Kiær's étages 8c & 8d), Oslo and Asker district, Sheinwoodian (*riccartonensis* to *linnarssoni* Biozones).

Diagnosis. A species of *Calymene* with weakly bell-shaped glabella; Anterior border furrow shallow and narrow; Anterior border broad, not rolled; intermediate lobe large; 4L well-defined on external mould, weakly defined on internal mould; 1S markedly constricting glabella; palpebral lobe as long as 1L (exsag.); anterior adaxial corner of fixed cheek bluntly rounded, slightly projecting. Pygidium with seven axial rings; five pygidial pleural ribs with a sixth pair fused into raised postaxial area. Dorsal surface with sculpture of coarse and fine granules which become predominantly coarse on glabella and anterior fixed cheek.

Description. Cranidium half as long (sag.) as wide (tr.). Occipital furrow transversely arranged, broad and shallow medially, narrowing, deepening and deflected posteriorly behind 1L. Occipital ring one-quarter cranidial length sagittally, narrowing to one-third this length behind 1L. 1L one-third width (tr.) of occipital ring. 2L half size of 1L, elongate transversely. Intermediate lobe not defined adaxially. 3L well-defined anteriorly and posteriorly, half length of 2L (exsag.), not defined adaxially. 1S broad and deep, bifurcating at intermediate lobe; posterior branch ending in a shallow rounded pit behind intermediate lobe, anterior branch confluent with 2S adaxial to 2L. 4S very shallow two-thirds length of 3S (tr.). Axial furrow deep, widest opposite 3L. Preocular fixed cheek one-third width of glabella (tr.). Posterior border as long (sag.) as abaxial part of occipital ring adjacent to axial furrow, widening abaxially. Posterior border furrow broad (exsag.) adaxially and abaxially. Preocular facial suture converging at 5° to an exsagittal line. Postocular facial suture transverse for adaxial half of length, deflected backwards at 30° to a transverse line then deflected onto an exsagittal line. Free cheek triangular, lateral border of constant width (tr.). Lateral border furrow shallow and broad.

Pygidium twice as wide as long (tr.). Axis one-third pygidial width (tr.) anteriorly, narrowing to one-third that width by terminal piece. Pleural furrows weakly-incised on abaxial two thirds of pleural ribs. Interpleural furrows more deeply incised than pleural.

Discussion. *Calymene tetartos* is distinguished from *C. tentaculata campana* Siveter, 1973 (p. 272, pl. 33, figs 1-8, pl. 34, figs 1-6) from beds of post-Whitcliffian age of Skyrkan, Ramsasa, Scania, by its broader, shallower anterior border furrow, better defined 4L and less well-defined intermediate lobe.

C. neotuberculata Schrank, 1970 (p. 134, pl. 8, figs 1-5; pl. 9, figs 1-4) from the Mulde Formation, Wenlock (*lundgreni* Biozone), of Gotland, Sweden, differs from *C. tetartos* by its relatively broader median glabellar lobe and lack of 4L.

Calymene ubiquitosus Howells, 1982. Pl. 30, figs 3-5; Pl. 33, figs 1-3, 8-10, 12, 14-16; Text-figs 44, 48.

1982 *Calymene* (s.l) *ubiquitosus* sp. nov., Howells, p. 37, pl. 9, figs 22, 25, 26, 28; pl. 10, figs 1-7 [includes full synonymy].

v. [*1982 Calymene* cf. *C. replicata*, Shirley, 1936, Siveter, p. 140.]

Holotype. By original designation BM In23337, internal mould of cranidium, from Newlands Formation (Rhuddanian & Aeronian, *triangulatus* to *argenteus* Biozones), Girvan, Scotland; figured Howells 1982, pl. 10, fig. 1.

Other material. Cranidia; PMO 53094, locality 31, PMO 91096-098, PMO 91100, -102, -107, -108, locality 27, PMO 109.942-945, -948, 109.953-955, -957, -958, -971, -974, locality 31; free cheeks, PMO 109.951, -956, -970, -972, locality 31; hypostomes, PMO 110.832, locality 31, PMO 85833, PMO 88823, locality 33; pygidia, PMO 91099, -103, -104, -107, locality 27, PMO 109.949, -950, -952, -959, -973, locality 31. PMO 52629, -783, PMO 88741, -747, -749, -764, -765, PMO 88840, PMO 109.960, 109.962-964, locality 33.

Stratigraphic range. Solvik Formation (Kiær's êtages 6b & 6c), Asker district (Aeronian, *atavus* to *convolutus* Biozones). Mulloch Hill Formation and Newlands Formation, Rhuddanian & Aeronian (*atavus* to *argenteus* Biozones), Girvan, Scotland.

Diagnosis (emended from Howells 1982, p. 37). A species of *Calymene* with weakly bell shaped glabella, slightly longer (sag.) than wide (tr.); preglabellar furrow deep, wide, anterior border rolled; intermediate lobe absent; 4L present as low ridge; fixed cheek without 2F, anterior adaxial corner bluntly rounded slightly projecting. Hypostome with conical projection on middle body. Pygidium with six well-defined axial rings anteriorly, a seventh defined only medially plus a terminal piece; pleural furrows extending for abaxial two-thirds length of pleural ribs. Dorsal surface with sculpture of predominantly coarse granulation.

Description. See Howells 1982, p. 37.

Discussion. Howells in her discussion of *C. ubiquitosus* (1982, p. 38) used the structure of the anterior border and anterior corner of the fixed cheek to differentiate it from *C. replicata* Shirley, 1936 but did not include these characters in her diagnosis. I agree as to the importance of these features and have emended the diagnosis accordingly.

The Scottish material is preserved as moulds in sandstone whilst the majority of the Norwegian material occurs in fine grained carbonate. This hampers comparison but enables better observation of characters such as surface sculpture, the structure of the intermediate lobe and of the pygidial pleural ribs in the latter. These characters are useful in determining species and I have therefore also added them to the diagnosis.

C. ubiquitosus is known from beds ranging in age from Rhuddanian (*atavus* Biozone) to Aeronian (*magnus* & *argenteus* Biozones) from Girvan, Scotland which is a similar stratigraphic range to that of the Norwegian specimens. *C. ubiquitosus* also closely resembles *C. frontosa* differing from it in possessing a narrower anterior border furrow, less strongly pointed anterior adaxial corner to the fixed cheek, coarser granulation and in lacking a 2F.

C. ubiquitosus is distinguished from *C. carlops* Lamont, 1949 (p. 319, pl. 18, figs 13-19), from the Llandovery, Telychian (*crenulata* Biozone) of the Pentland Hills, U.K. by its less well-defined intermediate lobe, narrower median glabellar lobe and more anteriorly

Text-fig. 38

	Anterior border furrow				Anterior of fixed cheek	Cranidial Sculpture	Anterior border	Interm. lobe	4L		2F		Palpebral lobe		Posterior margin of pygidium	Pygidial pleural furrows
	Deep	Shallow	Broad	Narrow					Present	Absent	Present	Absent	Small	Large		
C. frontosa	X		X		Adaxially pointed	Coarse & fine granules	Narrow & rolled	Small		X	X		X		Not notched	Whole length of rib
C. aff. frontosa	X		X		Adaxially projecting	Coarse & fine granules	Broader than C. frontosa	Small		X	X		?		?	?
C. pholeteros	X			X	Transverse	Fine granules larger on lobes	Broad & flattened	Poorly defined		X	X		X		?	?
C. aff. pholeteros	X			X	Rounded	?	Narrow & transverse	Poorly defined		X	X		?		?	?
C. sp.	X		X		Rounded	Fine granules	Narrow not rolled	Poorly defined		X	X		X		Not notched	?
C. planicurvata		X	X		Abaxially projecting	V. fine granules	Broad & flat	V. poorly defined		X		X		X	Strongly notched	Whole length of rib
C. tetartos	X			X	Bluntly rounded	Coarse & fine granules	Broad, curved gently convex	Large	X		X			X	Strongly notched	Abaxial third of rib
C. ubiquitosus	X		X		Rounded adaxially	Predominant coarse granules	Narrow rolled	Absent	X			X		X	Weakly notched	Abaxial two-thirds of rib

placed palpebral lobe.

Calymene exemia Siveter, 1973 (p. 201, pl 8) from the Hemse Formation, Ludlow (*nilssoni* to *leintwardinensis* Biozones) of Gotland, Sweden, possesses a relatively shorter cranidium with a finer granulation and a relatively shorter hypostome with a broader posterior indentation and narrower less strongly curved posterior wings than *C. ubiquitosus*.

Genus **Diacalymene** Kegel, 1927

Type species. By original designation *Calymene diademata* Barrande, 1846a, from the Liten Formation (Wenlock), Prague District, Czechoslovakia; figured Siveter, 1980, pl. 101, figs 6, 10.

Diagnosis. See Siveter 1982, p. 140.

Diacalymene crassa Shirley, 1936. Pl. 33, fig. 13; Pl. 34, figs 1-5, 7-9; Text-figs, 44, 48.

v* 1936 *Diacalymene crassa* sp. nov., Shirley, p. 416, pl. 29, figs 21-23.

1949 *Diacalymene crassa* Shirley; Bancroft, p. 309.

1961 *Diacalymene crassa* Shirley; Wolfart, p. 71.

1970 *Diacalymene* sp. (? *crassa* Shirley, 1936); Temple, p. 69, pl. 18, figs 13-20.

v [1973 *Diacalymene crassa* Shirley, 1936; Siveter, p. 166, pl. 12, figs 1-10, pl. 13, figs 2, 4, 5, 9, 13].

v *1980 Diacalymene crassa* Shirley; Siveter, p. 796.

v. *1982 Diacalymene* cf. *D. crassa* Shirley 1936; Siveter, p. 141.

Holotype. By original designation GSM 54910, internal mould cranidium (formerly GSM pg2364), from the Gasworks Mudstone, Llandovery (Rhuddanian, *atavus* to *cyphus* Biozones), of Haverfordwest, South Wales; figured Shirley 1936, pl. 29, figs 21, 22; Pl. 34, fig. 1.

Material from Norway. Cranidia, PMO 58647, PMO 65535, PMO 88872, -873, -877, -881, PMO 110.860, locality 10, PMO 91112, locality 38, PMO 53094, Solvik Formation, locality unknown, Asker.

Stratigraphic range. Solvik Formation (Kiær's étage 6b), Asker district (Rhuddanian & Aeronian, *acinaces* to *triangulatus* Biozones). Gasworks Mudstone, Rhuddanian (*atavus* to *cyphus* Biozones), Haverfordwest, S. Wales.

Diagnosis. Glabella weakly bell-shaped, as wide (tr.) as long (sag.); preglabellar furrow shallow, broad. Anterior border one-quarter length of glabella (sag. on internal mould); fixed cheek with anterior adaxial corner bluntly rounded and slightly projecting, no furrow opposite 2S.

Description. Occipital ring four times as wide (tr.), as long (sag.), constricted behind 1L. Occipital furrow broad, shallow, transverse medially, narrowing and deflected backwards abaxially. 1L subrectangular, long axis diverging anteriorly at 10° to an exsagittal line. 2L one-third size of 1L, circular. 3L of similar shape to and one-third size of 2L, well-defined abaxially. 1S deep, narrow, shallowing and bifurcating adaxially. Posterior branch of 1S passing between 1L and median glabellar lobe. Anterior branch of 1S defining 2L adaxially and confluent with 2S. 2S parallel to abaxial portion of 1S. 3S half as deep and long as (tr.) and parallel to 2S. Median glabellar lobe bluntly rounded to subangular. Axial furrow deep, narrow, widest opposite 2L and frontal lobe. Anterior pit opposite frontal lobe. Preglabellar furrow deep undercutting glabella on external mould, shallower and broader on internal, outer slope deflected strongly upwards on external (less so on internal) mould. Anterior border gently curved in dorsal view, of constant width (sag. exsag.). Preocular fixed cheek steeply sloping with ill-defined anterior corner on external mould (well-defined on internal mould).

Discussion. The most similar species of *Diacalymene* to *D. crassa* is *D. marginata* Shirley, 1936 (pl. 24, figs 19, 20) from the Dolyhir Beds, Ashgill (Rawtheyan, *anceps* Biozone) of Clwyd and the Lower Drummock Group, Ashgill (Cautleyan & Rawtheyan *anceps* Biozone) of the Craigshead-Glenshalloch Inlier, Girvan. *D. marginata* is distinguished from *D. crassa* by possessing a frontal glabellar lobe which is less well-rounded (in dorsal view), a slightly longer anterior border (sag.) which is less curved in dorsal view and a larger 1L.

D. crassa is readily distinguished from *D. gibberosa* sp. nov. (see below) in that it possesses a cranidium which is longer (sag.) and less convex, a 2L which is markedly smaller than 1L and separated from the median glabellar lobe by a shallow furrow, a 3L which is defined adaxially, narrower glabellar and axial furrows, better incised pygidial axial furrows and a less angular terminal piece.

The type material of *D. crassa* (Pl. 34, fig. 1) is from the Gasworks Mudstone, Llandovery (Rhuddanian, *atavus* to *cyphus* Biozones) of Haverfordwest, South Wales. The Norwegian material belonging to this species from the Oslo museum and the National Museum of Wales and is labelled as coming from étage 6b or just étage 6 (*atavus* to *cyphus* Biozones).

Wolfart (1961, p. 71, pl. 4, fig. 1) in a paper on the stratigraphy and fauna of the Silurian and Devonian of Paraguay figured a specimen which he referred to *D. crassa*. The specimen is a poorly preserved internal mould and the age of the beds in which it was found is uncertain but it closely resembles the Welsh and Norwegian specimens in glabellar outline and well-rounded frontal glabellar lobe.

Diacalymene gibberosa [Siveter, 1973]. Pl. 34, fig. 6; Pl. 35, figs 1-12; Pl. 36, figs 1-3; Text-fig. 44.

v* [1973 *Diacalymene gibberosa*, Siveter, p. 172, pl. 13, figs. 6, 7, pl. 14, figs 1-16].

Holotype. By original designation of Siveter 1973, PMO 41620, Solvik Formation (Kiær's étage 6a), Sjursøya, Oslo district (Hirnantian & Rhuddanian, *persculptus* to *atavus* Biozones); figured Siveter 1973, pl. 14, fig. 1, 2, 4; Pl. 36, fig. 1.

Paratypes. Cranidia, PMO 20945, -947, -948, PMO 41619, -625, -637, PMO 110.841, 110.852-857, PMO 110.841; hypostomes, PMO 41643, PMO 110.843; thoracic segments + pygidia, PMO 20946, PMO 41633; pygidia, PMO I0838, PMO 41636, PMO 91111, -113, PMO 110.842, 110.844-847. All material from locality 28. The material is in the form of a dense coquina of external moulds and the above numbers refer only to especially well preserved or figured material.

Stratigraphic range. This species is only known from the type locality.

Diagnosis. Glabella highly inflated in lateral view, seven-eighths as long (sag.) as wide (tr.), deeply undercut by anterior border furrow; 2 and 3L not divided from median glabellar lobe by adaxial furrows; preocular fixed cheek with rounded anterior margin without projecting corner, shallow furrow present opposite 2S. Pygidial axis with five well-defined axial rings anteriorly, a sixth defined only medially plus a terminal piece which is subangular posteriorly. Dorsal surface with sculpture of densely packed small granules of almost uniform size.

Description. Glabella tapering gently forwards from occipital ring, bluntly-rounded anteriorly. Occipital ring one-quarter as long (sag.) as wide (tr.) narrowing to half this width behind, although not constricted by 1L. Occipital furrow transverse medially, deepening and narrowing behind 1L. 1L suboval, long axis diverging forwards at 10° to an exsagittal line. No intermediate lobe. 2L half length of 1L (exsag.), rounded anteriorly and posteriorly. 3L a small swelling anterior to 2L. 1S narrow and deep abaxially, shallowing, broadening and bifurcating adaxially. Anterior branch broader than anterior extending adaxial to 1L and merging with occipital furrow. 2S broad and deep abaxially, shallowing and narrowing adaxially, parallel to abaxial portion of 1S. 3S short (tr.), one-third length of 2S. Axial furrow deep, widest opposite 3L, narrowest by 2L. Anterior furrow shallow, broad, one-sixth length (sag.) of glabella of constant length (sag. & exsag.), narrower on smaller specimens. Anterior pit just anterior and adaxial to 3S. Anterior border one-third length of glabella, on external mould, half this width on internal mould, of constant width (sag. & exsag.). Preocular fixed cheek gently sloping with a well-defined notch opposite 3L. and shallow well-defined palpebral furrow. Palpebral lobe with weak independant convexity. Posterior border convex and short (exsag.) adaxially, broadening and less convex abaxially. Posterior border furrow shallow adaxially, broadening and deepening abaxially. Free cheek subtriangular. Eye opposite and about as long (exsag.) as 2L.

Hypostome slightly longer (sag.) than wide (tr.) across anterior wings. Anterior border sharply downturned. Lateral border convex, narrow, broadening posteriorly into spine. Anterior lobe of median body twice length of posterior. Posterior lobe crescent shaped.

Pygidium twice as wide (tr.) as long (sag.). Axial rings becoming narrower and less distinct posteriorly, flattening medially in posterior view. Axial furrow shallow, faint, not visable by first axial ring. Terminal piece merging with postaxial region without independant convexity in lateral view. Four pleural ribs. Interpleural furrows narrow, and all equally well-incised. Pleural furrows defined only abaxially on some specimens, on others shallowing greatly and extending to axial furrow. Granules becoming slightly more densely packed on flanks of axis and immediately abaxial to axial furrow.

Discussion. This is the stratigraphically oldest species of *Diacalymene* from southern Norway. High convexity is a feature common to species of this genus but its extensive development in *D. gibberosa* serves to distinguish it from all other species of *Diacalymene*.

The locality from which all the material of *D. gibberosa* was collected is now covered by an industrial complex. Enough material is present in the collection however to adequatly describe the species.

D. gibberosa differs from *D. crassa* Shirley, 1936 (above) in possessing a far more convex glabella, a broader (tr.) anterior margin and a 1L and 2L of a more equal size. In addition 2L in *D. crassa* is divided from the median glabella by a shallow furrow not present in *D. gibberosa* where 2L and 3L merge with the median glabella lobe adaxially.

Family Cheiruridae Hawle & Corda, 1847

Subfamily Cheirurinae Hawle & Corda, 1847

Diagnosis. See Lane 1971, p. 11.

Genus **Hadromeros** Lane, 1971

Type species. By original designation *Cheirurus keisleyensis* Reed, 1896, p. 417, pl. 20, figs 7-9, from the Ordovician (Ashgill, Rawtheyan) of Northern England.

Diagnosis. See Lane 1971, p. 24 or 1982, p. 138.

Hadromeros elongatus (Reed, 1931). Pl. 26, figs 1-7, 9-13;
Text-figs 44, 47.

1931 *Cheirurus elongatus*, sp. n., Reed, p. 103, pl. 4, figs 5-7, pl. 5, fig. 4.

1971 *Hadromeros elongatus* (Reed, 1931); Lane, p. 28, pl. 5, figs 1-14, 16, 17 [includes full synonymy].

1971 *Hadromeros* cf. *H. elongatus* (Reed, 1935); Lane, p. 29, pl. 5, fig. 15.

1975 *Hadromeros elongatus* (Reed, 1935); Temple, p. 154, pl. 27, figs 5, 6, 8.

1982 *Hadromeros elongatus* (Reed, 1935); Howells, p. 25, pl. 7, figs 2-6.

v. *1982 Hadromeros* spp. indet, Lane, p. 139.

Lectotype. Selected by Lane (1971, p. 28, pl. 15, fig. 4), HM A1074, external mould pygidium, from Newlands Formation, Aeronian (*triangulatus* to *argenteus* Biozones) of Girvan, Ayrshire. Paralectotypes HM A1072-3, cranidia; HM A1075 hypostome, figured Lane 1971, pl. 5, figs 9, 7 and 8 respectively.

Material from Norway. Cranidia, PMO 110.809, locality 22, PMO 80458, locality 23, PMO 109.480, locality 32, PMO 109.478, -479, -483, PMO 109.809-811, PMO 110.800-804 locality 33; free cheek, PMO 110.807, locality 33; hypostomes, PMO 109.506, locality 20, PMO 80459, locality 23, PMO 85827, PMO 109.459, -496, PMO 110.793-799, -808, locality 33; pygidia, PMO 109.480, locality 32, PMO 109.507, PMO 110.791-792, locality 33.

Stratigraphic range. Solvik Formation (Kiær's étages 6b & 6c), Oslo and Asker districts, Rhuddanian to Aeronian (*atavus* to *convolutus* Biozones). Newlands Formation, Aeronian (*triangulatus* to *argenteus* Biozones), Girvan, Scotland. Haverford Mudstone Formation, Rhuddanian (*atavus* to *cyphus* Biozones), Wales.

Diagnosis. See Lane 1971, p. 28.

Description. See Lane 1971, p. 28.

Discussion. Hadromeros elongatus is known from Beds of Rhuddanian (mid *cyphus* Biozone) to Aeronian (*argenteus* Biozone) age of the Newlands Formation, Girvan, Scotland and from the Haverford Mudstone Formation, Rhuddanian (*atavus* to *acinaces* Biozones) of the Haverfordwest area, Wales. In Norway it is known from beds that range from Rhuddanian (*acuminatus* Biozone) to Aeronian (*argenteus* Biozone).

H. elongatus is most comparable with *H. clasoni* (Törnquist, 1905; see Warburg 1925, pl. 9, figs 1-9) from the Boda Limestone (Cautleyan to Rawtheyan) of Kallholn, Sweden. The Swedish species differs from *H. elongatus* by possessing a second pygidial axial ring which is deflected posteriorly medially and a broader second pair of pleural ribs.

Hadromeros? sp. A. Pl. 26, fig. 8; Text-fig. 44.

Material. Hypostome, PMO 54653, locality 29.

Stratigraphic range. Rytteråker Formation (Kiær's étage 7a), Holmestrand, Aeronian (lower *sedgwickii* Biozone).

Discussion. Without pygidia from this locality it is not possible to assign this specimen to a species; it is placed with doubt in *Hadromeros* because of its similarity to the hypostome of *H. elongatus* (Reed, 1931). This specimen differs from *H. elongatus* in possessing a much smaller posterior lobe of the middle body.

Hadromeros? sp. B. Pl. 27, fig. 1; Text-fig. 44.

Material. Hypostome, PMO 43242, locality 3.

Stratigraphic range. Rytteråker Formation (Kiær's étage 7a) Holmestrand, Aeronian (lower *sedgwickii* Biozone).

Discussion. This large hypostome is from a higher stratigraphic level than material herein assigned to *H. elongatus* (Reed, 1931). It cannot be assigned to a species without pygidia from the same locality and differs from *H. elongatus* (Reed, 1931) and *H.* sp. A (above) in possessing a more inflated anterior and less inflated posterior lobe of the median body and a surface sculpture of fine, closely packed, granules.

Subfamily Sphaeroxochinae Öpik, 1937

[emended Lane & Owens, 1982]

Diagnosis. See Lane 1971, p. 69.

Genus **Youngia** Lindström, 1885

Type species. By subsequent designation of Vogdes (1917, p. 115). *Cheirurus trispinosus* Young, 1868, p. 169, pl. 1, figs 4-6; from the Wood Burn Formation, Llandovery (Aeronian, *sedgwickii* Biozone), Penkill, Girvan, Scotland.

Diagnosis. See Lane 1982, p. 139.

Youngia aff. *Youngia globiceps* Lindström, 1885. Pl. 25, figs 9, 13; Text-fig. 44.

Material. Cranidia, PMO 82040, PMO 110.257, locality 9.

Stratigraphic range. Rytteråker Formation (Kiær's étage 7a), Asker district, Aeronian (lower *sedgwickii* Biozone).

Description. Glabella widest across 1L. Three pairs of glabellar furrows; abaxial end of 1S opposite mid point of palpebral lobe, terminating abruptly at adaxial end. 2L two-thirds as long as, and half as wide as 1L. 3L of similar depth to and parallel to 2L abaxially, adaxially deflected towards posterior and confluent with 2L. Occipital furrow broad well-incised. Occipital ring half length of 1L. Occipital spine with broad base. Surface sculpture of coarse granulation of irregular size and distribution.

Discussion. See *Y*. aff. *Y*. *inermis* below.

Youngia aff. *Youngia inermis* Lindström, 1885. Pl. 25, fig. 16; Text-fig. 44.

v. *1982 Youngia* sp., Lane, p. 139.

Material. Cranidium, PMO 110.093, locality 15.

Stratigraphic range. Vik Formation (Kiær's étage 7b), Asker district (*crispus* & *griestoniensis* Biozones).

Description. Glabella widest across 1L. Two pairs of lateral furrows preserved. 1S well-incised, shallowing gradually adaxially. 2S two-thirds as long as and parallel to 1S. Surface covered with large granules of irregular distribution. Occipital furrow broad and well-incised. Occipital ring half length of 1L. Occipital spine absent.

Discussion. These three specimens are from a similar horizon and lithology and are highly compressed and distorted making specific assignment impossible. The presence of an occipital spine is considered useful and is the chief basis for separating the two sets of material described above. Additionally the morphology of 1S differs in the two forms; it shallows gradually in *Y*. aff. *Y*. *inermis* and terminates abruptly in *Y*. aff. *Y*. *globiceps*.

Y. *globiceps* Lindström, 1885 (p. 50, pl. 13, fig. 11; see Ramsköld 1983, p. 200, pl. 26, figs 7, 10, 11), is known from the Upper Visby Formation, Wenlock (*centrifugus* & *murchisoni* Biozones) of Gotland, Sweden and is thus from a similar stratigraphic horizon to the Norwegian species which differs from the Swedish in possessing a longer 3S.

Y. inermis Lindström, 1885 (p. 50, pl. 13, fig. 12; see Ramsköld 1983, p. 201, pl. 26, fig. 14) is known from the Slite Group, Wenlock (*linnarssoni* to *lundgreni* Biozones) of Gotland, Sweden, a higher stratigraphic level than that from which the Norwegian material comes.

Family Encrinuridae Angelin, 1854

Subfamily Encrinurinae Angelin, 1854

Diagnosis. See Evitt & Tripp (1977, p. 121).

Genus **Encrinurus** Emmrich, 1844

(Synonyms *Cryptonymus* Eichwald, 1840; *Mitchellia* Vogdes, 1917 [non De Koninck, 1877]; *Mitchellaspis* Henningsmoen, 1959 [in Moore, 1959]; *Aristobeggia* Lamont, 1978; *Calgachia* Lamont, 1978; *Paracalgachia* Lamont, 1978; *Leitchia* Lamont, 1978; *Trippia* Lamont, 1978; *Paracalgachia* Lamont, 1978 [*fide* Strusz 1980, p. 17]. *Wallacia* Lamont, 1978 [*fide* Howells 1982, p. 27].

Type species. Subsequently designated (I.C.Z.N. 1959, opinion 537, p. 43); *Entomostracites punctatus* Wahlenberg, 1818, p. 32, pl. 2, fig 1; from the Wenlock (?Högklint Formation) of Gotland, Sweden.

Discussion. The attempts to define groupings at genus level amongst species referred to *Encrinurus* have been discussed by Holloway (1980, p. 45), Strusz (1980, p. 17), Howells (1982, p. 28).

Glabellar tubercle notation. Tripp (1962, 1972) first expressed the arrangement of encrinurid glabellar tubercles as formulae which he used in the diagnosis of species. His formulae were based on the position of all the glabellar tubercles in relation to the nearest glabellar lobes.

Strusz (1980, p. 3) observed that in species with many tubercles only the axial region possesses a regular arrangement. They subsequently altered the form of the formulae to take account of this and noted differences in the number, size and development of particular tubercles rather than in the overall pattern.

I believe that any conclusions based largely on glabellar tubercle notation should be treated with caution, firstly due to the considerable intraspecific variation shown by species of *Encrinurus* (see Best 1961, p. 1037; Howells 1982, text-fig. 3), and secondly I consider that in specimens possessing many tubercles the constraints of close packing may automatically produce a similar pattern amongst otherwise unrelated species.

Pygidial tubercle formulae. The system used here is that developed by Strusz (1980, p. 5) following work by Rosenstein (1941) and Best (1961) which revealed a degree of regularity in the position of axial tubercles. Best (1961, p. 1036) noted that the spacing of tubercles varied with sediment type, being closer in those specimens from carbonates compared to those from shales. Such variation, if intraspecific, would make the recognition of the same species from different sediments difficult, especially with relatively small samples. An attempt has been made here to assess the significance of the distribution of tubercles in Norwegian species of *Encrinurus.* The samples are small however and the specimens are from varying lithologies, so that results should not be regarded as conclusive.

Encrinurus punctatus (Wahlenberg, 1818). Pl. 27, figs 2, 4, 5, 7-9, 12-15; Text-figs 44, 47.

1818 *Entomostracites punctatus*, Wahlenberg, p. 32, pl. 2, fig. 1 (*non.* fig. 1) [*fide* Tripp 1962].

1962 *E. punctatus* Wahlenberg; Tripp, p. 461, pl. 66, figs

2-3; pl. 67, figs 5-8; pl. 68, figs 7, 8, 10. [Includes full synonymy].

Lectotype. By subsequent designation of Tripp & Whittard (1956, p. 259, pl. 3, figs 1, 2). PIU 1200, pygidium; figured Wahlenberg, 1821, pl. 2, fig. 1, from Högklint Formation?, Gotland, Sweden

Material from Norway. Cranidia, PMO 109.979, -982, -984, locality 19; free cheeks, PMO 109.997-999, locality 19; hypostomes, PMO 109.985, -991, -992, -996, locality 19; pygidia, PMO 54437, locality 16, PMO 109.558, -819, -980, 109.982-990, 109.993-995, locality 19, PMO 54426, PMO 110.829, locality 35.

Stratigraphic range. Skinnerbukta, Malmøya and Steinsfjorden Formations (Kiær's étages 8b to 9), Oslo and Holmestrand districts (*murchisoni* to *nassa* Biozones). Upper Visby Formation, Högklint Formation and Slite Group Sheinwoodian to Homerian (*centrifugus* to *lundgreni* Biozones), Gotland, Sweden.

Diagnosis. See Tripp 1962, p. 462.

Description. See Tripp 1962, p. 463.

Discussion. *E.* *punctatus* is known from the Upper Visby Formation, Högklint Formation and Slite Group (Sheinwoodian to Homerian, *centrifugus* to *lundgreni* Biozones) of Gotland Sweden and thus occurs at similar stratigraphic horizons in the two areas.

Henningsmoen (1959, p. O446, fig. 350.4) based his reconstruction of *E. punctatus* on material from "Llandovery shales" from Oslo. The illustration is not of sufficient quality to enable a specific assignment. However the apparently non mucronate pygidium and the stratigraphic information supplied indicate that the species illustrated by Henningsmoen was probably *E. mullochensis* (see below).

Tripp (1962) has compared *E. punctatus* with *E. macrourus* (Schmidt, 1859), *E. stubblefieldi* Tripp, 1962, and *E. deomenos* Tripp, 1962.

Encrinurus anthus sp. nov Pl. 27, figs 3, 6, 10, 11, 16, 17;
Pl. 28, figs 1-3, 10, 13, 17;
Text-figs 44.

(*Name*. Latin "anthus" a wagtail; referring to the pronounced pygidial mucronation).

Holotype. PMO 100.529, whole specimen, internal mould, Braksøya Formation (Kiær's étage 8a), opposite Garntangen Kiosk, Ringerike district; Pl. 27, fig. 16.

Paratypes. Whole specimens, PMO 110.045, -812, locality 6; cranidia, PMO 110.040-042, 813, locality 6, PMO 46453, locality 34; thorax plus pygidia; PMO 110.814-817, locality 6; pygidia, PMO 110.036-039, -046, locality 6, PMO 46088, -455, locality 34.

Stratigraphic range. Braksøya Format&n (Kiær's étage 8c & 8d), Ringerike district, Sheinwoodian (*centrifugus* to *murchisoni* Biozones).

Diagnosis. Glabella with randomly distributed "tubercles"; glabellar lobes large, semi-circular; 1L very weakly defined; preglabellar area with a single row of twelve to fourteen "tubercles", increasing in size abaxially. Pygidium mucronate; ten to eleven axial rings defined by transverse furrows, followed by a further four rings defined by transverse pairs of "tubercles" plus a posterior "tubercle" marking the termination of the axis; mucro slender, slightly upturned, four-fifths as long as axis.

Description. Cephalon half as long (sag.) as wide (tr.) across genal angles. Glabella half as wide (tr.) between 2L as long (sag.), widening gently to 3L then expanding to twice width across 2L by preglabellar area. Occipital ring two-fifths as long (sag.) as wide (tr.), narrowing abaxially. Occipital apodeme small, short (exsag.) and oval. Occipital furrow shallowing adaxially. 1L very small, of low convexity. 1S apodeme short (exsag.) well-defined and of similar form to 2S and 3S apodemes. 2L large with flat dorsal surface and of equivalent size and morphology to 3L and 4L. Fixed cheek subtriangular with randomly placed coarse "tubercles" behind eye. Posterior border furrow half as long (exsag.) as maximum sagittal length of occipital ring, lengthening slightly abaxially with short genal spine. Posterior border furrow broad, well-incised. Lateral border furrow well-defined, broadening anteriorly and posteriorly from mid point of free cheek.

Thorax of eleven segments. Axis one-third width (tr.) anteriormost segment. Axial segments narrowing abaxially. Ring furrows deeply-incised abaxially, shallowing adaxially. Pleurae widening abaxially. Pleural furrows deep and broad extending to near margin.

Pygidium twice as long (sag. including mucro) as wide (tr.). Axis with ring furrows expressed medially on internal mould, becoming faint medially on external mould. Eight pleural ribs increasingly posteriorly directed backwards, first two end in free points. Posterior pleural ribs fuse into a continuous lateral margin. Most posterior two pleural ribs fuse, with poorly-defined interpleural furrows abaxially which deepen markedly posteriorly.

Discussion. The development of a long pygidial mucro is a feature common to several species of *Encrinurus*. Pygidia of *E. anthus* display little variation in the length of the mucro which in some species can vary from being short to long e.g. *E. tuberculatus* (Buckland, 1836;

see Tripp 1962, p. 467, pl. 65, figs 5-8; pl. 67, figs 9, 10; pl. 68, figs 4-6) from the Much Wenlock Limestone Formation (*ludensis* Biozone) of Dudley, West Midlands). *E. tuberculatus* differs from *E. anthus* in possessing a regular pattern of glabellar "tuberculation", pygidial axial rings that are all defined by furrows and posterior pleural ribs that end in free points.

E. punctatus also occurs in southern Norway and possesses a mucronate pygidium. There is considerable intraspecific variation in the length of the mucro within the type specimens of this species and available specimens from Oslo all possess relatively short pygidial mucronations. *E. punctatus* also possesses a regular glabellar tuberculation unlike *E. anthus*.

Other species that develop a mucro of similar length to *E. anthus* include *E. deomenos* Tripp, 1962 (p. 473, pl. 67, figs 11-13; pl. 68, fig. 12) from the Jupiter Formation (Llandovery) of Anticosti Island, Canada, which possesses narrower pleural ribs than *E. anthus*, the most posterior of which end in free points.

E. macrourus Schmidt, 1859 (p. 438; see Tripp 1962, pl. 469, pl. 65, figs 1-4; pl. 66, fig. 1; pl. 67, figs 1-4; pl. 68, figs 1-3, 9) from the Lower Visby Formation (*crenulata* Biozone) to Hemse Group (*nilssoni* to *leintwardinensis* Biozone) of Gotland Sweden, possesses posterior pleural ribs which end in free points and are defined by better-incised interpleural furrows.

E. stubblefieldi Tripp, 1962 (p. 471, pl. 67, figs 14, 15; pl. 68, fig 11) from the Ludfordian (*leintwardinensis* Biozone), Whitcliff, Ludlow, Shropshire, possesses a narrower mucro and an axis which is better defined posteriorly.

E. onniensis Whittard, 1936 (see Tripp 1962, p. 471, pl. 67, fig. 16) from the Purple Shales, Aeronian to Telychian (*sedgwickii* to *crenulata* Biozones) of the Onny River section, Shropshire, possesses a proportionately shorter pygidium and more slender spine than the Norwegian species.

All the above species also differ from *E. anthus* in possessing a regular pattern of glabellar "tuberculation".

E. confusevarus Howells, 1982 (p. 33., pl. 8, figs, 19, 21, 22, 24, 29, 30) from the Lower Camregan Grits (lower to upper *sedgwickii* Biozones) of the Girvan district, Scotland possesses a random distribution of glabellar "tubercles" but has a non-mucronate pygidium.

Encrinurus mullochensis Reed, 1931. Pl. 28, figs 4-9, 11, 12, 14-16; Text-figs 37, 44.

1931 Encrinurus mullochensis nom. prop., Reed (pars), p. 19.

?. *1959 Encrinurus punctatus* Henningsmoen, fig. 350.4

1982 *Encrinurus mullochensis* Reed; Howells p. 28, pl. 7, figs 19-29 [Includes full synonymy].

v. *1982 Encrinurus mullochensis* Reed; Lane, p. 139.

Type material. Lectotype by designation of Howells (1982, p. 28, pl. 7, fig. 20) BM In23210, internal mould of complete specimen fig. 20) from the Wood Burn Formation (upper *sedgwickii* Biozone), Penkill Burn, Girvan, Scotland. Paralectotypes BM In23205, a complete specimen, and BM In23206, pygidium both from the same locality as holotype.

Material from Norway. Whole specimens, PMO 70597, locality 32, PMO 109.547, locality 33; Cranidia, PMO 110.048, locality 5, PMO 110.051, -061, -065, -079, 110.088-090, locality 9, PMO 109.910-912, -552, 109.554-557, PMO 110.134-138, -140, -142, -146, -150, -153, -155, -160, -161, locality 31, PMO 110.009, -818, -820, locality 32, PMO 110.021, -025, locality 33; free cheeks, PMO 110.094, locality 5, PMO 109.518, -549, -550, -564, PMO 110.123, -141, 110.156-160, locality 31, PMO 110.051, 110.081-082, -086, -089, locality 32, PMO 110.024, -026, -027, -029, -033, -035, -095, locality 33; hypostomes, PMO 109.508-514, locality 31, PMO 110.006, -010, -822, locality 32, PMO 110.005, locality 33; pygidia, PMO 110.052-058, -060, 110.062-064, 110.066-078, -080, 110.083-085, -087, locality 5, PMO 110.823, locality 20, PMO 42176, locality 22, PMO 51974, PMO 109.516, -511, -548, -551, -553, 109.560-563, PMO 110.043, -097, -098, -100, -103,

-104, 110.106-133, -144, -147, -148, -152, -159, locality 31, PMO 41750, PMO 110.000-002, -012, -020, locality 32, PMO 110.096, 110.030-032, 110.036-039, locality 33.

Stratigraphic range. Solvik and Rytteråker Formations (Kiær's étages 6b to 7a), Oslo and Asker districts (Rhuddanian & Aeronian, *acinaces* to *sedgwickii* Biozones). Mulloch Hill Formation (Aeronian, *sedgwickii* Biozone), Girvan area, Scotland.

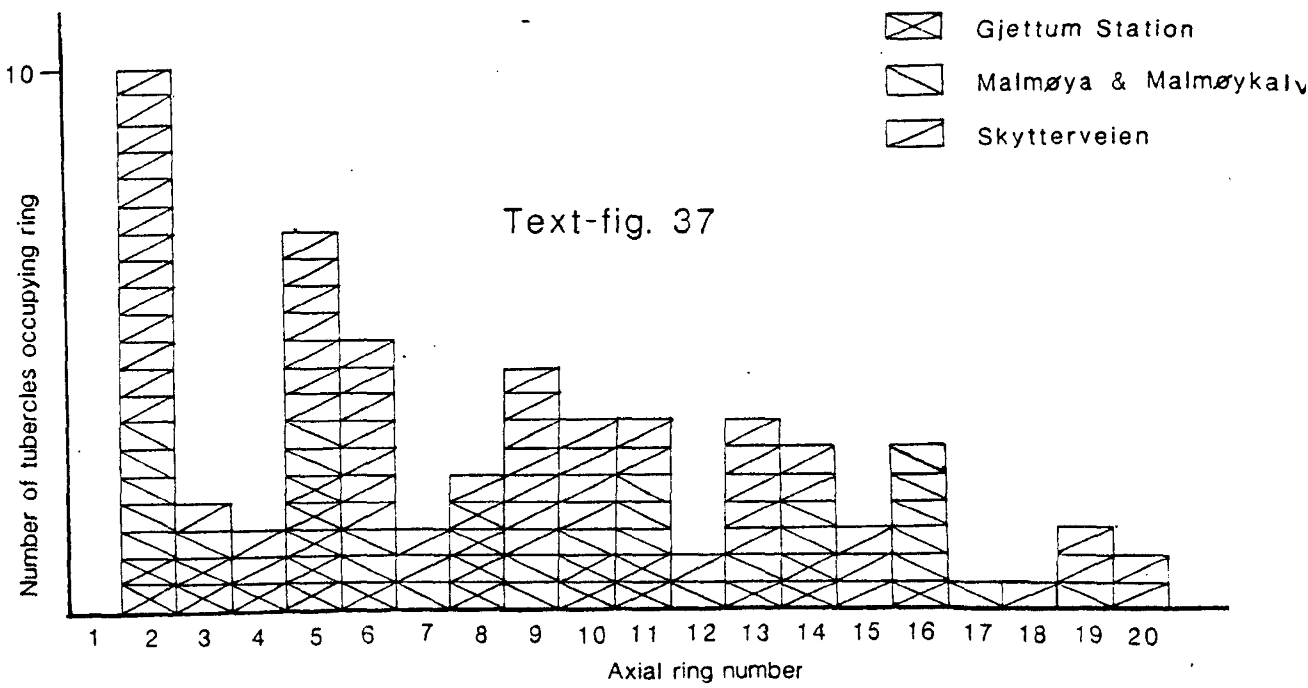
Diagnosis. See Howells, 1982, p. 28.

Description. See Howells, 1982, p. 28.

Generalized cranidial tubercle formula derived from Norwegian specimens of *E. mullochensis*; 1L-1. 2L-($0^{f}{}_{r}$), 3. 3L-(0), 1($^{f}{}_{r}$), $2^{f}{}_{r}$, 3(^{f}m), (4) (see appendix 16).

Generalized pygidial tubercle formula derived from Norwegian specimens of *E. mullochensis*; T^{1}_{2-3} (1-2), T^{2}_{5-7} (2-3), T^{3}_{9-11} (3-4), T^{4}_{11-16} (2-4), T^{5}_{16-20} (3-4), T^{21}_{6} (4).

(See Appendix 16 and Text-fig. 37)



Text-fig. 37

Histogram of tubercle distribution on axial rings of 28 specimens of *E. mullochensis* Reed, 1931 from loc. 9 (5 specimens), locs 22 & 32 (6 specimens) and loc. 31 (17 specimens).

Discussion. It appears likely that specimens used by Henningsmoen (1959, p. O446, fig. 350.4) in his reconstruction of *E. punctatus* belong to this species. The apparently non mucronate pygidium of Henningsmoen's reconstruction and his statement that the material is from "Llandovery shales" from Oslo would seem support this. Henningsmoen's illustration is not of sufficient quality however to allow a definite assignment to species and thus his work is included with doubt in the synonymy.

E. mullochensis is known from the Mulloch Hill Formation (*sedgwickii*) Biozone), of the Girvan area, Scotland. The Norwegian specimens therefore represent a downward extension of the range of *E. mullochensis*, occurring in beds belonging to the Solvik Formation (*acinaces* to *convolutus* Biozones) and Rytteråker Formation (*sedgwickii* Biozone). The features possessed by the Norwegian material that form the basis for an assignment to *E. mullochensis* are the cranidial tubercles occupying the positions 1-1, 2-0^{f}, 3-0, 1, the presence of ten to fourteen tubercles on the preglabellar area, the number and position of pygidial axial tubercles (see Howells 1982, p. 29 & Text-fig. 37) and the number of pleural ribs. The Norwegian specimens possess a slightly longer genal spine, better incised and longer 2S and 3S and a few more tubercles on the free cheek than those figured by Howells (1982). I do not consider these differences to be of specific significance.

E. mullochensis resembles several species allied to *E. variolaris* (Brongniart, 1822) by Tripp (1977) and several of the Scottish species described by Howells (1982).

E. variolaris (Brongniart, 1822; see Tripp 1977, p. 850, pl. 113) from the Coalbrookdale, Much Wenlock Limestone and Lower Elton Formations of the West Midlands and Shropshire (Sheinwoodian to Gorstian, *riccartonensis* to *nilssoni* Biozones) is distinguished from

E. mullochensis by its larger glabellar tubercles, and relatively smaller pygidium with fewer rings and pleural ribs.

I agree with Howells (1982, p. 32), who stated that *E. squarrosus* Howells, 1982 (p. 29, pl. 8, figs 1-16; text-figs 3-5) from the Mulloch Hill Formation (upper *sedgwickii* Biozone) of the Girvan area, Scotland differs from *E. mullochensis* in possessing a more tuberculate cranidium, a larger 1L, a tubercle in the ii-0 position, no genal spine on mature specimens, more axial rings and pleural ribs on the pygidium and smaller tubercles on the pygidial axis. In addition, pygidial axial tubercles in *E. squarrosus* occur most commonly on rings number three, six, ten, fourteen and nineteen whereas in *E. mullochensis* the most common tubercle sites are on rings numbers two, five, nine, thirteen or fourteen, sixteen and nineteen (compare Howells 1982, text-fig. 5 & Text-fig. 37).

E. rosensteinae Tripp, 1977 (p. 860, pl. 115, figs 1-13) from the Bringewood Formation, (Gorstian, *incipiens:tumescens* Biozone), Mortimer Forest, near Ludlow, Shropshire possesses a tubercle pair 1-1 which is smaller and closer together than that in *E. mullochensis*, and nine as opposed to seven or eight pleural ribs.

E. diabolus Tripp (1977, p. 858, pl. 11, figs 1-7) from the Purple Shales (Telychian) of Devil's Dingle, Shropshire, consistently possesses one fewer pair of glabellar tubercles in the position 3L-3, nine to ten tubercles on the preglabellar area (as opposed to ten to fourteen), thirteen to fifteen pygidial axial rings (as opposed to sixteen to nineteen) and fewer pleural ribs than *E. mullochensis*.

Family Phacopidae Hawle & Corda, 1847

Subfamily Phacopinae Hawle & Corda, 1847

Genus **Acernaspis** Campbell, 1967

(Synonyms: *Eskaspis* Clarkson, Eldredge & Henry, 1977
Murphycops Lésperance, 1968 [*fide* Howells 1982])

Type species. By original designation of Billings (1860, p. 60) *Phacops orestes* from the Jupiter and Gun River Formations (early Llandovery) of Anticosti Island, Canada.

Diagnosis. See Campbell 1967, p. 32.

Acernaspis elliptifrons (Esmark, 1833). Pl. 36, figs 4-12; Pl. 37, figs 1-3, 5, 6, 8, 10-19; Pl. 38, figs 1, 8, 11; Text-figs 39, 40, 44, 49.

1833 *Trilobites elliptifrons*, Esmark, p. 269, pl. 7, figs 6, 7.
1859 *Trilobites (Proetus?) elliptifrons* Esmark; Murchison, p. 370.
1927 *Phacops elliptifrons* Esmark; Kummerow, p. 16, pl. 1, figs 9a,b.
v* 1940 *Phacops elliptifrons* (Esmark); Størmer, p. 122, text-fig. 2, figs 6, 7 [=pl. 7, figs 6, 7 of Esmark, 1833], pl. 1,

figs 2-4.

v 1967 *Acernaspis (Acernaspis) elliptifrons* (Esmark); Campbell, p. 32, pl. 12, fig. 5.

?. 1972 *Phacops (Acernaspis)* cf. *elliptifrons* (Esmark); Schrank, p. 49, pl. 14, fig. 8, pl. 15, figs 1, 2.

. 1981 *Acernaspis (subgenus?)* n. sp. Lésperance & Letendre, p. 199, pl. 3, figs 9-12.

. 1982 *Acernaspis* cf. *elliptifrons* (Esmark); Howells, p. 44, pl. 11, figs 18-23, 25, 26.

v *1982 Acernaspis (Acernaspis) elliptifrons* (Esmark); Siveter, p. 141.

v. *1982 Acernaspis (Acernaspis?)* sp., Siveter, p. 141.

Neotype. By designation of Størmer (1940, p. 123) PMO 20966, enrolled specimen, external mould; Pl. 36, fig. 10; Solvik Formation, Kiær's étage 6 (Rhuddanian to Aeronian, *atavus* to *convolutus* Biozones), Malmøykalven, Oslo district.

Other material. Whole specimens, PMO 41532, -535, PMO 88671, -673, locality 21, PMO 110.182, locality 31, PMO 21256, -257, PMO 41448, -536, -537, -599, -566, PMO 56011, PMO 70595, -596, PMO 88666, -667, locality 32, PMO 112.682, -747, -769, -773, locality 33; cephala, PMO 88672, locality 21, PMO 52445-447, PMO 112.666, 112.744-746, locality 31, PMO 89473, PMO 112.173, -597, locality 32; cephalic doublures, PMO 112.473-478, PMO 112.495-497, 112.499-501, -595, -596, locality 12, PMO 112.208, locality 20, PMO 110.868-872, PMO 112.466-470, -479, -545, -546, -631, locality 31, PMO 112.502, locality 32, PMO 112.719, -721, -742, locality 33; cranidia, PMO 112.213, -216, 112.221-230, -260, -262, -329, -330, 112.356-365, 112.389-406, -462-465, -472, -486, -489, -494, -498, 112.503-500, -577, -594, -498, 112.503-500, -577, -594, 112.634-653, -789, -799, -811, -812, locality 12, PMO

112.174-197, locality 20, PMO 112.662-664, locality 21, PMO 43587, PMO 112.756-762, locality 22, PMO 21257, PMO 105.705, PMO 110.105, 110.862-865, 110.881-899, PMO 112.162-165, 112.171-172, 112.210-212, -214, -215, 112.217-220, -267, 112.308-328, 112.367-387, 112.433-447, -481, -482, 112.530-544, 112.611-627, locality 31, PMO S2430, PMO 43032, PMO 112.503-509, -812, locality 32, PMO 112.169, -170, 112.667-681, 112.722-741, -743, -748, locality 33; free cheeks, PMO 112.410, -810, locality 12, PMO 112.205, -206, locality 20, PMO 110.877, PMO 112.167, -409, 112.628-630, locality 31; hypostomes, PMO 109.505, PMO 110.866, -867, locality 31, PMO 112.665, locality 33; pygidia, PMO 112.231, -259, -261, -263, 112.329-354, -366, -407, -408, -450-461, -487, -488, 112.490-493, -547, -576, 112.654-658, 112.800-808, locality 12, PMO 112.198-204, -207, locality 20, PMO 112.659, -660, locality 21, PMO 112.749-755, locality 22, PMO 110.872-876, 110.878-880, -890, PMO 112.166, 112.264-266, 112.268-281, 112.283-307, -388, 112.412-432, -448, -449, -471, 112.483-485, 112.512-529, 112.598-610, -628, locality 31, PMO 112.510, -511, locality 32, PMO 112.699-700, -716, -717, locality 33.

Stratigraphic range. Solvik and Saelabonn Formations (Kiær's étages 6b & 6c), Oslo, Asker and Ringerike districts, Rhuddanian to Aeronian (*atavus* to *convolutus* Biozones). Mulloch Hill Formation (Aeronian, *atavus* to *cyphus* Biozones), Girvan, Scotland.

Diagnosis (see Text-fig. 39). A species of *Acernaspis* with glabella rounded to slightly angular anteriorly; 1S well-incised, almost reaching sagittal line; 2S and 3S deeply-impressed; intercalating ring slightly raised above posterior of glabella; glabellar auxilliary impressions forming two areas of rounded invaginations (see Text-fig. 40) less well-defined on external than on internal moulds; eye with fifteen files of lenses with a general lens formula of 455 565 555 554 454, maximum of six lenses per file, total 68; genal spine well-developed on external mould, less well-developed on internal; cephalic doublure with continuous well-defined vincular furrow and a upwardly-flexed posterior area with a weakly convex area between them; vincular furrow with seven or eight notches. Posterior border of hypostome well-defined, one-tenth length of median body (sag.) and with weak transverse furrow at half length (sag.). Pygidial axis strongly convex with seven rings.

Description. Cephalon twice as wide (tr.) as long (sag.). Minimum glabellar width (tr.) across 1L two-thirds maximum anterior width. Posterior of glabella slightly higher than palpebral lobe in longitudinal view, sloping gently from intercalating ring to posterior portion of 3S then steepening to become nearly vertical anteriorly. Preglabellar area very short, without furrow and continuing slope of glabella. 1S broad, shallow adaxially and almost reaching axial furrow. 2S transversely arranged, not reaching axial furrow. Proximal portion of 3S slightly convex forwards, almost reaching axial furrow; distal portion at about 45° to an exsagittal line, reaching axial furrow immediately anterior to palpebral lobe. Intercalating ring merges medially with glabella. Axial furrow broad and deep, diverging anteriorly at 20° to an exsagittal line. Occipital furrow straight, narrow and shallow on external, deep and broad on internal moulds. Occipital ring highly convex, rising above posterior of glabella. Palpebral lobe slightly inflated, extends from distal branch of 3S to occipital furrow, with well-defined palpebral furrow and convex rim. Posterior border short (exsag.) and highly convex adaxially, doubling in length and becoming less convex abaxially. Posterior border furrow becoming progressively wider and shallower abaxially. Free cheek triangular, sloping steeply below visual surface. Dorsal surface of cephalon excluding auxilliary impressions without sculpture. Cephalic doublure one-third cephalic length (sag.). Vincular notches becoming more elongate and more separated anteriorly.

Hypostome as wide as long, anterior margin curving forwards and extended laterally into a short wing. Posterior margin rounded, posterior border narrowing anterolaterally. Middle body convex, middle furrow indistinct; maculae small and oval, situated at half length (sag.) close to lateral margin. Surface sculpture of closely packed fine granules.

Thorax of eleven segments. Axis one-third width (tr.). Axial ring four times wider (tr.) than long (sag.). Articulating half ring same width (tr.) as axial ring. Axial ring furrow shallow. Pleura five times wider (tr.) than long (exsag.), almost parallel-sided. Pleural furrow deep and broad abaxially, narrowing and directed posteriorly adaxially.

Pygidium three-quarters as long (sag.) as wide (tr.). Pygidial axis not reaching posterior margin, narrowing slightly and bluntly rounded posteriorly. Axial rings well-defined anteriorly, posterior four not defined medially. Pleural field with four ribs, the most anterior being well-defined and narrow, the posterior three ribs developed on internal mould only where they are poorly-defined and become less well-defined posteriorly. Interpleural furrows not reaching margin. Pleural furrows broad, very faint and as long as interpleural on internal and external mould.

Discussion. This is the most common trilobite species from the Silurian of the Oslo region; over 550 specimens were collected by the author. It typifies the upper Rhuddanian to Aeronian (Kiær's étages 6b & 6c) being most common in the latter. Esmark's holotype specimen is lost but Størmer's neotype is available for study (PMO 20966, Pl. 36, fig 10). Collections were made from both Kiær's étage 6 of Malmøya (Esmark's type locality) and the equivalent beds on the closely neighbouring island of Malmøykalven (from which the neotype was collected).

I consider specimens referred to as *A.* cf. *A. elliptifrons* by Howells (1982, p. 44, pl. 11, figs 18-23, 25, 26) from the Mulloch Hill Formation, Llandovery (*atavus* to *cyphus* Biozones) of Girvan to be indistinguishable from Norwegian material and place them in *A. elliptifrons*. Howells referred these specimens to *A.* cf. *A. elliptifrons* on the basis of their slightly longer (exsag.) eye which I do not consider to be of sufficient magnitude to warrant separating the two sets of specimens.

Phacops (Acernaspis) cf. *A. elliptifrons* of Schrank (1972, p. 49, pl. 14, fig. 8, pl. 15, figs 1, 2) from erratic boulders of Llandovery age, from Czechoslovakia is placed in *A. elliptifrons* with doubt due to the apparently less convex cranidium and larger 1L. More material is required especially of the cephalic doublure, not figured by Schrank, before a more definite opinion can be advanced.

I agree with Howells (1982, p. 44) that specimens of "*Phacops elliptifrons*" from the Purple Shales, Llandovery (Telychian) of Shropshire described and figured by Whittard (1938, p. 127, pl. 5, figs 9, 10) do not belong to this species. This decision is based on the less convex glabella, shallower 3S, more rounded anterior glabellar margin and broader shorter pygidium of the Shropshire specimens.

Several authors have referred specimens to *A. elliptifrons* without reference to the type material and no description of material from Norway has been published since Størmer's (1940) work. Campbell (1967, p. 32, pl. 12, fig. 5), in erecting *Acernaspis*, refigured Størmer's neotype (referring to it as the lectotype) but did not discuss it in relation to the type species or other members of the genus. *A. elliptifrons* differs from the type species of *Acernaspis*, *A. orestes* (Billings, 1860), from the Jupiter and Gun River Formations (early Llandovery), of Anticosti Island, Canada in possessing a lower glabellar convexity, larger intercalating ring, shorter less well-incised 1S and a pygidial axis of higher convexity.

A. elliptifrons very closely resembles species of the genus from the Girvan region of Scotland: *A. superciliexcelsis* Howells, 1982 (p. 40, pl. 10, figs 17-24; pl. 11, figs 1-11, 13; text-figs 7, 8) from the Newlands Formation (Aeronian, *triangulatus* to *argenteus* Biozones) differs from *A. elliptifrons* in possessing a less convex intercalating ring, a visual surface with sixteen to seventeen files of lenses (as opposed to fifteen) with a maximum of five lenses per file (as opposed to six) and a total of 65 lenses (as opposed to 68), and a less convex and broader pygidial axis than *A. elliptifrons*. *A. xynon* Howells, 1982 (p. 43, pl. 11, figs 12, 14-17; text-fig. 9) from the Woodland Formation (Rhuddanian, *cyphus* Biozone) possesses a broader, shorter, less convex pygidial axis. *A. woodburnensis* Clarkson, Eldridge & Henry, 1977 (p. 44, pl. 11, fig. 24; pl 12, figs 1-3; text-fig. 10) from the Wood Burn Formation (Aeronian, *magnus* to *convolutus* Biozones) possesses a shorter 1S, smaller 1L and much longer pygidial axis than does *A. elliptifrons*.

A. sufferta (Lamont, 1849; see Howells 1982, p. 43, pl. 12, figs 4, 5) from the Wether Law Linn Formation (mid Telychian or a little younger) of the Pentland Hills, Scotland, is differentiated from *A. elliptifrons* by possessing no furrow joining the subfrontal depressions and vincular notches.

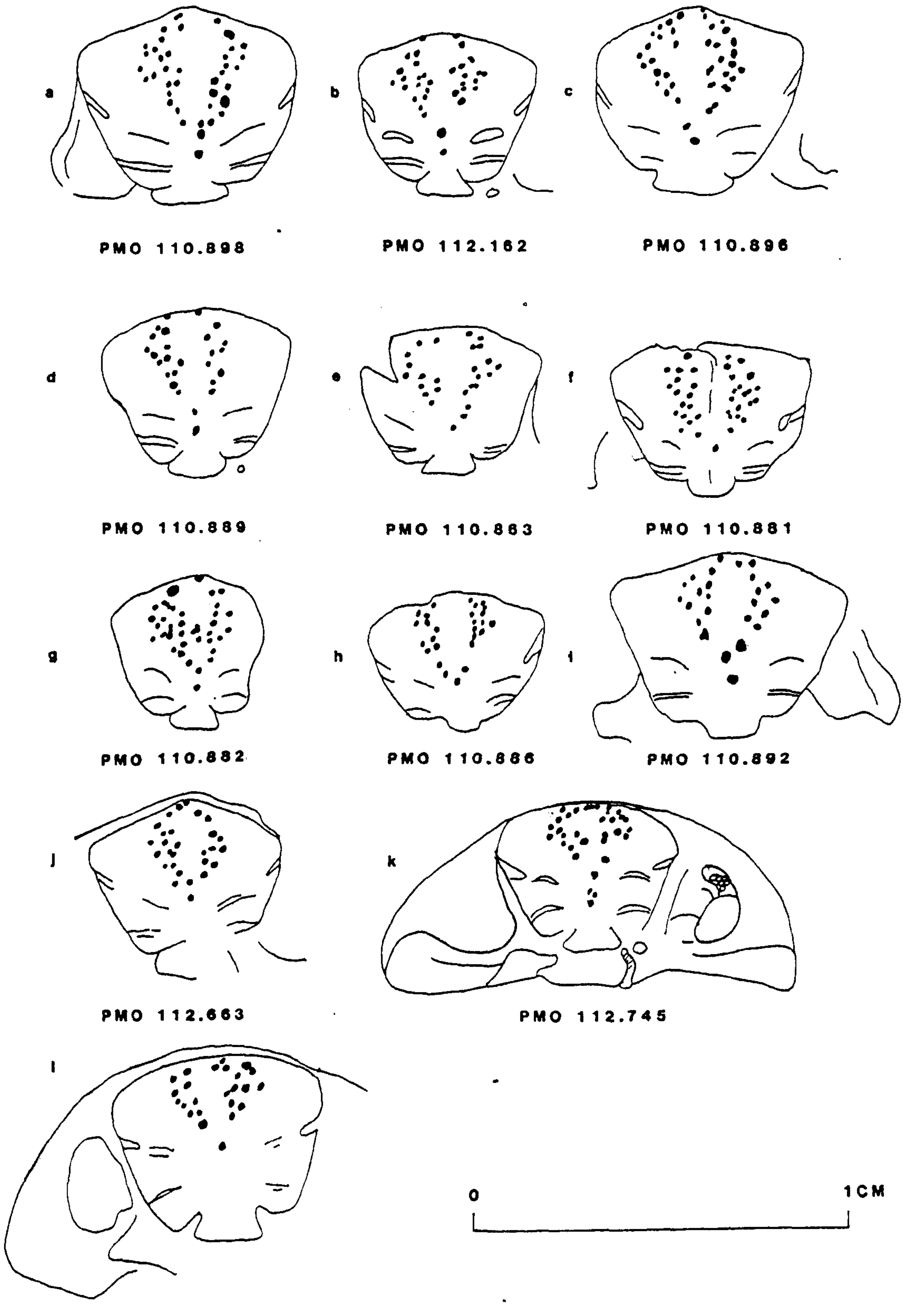
Temple (1970, p. 68, pl. 18, figs 10-12, 21) figured specimens as *Acernaspis* sp. from beds belonging to the *atavus* to *cyphus* Biozones of Fridd, Meifod, Powys, Wales that he compared to *A. elliptifrons*. The Welsh specimens apparently differ from the Norwegian in possessing a narrower and more deeply incised 1S on internal mould,

	Convexity of intercalating ring	Auxilliary cranidial impressions	No. of files in eye	Max. no. lenses per file	Vincular furrow	Pygidial axial convexity	No. of pygidial axial rings
A. elliptifrons	moderate	two areas	18	7	well defined continuous	high	7
A. labronios	low	two	15-16	6	not present	high	8
A. phyxis	low	one	15-16	7	shallow continuous	low	8
A. sp. A	V. low	one	?	?	V. well defined	high	?
A. sp. B	V. low	?	?	?	?	?	?
A. sp. C	?	?	?	?	?	high	7

Text-fig 39

Summary of the diagnostic features of *Acernaspis* species described herein

Text-fig. 40



Text-fig. 40.

Position of glabellar auxilliary impressions, in dorsal view, on cranidia of *Acernaspis elliptifrons* Esmark, 1833. All from internal moulds.

a-i = loc. 31.

j = loc. 21.

k-l = loc. 33.

and a pygidial axis which narrows more posteriorly. Comparison is hampered however by the relatively poor preservation of the Welsh specimens.

Acernaspis labronios sp. nov. Pl. 38, figs 10, 13, 14; Pl. 39, figs 1-4, 6, 7, 11, 13, 16, 21, 22; Text-figs 39, 44.

(Name. Latin "labronios" a cup; alluding to the shape of the glabella and occipital ring in dorsal view).

Holotype. Whole specimen, PMO 112.819, Pl. 39, fig. 1; Braksøya Formation, Kiær's étage 8c (Sheinwoodian, *murchisoni* & *riccartonensis* Biozones) Garntangen, Ringerike district.

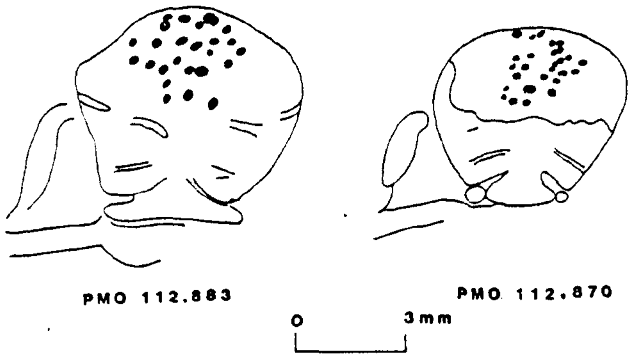
Paratypes. Whole specimens, PMO 100.530, -538, PMO 109.051, -052, PMO 113.813-817, -821, locality 6, PMO 45950, PMO 46199, locality 34; cephalon, PMO 46117, locality 34; cranidia, PMO 100.539, PMO 113.822-828, -843, locality 6, PMO 45967, PMO 46048, -049, -051, PMO 46117, -120, locality 34; cephalic doublures, 112.822, -830, locality 6; free cheeks, PMO 112.844-854, locality 6; thoracic segments, PMO 112.830-835, locality 6; pygidium & thorax, PMO 112.814, locality 6; pygidia, 112.836-842, -861, -869, -890, locality 6, PMO 21529, PMO 40100, PMO 46118, -225, PMO 49662, -663, locality 34.

Stratigraphic range. Bruflat and Braksøya Formations (Kiær's étage 8), Ringerike district, Telychian to Sheinwoodian (*crenulata* to *murchisoni* Biozones).

Diagnosis (see Text-fig. 39). A species of *Acernaspis* with intercalating ring of low convexity; vincular furrow discontinuous anteriorly, eye large with fifteen to sixteen files with a general lens formula of 455 566 566 454 544 ?, a maximum of six lenses to a file, total 74. Pygidial axis convex with eight rings.

Description. In overall morphology *A. labronios* is close to *A. elliptifrons*. The characters in the diagnosis serve to distinguish the two species (see Text-fig. 39).

Discussion. This species most closely resembles *A. sufferta* (Lamont, 1948; see Howells 1982, p. 43, figs 4, 5) from the Wether Law Lynn Formation (*cyphus* Biozone) of the Pentland Hills, Scotland. The Norwegian material is from a higher stratigraphic horizon than the Scottish - latest Telychian to early Sheinwoodian (*crenulata* to *centrifugus* Biozones) and is differentiated by possessing fewer files of lenses in the eye, a less incurved genal angle, less well-defined subfrontal depressions and a strongly upturned posterior margin to the cephalic doublure.



Text-fig. 41.

Distribution of glabellar auxilliary impressions, in dorsal view, on cranidia of *Acernaspis phyxis* sp. nov. from loc. 28. Both from internal moulds.

(See overleaf).

Acernaspis phyxis sp. nov. Pl. 37, figs 4, 9; Pl. 39, fig. 5, 8, 9, 12, 14, 15, 17, 18, 20, 23; Text-figs 39, 41, 44.

(Name; Greek "phyxis" escape; referring to the loss of the type locality due to the building of an industrial complex).

Holotype. Cranidium, PMO 112.880, Pl. 39, fig. 17; Solvik Formation, Kiær's étage 6a (Rhuddanian, *persculptus* to *acuminatus* Biozones), Sjursøya, Oslo district.

Paratypes. Cranidia, PMO 112.870-873, -874, -882, -883; cephalic doublure, PMO 112.877; pygidia, PMO 112.874, -875, -876, -881.

Stratigraphic range. This species is only known from the type locality.

Diagnosis (see Text-fig. 39). A species of *Acernaspis* of low convexity; intercalating ring of same convexity as glabella; visual surface with fifteen or sixteen files of lenses, maximum of seven lenses per file; well-developed genal spine; proximal branch of 3S short very weakly incised; glabellar auxilliary impressions forming one area; cephalic doublure with very shallow continuous furrow. Pygidial axis of very low convexity with up to eight axial rings and a very short terminal piece on external mould.

Description. Cephalon half as long (sag.) as wide (tr.). Glabella doubling in width forwards from 1S to anterolateral corner. Preglabellar furrow very shallow. Preglabellar field very short sagittally becoming slightly longer abaxially. Axial furrow well-incised, of constant depth and width (tr.). 1S shallow, very short, anteromedially directed at 5° to a transverse line. 2S a straight line, parallel to 1S, reaching axial furrow. Distal branch of 3S very weakly-incised, directed at 45° to a transverse line, widening adaxially. 1L large, circular. Occipital ring raised above level of glabella with occipital lobes defined as notches behind 1L. Occipital furrow broad, well-incised. Posterior border weakly convex adaxially one-third sagittal length of occipital ring, broadening and becoming less convex abaxially. Posterior border furrow well-incised and narrow, extending three-quarters width (tr.) of posterior portion of fixed cheek, then shallowing and terminating abruptly. Genal spine slender, directed at 20-30° to an exsagittal line. Fixed cheek of low convexity. Palpebral lobe with highly convex, well-defined rim extending from opposite mid point of 1L to opposite posterior end of 3S. Lateral border wide, of low convexity. Cephalic doublure extending one-third cephalic length (sag.). Vincular notches oval.

Pygidium twice as wide (tr.) as long (sag.). Axis one-third width (tr.) at anterior margin narrowing to less than half that width by last ring. Eight axial rings. Anterior four well-defined, posterior four not defined medially; anterior two ring furrows markedly broader than posterior furrows. Five pairs of very weakly-defined pleural ribs become fainter posteriorly. Interpleural furrows more deeply incised than pleural.

Entire dorsal surface with the exception of furrows, visual surface and auxilliary impressions with sculpture of fine granulation.

Discussion. The species of *Acernaspis* that most closely resembles *A. phyxis* is *A. xynon* Howells, 1982 (p. 43, pl. 11, figs 14-17, text-fig. 9) from the Woodland Formation, Aeronian (*cyphus* Biozone) of the Girvan district, Scotland. The Scottish species possesses a maximum of six (as opposed to seven) lenses per file on the visual surface, an intercalating ring of higher convexity, a better defined vincular furrow and better defined pygidial pleural furrows than the Norwegian species.

A. phyxis is distinguished from *A. elliptifrons* by possessing glabellar auxilliary impressions that form one (as opposed to two) areas, an intercalating ring of lower convexity, 15 to 16 (as opposed to 18) files of lenses on the visual surface, a shallower vincular furrow and a pygidial axis with eight (as opposed to seven) axial rings.

A. labronios is differentiated from *A. phyxis* on the basis of its discontinuous vincular furrow anteriorly and pygidial axis of higher convexity.

Acernaspis sp. A. Pl. 37, fig. 7; Text-figs 39, 44.

Material. Whole specimen, PMO 21405, -406 (counterparts), locality 35; cranidium, PMO 47220, Malmøya Formation (Kiær's étage 8c), locality unknown.

Stratigraphic range. Malmøya Formation (Kiær's étage 8c), Oslo district, Sheinwoodian (*rigidus* Biozone).

Discussion. This form most closely resembles *A. elliptifrons.* It differs in possessing the following characters; glabella narrower and more elongate, with its auxilliary impressions in one area, intercalating ring of lower convexity, vincular furrow deeper and broader, posterior margin of cephalic doublure not upwardly flexed, pygidial axis longer and narrowing more posteriorly. Specimen PMO 21405 is from the same locality and horizon as *Eophacops euthymos* (see below) from which it is readily distinguished in lacking a sagittal carina posteriorly, possessing a far narrower glabella anteriorly and a vincular furrow.

It is probable that this material represents a new species but more material is required to confirm this.

Acernaspis sp. B. Pl. 39, fig. 19; Text-figs 39, 44.

Material. Cranidium, PMO 54821, Rytteråker Formation (Kiær's étage 7a), Holmestrand district, Aeronian (lower *sedgwickii* Biozone).

Discussion. This specimen most closely resembles *A. woodburnensis* Clarkson, Eldredge & Henry, 1977 (p. 132, pl. 19, figs 11-13; text-fig. 5) from the Woodburn Formation (upper *sedgwickii* Biozone), of Girvan, Scotland differing in possessing more deeply incised glabellar furrows and a less convex intercalating ring. It is differentiated from *A. elliptifrons* in possessing a longer, more anteriorly directed 1S, much more deeply incised 2S and 3S, a very highly depressed intercalating ring and a palpebral lobe with a much narrower rim.

The specimen is damaged anteriorly but differs from *A.* sp. A in possessing deeper glabellar furrows and a broader glabella anteriorly.

Acernaspis sp. C. Pl. 38, fig. 5; Text-fig. 39, 44.

Material. Pygidia, PMO 42842, -843, locality 36, Rytteråker Formation (Kiær's étage 7a), Oslo district, Aeronian (lower *sedgwickii* Biozone).

Discussion. The most closely comparable form to this material is *Acernaspis* sp. A which appears to have less well-defined pygidial pleural furrows. The pygidium of *A.* sp. A is poorly preserved however and I consider it best to keep the two sets of specimens separate. These pygidia differ from that of *A. elliptifrons* in possessing a pygidial axis which narrows more posteriorly and pygidial pleural furrows which are more deeply incised. They are differentiated from *A. labronios* in possessing a more convex axis with seven (as opposed to eight) axial rings.

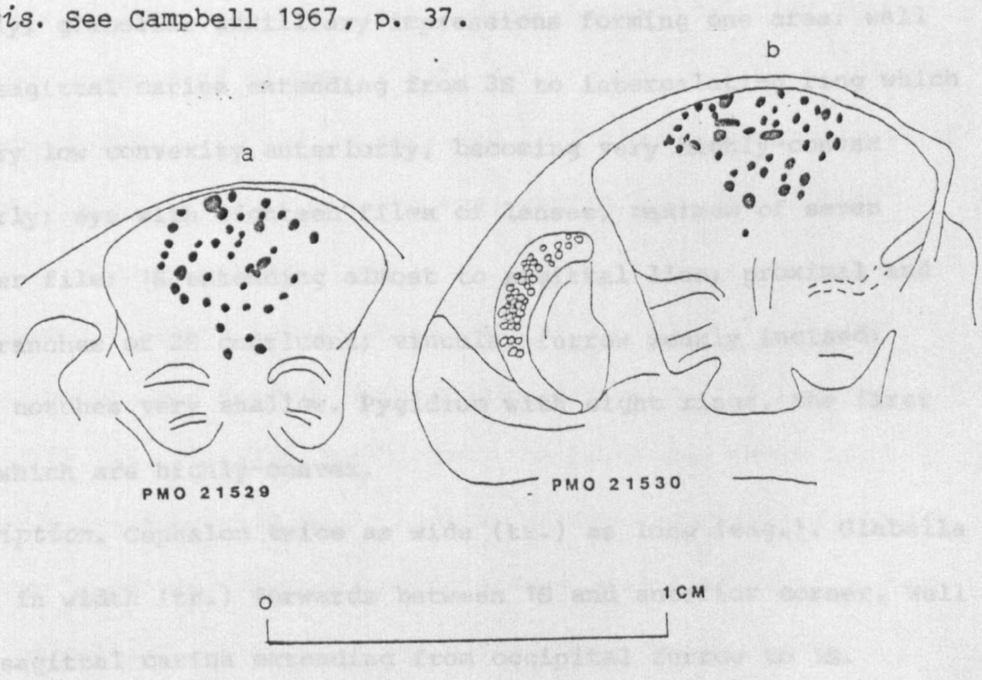
Subfamily Phacopidellinae Delo, 1935

Genus *Eophacops* Delo, 1935

(Junior subjective synonyms; *Glokeria* Wedekind, 1911 [*fide* Campbell 1967, p. 38], *Bullicephalus* Přibyl & Vaněk, 1971 [*fide* Chlupáč 1977, p. 22]).

Type species. *Phacops handwerki* Weller, 1907 (p. 271, pl. 24, figs 6-7; see Campbell 1967, pl. 12, figs 9-13) from the Niagaran dolomites at the Chicago Drainage Canal, Lemont, Illinois (probably late Wenlock but possibly early Ludlow).

Diagnosis. See Campbell 1967, p. 37.



Text-fig. 42.

Postition of glabellar auxilliary impressions, in dorsal view, on cranidia of *Eophacops euthymos* sp. nov. a = loc. 19, b = loc. 35.

(See overleaf).

Eophacops euthymos sp. nov. Pl. 38, figs 2-4, 6, 7, 9, 12, 15; Text-figs 42, 44.

(Name. Greek "euthymos" cheerful; pertaining to the fancied resemblence of the anterior border furrow to a smiling mouth in anterior view).

Holotype. Cephalon, PMO 50006; Pl. 38, fig. 15; Steinsfjorden Formation; Kiær's étage 9b (Sheinwoodian, *ellesae* Biozone), Langøya, Holmestrand district.

Paratypes. Cephala, PMO 21259, -531 (counterparts), PMO 50600, -647, -648, locality 19, PMO 21530, locality 35; pygidia, PMO 50644, -645, locality 19.

Stratigraphic range. Malmøya and Steinsfjorden Formations (Kiær's étages 8c & 9b respectively), Oslo and Holmestrand districts, Sheinwoodian (*rigidus* to *ellesae* Biozones).

Diagnosis. A species of *Eophacops* with glabella widening greatly anteriorly; glabellar auxilliary impressions forming one area; well defined sagittal carina extending from 3S to intercalating ring which is of very low convexity anteriorly, becoming very highly-convex posteriorly; eye with eighteen files of lenses, maximum of seven lenses per file; 1S extending almost to sagittal line; proximal and distal branches of 3S confluent; vincular furrow weakly incised; vincular notches very shallow. Pygidium with eight rings, the first five of which are highly-convex.

Description. Cephalon twice as wide (tr.) as long (sag.). Glabella doubling in width (tr.) forwards between 1S and anterior corner. Well defined sagittal carina extending from occipital furrow to 3S. Longitudinal furrows defining flanks of carina confluent with 2S and 3S. Proximal branch of 3S slightly independently incised. Distal branch of 3S reaching axial furrow to anterior of palpebral lobe.

Occipital furrow broad, well-incised. Occipital ring of low convexity, below posterior level of intercalating ring. Axial furrow very deep and broad anteriorly shallowing greatly opposite mid point of palpebral lobe, deepening again to reach half anterior depth by posterior margin. Palpebral lobe half length of glabella. Anterior border furrow well-incised, broadening abaxially. Anterior border very convex. Lateral border furrow very broad, undercutting visual surface. Posterior border furrow broad and shallow abaxially deepening and narrowing adaxially. Posterior border of very high convexity adaxially, becoming less convex and broader abaxially. Cephalic doublure a little less than one-third length (sag.) of cephalon. Subfrontal depressions as shallow flattened areas immediately posterior of anterior margin. Posterior margin of doublure strongly upturned.

Pygidium twice as wide (tr.) as long (sag.). Eight axial rings the posterior four of which are not defined medially. Five pairs of pleural ribs of low convexity. Interpleural furrows slightly better incised and longer than pleural.

Discussion. This material is assigned to *Eophacops* on the basis of its low cranidial convexity and the very weakly defined vincular notches.

E. euthymos differs from the type species *E. handwerki* (Weller, 1907; see above), and from *E. trapiziceps* (Barrande, 1852; see Campbell 1967, pl. 12, figs 14-18) from the Liten and Kopanina formations (late Wenlock & early Ludlow) of Czechoslovakia in being more convex in lateral view and possessing a glabella which is more expanded anteriorly with a sagittal carina posteriorly, better defined 2S and 3S glabellar furrows and posteriorly more convex intercalating ring. In addition *E. trapiziceps* possesses two areas of auxilliary glabellar impressions and a broader pygidial axis (tr.)

than *E. euthymos.*

E. bulliceps (Barrande, 1846a, p. 46; see Chlupáč 1977, p. 25, pl. 3, figs 1-15) from the Kopanina Formation (Ludlow) of Czechoslovakia is differentiated from *E. euthymos* by possessing a cranidium of lower convexity, two areas of invaginations, a narrower intercalating ring, lacks a sagittal cranidial carina and possesses five (as opposed to seven or eight) pygidial axial rings.

E. alter Chlupáč, 1977 (p. 27, pl. 3, figs 16-28) from the uppermost Liten or lowermost Kopanina Formations (late Wenlock & early Ludlow) of Kozolupy, Czechoslovakia possesses a 3S the proximal and distal portions of which are confluent in some specimens. This is a feature displayed by some specimens of *E. euthymos* but which also varies (compare Pl. 38, figs 2, 12). The glabella of the Czechoslovakian species expands less anteriorly and lacks the sagittal carina of the Norwegian form.

E. fontana Holloway, 1980 (p. 64, pl. 17, figs 1-15; text-fig. 10) from the St Clair Limestone, Wenlock, Arkansas, U.S.A. differs from *E. euthymos* in possessing a more convex glabella anteriorly with two areas of auxilliary impressions, a less convex intercalating ring, shallower 1S and 2S and a better incised vincular furrow. The American species does not possess the sagittal glabellar carina which is diagnostic of *E. euthymos.*

Eophacops aff. *E. euthymos* sp. nov. Pl. 39, fig. 10; Text-fig. 44.

Material. Whole specimens; PMO 51222-228, PMO 54469-471, locality 30.

Stratigraphic range. Braksøya Formation (Kiær's étages 8c & 8d), Skien district, Sheinwoodian (*centrifugus* & *murchisoni* Biozones).

Discussion. These highly compressed and distorted specimens resemble *E. euthymos* in possessing one area of auxilliary cranidial impressions and in the convexity of the pygidial axis. The better preserved specimens do not appear to possess the great degree of anterior cranidial widening diagnostic of *C. euthymos* and in view of the poor preservation and the lack of specimens showing the cephalic doublure I have separated these specimens from that species.

Family Lichidae Hawle & Corda, 1847

Subfamily Lichinae Hawle & Corda, 1847

Genus **Lichas** Dalman, 1827

[Junior objective synonym = *Autolichas* Reed, 1923 (*fide* Tripp 1959).

Junior subjective synonym = *Trimerolichas* Phleger, 1936 (See P.37)].

Type species. By original designation; *Entomostracites laciniatus* Wahlenberg, 1818, p. 34, pl. 2, fig. 2; from Ashgill, Dalmanitina Beds, Mösseberg, Besdorp, Sweden.

Diagnosis. See p. 30.

Lichas silvestris Reed, 1925. Pl. 40, fig 1; Text-figs 44, 50.

1925 *Lichas (Autolichas) silvestris,* Reed, p. 67, pl. 2, fig. 1.

1982 *Lichas silvestris* Reed; Howells, p. 46, pl. 13, figs 1-4, 7, 8 [includes full synonymy].

Holotype. By monotypy, BM In36954, internal mould of pygidium with incomplete counterpart, from Mulloch Hill Formation (*cyphus* Biozone), Girvan, Scotland; figured Howells 1982, pl. 13, fig. 7.

Material from Norway. Pygidium, PMO 112.879; thoracic segment, PMO 112.866, locality 28.

Stratigraphic range. Solvik Formation (Kiær's étage 6a), Oslo district, Rhuddanian (*persculptus* to *atavus* Biozones). Mulloch Hill Formation, Aeronian (*cyphus* Biozone), Girvan, Scotland.

Diagnosis. See Howells 1982, p. 46.

Description. See Howells 1982, p. 46.

Discussion. This is a distinctive species of *Lichas*, the sagittal carina of the postaxial band serving to distinguish it from all other known species. The Scottish material ranges in age from the lower to upper *cyphus* Biozone while the Norwegian material is from the *persculptus* to *atavus* Biozones (Kiær's ȇtage 6a). *L. silvestris* thus occurs earlier in southern Norway.

Genus **Arctinurus** Castelnau, 1843

[*pro Platynotus* Conrad, 1838 (*non* Fabricus, 1801).

[Junior objective synonyms = *Oncholichas* Schmidt, 1885.

Pterolichas Gürich, 1901].

Type species. By monotypy; *Paradoxus boltoni* Bigsby, 1825, p. 365, pl. 23, from the Rochester shale, (Wenlock) of Lockport, New York State, U.S.A.

Diagnosis. Longitudinal furrow may reach occipital furrow; occipital ring broad (tr.); L1a present; L1b not developed; palpebral lobe large; anterior process may be developed. Hypostome as long as wide, median furrow ending in an abaxial pit. Pygidial axis strongly-convex, one-third anterior width (tr.) and extending less than half length; three flat pleural segments not expanding greatly abaxially, ending in broad backwardly-directed spines; posterior pleural bands may be fused with postaxial band posteriorly; posterior margin indented between last pleural bands.

Discussion. Tripp (1959, p. O496) synonymized with *Arctinurus* the following five genera: *Arctinuroides* Phleger, 1936; *Oncholichas* Phleger, 1936; *Pseudotupolichas* Phleger, 1936); *Pterolichas* Gürich 1901) and *Trimerolichas* Phleger, 1936. For discussion of

Trimerolichas see p.37, and of *Arctinuroides*, *Oncholichas* and *Pseudotupolichas* see p.47. Gürich 1901 (p. 528) erected the genus *Pterolichas* for the group of species *"Lichas" boltoni* Bigsby, 1825 (the type species), *"L." breviceps* Hall, 1867 and "L." emarginata Hall, 1867. He was unaware of the previous selection of *"L." boltoni* as the type species of *Arctinurus* by Castelnau. *Pterolichas* is thus a junior objective synonym of *Arctinurus*.

Arctinurus norvegicus Angelin, 1854. Pl. 40, figs 2-9; Pl. 41, figs 1, 2, 6, 17; Text-figs 43, 44, 50.

v* 1854 *Lichas norvegicus*, Angelin, p. 73, pl. 38, fig. 2.

1882 *Lichas celorrhin* var. *norvegicus* Angelin; Brøgger, p. 129.

1905 *Lichas (Metopolichas) laciniatus* Wahlenberg; Reed, p. 103

v 1937 *Trimerolichas? norvegicus* (Angelin); Warburg, p. 212, figs 1-4.

v 1938 *Lichas* (s. l.) *norvegicus* Angelin; Whittard, p. 116, pl. 4, fig. 5.

. 1981 *Arctinurus* sp., Bolton, pl. 7, figs 13, 14.

?. 1981 *Amphilichas* sp., Bolton, pl. 7, fig. 3.

v. *1982* *Arctinurus* spp., Thomas, p. 142.

Holotype. By monotypy, PMO H2553, internal mould pygidium; figured Angelin 1854, pl. 37, fig. 2; Pl. 41, fig. 1; originally believed to be from Huk at Bygdö (formerly Ladergådsö) where only lower Ordovician strata occur. Angelin (1854, p. 73) with question referred the specimen to his Regio C (lower Ordovician) and Brøgger (1882, p. 129) thought it to be from the Expansus Shales (part of Angelin's "Regio C"). Warburg (1937, p. 212) subsequently suggested that the specimen was from the Llandovery on the grounds of both the lithology and the discovery of further pygidia showing identical features from étage 6 (Solvik Formation) of Malmøy.

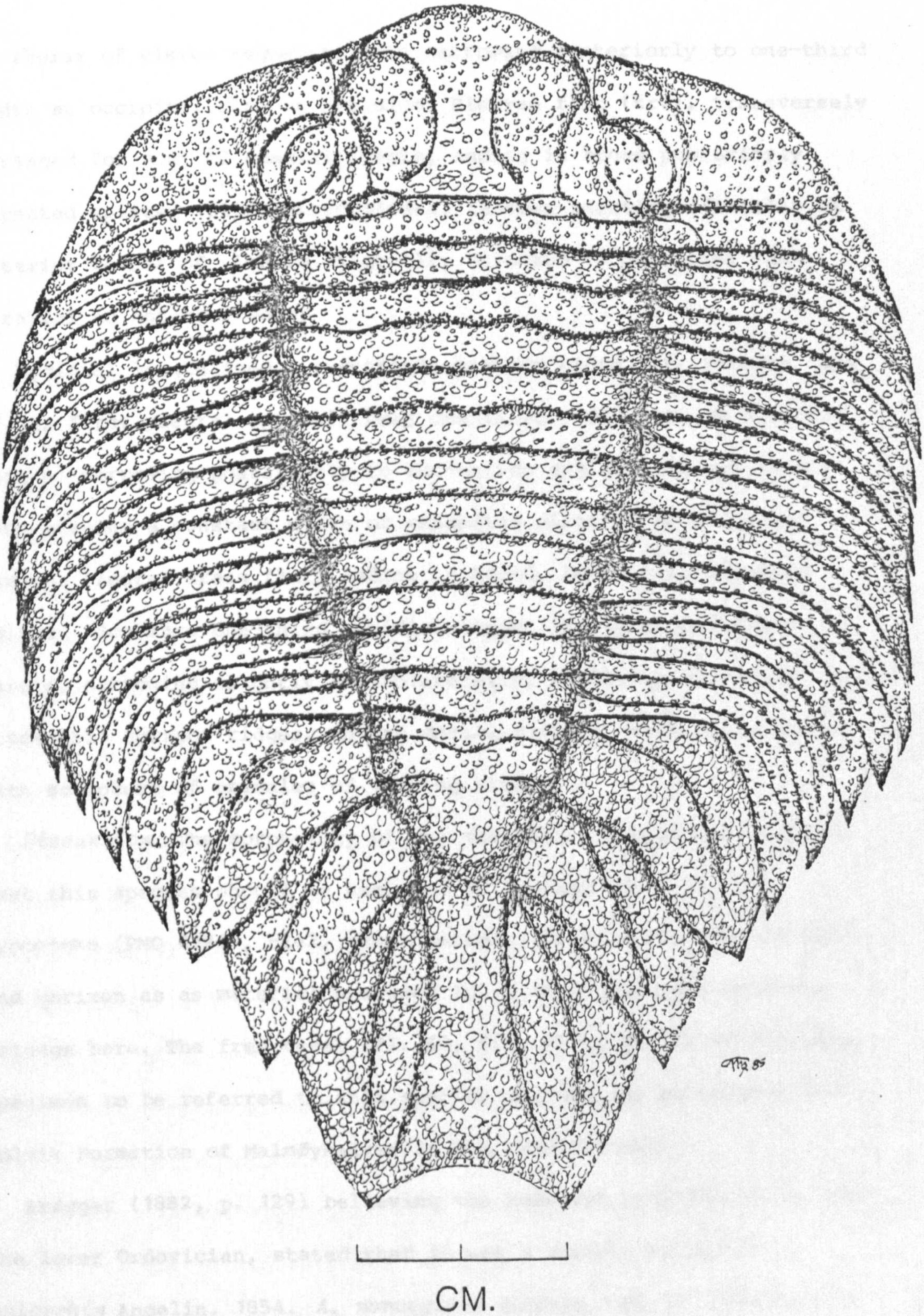
Other material. Whole specimen, PMO 44795, locality 32; cranidia, PMO H2570 (Warburg 1937, text-fig. 2; Pl. 40, fig. 2), PMO 44801, locality 32, PMO 88786, -879, -969, PMO 89020, PMO 109.482, locality 33; free cheek, PMO 109.900, locality 22; hypostomes, PMO 42241, -242 (same specimen), PMO 44795, locality 32, PMO 109.540, locality 33; thoracic segments, PMO 112.891, locality 22, PMO 112.888-890, locality 31, PMO 109.902, -903, -909, locality 33; pygidia, PMO 19261, locality 2, PMO H2566, locality 3, PMO 2550 (Warburg 1937, text-fig. 4; Pl. 40, fig. 3), PMO 2569, PMO 2577, -578 (same specimen; Warburg 1937, text-fig. 3; Pl. 40, fig. 5), PMO 2605, PMO 42140, PMO 109.520, -521, -539, -901, locality 32, PMO H2558, -572, PMO 89025, PMO 108.495, PMO 109.481, PMO 112.887, locality 33, PMO H2606, Solvik Formation, locality unknown, PMO H2565 Rytteråker Formation (Kiær's étage 7a), locality unknown, Ringerike district.

Stratigraphic range. Solvik and Rytteråker Formations (Kiær's étages 6b to 7a), Oslo, Asker, Holmestrand and Ringerike districts, Rhuddanian & Aeronian (*acinaces* to lower *sedgwickii* Biozones). Purple Shales, Telychian, Shropshire, U.K.

Diagnosis. A species of *Arctinurus* with longitudinal furrows reaching occipital furrow by L1a; bullar lobes of constant width (at 90° to their long axis), gently divergent anteriorly and lower than the median glabellar lobe; anterior border short and convex, with sculpture of terrace ridges parallel to margin, lacking anterior process. Pygidial axis with one well-defined ring anteriorly, a second defined only abaxially and a long terminal piece which is strongly inflated and merges with postaxial band; pygidial interpleural furrows reach margin, pleural furrows do not, both well-incised; posterior pleural band merging with postaxial band near margin; posterior margin with broad, semicircular indentation; postaxial band gently expanding backwards.

Description. Cranidium as wide (tr.) as long (sag.). Occipital ring broad (sag.) one-eighth cranidial length and of same height as median glabellar lobe, constricted to half that width behind most adaxial part of L1a. L1a well-defined, large, rounded adaxially, tapering to a sharp point abaxially, the long axis directed abaxially anteriorly. Occipital furrow well-incised, straight and narrow on external mould, broader on internal mould. Median glabellar lobe flat to mid point, of constant width between, and expanding greatly in front, of bullar lobe. Narrowest point of median glabellar lobe occurs opposite mid point of palpebral lobe. Longitudinal furrows well-incised, with occipital apodeme defined on internal mould only, between occipital furrow and bullar lobe. Axial furrows well-incised, parallel to longitudinal furrows from middle of occipital lobe forwards, curving round to meet longitudinal furrows in front of bullar lobe. Anterior border furrow well-incised. Anterior border widening in front of bullar lobe. Fixed cheek of moderate convexity, small and triangular. Palpebral lobe highly-convex, separated from rest of fixed cheek by a well-incised furrow. Free cheek slightly inflated beneath eye, becoming flat adaxially. Posterior border furrow broad, well-incised, transversely arranged adaxially, deflected posteriorly onto broad backwardly directed genal spine. Hypostome with lateral wings broadening greatly to posterior of median furrow, median body divided into two convex areas by deeply-incised median furrow which is not defined on median third of width. Posterior margin strongly indented.

Text-fig. 43



Text-fig. 43

Reconstruction of *Arctinurus norvegicus* (Angelin, 1854) in dorsal view. Based on specimens PMO 2570 (= cranidium, Pl. 40, fig. 2), PMO H2577 (= pygidium, Pl. 40, fig. 5), PMO 44795 (= whole specimen, not figured), PMO 109.900 (= free cheek, Pl. 40, fig. 9).

Thorax of eleven segments. Axis narrowing posteriorly to one-third width at occipital ring at pygidium. Pleurae flat (tr.), transversely arranged for most of adaxial length, ending in broad posteriorly directed spines. Well-incised pleural furrows starting adaxially at anterior corner of pleurae diagonally directed to mid point then parallel to anterior edge.

Pygidial length (sag.) two-thirds maximum width (tr. between tips of its first pleural spines). Axis one-third width (tr. at anterior margin) narrowing posteriorly to two-thirds pygidial length (sag.) then staying a constant width or expanding slightly to posterior margin. Pleural areas flat, ending in broad, backwardly-directed spines. Doublure one-third pygidial length (sag.) at posterior margin, narrowing slightly anterolaterally, a minimum of eleven concentric terrace ridges. Entire dorsal surface, excluding furrows, with sculpture of granules of varying size.

Discussion. The morphology of the glabella and pygidium suggests that this species should be assigned to *Arctinurus*. A lichid hypostome (PMO 42241, -242, same specimen) is from the same locality and horizon as as material assigned to *A. norvegicus* and probably belongs here. The free cheek (Pl. 40, fig. 9) is the first and only specimen to be referred to this species and was collected from the Solvik Formation of Malmøykalven in the Oslo district.

Brøgger (1882, p. 129) believing the holotype pygidium to be from the lower Ordovician, stated that it was a variety of *Lichas celorrhin* Angelin, 1854. *A. norvegicus* differs from *L. celorrhin* in having a wider pygidial axis, more backwardly-directed pleurae and fewer axial segments. The cranidia and hypostome are vastly morphologically different from Angelin's species.

Warburg (1937) made two errors in referring to Oslo museum specimen numbers. Firstly in her text-fig. 1 the holotype is given the number PMO H2552 whereas the specimen itself bears the number PMO H2553. Secondly in the text the specimen actually bearing the number PMO H2570 is referred to as PMO H2510 and in text fig. 2 as PMO H2576.

A. norvegicus differs from all other species of the genus in possessing a longitudinal furrow which reaches the occipital furrow, more elongate bullar lobes, no anterior process a less elongate median glabellar lobe and shorter broader pygidial pleural bands. Holloway (pers. comm.) believes these differences cast doubt on assigning the Norwegian material to *Arctinurus.* I consider the overall morphological similarity between *A. norvegicus* and the American species warrants placing *A. norvegicus* in this genus.

Whittard (1938, p. 116, pl. 4, fig. 5) recorded a specimen of *A. norvegicus* from the Purple Shales, Llandovery (Telychian), of Shropshire, U.K. However, after receiving Warburg's 1937 paper placing the Norwegian material in *Trimerolichas* he expressed doubts as to whether *Trimerolichas* would stand as a genus, and placed *A. norvegicus* in *Lichas* (s. l.). I agree with Whittard's original assignation of *L. norvegicus* to *Arctinurus* and can find no significant morphological differences between the Shropshire pygidium and the type specimen.

Whittard, in the synonymy accompanying his description made two errors. Firstly in his reference to Brøgger 1882, he did not show the assignation of *norvegicus* to a variety of *L. celorrhin.* Secondly Warburg placed a question mark after the generic name to draw attention to doubts as to the affinities of *Arctinurus* and *Trimerolichas.* Whittard placed the question mark before the generic name making it appear that Warburg was questioning both genus and species.

I believe the pygidium assigned to *Arctinurus* sp. by Bolton (1981, pl. 7, figs 13, 14) from the Ellis Bay Formation (earliest Silurian), Anticosti Island, Canada to be conspecific with *A. norvegicus*. A cranidium figured by Bolton (*ibid*, pl. 7, fig. 3) as *Amphilichas* from the same formation at a different locality may also belong here, since the longitudinal furrow of the Canadian specimen is deflected towards the axial furrow instead of continuing in a straight line to the occipital furrow as is typical of *Amphilichas*. The posterior of this specimen is largely missing however and more material is required before this cranidium can be assigned to a genus with certainty.

In pygidial morphology *A. norvegicus* resembles *L. laciniatus* (Wahlenberg, 1818; see Warburg 1939, pl. 9, figs 1-7) the latter species differing from the former by possessing two axial rings defined across the width of the axis as opposed to one, an unindented posterior margin and broader pleurae abaxially.

A pathological pygidium exists within the museum collection which displays deflections of both pleural and interpleural furrows (see Pl. 41, fig. 6). It has been suggested (Dr. A. Owen, pers. comm.) that the pathology may be due to the close proximity of the pygidial doublure to the ventral side of the dorsal exoskeleton which may have caused damage to the soft tissue during ecdysis. If this is so the retention of the original pygidial outline in the Norwegian specimen may be indicative of an ability to regenerate in sucessive instars. Rudlin (1985, p. 479) described pathological pygidia of *A. boltoni* (Bigsby, 1825) in which the pathology is clearly of a different type. The specimen figured by Rudlin displays a thickening of the exoskeleton at the posterior margin and a subsequent disruption of the pygidial outline. Rudlin does not attribute this injury to any specific cause but it seems likely that loss of soft tissue occurred in the Canadian specimen which would indicate an external source for the damage such as attempted predation.

Genus **Dicranopeltis** Hawle & Corda, 1847

[Obj. syn. = *Trachylichas* Gürich, 1901].

[Subj. Syn. = *Dicranopeltoides* Phleger, 1936. *Makromutis* Phleger, 1936. *Raymondarges* Phleger, 1937. *Tsunylichas* Chang, 1974].

Discussion. Of the above synonyms the first three are *fide* Tripp, 1959 and the last *fide* Thomas 1981, p. 68.

Type species. By subsequent designation of Reed 1902, p. 71; *Lichas scabra* Beyrich, 1845, p. 28, unnumbered plate, fig. 16, from the Liten Formation (Wenlock) of St. Yvan (=Svaty Jan), near Beroun, Czechoslovakia.

Diagnosis See p. .

Dicranopeltis galbinus sp. nov. Pl. 40, fig. 10; Pl. 41, figs 3, 7, 9-11; Text-figs. 44, 50.

(Name. Latin "galbinus" jaundice; referring to the distinctive yellow weathered colour of the type specimens).

v. [*1949 Dicranopeltis polytomus* (Angelin); Spjeldnaes, p. 34].

. 1982 *Dicranopeltis* sp., Howells, p. 47, pl. 13, figs 5, 6, 9, 11.

Holotype. Cranidium; PMO 88650, Solvik Formation, Kiær's étage 6b (Rhuddanian & Aeronian, *acinaces* to *triangulatus* Biozones); Pl. 41, fig. 9.

Paratypes. Cranidia, PMO 88654, -700, -701, locality 10, BM In43155, HM A17376, HM A17420, Newlands Formation (*triangulatus* to *argenteus* Biozones), Newlands, Girvan, HM A8948, Newlands Formation (*triangulatus* to *argenteus* Biozones), Kirk Hill, Girvan, BM In 22792, HM A17421, Woodland Formation (*cyphus* Biozone), Woodland Hill, Girvan; Hypostomes, PMO 88644, PMO 65556, -557 (counterparts), locality 10.

Stratigraphic range. Solvik Formation (Kiær's étage 6b), Asker district, Rhuddanian-Aeronian (*acinaces-triangulatus* Biozones). Newlands and Woodland Formations (*cyphus* to *argenteus* Biozones), Girvan, Scotland.

Diagnosis. L1a very well-defined, oval; L1b expanding greatly abaxially; bullar lobe subangular posteriorly, rounded anteriorly, elongate and highly convex; median glabellar lobe extending anteriorly well in front of bullar lobe, not overhanging anterior margin. Hypostome with well incised border furrows; posterior notch narrow. Dorsal surface with sculpture of coarse granulation.

Description. Cranidium two-thirds as long (sag.) as wide (tr.) across palpebral lobes, flat anteriorly in lateral view becoming convex forwards. Occipital ring one-eighth length (sag.) of cranidium, markedly constricted behind L1a. Median lobe one-sixth cranidial width (tr.) at L1b, expanding to three times that width in front of bullar lobe. Longitudinal furrow deep and broad opposite bullar lobe very shallow by L1b. Bullar lobe very slightly below level of median lobe posteriorly. Axial furrow deepest opposite anterior end of bullar lobe. Fixed cheek broad of low independent convexity.

Hypostome three-quarters as long (sag.) as wide (tr.). Anterior margin convex forwards. Anterior wing small, upwardly flexed. Lateral notch extending from opposite mid point of middle body to opposite posterior of maculae, gently curved. Anterior border narrow medially, expanding slightly abaxially. Posterior border not defined. Posterior margin with notch one-fifth maximum width (tr.) of median body. Lateral border furrows very deep and broad extending to close to posterior margin. Middle body with posteriorly narrowing anterior lobe, merging posteriorly with less convex, narrower posterior lobe. Middle furrow deep, broad, not defined on median quarter of middle body, posteriorly directed at 45°. Maculae well-developed, convex.

Discussion. I consider *Dicranopeltis* sp. of Howells (1982, p. 47, pl. 13, figs 5, 9, 6, 11) from the Newlands, Mulloch Hill and Woodland Formations (*cyphus* to *argenteus* Biozones), of Girvan, Scotland to be conspecific with the Norwegian material on the basis of the well-defined L1a, anterior morphology of the bullar lobes and the anterior extension and widening of the median glabellar lobe. The Norwegian material is from the Solvik Formation (Kiær's êtage 6b, *cyphus* to *triangulatus* Biozones) and thus from a similar stratigraphic horizon.

The Norwegian specimens bear cards attributing them to *D. polytomus* (Angelin, 1854; p. 69, pl. 36 fig. 3; see Warburg 1939, p. 134, pl. 11, figs 4-6). *D. polytomus* from the Boda (Upper Leptaena), Limestone (Rawtheyan) and Dalmanites Shales (Rawtheyan) of Ålleberg, Vastergotland, Sweden and the Chair of Kildare Limestone (Rawtheyan, Ashgill) of Ireland (see Dean 1974, pl. 35, figs 4, 6, 7, 9, 10). Spjeldnaes (1949, p. 34) in labelling the specimens had access to the lectotype and other material of *D. polytomus* and doubted if all the material assigned to *D. polytomus* belonged there. The Norwegian species possesses a narrower median glabellar and bullar lobe anteriorly, a larger L1b, and a posterolateral corner to L1a which is rounded as opposed to pointed in comparison to Warburg's figured topotype material of *D. polytomus*.

Genus **Pseudotupolichas** Phleger, 1936

Type species. By original designation *P. ornatus* (Angelin, 1854), p. 72, pl. 37, figs 7, 7a from the Slite and Högklint Formations, Sheinwoodian to Homerian (*riccartonensis* to *lundgreni* Biozones) of Gotland, Sweden (see herein p. , Pl. 2, figs 3, 5, 8, 9, 11-15, 17; pl. 3, figs 1-7).

Diagnosis & discussion. See p. 47.

Pseudotupolichas ornatus (Angelin, 1854) Pl. 41, fig. 4; Text-figs 6, 44, 50.

1854 *L. ornatus*, Angelin, p. 72, pl. 37, figs 7, 7a.

[For full synonymy see herein p. 50].

Type material. The whereabouts of Angelin's figured specimen (1854, pl. 37, figs 7, 7a) is unknown. In view of the high degree of similarity between specimens in the Riksmuseet collection and that figured by Angelin, specimen Ar2930 (pygidium, from Gotland locality 20; Pl. 2, fig. 9) is herein selected as neotype.

Material from Norway. Pygidium, PMO H2554, locality 19.

Stratigraphic range. Steinsfjorden Formation (Kiær's étage 9b), Holmestrand district, Sheinwoodian-Homerian (*linnarssoni-nassa* Biozones). Slite Group and Högklint Formation (*murchisoni* to *lundgreni* Biozones), Gotland, Sweden.

Diagnosis & description. See page.

Discussion. See herein p. 47.

The Gotland and Norwegian specimen are from rocks of equivalent age.

This pathological specimen shows similar distortion of the pygidial interpleural and pleural rib furrows to those seen in a specimen of *Arctinurus norvegicus* from the Oslo district (see Pl. 41, fig. 6).

Subfamily Homolichinae Phleger, 1936

Diagnosis. See p. 59.

Genus **Platylichas** Gürich, 1901

Type species. By monotypy *Lichas margaritifer* Nieskowski, 1857, p. 54, pl. 1, fig. 15; from the Porkuni Limestone (Ashgill), Estonia.

Platylichas scoticus (Reed, 1906) Pl. 41, figs 8, 12, 15; Text-figs 44, 50.

1906 *Lichas (Platylichas) grayii*, Fletcher, 1850, var. nov. *scoticus*, Reed, p. 100, pl. 14, figs 5-9, *non* fig. 10 [= *P.* cf. *scoticus* (Reed, 1906). *Fide* Howells 1982].

1958 Platylichas scoticus (Reed, 1906); Tripp, p. 576.

1982 Platylichas scoticus (Reed, 1906); Howells, p. 48, pl. 13, figs 10, 12-16, 18, 20, 21, 23 [includes full synonymy].

Lectotype. By designation of Howells 1982, p. 48, pl. 13, fig. 13 from the Mulloch Hill Formation, Rhuddanian (*vesiculosus* Biozone), Girvan, Scotland.

Paralectotypes. Cranidia, BM In22738, -794; hypostome, BM In22727; pygidia, GSM 16192, BM In 22725, -732, from type locality and horizon.

Material from Norway. Cranidium, PMO 108.496, locality 21; hypostome, PMO 112.892, locality 33; pygidium, PMO 109.541, locality 33.

Stratigraphic range. Solvik and Saelabonn Formations (Kiær's étages 6b & 6c), Asker and Ringerike districts, Rhuddanian & Aeronian (*cyphus* to *convolutus* Biozones). Mulloch Hill Formation, Aeronian (*vesiculosus* Biozone), Girvan, Scotland.

Diagnosis. See Howells 1982, p. 48.

Description (for description of cephalon and pygidium see Howells 1982, p. 48). Hypostome two-thirds as long (sag.) as wide (tr.). Anterior margin convex forwards. Anterior wing absent. Posterior wing broad narrowing posteriorly. Anterior border, convex short (sag.). Posterior border broad, well-defined. Posterior margin with deep, narrow, rounded indentation. Lateral border furrow well-incised, broad. Median body convex, as wide (tr.) as long (sag.). Middle furrow short, posteriorly directed at 45° for one-quarter of width, sharply deflected onto an exsagittal line at abaxial end. Sculpture of fine granulation on median body and anterior part of posterior wing, deeply incised terrace ridges on posterior part of wing.

Discussion. *P. scoticus* is closest morphologically to *P. grayii* (Fletcher, 1850) from the Much Wenlock Limestone Formation (*lundgreni* Biozone) and Coalbrookdale Formation of the Malverns. For discussion of *P. scoticus* and *P. grayii* see p. 61.

The surface granulation of the Norwegian pygidium is coarser than that of Scottish material. However sculpture is a feature that often varies between specimens of the same species of lichid. The small size of the Oslo specimen may also account for this difference.

The Scottish material ranges in age from the upper *vesiculosus* to *acinaces* Biozones a range which includes that of the Norwegian specimens which are from the Solvik and Saelabonn Formations (Kiær's étages 6b & 6c) *cyphus* to *convolutus* Biozones.

Subfamily **Ceratarginae** Tripp, 1957

Diagnosis. See Tripp 1959, p. O500.

Genus **Choneliobarges** Phleger, 1936

Type species. Corydocephalus macculLochi Reed, 1913 (p. 28, pl. 4, figs 9, 10), from the Drummock Group, Cautleyan to Rawtheyan (*anceps* Biozone) of Girvan, Scotland.

Diagnosis. See herein p. 69.

Discussion. See herein p. 69.

Choneliobarges sp. Pl. 41, figs 5, 13, 14, 16; Pl. 42, fig. 5; Text-fig. 44.

Material. Cranidia, PMO 50355, locality 16, PMO S2803, PMO 109.546, locality 19; hypostomes, PMO 109.544, -545, locality 19; pygidium, PMO 112.893, locality 19.

Stratigraphic range. Steinsfjorden Formation (Kiær's étage 9c), Holmestrand district, Homerian (*ludensis* Biozone).

Description. Cranidium with median lobe slightly narrower than occipital ring posteriorly, weakly-defined opposite posterolateral cranidial lobe, becoming wider to opposite mid point of bullar lobe then narrowing slightly forwards before expanding in front of bullar lobe. Bullar lobe angular posteriorly, rounded anteriorly, convex and with well-incised adaxial notch at half length (exsag.). Longitudinal furrow deepest opposite posterior corner of bullar lobe and confluent with axial furrow anteriorly. Posterolateral cranidial lobe highly convex expanding slightly abaxially. Anterior border broad for genus, of low convexity, expanding slightly abaxially. Dorsal surface with sculpture of coarse granules.

Hypostome four-fifths as long (sag.) as wide (tr.). Anterior margin gently convex forwards. Middle body subangular narrowing posteriorly. Middle furrow weakly impressed on abaxial quarter width of median body. Lateral border furrow very deep and broad, merging with posterior border furrow. Lateral border narrow, convex. Posterior border broad, gently convex. Ventral surface with sculpture of pitting on median body and posterior border with strongly defined terrace ridges on lateral border.

Pygidium with axis one-third width (tr.) at anterior narrowing very slightly and bluntly rounded posteriorly with at least eight axial rings becoming less well-defined posteriorly. Pleural field with two pairs of pleural ribs anteriorly ending in slender elongate spines of equal length. Posterior pleural band of each rib more convex than anterior. Posterior margin with at least four spines. Posterior border of low convexity. Dorsal surface with sculpture of coarse randomly arranged granules. Well defined caecal markings present on posterior pleural area.

Discussion. The cranidium of this species is distinctive in the convexity of its bullar and posterolateral lobes and the well-defined furrow in front of the bullar lobe which is usually to some degree effaced in most species of this genus. I have not erected a new species for this material due to the poor preservation of the only available pygidium. However a large spine is clearly present posterior to the pygidial pleurae and it is on this basis that this material is placed in *Choneliobarges*.

Family Odontopleuridae Burmeister, 1843

Subfamily Odontopleurinae Burmeister, 1843

Diagnosis. See Whittington 1959, p. O504.

Genus **Leonaspis** Richter & Richter, 1917

Type species. By original designation *Odontopleura Leonhardi* Barrande, 1846a, p. 58 (see Barrande 1852, pl. 37, fig. 1) from the Kopanina Formation (Ludlow), Klodenik, Beroun district, Czechoslovakia.

Diagnosis. See Thomas 1982, p. 143.

Leonaspis varbolensis Bruton, 1967 — Pl. 41, fig. 18; Pl. 42, figs 2, 4, 6-13, 15-21; Text-figs 44, 49.

?. 1938 *Leonaspis marklini* (Angelin); Whittard, p. 108, pl. 3, fig. 4.

1967 *Leonaspis varbolensis*, Bruton, p. 230, pl. 35, figs 1-2, 4.

. 1982 *Leonaspis* aff. *varbolensis* Bruton; Howells, p. 53, pl. 14, fig. 16.

v. *1982 Leonaspis* aff. *varbolensis* Bruton; Thomas, p. 130.

Holotype. By original designation EA Tr 1802/1, Bruton 1967, pl. 35, fig. 2 from Varbola Well, Juuru stage, G1 (*persculptus* & *acuminatus* Biozones), Estonia.

Material from Norway. Whole specimens, PMO 108.464, locality 31, PMO 44389, locality 32; cranidia, PMO 109.913, PMO 112.901-904, -907, locality 12, PMO 108.494, PMO 109.526, -528, -533, -535, locality 31, PMO 109.524, PMO 112.912, locality 32, PMO 109.920, -928, -929, PMO 110.467, PMO 112.909, locality 33; free cheeks, PMO 112.894-896, 112.898-900, locality 12, PMO 109.527, -531, -536, locality 31, PMO 109.525, PMO 112.908, -910, -911, 112.913-915, locality 32, PMO 109.921, PMO 110.348, PMO 112.767, locality 33; hypostome; PMO 109.918, locality 33; pygidia, PMO 109.914, PMO 112.905, -906, locality 12, PMO 109.530, -534, locality 31, PMO 109.523, -930, locality 32, PMO 109.928, PMO 112.920, locality 33.

Stratigraphic range. Solvik and Saelabonn Formations (Kiær's étages 6b & 6c), Oslo, Asker and Ringerike districts, Rhuddanian to Aeronian (*atavus* to *convolutus* Biozones). Juuru Stage (G1, *persculptus* & *acuminatus* Biozones), Estonia. Mulloch Hill Formation (upper *sedgwickii* Biozone) Girvan, Scotland. Purple Shales (Telychian), Shropshire?.

Diagnosis (emended from Bruton 1967, p. 231). Cranidium with maximum length (sag.) slightly less than maximum width (tr.); maximum transverse width of median glabellar lobe opposite anterior end of S1; frontal lobe with bluntly rounded outline; occipital ring without spines, median granule strongly developed; field of free cheek steeply sloping with granules decreasing in size downwards, lateral margin with thirteen spines increasing in size to opposite genal angle and then decreasing. Hypostome with shallow, broad lateral border furrows and weakly convex, circular middle body. Pygidium with two pairs of spines on posterior margin, middle pair slightly longer than outer pair. Dorsal surface with sculpture of mainly equally sized granules.

Description. Occipital ring one-quarter length (sag.) of cranidium, narrowing to half that length abaxially, gently convex. L1 angular posteriorly rounded anteriorly one-third length (exsag.) and below level of median lobe. L2 convex, below level of median lobe, long axis diverging forwards at 45°, half size of L1. S1 deep between L1 and L2 shallowing adaxial to L1 and merging with occipital furrow. S2 deep, slightly more posteriorly directed than L2, shallowing for abaxial portion of length where it markedly constricts the median glabellar lobe. Anterior branch of facial suture converging forwards at 30° to an exsagittal line from anterior of palpebral lobe to opposite mid part of fixed cheek. Posterior branch of facial suture exsagittally arranged immediately behind palpebral lobe then deflected at 5° to a transverse line. Axial furrow, broad, shallower than glabellar furrows. Palpebral lobe half length of and extending forwards from opposite anterior corner of L1. Anterior border flat half length of occipital ring medially, broadening, abaxially. Anterior border furrow shallow, broad.

Free cheek with long slender genal spine, sculpture of coarse granulation at base of spine decreasing in size posteriorly. Lateral and posterior border furrows shallow, broad.

Hypostome with well-incised shallow lateral border furrow confluent with and of similar form to posterior border furrow. Middle body with lateral furrows extending one-third width (tr.). Anterior lobe of median body gently convex merging posteriorly with less convex posterior lobe.

Thorax of ten segments of equal length (sag. & exsag.) transversely arranged, becoming progressively longer and more posteriorly deflected backwards.

Pygidium, excluding spines, one-third as long (sag.) as wide (tr.). Axis with two convex rings and a terminal piece. Anterior axial ring strongly convex confluent with highly convex pleural ridge, separated by a well incised furrow from second ring. Posterior ring narrower and of equal convexity to anterior, posterior ring furrow only defined on median half of axis. Terminal piece flat dorsally. Pleural area flat between anterior and posterior borders and pleural rib. Anterior border narrow of low convexity. Lateral and posterior borders broader than anterior, but of similar convexity. Anterior pair of spines short, straight or gently curved. Major spines twice sagittal length of pygidium, diverging posteriorly. Posterior spines about two-thirds length of major.

Discussion. Bruton (1967, figs 1, 2) figured and described well-preserved cranidia of *L. varbolensis* but the only pygidium available to him was a poorly-preserved internal mould. I have subsequently emended the diagnosis to include features seen in well-preserved external moulds of pygidia and a hypostome from southern Norway. Bruton figured but did not describe a pygidium. The hypostome described and figured herein is the first recorded for this species.

Thomas (1982, p. 143) differentiated specimen PMO 44389 from *L. varbolensis* on the basis of the more parallel-sided outline of the median glabellar lobe. This varies amongst Norwegian specimens herein assigned to *L. varbolensis* (compare Pl. 42, figs 4, 8, 9, 10 & 20). Furthermore the specimen available to Thomas was a relatively poorly-preserved internal mould (Pl. 42, fig. 10) and the poor preservation of this specimen I believe accounts for the difference between it and the type material of the species. Howells (1982, pl. 14, fig. 16) figured a specimen which she referred to *L.* aff. *L. varbolensis* from the Mulloch Hill Formation (upper *sedgwickii*

Biozone) of Girvan, Scotland. She differentiated this specimen from Bruton's figured pygidium (1967, pl. 14, fig. 4) on the basis of its straighter anterior spines, lack of a constriction to the lateral margin posterior to the anterior margin and and shallower pleural areas. I do not consider the difference in curvature of the anterior spines to be to be of specific significance and that the Estonian specimen is not sufficiently well-preserved for comparison of the pleural areas. The constriction of the lateral margin does occur in the Norwegian and Estonian material and not in the Scottish, but amongst the Norwegian specimens it is a variable feature (compare Pl. 42, figs 16, 21) and I do not consider it to be significant.

The inclusion of the Scottish and the Norwegian specimens extends the range of this species to Rhuddanian to Aeronian (*persculptus* to *convolutus* Biozones). Both the Norwegian and Scottish specimens are from higher stratigraphic horizon than the Estonian material.

I agree with Bruton (1967, p. 232) that the cranidium figured by Whittard (1932, pl. 3, fig. 14) as from the Purple Shales, Telychian, of Shropshire, U.K. as *L. marklini* (Angelin, 1854) more closely resembles *L. varbolensis*. The specimen is not sufficiently well-preserved to make a definite assignment and is thus included in the synonymy with doubt.

L. varbolensis most closely resembles the two species *L. coronata* (Salter, 1865; see Thomas 1981, p. 88, pl. 23, figs 10, 12-14, 16, 18, 20, 22, 26) from the Mulde Formation (*lundgreni* & *nassa* Biozones) of Gotland, Sweden and Much Wenlock Limestone Formation (*ludensis* Biozone) of Dudley, U.K. and *L. marklini* (Angelin, 1854; see Bruton 1967, pl. 30, figs 2-8; pl. 31, figs 1-3) from the Halla and Mulde Formations (*lundgreni* & *nassa* Biozones) of Gotland, Sweden. All three species are differentiated from other species of *Leonaspis* in possessing two pairs of elongate posterior pygidial spines. *L.*

varbolensis differs from both *L. coronata* and *L. marklini* in possessing a widening of the median glabellar lobe opposite the anterior end of 1S, a less rounded anterior end to the median lobe and no large granules at the base of each pygidial spine. In addition, the major pygidial spines of *L. coronata* are distinctly incurved posteriorly and the anterior branch of the facial suture in *L. marklini* converges more sharply anteriorly than in either of the other species.

Leonaspis sp. Pl. 42, fig. 1; Text-fig. 44.

Material. Cranidium, PMO 112.907, locality 6.

Stratigraphic range. Braksøya Formation (Kiær's étage 8c), Ringerike district, Sheinwoodian (*centrifugus* & *murchisoni* Biozones).

Discussion. This single, internal mould, cranidium represents the stratigraphically youngest known specimen of *Leonaspis* from the Oslo Region. The specimen is poorly preserved but possesses a similar swelling of the glabella in front of 1L to *L. varbolensis* Bruton, 1967 (see above). Without pygidia from this locality it is difficult to establish affinities of this specimen and in view of the preservation and the large stratigraphic difference between this and other specimens of *L. varbolensis* from the Oslo Region I have kept this cranidium separate.

Genus **Dudleyaspis** Prantl & Přibyl, 1949

Type species. By original designation; *Acidaspis quinqespinosa* Lake, 1896, p. 240, pl. 7, figs 3, 4; from the Much Wenlock Limestone Formation (*ludensis* Biozone) of Dudley and Sedgley, West Midlands, U.K.

Diagnosis & discussion. See Bruton 1968, p. 34.

Subgenus **Dudleyaspis (Dudleyaspis)** Prantl & Přibyl, 1949

Type species. As for genus.

Diagnosis. See Ramsköld 1984, p. 248.

Dudleyaspis aff. *D. (Dudleyaspis) unicifera,* Ramsköld, 1984.

Pl. 42, figs 3, 14;

Text-fig. 44.

Material. Pygidia, PMO 112.916, 917, locality 31.

Stratigraphic range. Solvik Formation (Kiær's ētage 6c), Asker district, Aeronian (*cyphus* to *convolutus* Biozones).

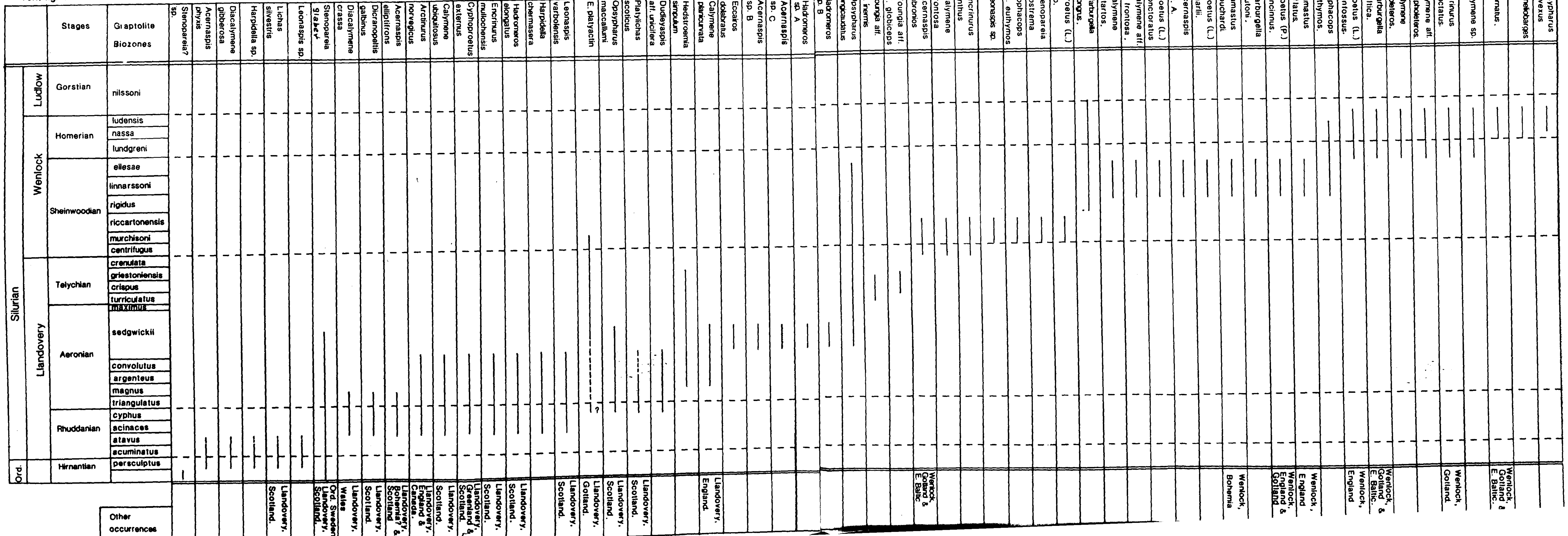
Description. Pygidium, excluding spines, one-quarter as long (sag.) as wide (tr.). Axis of two rings and a triangular end piece which joins axis to a convex and well defined posterior margin. Five pairs of secondary marginal spines. Two pairs between major spines of equivalent length. Three pairs anterior of major spines increasing in size posteriorly; second pair joined to anterior margin across field of pleural area by a weak ridge. Major spines slightly divergent posteriorly joined to first ring of axis by convex pleural ridge which continues the line of the spines until immediately proximal to axis before being deflected. Dorsal surface with sculpture of coarse, randomly distributed, granules with a pair of larger granules on each axial ring and a single row of large granules along major spines.

Discussion. The Norwegian pygidia bear a strong resemblance to several species of *Dudleyaspis*. *D. (Dudleyaspis) unicifera* Ramsköld, 1984 (p. 249, pl. 28, figs 1-11, pl. 30, fig. 17) from the Visby and Högklint Formations of Gotland, Sweden differs from the Norwegian specimens only in having a wider axis, relatively longer anteriormost secondary marginal spines and more widely spaced posterior pygidial spines.

The Norwegian specimens are differentiated from *D. portlocki* (Hawle & Corda, 1847; see Thomas 1981, p. 87, pl. 23, figs 4, 5) from the late Wenlock of Listice, near Beroun, Czechoslovakia, by the narrower, longer, more divergent major spines and coarser granulation of the dorsal surface.

The type species of *Dudleyaspis*, *D. quinquespinosa* (Lake, 1869; see Thomas 1981, p. 85, pl. 22, figs 1-3, 6, 7, 9) possesses a more transverse anterior margin, two as opposed to three anterior secondary spines and a finer surface granulation.

Text-fig. 44


Stages
Graptolite Biozones
Silurian
Ord.
Ludlow
Wenlock
Llandovery
Gorstian
Homerian
Sheinwoodian
Telychian
Aeronian
Rhuddanian
Hirnantian
nilssoni
ludensis
nassa
lundgreni
ellesae
linnarssoni
rigidus
riccartonensis
murchisoni
centrifugus
crenulata
griestoniensis
crispus
turriculatus
maximus
sedgwickii
convolutus
argenteus
magnus
triangulatus
cyphus
acinaces
atavus
acuminatus
persculptus
Other occurrences
Stenopareia? sp.
Acernaspis phyxis
Diacalymene gibberosa
Harpidella sp.
Lichas silvestris
Leonaspis sp.
Stenopareia glaber
Diacalymene crassa
Dicranopeltis galbinus
Acernaspis elliptifrons
Arctinurus norvegicus
Calymene ubiquitosus
Cyphoproetus externus
Encrinurus mullochensis
Hadromeros elongatus
Harpidella chermasera
Leonaspis varbolensis
E. platyactin
Opsypharus maccallumi
Platylichas scoticus
Dudleyaspis aff. unicifera
Hedstroemia simpulum
Calymene planicurvata
Eccaros dolabratus
Acernaspis sp. B
Acernaspis sp. C
Hadromeros sp. A
Hadromeros sp. B
Opsypharus longicaudatus
Youngia aff. Y. inermis
Youngia aff. Y. globiceps
Acernaspis labronios
Calymene frontosa
Encrinurus anthus
Leonaspis sp.
Eophacops cf. euthymos
Stenopareia postrema
Proetus (L.) sp.
Warburgella gongrus.
Calymene tetartos.
Calymene aff. C. frontosa.
Proetus (L.) concloratus
Acernaspis sp. A.
Proetus (L.) baarlii.
Bumastus bouchardi.
Warburgella brutoni.
Proetus (P.) concinnus.
Bumastus inflatus.
Eophacops euthymos.
Proetus (L.) confossus.
Warburgella baltica.
Calymene pholeteros.
Calymene aff. C. pholeteros.
Encrinurus punctatus.
Calymene sp.
P. ornatus.
Chonetobarges sp.
Opsypharus convexus
?
Llandovery. Scotland.
Llandovery. Scotland.
Ord. Sweden Wales
Llandovery. Scotland.
Llandovery. Scotland.
Llandovery. Bohemia? & Scotland
Llandovery. England & Canada.
Llandovery. Scotland.
Llandovery. Greenland & Scotland.
Llandovery. Scotland.
Llandovery. Scotland.
Llandovery. Scotland.
Llandovery. Gotland.
Llandovery. Scotland.
Llandovery. Scotland.
Llandovery. England.
Wenlock, Gotland & E. Baltic
Wenlock, Bohemia
Wenlock, England & Gotland
Wenlock, England
Wenlock, England
Wenlock, Gotland & E. Baltic.
Wenlock, Gotland.
Wenlock, Gotland & E. Baltic.

Correlation

Text-figures 45-50

Silurian trilobites have in the past been little used as biostratigraphical tools. This has principally been due to the lack of detailed taxonomy, especially of Llandovery trilobites. The publication of recent work on the trilobite faunas of the Girvan area, Scotland (Howells 1982), the Wenlock of Britain (Thomas 1978, 1981) and the Silurian of Gotland, Sweden (Ramsköld 1983, 1984) have contributed to an improvement of this situation. The following section is an attempt to summarize the known occurrences of the trilobite taxa which occur both in southern Norway and elsewhere, to refine and expand the tentative correlations both within southern Norway and outside suggested in Helbert *et al.* 1982 (p. 143) and to comment on the relative abundance of those taxa. The ranges of Silurian trilobites from southern Norway are shown in Text-fig. 44. The occurrence and ranges of those taxa occurring both in southern Norway and elsewhere are shown in Text-figs 45-50. The relative abundance of taxa at localities from which collections were made by the author are given in Appendix 17.

The earliest Silurian trilobites from southern Norway occur in the lowermost parts of the Solvik Formation (Kiær's ètage 6a, Hirnantian? & Rhuddanian, *persculptus* to *atavus* Biozones), and are from Sjursøya in the Oslo district and Kunglungen in the Asker district. The material from Sjursøya is limited to the museum collection (due to industrial development of the locality) and has yielded four trilobite taxa of which only *Diacalymene gibberosa* is known from elsewhere in southern Norway (from a single specimen labelled "Ousto, Kiær's ètage 6a", from the Oslo district). The beds at Kunglungen are sparsely fossiliferous and have yielded few trilobites. Only *S. glaber* can be identified with any certainty and as this is a long-ranging species (*linearis* to *sedgwickii* Biozones) it is of little use in correlation.

Higher in the succession several taxa are common to both the Solvik Formation of the Oslo and Asker districts (Kiær's ètages 6b & 6c, Rhuddanian & Aeronian, *atavus* to *convolutus* Biozones) and the upper part of the Saelabonn Formation (Kiær's ètage 6c, Aeronian, *triangulatus* to *convolutus* Biozones) of the Ringerike district. These are *S. glaber*, *H. elongatus*, *E. mullochensis*, *A. elliptifrons* and *L. varbolensis*. In addition to these species *A. norvegicus* and *O. maccallumi* are fairly common in both the Oslo and Asker districts but have not been collected from the Ringerike district. *C. externus* is very common in the Asker and Ringerike districts but unknown from the Oslo district. *S. glaber* is common in the Oslo and Asker districts but rare in the Saelabonn Formation (Kiær's étage 6c) and its range extends into the overlying Rytteråker formation from which it has been collected in the Asker and Holmestrand districts. The most common trilobite in both the Solvik and upper parts of the Saelabonn Formation is *Acernaspis elliptifrons* which has a range corresponding to the *acinaces* to *convolutus* Biozones. Lower in the succession at Sjursøya *A. phyxis* occurs and *A. elliptifrons* does not and *A. elliptifrons* together with *L. varbolensis* and *H. elongatus* (which have a similar range) is probably a good indicator of beds of middle Llàndovery age (*atavus* to *convolutus* Biozones). Several species which occur in the Solvik and Saelabonn Formations continue into the overlying Rytteråker Formation (Aeronian & Telychian) these are *O. maccallumi*, *E. mullochensis* and *A. norvegicus* which range from the middle part of the Solvik Formation (Kiær's ètage 6b, *cyphus* Biozone) to the lower Rytteråker Formation (Kiær's ètage 7a, lower *sedgwickii* Biozone). In addition to the Oslo and Asker Districts *A. norvegicus* is known from the Rytteråker Formation of the Holmestrand district.

S. longispinosa is known from the Rytteråker Formation (Kiær's ètages 7a, 7b) of the Oslo, Asker and Holmestrand districts but not from the underlying Solvik or overlying Vik Formations and is probably a good indicator of beds of Aeronian & Telychian age (*sedgwickii* to *crispus* Biozones).

C. tetartos has been collected from the Malmøya Formation (Kiær's ètages 8c & 8d, Sheinwoodian, *rigidus* & *linnarssoni* Biozones) of both the Oslo and Asker districts.

C. frontosa is known from the Bruflat and Braksøya Formations (Kiær's ètages 8a to 8d, Telychian & Sheinwoodian, *crenulata* to *murchisoni* Biozones) at several localities in the Ringerike district and from the younger Malmøya Formation (Kiær's èages 8c) of the Oslo district. In general however species of *Calymene* from southern Norway are known from at most only a few localities and then within one district.

In Helbert *et al.* 1982 (p. 144) *W. baltica* was recorded as occurring in the Steinsfjorden Formation (Kiær's ètage 9, Sheinwoodian & Homerian) of the Skien, Holmestrand and Ringerike districts. A further examination of the museum material and further collections by the author has led to the erection of the new species *W. gongros* for those specimens from the Skien and Ringerike districts and the restriction of *W. baltica* to the Holmestrand district. The available specimens of *W. gongros* from Skien are poorly localized and the overall number of available specimens is small, the range of this species therefore is poorly known.

Both *E. euthymos* and *E. punctatus* are known from the Malmøya Formation of the Oslo district and younger Steinsfjorden Formation of the Holmestrand district. Few specimens of either species are available from the Oslo district, where the Steinsfjorden Formation is not exposed, and neither species is known from the Malmøya Formation of the Holmestrand district. Nothing can therefore be said about the relative ranges of these species in the two areas.

Outside southern Norway the most similar described Llandovery trilobite Fauna is that of the Girvan area, Scotland (Howells 1982). The following species are common to both areas; *S. glaber* (Text-fig. 45), *O. maccallumi* (Text-fig. 45), *C. externus* (Text-fig. 46), *H. elongatus* (Text-fig. 47), *E. mullochensis* (Text-fig. 47), *C. ubiquitosus* (Text-fig. 48), *C. frontosa* (Text-fig. 48), *A. elliptifrons* (Text-fig. 49), *L. sylvestris* (Text-fig. 50), *P. scoticus* (Text-fig. 50), *D. galbinus* (Text-fig. 50) and *L. varbolensis* (Text-fig. 49).

S. glaber is known from the Mulloch Hill Formation of Girvan (*cyphus* to *convolutus* Biozones). *O. maccallumi* was recorded in Helbert *et al.* 1982 (p. 144) as coming from slightly younger beds in Scotland than in Norway. Further examination of the museum material and collecting by the author indicates that both sets of material have a similar range (see Text-fig. 45). *C. externus* is known from the Newlands and Mulloch Hill Formations of Girvan, an equivalent range to the Norwegian material, and also from the Kap Schuchert Formation (*triangulatus* Biozone) of Washington Land, western North Greenland and appears to be a good indicator of a Rhuddanian & Aeronian age (*acinaces* to *convolutus* Biozones; see Text-fig. 46). *H. elongatus* is known from the Newlands and Mulloch Hill Formation of Girvan and the Haverford Mudstone Formation of S. Wales and is a good indicator of beds of Rhuddanian & Aeronian age (*acinaces* to *argenteus* Biozones; see Text-fig. 47).

E. mullochensis occurs in the Wood Burn Formation of Girvan (Aeronian, *sedgwickii* & *maximus* Biozones) which is equivalent to the upper part of its range in Norway (Aeronian, *cyphus* to *sedgwickii* Biozones) (Text-fig. 47). *C. ubiquitosus* is known from the Newlands, Woodland and Mulloch Hill Formations of Girvan (Rhuddanian, *atavus* to *cyphus* Biozones) which is a similar range to that in Norway (Rhuddanian & Aeronian, *atavus* to *triangulatus* Biozones). *C. frontosa* is known from the Newlands and Mulloch Hill Formations of Girvan, the Wether Law Lynn Formation of the Pentland

Hills, the Bruflat and Braksøya Formations of the Oslo district, the Visby Formation of Gotland, and the Velise and Rumba Formations of the East Baltic. The range of *C. frontosa* in Girvan, the Pentland Hills, Oslo and Gotland appears closely equivalent (*griestoniensis* to *murchisoni*, *griestoniensis* & *crenulata*, *crenulata* to *rigidus* and *crenulata* & *centrifugus* Biozones respectively) the East Baltic material is recorded from beds equivalent in age to the lower part of the range of this species elsewhere (*griestoniensis* to *centrifugus* Biozones) and from beds which are much older (*sedgwickii* to *griestoniensis* Biozones; see Text-fig. 48). *A. elliptifrons* occurs in the Mulloch Hill Formation of Girvan (Rhuddanian, *acinaces* & *cyphus* Biozones) and in the Solvik and Saelabonn Formations of southern Norway where it is known from beds of equivalent and younger age (Rhuddanian & Aeronian, *atavus* to *convolutus* Biozones) (Text-fig. 49). The only known specimens of *L. sylvestris* from southern Norway are from the Solvik Formation of Sjursøya (Kiær's ètage 6a) of the Oslo district (Hirnantian? & Rhuddanian, *persculptus* to *acuminatus* Biozones) which is a lower stratigraphic horizon than that at which it is recorded from Girvan where it occurs in the Woodland and Mulloch Hill Formations (Rhuddanian, *acinaces* & *cyphus* Biozones; see Text-fig. 50). *D. galbinus* possesses a similar range in southern Norway to Scotland; Solvik Formation (Aeronian, *acinaces* to *triangulatus* Biozones) and Newlands, Mulloch Hill and Woodland Formations (Aeronian, *atavus* to *triangulatus* Biozones) respectively (Text-fig. 50). *L. varbolensis* occurs in the Woodland Formation (*sedgwickii* Biozone) of Girvan, the Solvik and Saelabonn Formations (*acuminatus* to *convolutus* Biozones) of southern Norway and the Juuru Stage of the East Baltic (*persculptus* to *acuminatus* Biozones; see Text-fig. 49). *L. varbolensis* is known from few specimens from Girvan and the East Baltic and little can therefore be said about the relative ranges in the three areas. *P. scoticus* is known from few specimens from Norway where it occurs in the Solvik and Saelabonn Formations (Aeronian *convolutus* & *sedgwickii* Biozones) which agrees with its range in the Girvan district where it is known from the Woodland and Mulloch Hill Formations (Aeronian, *magnus* to *sedgwickii* Biozones) (Text-fig. 50).

In addition to *C. frontosa*, species occurring both on Gotland and in Norway are *E. platyactin*, *P. (P.) concinnus*, *W. baltica*, *E. punctatus* *H. simpulum* and *P. ornatus*. Specimens of *E. platyactin* are known from the Solvik Formation (Aeronian, *magnus* to *convolutus* Biozones) of the Oslo district which is considerably older than the type material which is from the Lower Visby Formation of Gotland (*crenulata* Biozone). The majority of the Norwegian material however is from the Rytteråker and Malmøya Formations (*sedgwickii* to *murchisoni*) Biozones which corresponds to the level at which it is found on Gotland (Text-fig. 45).

P. (P.) concinnus is known from the Mulde Formation (*lundgreni* & *nassa* Biozones) of Gotland, the Much Wenlock Limestone and Lower Elton Formations (*ludensis* to *nilssoni* Biozones) of England, the Malmøya Formation (*centrifugus* & *murchisoni* Biozones) of Norway and the Kopanina Formation (Ludlow) of Czechoslovakia; this species is therefore a good indicator of late Wenlock & early Ludlow age (Homerian & Gorstian, *ellesae to nilssoni* Biozones; Text-fig. 46). *W. baltica* is known from the Visby Formation (*crenulata* & *centrifugus* Biozones) of Gotland at a lower stratigraphic level than its other occurrences in the Steinsfjorden Formation (*ellesae* to *nassa* Biozones) of Norway and the Jaagarahu Formation (*linnarssoni* to *lundgreni* Biozones) of the East Baltic which agree more closely with one another (Text-fig. 46). *H. simpulum* is known from the Solvik and Rytteråker Formations (Aeronian & Telychian, *triangulatus* to *crispus* Biozones) of Norway and from the Lower Visby Formation (Telychian, *crenulata* Biozone) of Gotland. The Gotland material is therefore stratigraphically younger than the Norwegian. Few specimens of *H. simpulum* and *W. baltica* are known from Gotland however and the range of these species may be extended when a full review of the Gotland Proetidae is undertaken. The range of *E. punctatus* on

Gotland where it is found in the Högklint Formation and Slite Group (Sheinwoodian & Homerian, *riccartonensis* to *ellesae* Biozones) corresponds closely to the range in southern Norway where it occurs in the Malmøya and Steinsfjorden Formations (*ellesae* & *lundgreni* Biozones). Only one specimen of *P. ornatus* is known from Norway from the Steinsfjorden Formation (Homerian, *lundgreni* & *nassa* Biozones) corresponding to the upper part of its range on Gotland where it occurs in the Högklint Formation and Slite Group (*rigidus* to *ludensis* Biozones) (Text-fig. 50). *P. ornatus* also occurs in the Jaagarahu Formation (*linnarssoni* to *lundgreni* Biozones) of the East Baltic and I therefore consider this species to be a good indicator of Sheinwoodian & Homerian age (*riccartonensis* to *ludensis* Biozones).

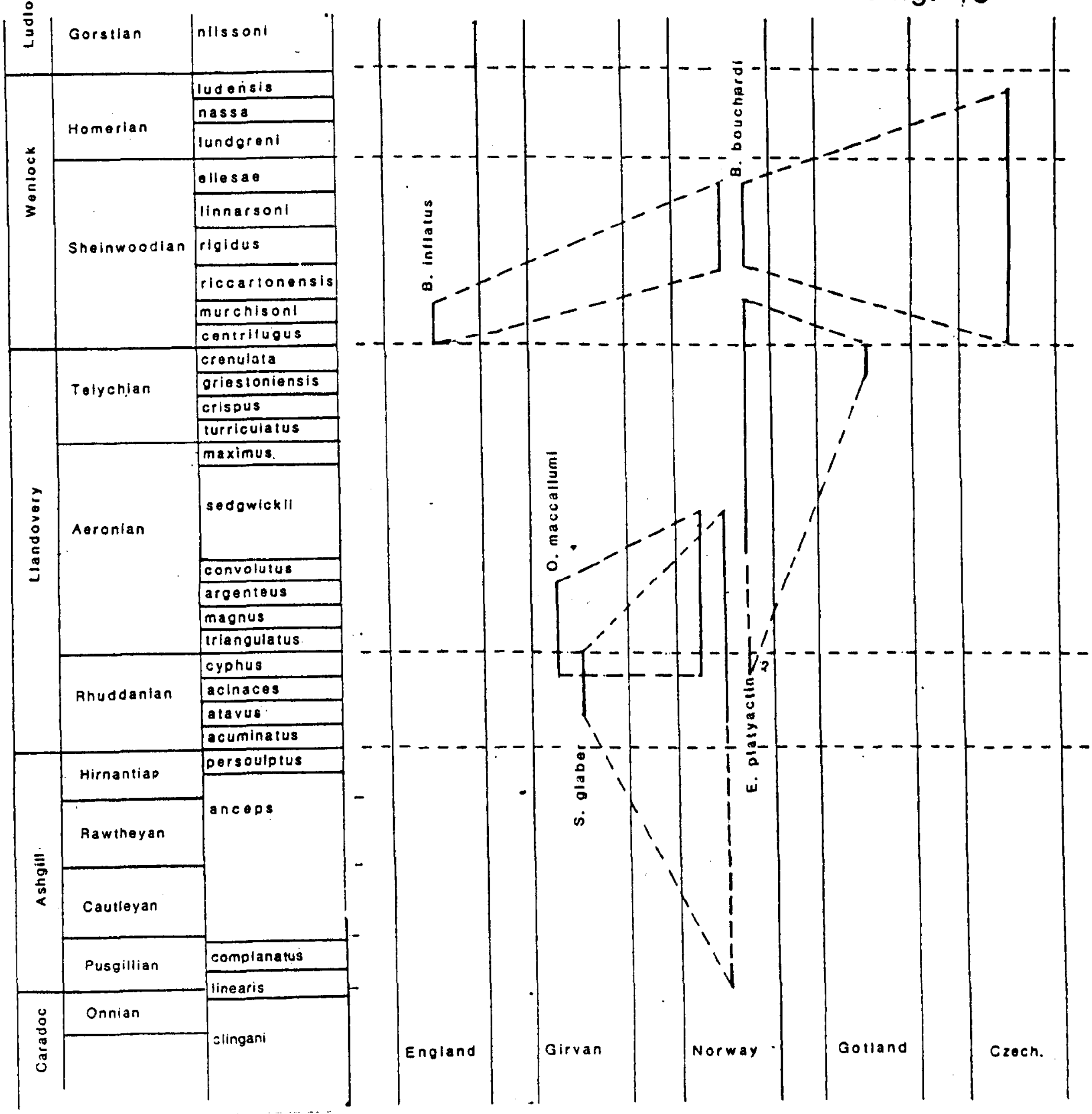
In addition to *H. elongatus*, *D. crassa* occurs both in the Solvik Formation of southern Norway and the Haverford Mudstone Formation of S. Wales. The Oslo specimens are from Gulleråsen (*atavus* to *convolutus* Biozones) which corresponds closely to the range of the Welsh specimens (*atavus* to *cyphus* Biozones) (Text-fig. 48).

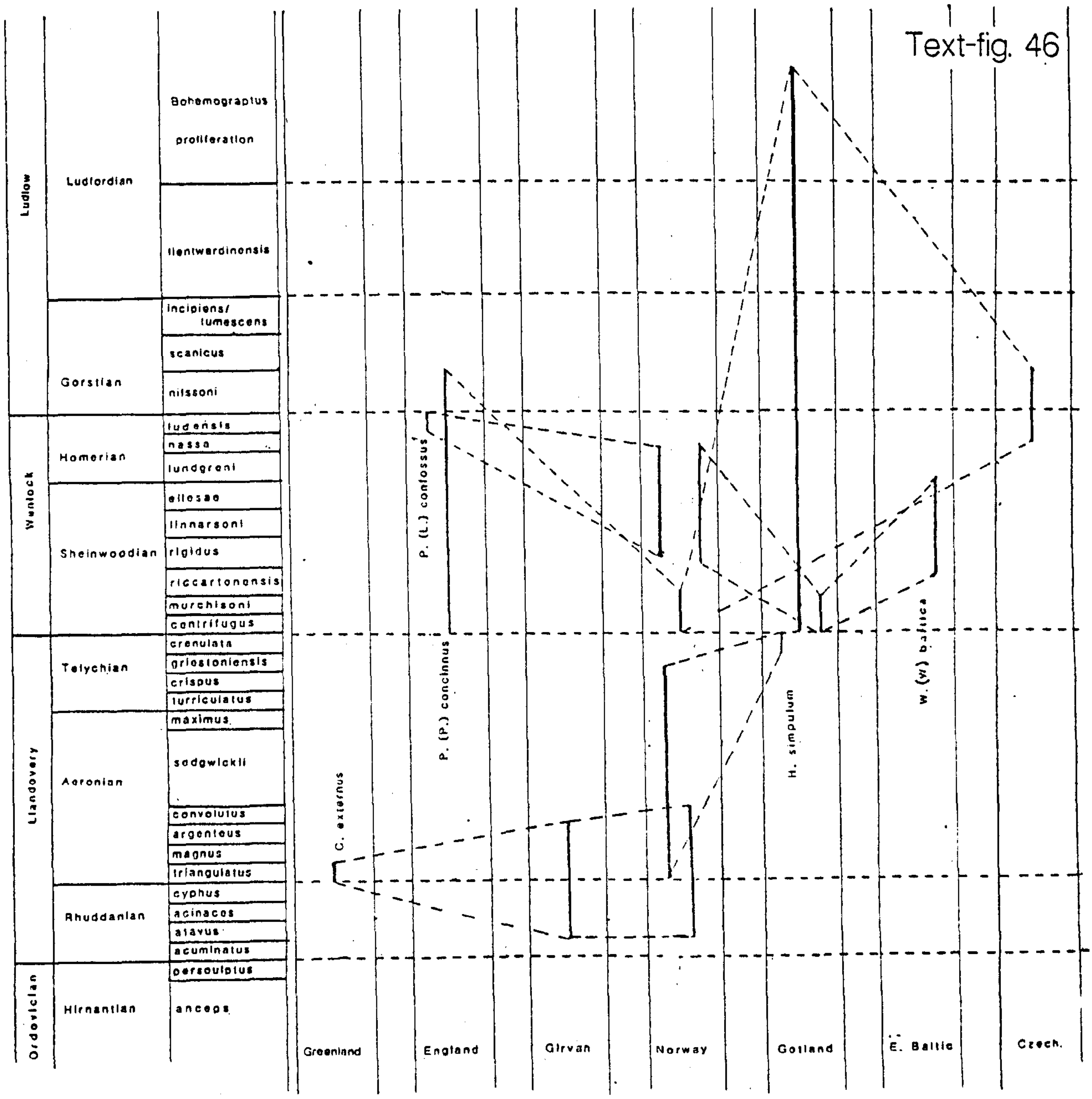
C. planicurvata is known from the upper part of the Solvik Formation and lower part of the Rytteråker Formation of Malmøya in southern Norway (*magnus* to *sedgwickii* Biozones) which supports the middle Llandovery age suggested for the Bog Mine Quartzite of Shropshire by Ziegler, Cocks & McKerrow (1968, p. 744) where the species also occurs.

B. inflatus occurs at a slightly higher horizon in the Malmøya Formation of Norway (*rigidus* & *linnarssoni* Biozones) than in the Dolyhir and Nash Scar Limestones (*centrifugus* & *murchisoni* Biozones) of England (Text-fig. 45). Numbers of specimens from both areas are small however and the range of this species is subsequently poorly known.

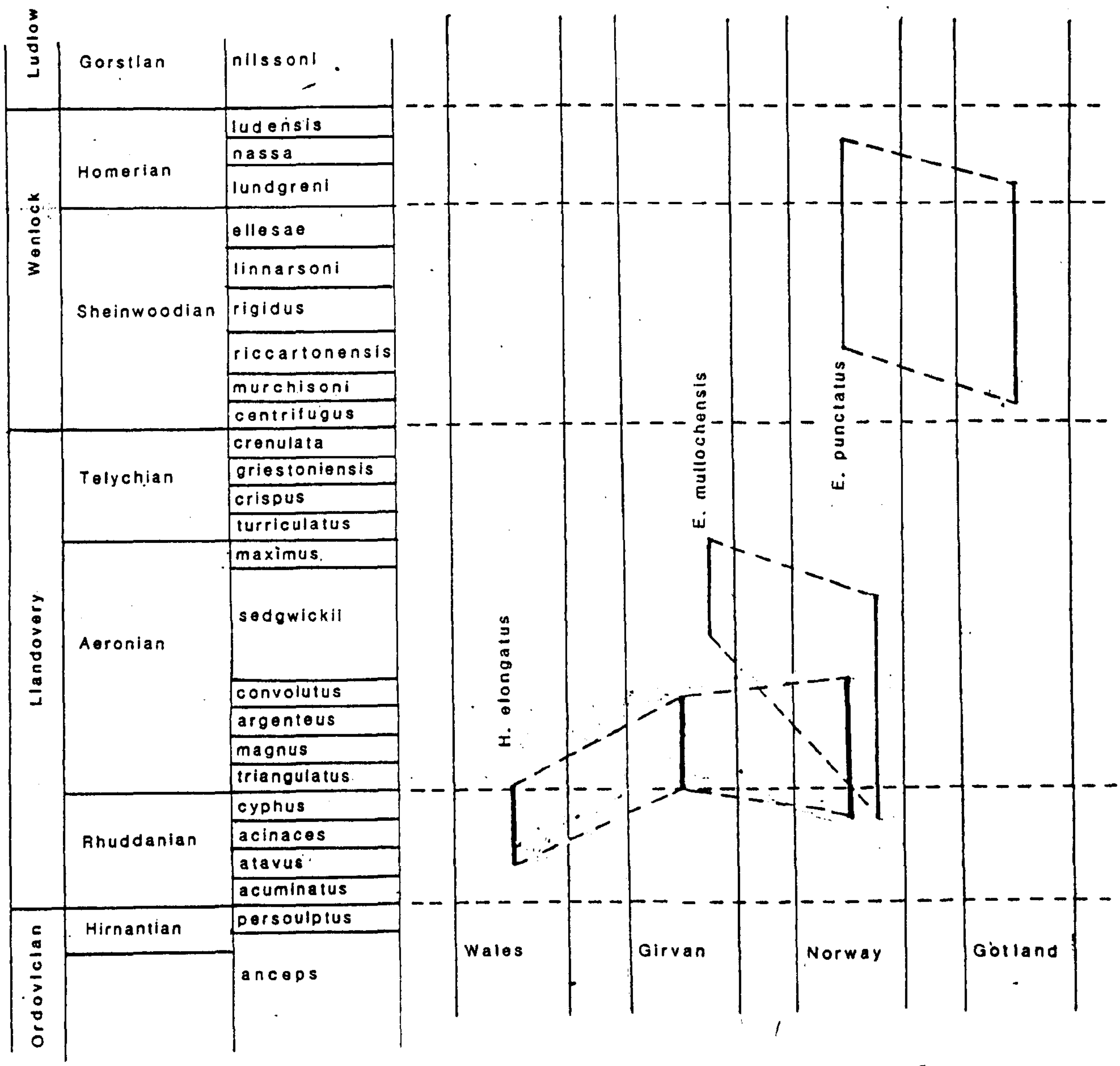
B. bouchardi occurs in the Malmøya formation of southern Norway (*rigidus* & *linnarsoni* Biozones) and the Liten Formation (Wenlock) of the East Baltic. In neither area is the range of this species well known.

Text-fig. 45

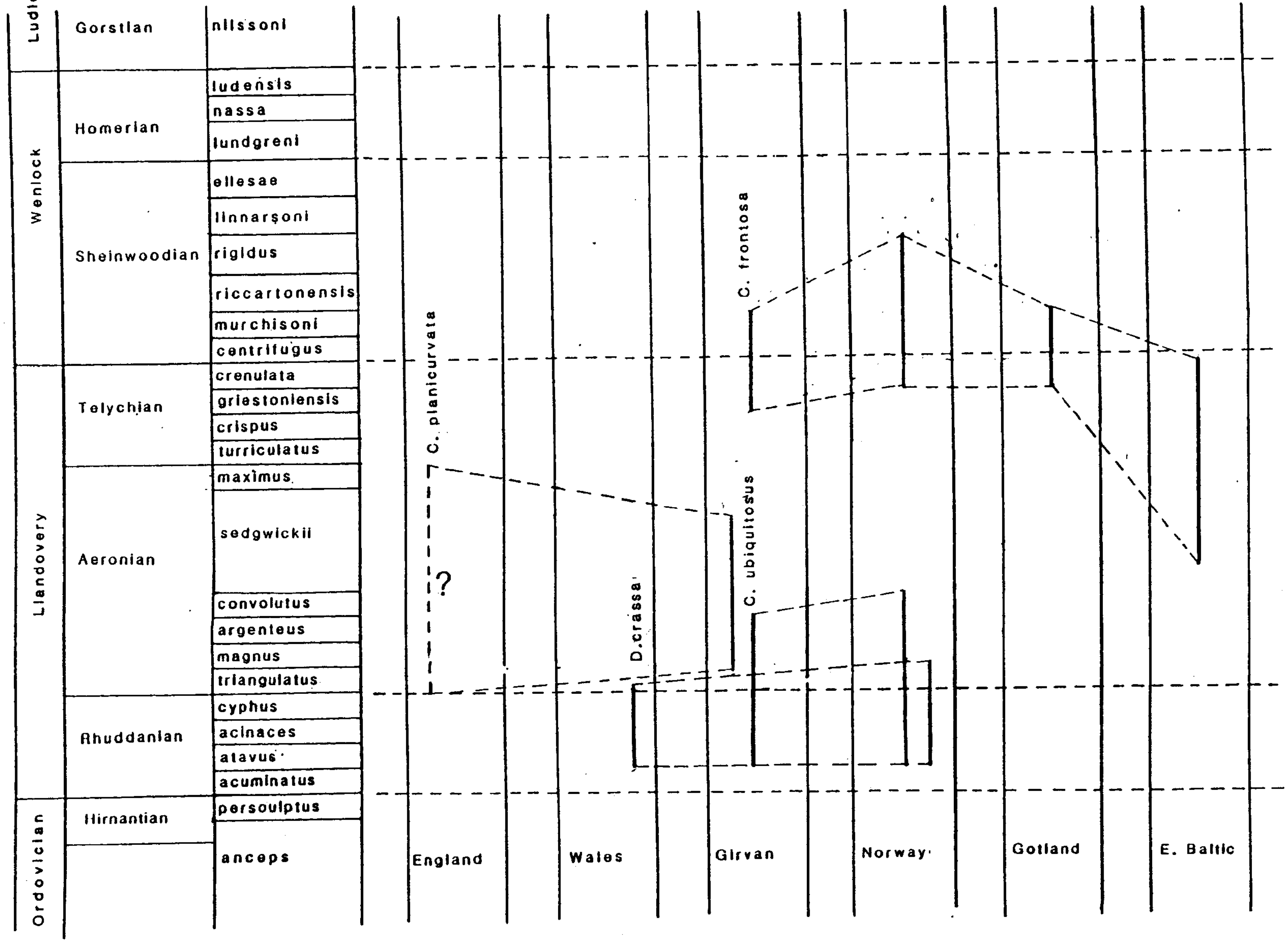

Ludlow
Gorstian
nilssoni
Wenlock
Homerian
ludensis
nassa
lundgreni
Sheinwoodian
ellesae
linnarsoni
rigidus
riccartonensis
murchisoni
centrifugus
Llandovery
Telychian
crenulata
griestoniensis
crispus
turriculatus
Aeronian
maximus
sedgwickii
convolutus
argenteus
magnus
triangulatus
Rhuddanian
cyphus
acinaces
atavus
acuminatus
Ashgill
Hirnantian
persculptus
Rawtheyan
anceps
Cautleyan
Pusgillian
complanatus
linearis
Caradoc
Onnian
clingani
B. inflatus
B. bouchardi
O. maccallumi
S. glaber
E. platyactin
?
England
Girvan
Norway
Gotland
Czech.

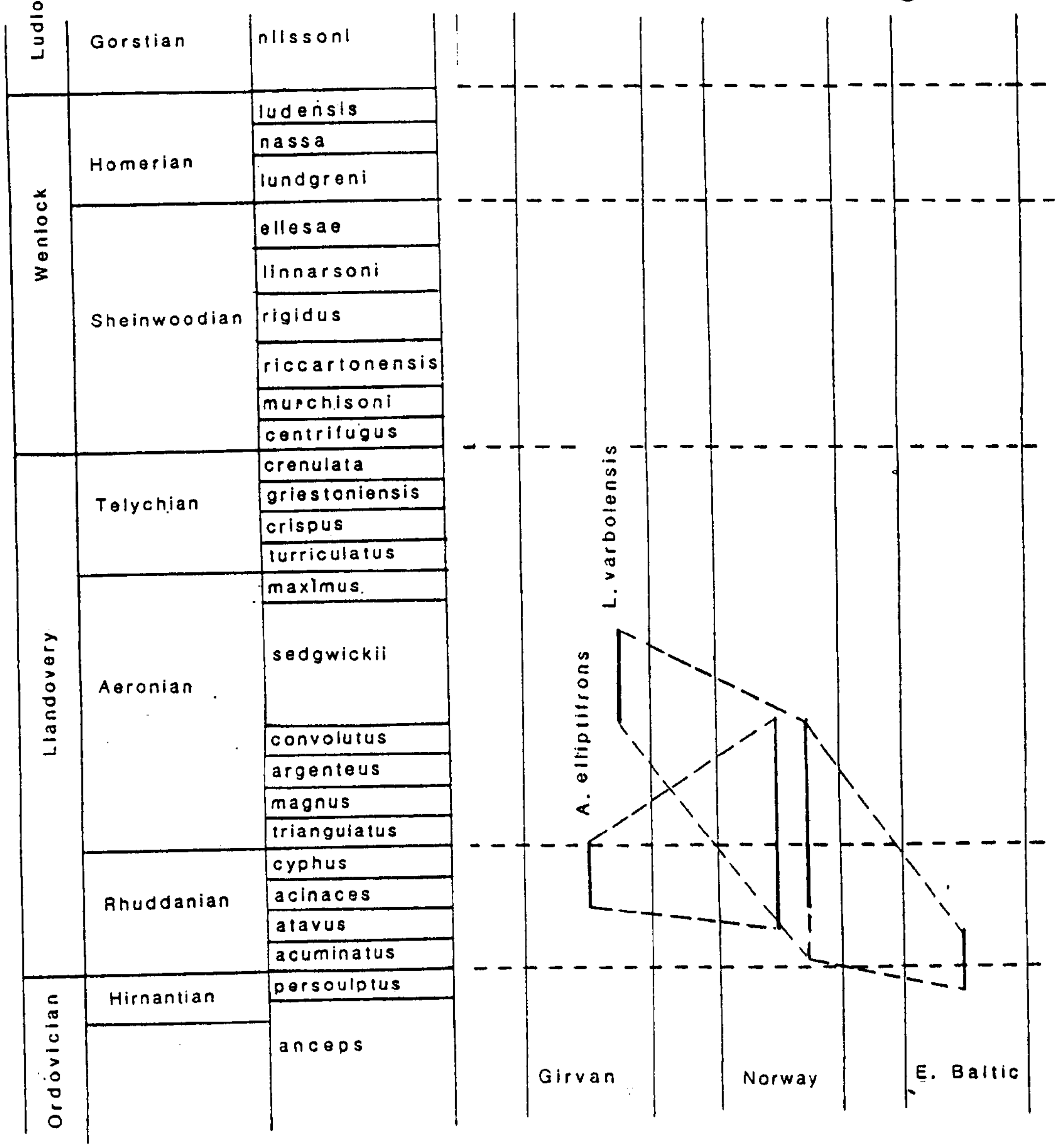

Text-fig. 46
Ludlow
Ludfordian
Bohemograptus
proliferation
leintwardinensis
Gorstian
incipiens/
tumescens
scanicus
nilssoni
Wenlock
Homerian
ludensis
nassa
lundgreni
Sheinwoodian
ellesae
linnarssoni
rigidus
riccartonensis
murchisoni
centrifugus
Llandovery
Telychian
crenulata
griestoniensis
crispus
turriculatus
Aeronian
maximus
sedgwickii
convolutus
argenteus
magnus
triangulatus
Rhuddanian
cyphus
acinaces
atavus
acuminatus
Ordovician
Hirnantian
persculptus
anceps
C. externus
P. (L.) confossus
P. (P.) concinnus
H. simpulum
W. (W.) baltica
Greenland
England
Girvan
Norway
Gotland
E. Baltic
Czech.

Text-fig. 47

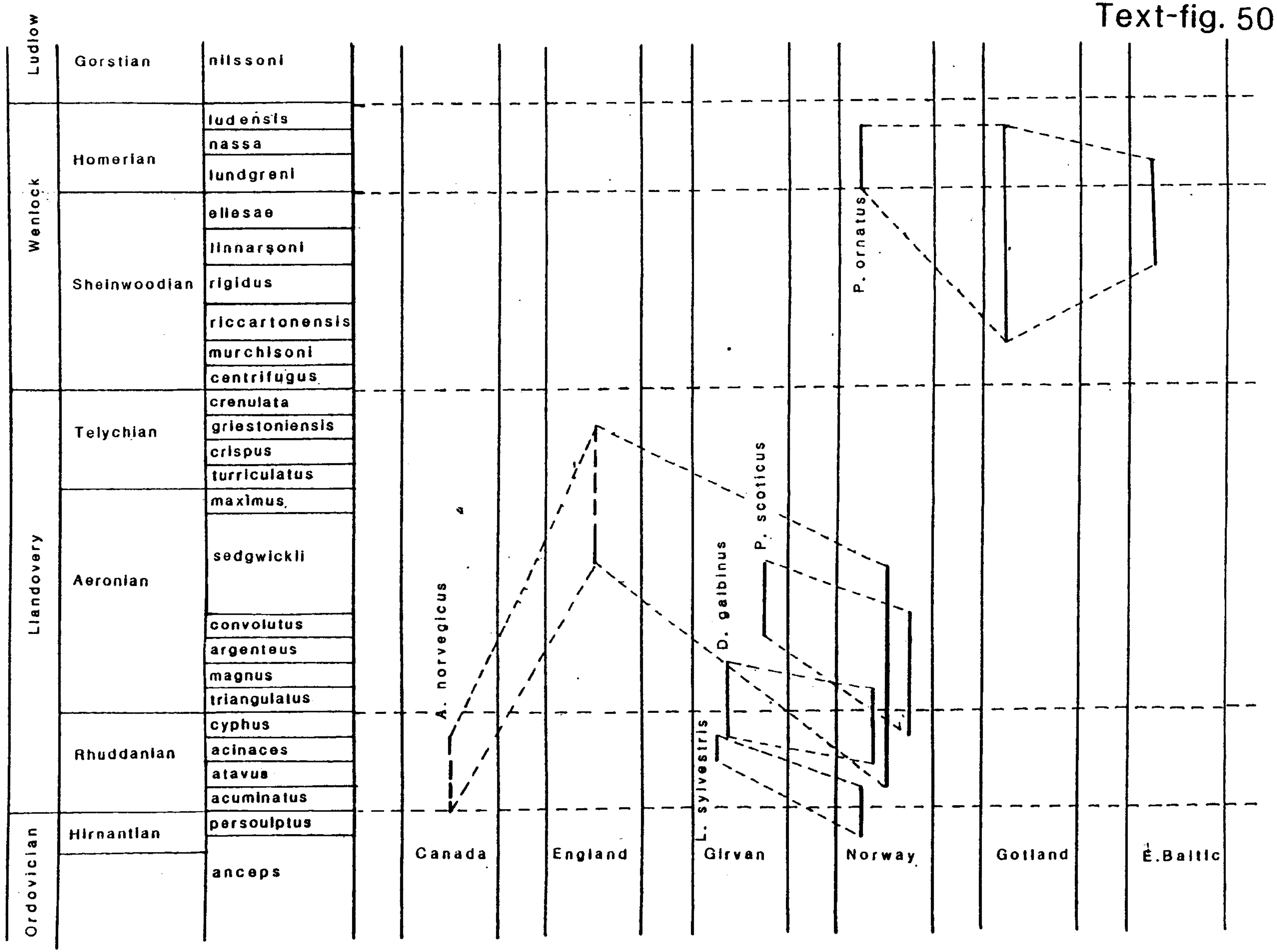

Ludlow
Wenlock
Llandovery
Ordovician
Gorstian
Homerian
Sheinwoodian
Telychian
Aeronian
Rhuddanian
Hirnantian
nilssoni
ludensis
nassa
lundgreni
ellesae
linnarsoni
rigidus
riccartonensis
murchisoni
centrifugus
crenulata
griestoniensis
crispus
turriculatus
maximus
sedgwickii
convolutus
argenteus
magnus
triangulatus
cyphus
acinaces
atavus
acuminatus
persculptus
anceps
H. elongatus
E. mullochensis
E. punctatus
Wales
Girvan
Norway
Gotland

Text-fig. 48


Ludlow
Wenlock
Llandovery
Ordovician
Gorstian
Homerian
Sheinwoodian
Telychian
Aeronian
Rhuddanian
Hirnantian
nilssoni
ludensis
nassa
lundgreni
ellesae
linnarsoni
rigidus
riccartonensis
murchisoni
centrifugus
crenulata
griestoniensis
crispus
turriculatus
maximus
sedgwickii
convolutus
argenteus
magnus
triangulatus
cyphus
acinaces
atavus
acuminatus
persculptus
anceps
C. planicurvata
?
D.crassa
C. ubiquitosus
C. frontosa
England
Wales
Girvan
Norway
Gotland
E. Baltic


Ludlow
Gorstian
nilssoni
Wenlock
Homerian
ludensis
nassa
lundgreni
Sheinwoodian
ellesae
linnarsoni
rigidus
riccartonensis
murchisoni
centrifugus
Llandovery
Telychian
crenulata
griestoniensis
crispus
turriculatus
Aeronian
maximus
sedgwickii
convolutus
argenteus
magnus
triangulatus
Rhuddanian
cyphus
acinaces
atavus
acuminatus
Ordovician
Hirnantian
persculptus
anceps
L. varbolensis
A. ellipitifrons
Girvan
Norway
E. Baltic

Text-fig. 50



Ludlow
Wenlock
Llandovery
Ordovician
Gorstian
Homerian
Sheinwoodian
Telychian
Aeronian
Rhuddanian
Hirnantian
nilssoni
ludensis
nassa
lundgreni
ellesae
linnarsoni
rigidus
riccartonensis
murchisoni
centrifugus
crenulata
griestoniensis
crispus
turriculatus
maximus
sedgwickii
convolutus
argenteus
magnus
triangulatus
cyphus
acinaces
atavus
acuminatus
persculptus
anceps
Canada
England
Girvan
Norway
Gotland
E.Baltic
A. norvegicus
L. sylvestris
D. galbinus
P. scoticus
P. ornatus

P. (L.) confossus is known from the Much Wenlock Limestone Formation (*ludensis* Biozone) of U.K. and the Steinsfjorden Formation of Gotland (*ellesae* to *nassa* Biozones). They therefore have similar ranges in the two areas.

In conclusion those trilobites from southern Norway which are known from elsewhere and for which the range is well understood show a good deal of agreement in stratigraphic range. Those species which occur elsewhere and for which the range is not well known (due mainly to the small number of specimens) show clear potential for a similar usage, should more material become available.

Trilobite associations

Appendix 17

The most striking feature of the trilobite faunas of southern Norway is the distinct break between those species occurring before and after the *crenulata* Biozone. The genera present above and below the *crenulata* Biozone are little different, however only the species *O. longicaudatus* and *E. platyactin* cross this line. This division may be in part due to a general lack of specimens from the Vik and Skinnerbukta Formations (*crispus* to *riccartonensis* Biozones). Howells (1982, p. 64) recorded a similar changeover in species in the Girvan area, Scotland, above and below the *convolutus* Biozone and she suggested greater links with the East Baltic in rocks younger than the *convolutus* Biozone.

Localities from which large samples are available have yielded several trilobite associations. In the Solvik Formation of Leangbukta, Malmøya and Skytterveien the fauna is dominated by *Acernaspis* with common *Encrinurus* and "illaenimorph" (= *Stenopareia* and *Opsypharus*) trilobites. Thomas & Lane (1984, p. 58) stated that *Acernaspis* and *Encrinurus* often occur together almost to the exclusion of other trilobites and related this association to marginal marine environments with high energy and or varying salinity conditions. *Encrinurus* is not as common as *Acernaspis* at any locality in the Solvik Formation and it is probable that environmental conditions may not have been as stressful. At Spirodden the fauna is the most diverse of any collected from the Silurian of Norway and is dominated by *Cyphoproetus* with common *Acernaspis* and less common *Arctinurus, Encrinurus, Hadromeros, Harpidella, Leonaspis* and "illaenimorph" trilobites (= *Stenopareia* & *Opsypharus*) which all occur in similar numbers. Lane (1971) and Mikulic (1981) have both noted a dominance of "illaenimorph" trilobites in carbonate buildups where phacopid trilobites are rare. It seems likely that there is a decrease in the dominance of "illaenimorph" trilobites and an reciprocal increase in the proportion of *Acernaspis* with increasing amounts of clastic sedimentation. This is supported by the trilobite association collected from the Saelabonn Formation of the Ringerike district which is dominated by *Acernaspis* and *Encrinurus* with rare *Stenopareia*. The Saelabonn Formation is considered to be the shallower water equivalent of the Solvik Formation (Worsley *et al*. 1983, p. 47) and contains a higher proportion of clastic sediments. The *Acernaspis*:*Encrinurus* association is best developed in the Braksøya Formation of the Ringerike district where it is dominant. Worsley *et al*. (1983, p. 35) recorded the occurrence of desiccation cracks and evaporation pseudomorphs in the upper parts of this formation and suggest intra tidal:supertidal depositional environments with periodic varying salinity conditions. This supports Thomas & Lane's conclusion that the *Acernaspis*:*Encrinurus* association may be related to restricted hypersaline conditions.

The trilobite associations collected from the Steinsfjorden Formation of the Holmestrand district are dominated by *Warburgella (W.) baltica* with less common *Calymene* and *Encrinurus*. This association corresponds to the *Proetus*:*Warburgella* association recorded by Thomas (1979, p. 448) from the Wenlock of the U.K. and the *Encrinurus punctatus* association recorded from the Wenlock of the East Baltic by Männil (1982, p. 65). Both *E. punctatus* and *Proetus* occur in the Steinsfjorden Formation but the former is not very common and the latter is very rare. Thomas and Männil both regarded this association as being typical of shallow shelf environments. The Norwegian *Warburgella* association is less diverse than that of the East Baltic or U.K. associations and this may be the result of more restricted environmental conditions in that Worsley *et al.* (1983, p. 41) believed this formation to have been deposited in supratidal, intertidal and restricted subtidal environments.

REFERENCES

Abbreviations referred to below are those of Leake 1978.

Aarhus, N. 1982. Lower Silurian tabulate corals of the Oslo Region. *Paleontological Contributions from the University of Oslo*, No. 278, 43-46, 3 pls.

Alberti, G.K.B. 1963. Zur Kenntnis rheinish-herzynischer Mischfaunen (Trilobiten) im Unterdevon. *Mitt. geol. Staatinst. Hamburg.*, **32**, 148-59, pls 15, 16.

-----1969. Trilobiten des jüngeren Siluriums sowie des Unter- und Mitteldevons. Mit Beiträgen zur Silur-Devon Stratigraphie einiger Gebiete Marokkos und Oberfrankens. *Abh. Senckenb. naturforsch. Ges. Frankfurt*, No. 520, 1-692, pls 1-52.

Aldridge, R.J. & Mohamed, I. 1982. Conodont stratigraphy of the early Silurian of the Oslo Region. *Paleontological Contributions from the University of Oslo*, No. 278, 109-120, 2 pls.

Alth, A. 1874. Über die paläozoischen Gebilde Podoliens und deren Versteinerungen. *Abh. K-K geol. Rheichsanst. Wein.*, **7**, 1-79, 5 pls.

Angelin, N.P. 1854. *Palaeontologia Scandinavica* I. *Crustacea formationis transitionis.* Fasc. 2, I-IX, 21-92, pls. 25-41. Lund.

Balashova, E.A. 1968. [*Trilobites of the Skala & Borschev horizons in Podolia*, In *Siluro-Devonian faunas of Podolia*], 95-124, 3 pls. Leningrad University [In Russian].

Bancroft, B.B. 1949. Upper Ordovician trilobites of zonal value in south-east Shropshire. (Edit. A. Lamont), *Proc. R. Soc. London* (B), **136**, 291-315, pls 9-11.

Barrande, J. 1846a. *Notice préliminaire sur le Systeme Silurien et les trilobites de Boheme.* vi+97 pp. Leipsic.

-----1846b. *Nouveaux trilobites Supplément à la notice préliminaire sur le Systeme Silurien et les trilobites de Boheme.* 40 pp. Prague.

-----1852. *Systeme Silurien du centre de la Boheme. 1ére partie: Recherches palontologiques. Vol. 1. Crustacés: Trilobites.* xxx+647 pp., 51 pls. Prague.

Bassett, M.G. & Rickards, R.B. 1971. Notes on Silurian stratigraphy and correlation in the Oslo district. *Nor. geol. Tidsskr.*, **51**, 247-260.

-----& Cocks, L.R.M. 1974. A review of Silurian brachiopods from Gotland. *Fossils and Strata,* No. 3, 1-56.

Begg, J.L. 1950. New trilobites from Girvan. *Geol. Mag.* **87**, 285-91, pl. 14.

Best, R.V. 1961. Intraspecific variation in *Encrinurus ornatus* *J. Paleontol.* **35**, 1029-40, pl. 124.

Beyrich, E. 1845. *Ueber einige Böhemischen Trilobiten.* 47 pp., 1 pl. Berlin.

Bigsby, J.J. 1825. Description of a new species of trilobite. *J. Acad. nat. Sci. Philadelphia,* **4**, (2), pl. 23.

Billings, E. 1860. Description of some new species of trilobites from the Lower and Middle Silurian rocks of Canada. *Can. Nat. Geol.*, **4**, 367.

Bilton, W. 1840. *Two Summers in Norway.* Saunders & Otley, London, Vol. 1, 332 p.; Vol. 2, 290 p.

Bolton, T.E. 1965. Trilobites from upper Silurian rocks of the Canadian arctic archipelago: *Encrinurus (Frammia)* and *Hemiarges. Bull. geol. Surv. Can.*, No. 134, 1-14, pls 1-3.

-----1981. Ordovician and Silurian Biostratigraphy, Anticosti Island, Quebec. *In* Lespérance, P.J. (Editor). *Subcommission on Silurian stratigraphy, Ordovician:Silurian boundary working group. Field meeting, Anticosti-Gaspé, Quebec. 1981, Vol II: Stratigraphy and Paleontology,* 197-203, pls 1-3.

Bradley, J.H. 1930. Fauna of the Kimswick Limestone of Missouri and Illinois. *Contr. Walker Mus.*, **2**, (6), 219-90, pls. 23-30.

Brøgger, W.C. 1900. Norges geologi *In Norge i det Nittende Aarhundrede,* pp. 1-32.

Brongniart, A. 1822. *Histoire naturelle des Crustacés fossiles, sous les rapports zoologique et géologique, savoir les Trilobites. Les Crustacés proprement dits, par A.-G. Desmarest.* 1-154, 11 pls, Paris.

Bruton, D.L. 1967. Silurian odontopleurid trilobites from Sweden, Estonia and Latvia. *Palaeontology* , **10**, 214, pls 30-36.

-----1980. See Owen & Bruton.

Buckland, W. 1836. *Geology and mineralogy considered with reference to natural theology*. **1**, xvi+618 pp., **2**, vii+128 pp., 69 pls. London.

Burmeister, H. 1843. *Die organisation der Trilobiten, aus ihren lebenden Verwandten entwickelt; nebst einer systematischen. Ubernicht aller zeither beschrieben Arten*. 147 pp., 6 pls. Berlin.

Campbell, K.S.W. 1967. Trilobites of the Henryhouse Formation (Silurian) in Oklahoma. *Bull. Oklahoma geol. Surv.*, No. 115. 1-68,

-----1977. Trilobites of the Haragan, Bois d'Arc and Frisco Formations (early Devonian), Arbuckle Mountain region, Oklahomahoma. *Bull. Okla. geol Surv*, **123**, vi+22pp, pls 1-40.

Castelnau, F.[L.] De. 1843. *Essai sur le systeme Silurien de l'Amerique Septentrionale*. xv+56 pp., 27, pls. Paris & Strasbourg.

Chang, W.T. 1974. In *A handbook of the stratigraphy and paleontology in southwest China*. Edited by the Nanking Institute of Geology and Paleontology, Academica Sinica. Science Press. III+45pp., 202 pls [In Chinese].

Chatterton, B.D.E. 1971. Taxonomy and ontogeny of Siluro-Devonian trilobites from near Yass, New South Wales. *Palaeontographica (A)*, **137**, 1-108, 24 pls.

-----1980. Ontogenetic studies of Middle Ordovician trilobites from the Esbataottine Formation, Mackenzie Mountains, Canada. *Palaeontographica* (A), **171**, 1-103, pls 1-19.

-----& Ludvigsen, R. 1976. Silicified middle Ordovician trilobites from the South Nahanni River area, district of Mackenzie, Canada. *Palaeontographica* (A), **154**, 1-106, pls 1-24.

Chlupâc, I. 1977. The phacopid trlobites of the Silurian and Devonian of Czechoslovakia. *Rozpr. Ustred. Ustavu geol.*, **43**, 172 pp., 32 pls.

Clarke, J.M. 1889). The structure and development of the visual surface in the trilobite *Phacops rana* Green. *J. Morphology*, **2**, (2), Nov. 1888, 253-270.

Clarkson, E.N.K., Eldridge, N. & Henry, J.L. 1977. Some Phacopina (Trilobita) from the Silurian of Scotland. *Palaeontology*, **20**, 119-42, pls 18-20.

-----& Howells, Y. 1981. Upper Llandovery Trilobites from the Pentland Hills, near Edinburgh, Scotland. *Palaeontology,* **24,** 507-3, pls 77-82.

Cocks, L.R.M. & Baarli, B.G. 1982. Late Llandovery brachiopods from the Oslo Region. *Paleontological Contributions from the University of Oslo,* No. 278, 79-82, pls 1-3.

-----Woodcock, N.H., Rickards, R.B., Temple, J.T., & Lane, P.D. The Llandovery Series of the Type Area. *Bull. Br. Mus. nat. Hist.,* **38,** (3), 131-182.

Conrad, T.A. 1838. Report of T.A. Conrad on the Palæontological Department of the Survey. *Report New York Geological Survey,* 107-119.

Dalman, J.W. 1827. On Palaederna, eller de så kallade Trilobiterna. *K. svenska Vetensk-Akad. Handl.* (for 1826), 113-52, 226-94, pls 1-6.

Dames, W. 1877. Über *Hopolichas* and *Conolichas,* zwei Untergattungen von *Lichas. Deutsch. geol. Gesell. Zeitschr.,* vol. 29.

Dean, W.T. 1971-74. The trilobites of the Chair of Kildare Limestone (Upper Ordovician) of eastern Ireland. *Palaeontogr. Soc. [Monogr.]*: (1), 1-60, pls 1-25; (2) 1974, 61-98, pls 26-44.

Delgado, J.F. 1892. Fauna silurica de Portugal. *Commisao Trab. Geol. Portugal.*

Delo, D.M. 1935. A revision of the phacopid trilobites. *J. Paleont.,* **9,** 402-420.

Dorning, K.J. & Aldridge. R.J. 1982. A preliminary investigation of palynological assemblages from the early Silurian of Ringerike. *Paleontological Contributions fron the University of Oslo,* No. 278, 105-108.

Edgell, H.S. 1955. A middle Devonian lichid Trilobite from southeastern Australia. *Paläontol. Z. Berlin,* **29,** 136-145, pl. 14, 15.

Eichwald, E. 1840. Über das silurische system in Esthland (*fide* Fletcher 1950).

Emmrich, H.F. 1844, *Zur Naturgeschicte der Trilobiten.* 28 pp., 1 pl. Meiningen.

Esmark, H.M.T. 1833. Om nogle nye Arter af Trilobiter. *Mag. f.*

naturvid., **11**, 268-70, pl. 7.

Evitt, W.R. & Tripp, R.P. 1977. Silicified Middle Ordovician trilobites from the families Encrinuridae and Staurocephalidae *Palaeontographica* (A), **157**, 109-74, pls, 1-24.

Fletcher, H.O. 1950. Trilobites from the Silurian of New South Wales. *Rec. Aust. Mus.*, **22**, 220-233.

Fletcher, T.W. 1850. Observations on Dudley Trilobites. Part 1. *Q. J. geol. soc. London*, **6**, 235-39, pls 27, 27 bis.

-----& Salter, J.W. 1873. *In* Salter J.W. *A catalogue of the collection of Cambrian and Silurian fossils contained in the Geological Museum of the University of Cambridge.* ix-xlviii, 204 pp., Cambridge.

Foerste, A.F. 1920. The generic relations of the American Ordovician Lichidae. *Am. J. Sci.* ser. 4, **49**, 419-422.

Fortey, R.A. & Clarkson E.N.K. 1976. The function of the glabellar "tubercle" in *Nileus* and other trilobites. *Lethia*, **9**, 101-106.

Gardiner, C.I. 1920. The Silurian rocks of May Hill with a palaeontological appendix by Dr. F.R. Cowper Reed. *Proc. Cotteswold Nat. Field Club.*, **20**, pp. 185-222.

Gray, J., Laufeld, S. & Boucot, A.J. 1974. Silurian trilete spores and spore tetrads from Gotland: Their implications for land plant evolution. *Science*, No. 185, 260-263.

Gürich, G. 1901. Ueber eine nue Lichas-Art dem Devon von Nue-Süd Wales und über die Gattung *Lichas* überhaupt. *Neus Jahrb. Mineral. Geol. Palaeontol.*, **14**, 519-39.

Hadding, A. 1941. The Pre-Quaternary sedimentary rocks of Sweden. VI. Reef limestones. *Lunds Univ. Arsskr.*, N.F. Ard. 2, Bd. 37, no. 10, 137 pp., Lund. Also as *Kungl. Fysiogr. Sällsk Handl.* NF. Bd. 52, No. 10.

Hall, J. 1862. Physical geography and general geology. *In.* Hall, J. & Whitney, J.D. *Report of the Geological Survey of the State of Wisconsin*, no. 1, 1-72 for 1861.

-----1867. Account of some new or little known species of fossils from rocks of the Niagra group. *Report of the New York State Museum of Natural History*, **20**, 305-401, pls 10-23.

-----1882. Descriptions of the species of fossils found in the Niagara Group at Waldron, Indiana. *Annual report of the*

Indiana Department of Geology & Natural History, No. 11, 217-409, pls 1-55.

-----& Clarke, J.M. 1888. Trilobites and other crustacea, *Nat. Hist. New York. Paleontology*, 7, supp. to 5, (2), 236+42p., pls 1-36+114-229.

Hanken, N.-M., Olaussen, S, & Worsley, D. 1979. Silurian Bioherms in the Oslo Region (Norway). *Reefs Newsletter*, No. 5, 33-35.

Hawle, I. & Corda, A.J.C. 1847. *Prodrom einer Monographie der böhemischen Trilobiten.*, 176 pp., 7 pls., Prague.

Hede, J. 1919. Djupborringen vid Burgsvik på Gotland 1915. Paleontologisk-stratigrafiskat resultat. *Sver. geol. Unders.* C., No. 305, 100 pp.

-----& Lundqvist, G. 1929. Beskrivning till kartbladet Slite. *Sver. Geol. Unders.*, Aa., No. 170, 14-57.

-----1958. [Silurian entries in] *Lexique stratigraphie international 1, Europe, 2c, Suede-Sweden-Sverge*, 498 pp., Paris.

-----1960. The Silurian of Gotland *In* Regnell, G. & Hede, J.E. The Lower Paleozoic of Scania. The Silurian of Gotland. *Int. Geol. Congr. XXI Sess. norden* 1960, Guidebook Sweden d. Stockholm. Also in *Publ. Inst. Min. Pal. Quart. Geol. Lund*, **9**, 44-49.

Hedström, H. 1923. Contributions to the fossil fauna of Gotland. *Sver. geol. Unders*, C, **316**, 1-24, pls 1-5.

Helbert, G.J., Lane, P.D., Owens, R.M., Siveter, Derek.J. & Thomas, A.T. 1982. Lower Silurian trilobites from Norway. *Paleontological Contributions from the University of Oslo*, No. 278, 129-146.

Holloway, D.J. 1980. Middle Silurian trilobites from Arkansas and Oklahoma, U.S.A. (1). *Palaeontographica*, (A), **170**, 1-85, 20 pls.

Holm, G. 1886. Revision der ostbaltischen silurischen Trilobiten. Abth. 3. Die ostbaltischen Illaeniden. *Mém. Acad. imp. Sci. St. Pétersbourg.*, **33**, 1-173, pls 1-12.

Holzapfel, E. 1895. Obere Mitteldevon (Schichten mit Stringocephalus burtini und Maeniceras terebratum) im Rheinischen Gebirge. *Abh. K.* O"*niglich Preuss Geol. Landesanst*, NF 16, 1-459, pls 1-19 [*fide* Thomas *pers. comm.*].

Horny, R. & Bastl, F. 1970. *Type specimens of fossils in the National Museum, Prague. Volume 1. Trilobita.* 354 pp, 20 pls, National Museum, Prague.

Howe, M.P.A. 1982. The Lower Silurian graptolites of the Oslo Region. *Paleontological contributions from the University of Oslo,* No. 278, 21-32, 2 pls.

Howells, Yvonne 1982. Scottish Silurian trilobites. *Monogr. Palaeontogr. Soc. London,* 1-76, pls. 1-15.

Hupé, P. 1953. Contribution a l'étude du Cambrien inférieur et du Precambrien III de l'Anti-Atlas marocain. *Service géol Maroc. (Rubat). Notes et Mém.*, no. 103, 402pp, 24 pls.

-----1955. Classifications des trilobites. *Annls Paléont.*, **41**, 91-317. [Part 2 of this work; part 1 published *ibid.* 39. *Fide* Lane & Thomas 1984].

Hurst, J.M. 1974. Selective epizoan encrustation of some Silurian Brachiopods from Gotland. *Palaeontology,* **17**, (2), pp. 423-430.

Huxley, T.H. & Etheridge, R. 1865. *A catalogue of the collection of fossils in the Museum of Practical Geology, with an explanitory introduction.* lxxix+381 pp., London.

International Code of Zoological Nomenclature (Third Edition). International Trust for Zoological Nomenclature.

Johnson, M.E. 1982. Historical overview of research on Lower Silurian (Llandovery) strata in Norway. *Paleontological Contributions from the University of Oslo,* No. 278, 1-10.

-----& Worsley, D. 1982. Development and chronology of early Silurian depositional environments in southern Norway. *Paleontological Contributions from the University of Oslo,* No. 278, 149-159.

Kegel, W. 1927. Uber obersilurische trilobiten aus dem Harz und dem Rheinischen Scheifergeberge. *Jahrb. K. Preuss. geol. Landesanst. Berg. Akad. Berlin,* **48**, 616-47, pls 31, 32.

Kiær, J. 1908. Das Obersilur im Kristianiagebiete. *Videnskabs-Selskabets Skrifter.* I. *Math.-Naturv. Klassa* B II, (1906), 595 pp, 3 pls.

-----1922. Oversigt over kalkalgefloraene i Norges Ordovicium og Silur. *Norsk geol. Tidsskr.* **7**, 113-142.

Kielhau, B.M. 1838. *Gaea Norvegica I, Christianias Uebergangs-Territorium.* Christiania, 145 pp.

Kjerulf, T. 1857. Über die Geologoie des südlichen Norwegens. *Nyt Mag. for Naturvid.* 9, 193-333. *Fide* Johnson, 1982.

-----1865. Veiveser ved Geologiske Excursioner i Christiania omegn. *Univ. Programm sem.*, 2, iv+43pp.

Koninck, L.G. De. 1898. Descriptions of the Palaeozoic fossils of New South Wales (Australia). *Mem. geol. Surv. N.S.W.* (Palaeont), 6, xiii+298 pp., 24 pls.

Kummerow, E. 1928. Beiträge zur Kenntnis der Fauna und der Herkunft der Diluvialgescheibe. *Jb. preuss Landesanst. BergAkad.*, **48** (for 1927), 1-59, pls 1-2.

Lake, P. 1896. British Silurian species of *Acernaspis. Q. J. geol. Soc. London*, **52**, 235-45, pls 7, 8.

Lamont, A. 1949. New species of Calymenidae from Scotland and Ireland. *Geol. Mag.*, **86**, 313-23.

-----1978. Pentlandian Miscellany: Mollusca, Trilobita, etc. *Scott. J. Sci.*, 1, (5), 33-46, pl. 5.

Lane, P.D. 1971. British Cheiruridae (Trilobita). *Monogr. Palaeontogr. Soc. London*, 95 pp, 16 pls.

-----1972. New trilobites from the Silurian of north east Greenland with a note on trilobite faunas in pure limestone. *Palaeontology London*, **15**, 336-64, 59-64.

-----1979. Llandovery trilobites from Washington Land, North Greenland. *Bull. Grønlands geol. Unders.*, No. 131, 1-37, pls 1-6.

-----1980. A new Silurian *Hemiarges* (Trilobita) from North Greenland and the question of the Polaris Harbour Formation. *Rapp. Grønlands geol. Unders.*, No. 101, 45-53.

-----1982. See Helbert *et. al.*

-----1984. Silurian trilobites from Hall Land and Nyeboe Land, Western North Greenland. *Rapp. Gronlands geol. Unders.*, No. 121, 53-75, 4 pls.

-----& Owens, R.M. 1982. Silurian trilobites from Kap Schuchert, Washington Land, western North Greenland. *Rapp. Grønlands Unders.*, No. 108, 41-69.

-----& Thomas, A.T. 1978a. Silurian trilobites from N. E. Queensland

and the classification of effaced trilobites. *Geol. Mag.*, No. 115, (5), 351-58, pls 1, 2.

-----& Thomas, A.T. 1978b. Family Scutelluidae. *In* Thomas, A.T. British Wenlock trilobites. *Monogr. Palaeontogr. Soc. London*, (1), 1-56, pls 1-14.

-----& Thomas, A.T. 1984. A review of the Trilobite Suborder Scutelluina *Special Papers in Palaeontology*, No. 30, pp. 141-160.

Larsson, K. 1979. Silurian tentaculitids from Gotland and Scania. *Fossils Strata*. No. 11, 180 pp.

Laufeld, S. 1974a. Silurian Chitinozoa from Gotland. *Fossils Strata*, **5**, 130 pp.

-----1974b. Reference localities for palaeontology and geology in the Silurian of Gotland. *Sver. Geol. Unders*. No. 705, pp. 1-172.

Lauritzen, O. & Worsley, D. 1974. Algae as depth indicators in the Silurian of the Oslo region. *Lethaia*. **7**, 157-161.

Leake, B.E. 1978. *List of serial publications held in the library of the Geological Society, London*, 172 pp. Geological Society.

Lespérance, P.J. 1968. Ordovician and Silurian trilobite faunas of the White Head Formation, Percé region, Quebec. *J. Paleontol.*, **42**, 811-26, pl. 106.

-----& Letendre, J. 1981. Phacopid trilobites of the Anticosti Series of Anticosti Island and of the Matapédia Group in Gaspé (Quebec). *In* Lespérance, P.J. (Editor) *Subcommission on Silurian Stratigraphy, Ordovician:Silurian boundary working group. Field Meeting, Anticosti-Gaspé, Quebec 1981, Vol II. Stratigraphy and Paleontology*, 197-203, pls 1-3.

Lindström, G. 1885. Förteckning på Gotlands Siluriska crustacéer. *Ofvers. K. Vetensk-Akad. Förh.*, 6, 37-100, pls 12-16.

-----1901. Researches on the visual organs of the trilobites. *Ofvers K. Vetensk-Akad, Förh.*, **34**, 1-89, pls 1-6.

Linnarsson, J.G.O. 1869. Om Vestergötlands Cambriska och Siluriska Aflagringar. *K. Svenska Vetensk-Akad. Handl.*, 8, (2), 1-89, pls 1, 2.

Lóven, S.L. 1845. Svenska Trilobiter. *Ofvers K. Vetensk-Akad, Förh.*, 2, 46-56, pl. 1.

Maksimova, Z.A. 1970. [*Silurian trilobites of Vajgac Island*] In: [*Silurian stratigraphy and fauna of Vajgac Island*]. *Nauchno issled. Int. Geol. Artiki*, 195-209, pls 1, 2. [In Russian].

Mannil, R. 1977a. Distribution of trilobites in the Silurian of the east Baltic area. *In* Kaljo, D. (Editor). "Facies and faunas of the Prebaltic Silurian". *Izv. Akad. Nauk. Est. SSR.*, 148-158.

-----1977b. East Baltic Lower Silurian Calymenidae (Trilobita). *In*. Kaljo, D. (Editor), "Facies and Faunas of the Prebaltic Silurian". *Izv. Akad. Nauk. Est. SSR.*, 240-258, pls 1-6 (in Russian with English and French summaries).

-----1979. Silurian Trilobites of the Subfamily Warburgellinae of the East Baltic Area. *Eesti NSV. Teaduste Akadeemia Toimetised* 28 *Köide Geologica*, Nr. 3, pp. 99-107, pls 1, 2.

-----1982. Wenlock and late Silurian trilobite associations of the East Baltic and their stratigraphiphic value. *In Ecostratigraphy of the East Baltic Silurian.* Academy of Sciences of the Estonian SSR, Institute of Geology, pp. 63-69.

-----1983. *Upper Silurian Calymenidae (trilobita) of the East Baltic* In: *Palaeontology of the oldest Palaeozoic of the prebaltic and Podolia.* Akademia Nauk Estonian S.S.R., Institute of Geology publication no. 1257.

Martinsson, A. 1962. Ostracodes of the family Beyrichiidae from the Silurian of Gotland. *Bull. Geol. Inst. Uppsala*, **41**, 369 pp.

-----1966. Beyrichiacean ostracodes associated with the earliest Silurian vertebrates from Gotland. *Geol. Fören. Stockh. Förh.* **88**, pp. 327-339.

-----1967. The succession and correlation of ostracode faunas in the Silurian of Gotland. *Geol. Fören. Stockh. Förh.*, **89**, 125-161.

McCoy, F. 1846 *A synopsis of the Siluruian fossils of Ireland.* 72 pp., 5 pls. Dublin.

-----1849. On the clasification of some Britissh fossil Crustacea, with notice of some new forms in the University collection at Cambridge. *Ann. Mag. nat. Hist. London*, (2), **4**, 161-79, 330-5, 392-414, 15 figs (not numbered).

Mikulic, D.G. 1981. Trilobites in Paleozoic carbonate buildups.

Lethaia, **14**, pp. 45-46.

Milne Edwards, H. 1840. *Histoire naturelle des crustacés, comprenant l'anatomie, la physiologie et la classification de ces animaux.* **3**, 638 pp., Paris.

Moore, R.C. 1959. *Treatise on Invertebrate Paleontology. Part O, Arthropoda 1.*, 415 figs., Geol. Soc. Amer. and Univ. Kansas Press.

Mori, K. 1968. Stromatoporoids from the Silurian of Gotland. Part 1. *Stockh. Contr. Geol.*, **19**, 100 pp., Stockholm.

-----1970. Stromatoporoids from the Silurian of Gotland. Part 2. *Stockh. Contr. Geol.* **22**, 152 pp., Stockholm.

-----1978. Stromatoporoids from the Silurian of the Oslo region. *Norsk geol. Tidsskr.*, **58**, 121-144.

Murchison, R.I. 1839. *On the Silurian System, founded on geological researches in the counties of Salop, Hereford, Radnor, Montgomery, Caermaerthen, Brecon, Pembroke, Monmouth, Gloucester and Stafford; with descriptions of the coalfields and underlying formations.* xxxi+768 pp., 37 pls, London.

-----1845. On the Palaeozoic deposits of Scandinavia and the Baltic provinces of Russia. *Q. J. geol. Soc. London*, **1**, 467-494.

-----1855. Additional observations on the Silurian and Devonian rocks near Christiania in Norway. *Q. J. geol. Soc. London*, **11**, 161-165.

-----1859. *Siluria.* 3rd edition, John Murray, London, 566 pp.

Neiszkowski, J. 1857. Versuch einer Monographie der in den Silurischen schichten der ostsee provinzen vorkomenden Trilobiten. *Arch. naturkd. Liv.-Est-Kurlands*, **1**, 517-626, pls 1-3.

Neuman, B. 1982. Early Silurian rugose corals of the Oslo Region a preliminary report. *Paleontological Contributions from the University of Oslo*, No. 278, 33-41, 2 pls.

Nicholson, H.A. & Etheridge, R. 1878-80. *A monograph of the Silurian fossils of Girvan in Ayrshire with special reference to those contained in the "Gray Collection".* Vol. I: (1), i-x, 1-135, pls 1-9, 7 figs. (2) 1879, i-vi, 136-233, pls 10-15. (3) 1880, i-vi, 237-341, pls 16-24.

Norford, B.S. 1982. The trilobite fauna of the Silurian Attawapiskat Formation, Northern Ontario and Northern Manitoba. *Bull. geol.*

Surv. Can., No. 327, 37 pp., 11 pls.

Öpik, A.A. 1937. Trilobiten aus Estland. *Acta Comment. Univ. Tartu.* (A), **32**, (3), 1-163, pls 1-26.

Opinion 615. *Lichas araneus* Lindström, 1885 and *Lichas araneus* Holzapfel, 1895 (Trilobita); ruled not to be homonyms. *Bull. zool. Nomencl. London*, No. 18, (6).

Osmólska, H. 1970. Revision of non-cyrtosymbolinid trilobites from the Tournasian-Namurian of Eurasia. *Palaeontol. Pol.*, **23**, 1-165, pls. 1-22.

Owen, A. & Bruton, D.L. 1980. The Caradoc-early Ashgill trilobites of the central Oslo Region, Norway. *Paleontological Contributions from the University of Oslo*, No. 245, 62 pp., 10 pls.

Owens, R.M. 1973. British Ordovician and Silurian Proetidae (Trilobita). *Monogr. Palaeontogr. Soc. London*, 98 pp., 15 pls.

-----1982. See Helbert *et al.*

Peel, J.S. & Yochelson, E.L. 1976. Two new gastropod genera from the Lower Silurian of the Oslo Region, Norway. *Nor. geol. Tiddskr.*, **56**, 15-27.

Perry, D.G. & Chatterton, B.D.E. 1977. Silurian (Wenlock) trilobites from Baillie-Hamilton Island, Canadian, Arctic, Archipelago. *Can. J. Earth Sci.*, **14**, 285-317, pls 1-7.

Phleger, F.B. 1936. Lichidacean trilobites. *J. Paleontol.*, **10**, 593-615.

-----1937a. Species and geographic distribution of the Lichidacea. *Am. Midl. Nat.*, **18**, 1085-92.

-----1937b. Further notes on the Lichadacea. *J. Paleontol.*, **11**, 253-6.

-----1937c. New Lichadacea in the collections of the Museum of Practical Zoology. *Bull. Mus. comp. Zool. Harvard*, No. 80, 415-23, 2 pls.

Prantl, F. & Pribyl, A. 1949. A study of the superfamily Odontopleuracea nov. superfam. (Trilobites). *Rozpr. Ustred. Ustavu geol.*, **12**, 1-221, pls 1-11. [In Czech and English with Russian summary].

-----& Pribyl, A. 1951. A revision of the Bohemian representatives of the Family Otarionidae R. & E. Richter (Trilobitae). *Rozpr.*

Statniho geol. Ustav. Cesk. Republ., **17** (for 1950), 353-512, 5 pls. [Czech and English with Russian summary].

Pribyl, A. 1946. Prispevek k poznání trilobitovýtch rodech ceskýtch proetidů (Trilobitae). *Rozpr. Cs. Akad. Ved*, (10), 1-37. Praha. [*Fide* Snajdr 1980]

-----1953. Seznam ceských trilobitových rodů (Index of trilobite genera in Bohemia). *Knihovna Ustr. Red. ůst. geol.*, **25**, 80 pp. [Czech text, English and Russian summaries].

-----1960. Nové poznatky stredoceskytch trilobitech z nadceledi Proetacea. *Sbor. Ústr. Úst. geol., Odd. paleont.*, **25**, 177-221.

-----& Vanek, J. 1971. Studie über die Familie Scutelluidae Richter et Richter (Trilobita) und ihre phylogenetische entwickling. *Acta. Univ. Carol.*, **4**, 361-94, 10 pls.

-----& Vanek, J. 1978. Studie zu einigen neuen trilobiten der Proetidae familie. *Acta. Univ. Carol.*, **1 & 2**, pp. 163-182, 3 pls.

Price, D. 1974. Trilobites from the Sholeshook Limestone (Ashgill) of South Wales. *Palaeontology London*, **17**, (4), 841-868, pls 112-116.

Ramsköld, L. 1983. Silurian cheirurid trilobites from Gotland. *Palaeontology*, **26**, (1), 175-210.

-----1984. Silurian odontopleurid trilobites from Gotland. *Palaeontology*, **27**, (2), 239-264.

Reed, F.R. 1896. The fauna of the Keisley Limestone-part 1. *Q. Jl. Geol. Soc. London.*, **52**, 407-37, pls 20-21.

-----1902. Notes on the genus *Lichas*. *Q. J. geol. Soc. London*, **58**, 59-82.

-----1903. Woodwardian Museum notes: on some Wenlock species of *Lichas*. *Geol. Mag.*, **50**, 2-12, pl. 1.

-----1906. The Lower Palaeozoic trilobites of the Girvan district Ayrshire. *Monogr. Palaeontogr. Soc. London*, (1). 1-48, pls 1-6.

-----1913-14. The Lower Palaeozoic trilobites of the Girvan district Ayrshire, suppliment. *Monogr. Palaeontogr. Soc. London*, 1-56, pls 1-8.

-----1920. See Gardiner, C.I.

-----1923. The subgenera of *Lichas*. *Geol Mag.*, **60**, 454-62.

-----1925. Some new Silurian trilobites. *Geol Mag.*, **62**, 67-76, pl. 2.

-----1931. The Lower Palaeozoic trilobites of Girvan, suppliment No. 2. *Monogr. Palaeontogr. Soc. London*, 30 pp. (Publ. no. 329, part of Vol 83 for 1929).

-----1935. The Lower Palaeozoic trilobites of Girvan, suppliment No. 3. *Monogr. Palaeontogr. Soc. London*, 64 pp., 4 pls. (Publ. no. 400, part of Vol. 88, for 1934).

-----1941. A new genus of trilobites and other fossils from Girvan. *Geol. Mag.*, **78**, 268-78, pl. 5.

Regnell, G. & Hede, J.E. 1960. *The Lower Palaeozoic of Scania. The Silurian of Gotland.* Int. geol. Congr. xxi. Sess. Norden Guidebook Sweden. Stockholm. 89 pp. Also Publ. *Inst. Min. Pal. Quat. Geol. Univ. Lund.*

Richter, R. & Richter, E. 1917. Über die Einteilung der Familie Acidaspidae und über einige ihrer devonische vertreter. *Centrabl. Mineral. Geol. Palaeontol.*, 1917. 462-72.

-----&----- 1956 Grundlagen für die Beuteilung und Einteilung der Familie Scutelluidae (Tril.). *Senckenberg lethaea*, **37**, 79-124, figs 1-7.

Röemer, F.A. 1852. Beiträge zur geologischen Kenntnis des nordwestlichen Harzegebirges (Abt. 2). *Palaeontographica* (A), **3**, 67-111.

Rudkin, D.M. 1985. Exoskeletal abnormalities in four trilobites. *Can. J. Earth Sci.*, **22**, (3), 479-483.

Rosenstein, E. 1841. Die Encrinurus-Arten des estländen Silurs. *Publ. geol. Inst. Tartu.*, No. 62, 49-77, pls 1-4.

Salter, J.W. 1848. *In* Phillips, J. & Salter J.W. Palaeontological appendix to Professor John Phillip's memoir on the Malvern hills, compared with the Palaeozoic districts of Abberly and *Mem. geol. Sur. U.K.*, 2, viii-xiv+331-86, pls 4-30.

-----1867. A monograph of the British trilobites. *Monogr. Palaeontogr. soc. London.* pp. 177-214, pls 26-30.

-----1873. *A catalogue of the collection of Cambrian and Silurian fossils contained in the Geological Museum of the University of Cambridge.* ix-xlvii, 204 pp., Cambridge.

Schmidt, F. 1885. Revision der Ostbaltischen Silurischen Trilobiten, Abt. 2. Acidaspiden und Lichiden. *Zap. imp. Acad. Nauk [=Mém.*

Acad. imp. Sci. St.-Pétersbourg], (7), **33**, (1), 127 pp., 6 pls.

-----1894. Revision der Ostbaltischen Silurischen Trilobiten, Abt 4. Calymmeniden, Proetiden, Bronteiden, Harpediden, Trinucleiden, Remopleuriden und Agnostiden. *Zap. imp. Akad. Nauk [= Mém, Acad. Sci. St.-Pétersbourg*, **42**, (5), 1-94, pls 1-6.

Schrank, E. 1970. Calymeniden (Trilobita) aus silurischen Gescheiben. *Ber. deutsc. Ges. geol. Viss*, A, **15**, (1), 109-146.

Sdzuy, K. 1979. Two rare trilobites from the Tremadoc Leimitz Shales, Germany. *Alcheringa*, **3**, 63-72.

Selden, P.A. 1981. Functional morphology of the prosoma of *Baltoeurypterus-tetragnopthalmus* (Fischer). (Chelicerata:Eurypterida). *Trans. R. Soc. Edinburgh*, **72**, 9-48.

Shirley, J. 1933. A redescription of the known British Silurian species of *Calymene* (s.l.). *Mem. lit. phil. Soc. Manchester*, **77**, 51-67, pl. 1.

-----1936. Some British trilobites of the family Calymenidae. *Q. J. geol. Soc. London*, **92**, 384-421, pls 29-31.

-----1962. Review of the correlation of the supposed Silurian strata of Artois, Westphalia, the Taunus and Polish Podolia. *Symposiums-Band der 2 internationalen Arbeitstagung Uber die Silur/Devon-Grenze und die Stratigraphie von Silur und Devon* 234-242.

Siveter, David 1982. Late Ordovician and early Silurian Ostracods from the Oslo region. *Paleontological Contributions from the University of Oslo*. No. 278, pp. 121-128, pl. 1.

[Siveter, Derek.J. 1973. *Trilobites of the family Calyenidae from the Ordovician, Silurian and Devonian Systems of Northwest Europe*. Unpublished Ph.D. thesis University of Leicester 2 vols. xii+380 pp. (Vol. 1); 92 pls & appendix (99 pp., Vol. 2).]

-----1980. Evolution of the Silurian trilobite *Tapinocalymene* from the Wenlock of the Welsh borderlands. *Palaeontology*. **23**, (4), pp. 783-802, pls 97-101.

-----1982. See Helbert *et al.*.

Snajdr, M. 1957. Classification of the Family Illaenidae (Hawle et Corda) in the Lower Palaeozoic of Bohemia. *Sbornik Ústr. Úst geologickeho* no. 23, 159 pp., 11 pls.

-----1958. Nekolik norych rodû trilobita z celedi Scutelluidae *Vest. Ústred. Úst geol,* **26,** 11-221,
pls 1-36, text-figs 1-61. (English summary 227-265).

-----1960. Studie o celedi Scutelluidae (Trilobitae). *Rozpr. ustred. Ustavu geol.,* **26,** 11-221, pls 1-36, text-figs 1-61. [English summary].

-----1980. New Silurian trilobites from the Barrandian area (Czechoslovakia). *Vesn. ustred. Ustavu geol.,* CAV. **55,** (2), pp. 105-110, 2 pls.

[Spjeldnæs, N. 1949 *Studies on the lowest Silurian rocks north of Oslo.* pp 31-39, text fig. 4. Unpublished thesis university of Oslo].

-----1982. Silurian Bryozoa of the Oslo region. *Paleontological Contributions from the University of Oslo.* No. 278, pp. 55-62, 1 pl.

Steininger, J. 1831. Observations sur les fossils du calcaire intermédiare de L'Eifel. *Mem. Soc. géol. Fr.,* **1,** (1), 331-71, pls 21-23.

Størmer, L. 1940. Early descriptions of Norwegian trilobites. *Nor. geol. Tiddskr.,* **20,** 113-151, 3 pls.

-----1943. Suppliment to "Early descriptions of Norwegian trilobites".
trilobites". The type specimen of *Illaenus glaber* Kjerulf. *Nor. geol. Tidsskr.,* **22,** 47-50.

-----1953. The Middle Ordovician of the Oslo Region, Norway. 1. Introduction to stratigraphy. *Nor. geol. Tidsskr.,* **31,** 37-141.

Strusz, D.L. 1980. The Encrinuridae and related trilobite families, with a desxcription of Silurian species from South eastern Australia.
Palaeontographica Abt A, Bd 168, pp. 1-68, pls 1-4.

Temple, J.T. 1969. Lower Llandovery (Silurian) trilobites from Keisley, Westmoreland. *Bull. Br. Mus. nat. Hist.,* **18,** 197-230, pls 1-6.

-----1970. A Monograph of the Lower Llandovery brachiopods and trilobites from Ffridd Mathrafal, near Meifod, Montgomeryshire. *Monogr. palaeontogr. Soc. London,* 76 pp., 19 pls.

-----1972. Ontogenies of Devonian trilobites from New South Wales [Essay review of Chatterton, 1971]. *Geol. Mag.*, **109**, 373-6.

-----1975. Early Llandovery trilobites from Wales with notes on British Llandovery Calymenids. *Palaeontology*, **18**, 137-59, pls 25-27.

Thomas, A.T. 1978-81. British Wenlock trilobites. *Monogr. Palaeontogr. Soc. London*, (1), 1-56, pls 1-14; (2) 1981, 57-99, pls 15-25.

-----1979. Trilobite associations in the British Wenlock. *In* Harris, A.L., Holland, C.H. & Leake, B.E. (Editors), *The Caledonides of the British Isles-reviewed.* Spec. Publ. Geol. Soc. London, No. 8, 447-51, 1 pl.

-----1982. See Helbert *et al.*

-----1984. Autecology of Silurian trilobites. *Special Papers in Palaeontology* No. 32, pp. 55-69.

Thomas, A.T. & Owens, R.M. 1978. A review of the trilobite family Aulacopleuridae. *Palaeontology*, **21**, 65-81, pl. 7.

Thomson, E. & Baarli B.G. 1982. Brachiopods of the lower Llandovery Sælabonn and Solvik Formations of the Ringerike, Asker and Oslo districts. *Paleontological Contributions from the University of Oslo*, No. 278, 63-78, 3 pls.

Törnquist, S.L. 1884. Undersökning ofver Siljansområdets trilobitfauna. *Sver. geol. Unders. Afh., Ser. C*, **66**, 101 pp., 3 pls.

Tripp, R.P. & Whittard, W.F. 1956. Proposed use of the plenary powers (a) to designate type species in harmony with accustomed usage for the genera *"Encrinurus"* Emmrich, 1844, ...and (b) to validate the specific name *"punctatus"* Wahlenberg, 1821, as published in the combination *"Entomostracites punctatus"* (Class Trilobita). *Bull. zool. Nomencl. London*, **12**, 259-262.

-----1957. The classification and evolution of the superfamily Lichacea (Trilobita). *Geol. Mag.*, **94**, 104-22.

-----1958. Stratigraphical and geographical distribution of the named species of the Trilobite superfamily Lichacea. *J. Paleontol.*, **32**, 574-83, pl. 85.

-----1959. See Moore 1959.

-----1962. The Silurian trilobite *Encrinurus punctatus* (Wahlenberg) and allied species. *Palaeontology*, 5, 460-77, pls 65-68.

-----1969. Request for a ruling as to whether *Lichas aranea* Holzapfel, 1895 is to be treated as a juniour primary homonym of *Lichas araneus* Lindström, 1885 (Class Trilobita). *Bull. zool. nomencl. London.*, **17**, (6-8).

-----1977. The Silurian trilobite *Encrinurus variolaris* and allied species with notes on *Frammia*. *Palaeontology*, **20**, 847-867, pls 113-115.

-----& Evitt, W.R. 1981. Silicified Lichidae (Trilobita) from the Middle Ordovician of Virginia. *Geol. Mag.*, **118**, (6), 665-667, pls 1, 2.

Vanek, J. 1959. Celed Lichaidae Hawle & Corda, 1847, ze stredoceskeho starsiho paleozoika. *Bohem. Cent.*, **1**, 81-168.

Vogdes, A.W. 1890. A bibliography of Palaeozoic Crustacea from 1698-1889. *Bull. U.S. geol. Surv.*, No. 63, 1-177.

-----1917. Palaeozoic Crustacea. The publications and notes on the genera and species during the past twenty years, 1895-1917. *Trans. San Diego Soc. nat Hist.*, 3, (1), 3-141, pls 1-5.

Wahlenberg, G. 1818. Petrifacta telluris suecanae. *Nova Acta R. Soc. Scient. Uppsala*, 8 (for 1821), 1-116, pls. 1-4.

Warburg, Elsa 1925. The trilobites of the Leptaena Limestone in Dalarne. *Bull. geol. Instn. Univ. Uppsala*, **17**, (4), i-vi, 1-446, pls 1-11.

-----1937. Angelin's *Lichas norvegicus* - a Silurian species. *Bull. geol. Instn. Univ. Uppsala*, **27**, 212-218.

-----1939. The Swedish Ordovician and Lower Silurian Lichidae. *K. Svenska Vetensk.-Akad. Handl.*, **17**, (4), 1-62.

Webby, B.D. 1974. Upper Ordovician trilobites from central New South Wales. *Palaeontology*, **17**, 203-52, pls 28-34.

Wedekind, R. 1911. Klassification der Phacopiden. *Z. Dtsch. geol. Gesell.*, **63**, 317-336.

Weller, S. 1907. The paleontology of the Niagaran Limestone in the Chicago area. The Trilobita. *Bull. Chicago Acad. Sci.*, **4**, (2), 163-281, pls 16-25.

Westergård, A.H. 1910. Index to Angelin's. Palaeontologia Scandinavica with notes. *Acta Univ. Lund.*, *N. F.*, *Afd. 2*, **6**, (2), 1-48.

REFERENCES

Whittaker, J.H. McD. 1977, *A guide to the geology around Steinsfjord, Ringerike.* Universitetsfollaget, Oslo.

Whittard, W.F. 1938. The Upper Valentian trilobte fauna of Shropshire. *Ann. Mag. nat. Hist. London,* (11), **1**, 85-140

-----1940. The Silurian illaenids of the Oslo region. *Nor. geol. Tiddskr.,* **19**, 275-95, pls 1-4.

Whiteaves, J.F. 1904. Preliminary list of fossils from the Silurian (Upper Silurian) rocks of the Ekwan River and Sutton Mill Lakes, Keewatin, collected by D.B. Dowling in 1901, with descriptions of such species as appear to be new. *Geological Survey of Canada Annual report,* **14**, pp. 38f-59f.

Whittington, H. 1961. Silurian *Hemiarges* (Trilobita) from Cornwallis Island and New York State. *J. Paleont.,* **35**, 433-44, pls 55-57.

-----1971. Silurian calymenid trilobites from the United States, Norway and Sweden. *Palaeontology,* **14**, 455-477.

-----& Campbell, K.S.W. 1967. Silicified Silurian trilobites from Maine. *Bull. Mus. comp. Zool. Harvard,* No. 135, 447-83, 19 pls.

Wiman, C. 1908. Studien Uber das nordbaltische, Silurgebeit, II. *Bull. geol. Instn Univ. Uppsala.* **8**, 73-168, pls. 5-8.

Wolfart, W. 1961. Stratigraphie und fauna des alteren Paläozoikums (Silur-Devon) in Paraguay. *Geol. Jahrb. Hannover,* **78**, 29-102, pls 2-7.

Woods, H. 1891. *Catalogue of the type fossils in the Woodwardian museum, Cambridge.* i-xiv, 180 pp. Cambridge.

Woodward, H. 1877. *A catalogue of British fossil Crustacea, with their synonyms and the range in time of each genus and order* i-xiii, 147 pp., London.

Worsley, D. & Broadhurst, F.M. 1975. An environmental study of Silurian atrypid communities from southern Norway. *Lethaia,* **8**, 271-286.

-----1982. The Silurian succession of the Oslo Region a Lithostratigraphical Framework. *Paleontological Contributions from the University of Oslo.* No. 278, 11-20.

-----, Aarhus, N., Bassett, M.G., Howe, M.P.A., Mørk, A. & Olaussen, S. 1983. The Silurian succession of the Oslo Region. *Nor. geol. Unders.,* No. 384, 57 pp.

Appendix 1

Pygidial dimensions in mm. of *L. latifrons* (Angelin, 1854);

Specimen No.	Length	Width		Postaxial band		
	(sag.)	(tr.)		narrowest	widest	
			L W	point	point	W N
Ar2384	33	42	8.0	0.7	15.0	0.46
Ar2385	33	44	0.75	5.0	13.5	0.37
Ar2400	17	28	0.60	4.0	7.0	0.57
Ar2401	32	44	0.72	6.0	17.0	0.35
Ar2409	16	23	0.60	4.0	8.0	0.50
Ar2410	28	40	0.7	6.0	17.0	0.35
Ar2415	21	33	0.63	5.5	10.0	0.55
Ar5001	22	30	0.73	4.5	8.0	0.56
Ar5002	14	20	0.7	3.0	6.0	0.50
Ar5008	25	40	0.62	6.0	14.0	0.42
Ar5009	17	26	0.67			
Ar5010	16	22	0.72	3.5	6.0	0.58
Ar5011	22	27	0.65	3.5	10.0	0.35
Ar5012	15	20	0.75	2.5	6.0	0.41
Ar5014	33	44	0.75	0.6	15.0	0.40
Ar5016	15	23	0.60	3.0	7.0	0.42
Ar5031	14	20	0.70			
Ar5065	17	25	0.68			

Appendix 2

Cranidial dimensions of Silurian specimens of *S. glaber* Kjerulf, 1865, from southern Norway;

Dimensions in centimeters

Specimen No.	Sagittal	Transverse width across palpebral lobes	
Billingstad, Asker, Solvik Formation (Kiær's êtage 6c)			
PMO 19264	1.8	2.4	
PMO 19422	2.1	1.4	Lectotype of *S. rotunda*
PMO 19424	2.4	2.7	Paralectotype of *S. rotunda*
PMO 110.164	1.4	1.7	Paralectotype of *S. rotunda*
PMO 110.166	0.9	1.0	Paralectotype of *S. rotunda*
Bjerkøya, Holmestrand, Rytteråker Formation (Kiær's êtage 7a)			
PMO 19413	5.7	6.4	
PMO 19470	1.6	1.7	
Gulleråsen, Asker, Solvik Formation Kiær's êtage 6b)			
PMO 65548	1.5	1.9	
Honeföss road, Ringerike, Saelabonn Formation (Kiær's êtage 6c)			
PMO 109.915	1.5	1.5	
Hvalbakken, Asker, Solvik Formation (Kiær's êtage 6)			
PMO 19247	1.1	1.1	Paralectotype of *S. rotunda*
Kunglungen, Asker, Solvik Formation (Kiær's êtage 6a)			
PMO 53369	6.1	6.2	
Leanghagda, Asker, Solvik Formation (Kiær's êtage 7a)			
PMO 52514	1.1	1.3	

Sandvika, Asker, Solvik Formation (Kiær's étage 6)			
PMO 19164	5.4	5.2	Lectotype *S. norvegica*
Spirodden, Asker, Solvik Formation (Kiær's étages 6a to 6c)			
PMO 19135	1.9	2.2	Lectotype of *S. sculpta*
PMO 19137	1.2	1.5	
PMO 19140	2.1	1.6	Paralectotype of *S. sculpta*
PMO 19174	5.2	4.6	Paralectotype *S. norvegica*
PMO 52549	8.3	7.6	
Locality & horizon unknown			
PMO 41384	1.8	2.1	
PMO 110.271	0.8	2.1	

Appendix 3

Dimensions in mm. of the holotype and Norwegian specimens of *Proetus (Proetus) concinnus* Dalman, 1827;

Cranidia.

Specimen No.	A	A1	A2+A3	A4	K	-	
UM G 773 (E)	-	5.0	-	1.0	3.8	5.8	Holotype
PMO 21401	5.1	3.7	0.7	0.8	3.6	5.2	
PMO 44668	4.5	3.0	0.5	0.6	2.7	-	
PMO 44672	2.6	1.6	0.2	0.3	1.5	2.1	
PMO 44716	3.8	3.0	0.5	0.6	2.6	-	
PMO 44721	4.1	2.9	0.6	0.5	2.6	4.2	
PMO 44723	5.2	4.1	0.6	-	3.4	-	
PMO 44725	5.0	3.5	0.8	0.8	2.0	5.9	
PMO 44797	6.0	4.2	0.7	1.0	3.6	6.0	
PMO 44802	3.0	3.2	0.5	0.5	3.0	4.2	

Pygidia

	Z	Y	W	X	No. axial rings
PMO 21402	3.1	2.7	5.2	2.1	8
PMO 44666	2.7	2.3	4.4	2.2	7
PMO 44667	2.2	1.8	3.6	1.5	-
PMO 44687	3.3	3.0	5.1	2.1	8
PMO 44718	4.2	3.7	6.4	2.4	7
PMO 44722	2.5	2.0	4.0	1.8	-
PMO 44724	5.1	4.1	7.0	3.0	8
PMO 44808	3.1	2.9	6.2	2.5	-

Appendix 4

Dimensions in mm. of the holotype and Norwegian material of *Proetus (Lacunoporaspis) confossus* Owens, 1973;

Cranidia

Specimen No.	A	A1	A2+A3	A4	K	-	
NMW 71.6G.50	6.5	4.5	0.7	1.3	4.4	5.8	Holotype.
PMO 50007	2.7	2.0	0.3	0.5	1.8	2.3	
PMO 50009	4.7	3.4	0.5	0.7	3.2	3.6	
PMO 50010	4.8	3.5	0.6	0.8	3.4	-	
PMO 50210	-	3.0	0.4	-	2.9	-	
PMO 50240	4.5	3.2	0.4	0.6	2.8	4.0	
PMO 89319	2.6	1.7	0.3	0.4	1.3	3.2	

Pygidia.

	Z	Y	W	X	No. axial rings.	
NMW 7.1.6G.50	4.9	4.0	7.6	2.0	7	Paratype.
PMO 49989	4.5	4.0	6.0	2.3	8	
PMO 50008	-	-	6.4	2.4	7	
PMO 50170	2.7	2.2	4.4	1.5	7	
PMO 89318	4.7	4.2	6.0	2.0	8	
PMO 110.342	3.5	2.6	5.6	1.8	7	

Appendix 5

Dimensions in mm. of the holotype and other specimens of *Proetus (Lacunoporaspis) baarlii* sp. nov.;

Cranidia.

Specimen no.	A	A1	A2+A3	A4	K	-	
PMO 49320	7.0	5.5	0.7	1.0	5.3	7.4	Holotype
PMO 49294	2.3	1.5	0.2	3.0	1.5	-	
PMO 53293	5.8	4.2	0.7	0.9	4.4	-	

Pygidium

	Z	Y	W	X	No. of axial rings
PMO 19659	3.4	2.8	5.0	1.8	7

Appendix 6

Dimensions in mm. of the holotype & other specimens of *Proetus (Lacunoporaspis) conctoratus* sp. nov.;

Cranidia

Specimen no.	A	A1	A2+A3	A4	K	-	
PMO 110.334	5.1	4.0	0.3	0.7	3.6	4.0	
PMO 110.335	3.6	2.8	0.2	0.7	2.3	2.6	Holotype

pygidia

	Z	Y	W	X	No. of axial rings
PMO 110.339	5.1	5.1	9.0	3.7	8
PMO 110.340	5.8	5.5	9.4	3.7	8
PMO 110.341	5.5	4.7	9.4	3.2	8

Appendix 7

Dimensions in mm. of *Proetus (Lacunoporaspis)* sp.;

Cranidia

Specimen no.	A	A1	A2+A3	A4	K	
PMO 110.331	-	2.2	0.5	-	2.1	-
PMO 110.333	2.1	1.6	0.3	0.2	1.5	1.8

Pygidia

	Z	Y	W	X	No. of axial rings
PMO 110.314	-	1.8	-	-	8
PMO 110.315	-	2.2	4.4	1.2	-
PMO 110.316	-	-	-	-	8
PMO 110.317	3.6	3.1	5.1	2.2	8
PMO 110.318	-	-	2.4	0.6	7
PMO 110.323	4.3	3.3	5.0	2.2	-

Appendix 8

Dimensions in mm. of specimens of *Cyphoproetus externus* (Reed, 1935) from Norway;

Cranidia

Spirodden

Specimen No.	A	A1	A1+A2	A4	K	-
PMO 88759	2.8	1.9	0.4	0.5	1.7	2.5
PMO 88824	2.9	1.9	0.3	0.5	1.4	2.2
PMO 88826	4.5	2.9	0.6	0.8	2.6	3.0
PMO 88841	3.1	2.1	0.5	0.7	2.1	3.0
PMO 88824	2.9	1.9	0.3	0.5	1.4	2.2
PMO 88957	1.9	1.5	0.2	0.2	1.2	1.6
PMO 88974	2.3	1.4	0.5	0.4	1.3	1.8
PMO 88983	2.5	1.5	0.5	0.5	1.3	1.9
PMO 89010	2.7	1.6	0.5	0.6	1.4	2.0
PMO 93801	4.6	3.0	0.7	0.7	2.5	1.7
PMO 93818	2.0	1.3	0.3	0.3	1.2	1.7
PMO 93822	2.3	1.7	0.5	0.5	1.3	1.8
PMO 109.484	4.4	3.0	0.5	0.9	2.5	-
PMO 109.487	2.4	1.5	0.4	0.5	1.5	1.8
PMO 109.489	3.0	2.1	0.5	0.5	2.0	-
PMO 110.352	2.2	1.3	0.4	0.4	1.2	1.6
PMO 110.358	2.6	1.6	0.5	0.5	1.2	1.8
PMO 110.359	3.0	2.0	0.5	0.5	1.8	2.4
PMO 110.360A	2.7	1.7	0.5	0.5	1.5	1.9
PMO 110.363	3.3	2.2	0.5	0.5	2.1	2.6
PMO 110.364	2.2	1.5	0.3	0.4	1.2	1.8

PMO 110.365	2.3	1.5	0.4	0.4	1.0	1.4
PMO 110.366	1.7	1.0	0.3	0.3	0.9	-
PMO 110.375	2.3	1.5	0.4	0.4	1.4	2.1
PMO 110.390	2.1	1.3	0.5	0.4	1.1	1.5
PMO 110.465	3.3	2.3	0.3	0.4	1.9	3.0
PMO 110.466	3.5	2.4	0.7	0.6	2.2	3.2
Skyttervein						
PMO 110.468	-	2.0	-	0.6	2.2	2.8

Pygidia

Spirodden

	Z	Y	W	X	No. of rings.
PMO 52762	4.9	3.0	6.4	2.0	4
PMO 52774	3.0	2.3	4.6	1.6	4
PMO 52777	1.2	1.0	2.4	1.0	4
PMO 88855	2.2	1.7	3.5	1.4	4
PMO 89007	1.7	1.3	3.4	1.1	-
PMO 89011	2.1	1.8	3.2	1.3	-
PMO 109.467	1.7	1.4	3.2	1.0	4
PMO 109.475	2.0	1.6	3.6	1.2	-
PMO 109.485	1.5	1.1	2.4	0.8	4
PMO 109.490	1.3	1.0	2.5	0.8	4
PMO 110.443	2.5	2.0	4.0	1.0	-
PMO 110.454	2.1	1.5	3.7	1.3	4
PMO 110.455	2.2	1.8	3.6	1.2	4
PMO 110.460	1.6	1.2	2.9	1.0	4

Appendix 9

Dimensions in mm. of specimens of *Harpidella (Harpidella) chermasera* sp. nov.;

Cranidia.

Spirodden

Specimen no.	A	A1	A2+A3	A4	K	-
PMO 88904	2.3	1.3	0.9	0.3	1.2	2.3
PMO 52556	2.7	1.4	0.9	0.3	1.4	-
PMO 88756	2.2	1.1	0.7	0.2	1.2	2.2
PMO 88788	2.1	1.0	0.8	0.3	1.2	-
PMO 88856	2.5	1.4	0.8	0.3	1.5	2.7
PMO 88886	2.7	1.4	1.0	0.3	1.6	2.7
PMO 88900	1.8	1.0	0.6	0.2	1.0	-
PMO 88902	2.0	0.9	0.6	0.2	1.0	1.8
PMO 88915	3.0	1.5	1.2	0.3	1.5	1.4
PMO 88918	2.4	1.3	0.7	0.3	1.5	2.2
PMO 88973	2.3	1.2	0.8	0.3	1.2	2.3
PMO 88995	3.0	1.6	1.0	0.4	1.6	-
PMO 88999	1.6	0.9	0.5	0.2	1.0	1.8
PMO 91368	-	1.6	-	0.3	1.6	-
PMO 110.480	2.7	1.3	1.0	0.3	1.4	-
PMO 110.483	2.9	1.5	1.0	0.3	1.5	2.8
PMO 110.485	3.3	1.7	1.2	0.4	1.9	3.6
PMO 110.486	2.2	1.2	0.8	0.3	1.2	2.4
PMO 110.490	3.2	1.7	1.1	0.4	1.7	2.9
PMO 110.494	-	1.8	-	0.3	1.5	-

PMO 110.498	2.0	1.0	0.7	0.2	1.0	-
PMO 110.511	2.7	1.3	1.0	0.2	-	-
PMO 110.523	2.3	1.2	0.8	0.3	1.2	2.0
PMO 110.525	3.1	1.6	1.2	0.3	1.4	-
PMO 110.526	1.9	1.0	0.6	0.3	1.1	1.0
PMO 110.528	3.0	1.6	0.9	0.4	0.6	3.4

Appendix 10

Dimensions in mm. of *Harpidella (Harpidella)* sp.;

Specimen no.	A	A1	A2+A3	A4	K	-
PMO 112.878	2.2	0.9	1.0	0.3	1.2	1.9

Appendix 11

Dimensions in mm. of *Warburgella (Warburgella) baltica* (Alberti, 1963) from southern Norway;

Cranidia

Langøya, Holmestrand

Specimen no.	A	A1	A2+A3	A4	K	Z
PMO 21461	3.1	1.9	0.9	0.4	2.0	-
PMO 21462	4.0	2.6	0.9	0.6	2.8	4.0
PMO 110.545	3.5	2.2	0.8	0.6	2.4	-
PMO 110.546	3.8	2.3	0.9	0.6	2.3	3.4
PMO 110.547	2.9	1.7	0.8	0.5	2.0	2.8
PMO 110.548	3.2	2.0	0.7	0.5	2.2	3.0
PMO 110.549	3.5	2.3	0.9	0.5	2.4	3.4
PMO 110.565	4.3	1.3	1.2	0.6	2.8	4.4
PMO 110.570	3.4	2.1	0.8	0.5	2.4	-
PMO 110.574	3.2	1.5	0.7	0.5	2.0	3.0
PMO 110.583	5.0	3.2	1.2	0.7	3.1	-
PMO 110.585	2.0	1.2	0.5	0.4	1.4	2.0
PMO 110.587	5.5	3.5	1.4	0.7	2.4	-
PMO 110.591	-	4.7	-	0.7	3.6	5.4
PMO 110.592	2.4	1.4	0.7	0.4	1.5	2.2
PMO 110.598	3.2	2.0	0.7	0.5	2.5	-
PMO 110.599	3.0	1.7	0.8	0.5	2.9	-
PMO 110.600	4.2	2.5	1.2	0.5	2.7	-
PMO 110.601	3.4	2.2	0.9	0.5	2.5	3.0
PMO 110.675	2.3	1.4	0.6	0.3	1.2	1.8
PMO 110.676	3.5	2.0	0.9	0.6	2.1	3.1

Pygidia

Langøya, Holmestrand.

Specimen No.	Z	Y	W	X	No. of axial rings
PMO 49869	2.9	2.4	4.6	1.3	7
PMO 49979	3.2	2.6	6.4	1.6	7
PMO 50150	3.5	2.9	7.0	1.9	7
PMO 50183	1.8	1.5	3.8	1.1	-
PMO 110.692	3.6	2.9	6.2	2.0	8
PMO 110.700	2.8	2.1	5.9	1.6	-
PMO 110.705	2.1	1.8	3.6	1.2	8
PMO 110.707	3.3	2.7	4.6	1.7	-
PMO 110.713	2.0	1.8	3.7	1.1	8
PMO 110.717	1.5	1.1	2.8	0.6	-
PMO 110.723	1.2	0.9	2.5	0.7	6
PMO 110.725	2.5	2.0	4.8	1.3	7
PMO 110.730	2.0	1.8	4.3	1.3	8
PMO 110.739	1.5	1.2	3.1	0.7	6
PMO 110.740	2.0	1.7	3.8	1.2	-

Appendix 12

Dimensions in mm. of the holotype and other material of *Warburgella (Warburgella) brutoni* sp. nov.;

Cranidia

Specimen no.	A	A1	A2+A3	A4	K	-
PMO 89288	4.7	2.8	1.6	0.6	3.0	-
PMO 89301	3.3	1.7	1.2	0.4	1.9	2.2
PMO 89306	3.7	2.3	1.2	0.5	2.3	-
PMO 89307	3.0	1.5	1.0	0.3	1.5	2.1
PMO 89308	2.5	1.2	1.2	0.4	-	-
PMO 44707	3.2	2.1	1.0	0.5	2.0	-

Pygidia

	X	Y	W	Z	No. of axial rings.
PMO 44651	2.3	1.7	4.0	1.0	7

Appendix 13

Dimensions in mm. of the holotype and other specimens of *Warburgella (Warburgella) gongrus* sp. nov.;

Cranidia

Specimen no.	A	A1	A2+A3	A4	K	-
Hæroya, Ringerike, Steinsfjorden Formation (Kiær's étage 9)						
PMO 47945	3.2	1.9	1.1	0.4	1.8	?
Porsgrunn, Skien, Steinsfjorden Formation (Kiær's étage 9)						
PMO 51777	5.5	3.3	1.4	0.7	3.4	?
Unknown locality, Ringerike, Steinsfjorden Formation (Kiær's étage 9)						
PMO 48463	6.4	3.4	1.9	0.7	4.0	5.0

Pygidium

Hæroya, Ringerike, Steinsfjorden Formation (Kiær's étage 9)

	X	Y	W	Z	No. of axial rings
PMO 44651	2.2	1.7	4.2	1.1	7

Appendix 14

Dimensions in mm. of specimens of *Hedstroemia? simpulum* sp. nov.

Cranidia

Specimen No.	A	A1	A2+A3	A4	K	-	
Malmøya, 6c & 7a							
PMO 41905	-	5.0	-	0.9	4.7	6.2	
PMO 43612	6.8	4.6	1.2	1.0	4.3	4.8	
Bjerkøya, 7a							
PMO 54838	9.1	6.0	1.7	1.2	5.6	6.6	Holotype
Malmøykalven, 7bb.							
PMO 70610	3.2	2.0	0.5	0.5	1.9	2.4	
Malmøya, 7bb.							
PMO 93816	-	3.0	-	0.7	2.8	3.4	
Skytterveien 6bb							
PMO 110.750	3.5	2.2	0.8	0.5	2.1	2.8	
PMO 110.757	3.0	1.9	0.7	0.4	1.9	2.4	
PMO 110.759	4.0	2.5	0.7	0.6	2.5	3.2	

Pygidia

Specimen no.	Z	Y	W	X	No. of axial rings
Malmøy, 6c.					
PMO 41589	4.9	4.2	6.2	2.6	9
Ulvøya, 7bb					
PMO 43112	3.7	2.8	4.7	2.0	8
Ulvøya, 7ab					
PMO 42999	6.0	4.8	8.0	3.0	9

Malmøykalven, 7bb.

PMO 43577	4.7	4.0	5.5	2.0	8

Malmøy, 7ab

PMO 43611	10.2	8.5	12.5	4.9	10

Bjerkøya, 7a.

PMO 54850	5.0	4.3	7.0	2.5	?7

Appendix 15

Glabellar tubercle formulae of specimens of *Encrinurus punctatus* (Wahlenberg, 1818) from southern Norway;

Steinsfjorden Formation (Kiær's ȇtage 9), Langøya, Holmestrand

Specimen no.	1L	2L	3L
PMO 179.979	0	0^{f}, 1, $\underline{2}$.	$0^{f}m$, 1, 2, $\underline{3}$.
PMO 109.984	0	0^{f}_{r}, 2, $\underline{3}$.	

Pygidial tubercle disposition, number of axial rings, number of pleural ribs and sagittal length of specimens of *E. punctatus* from southern Norway;

Specimen No.	No. of axial ring occupied by tubercle						Sag. length cm.	No. of axial rings	No. of pleural ribs
	T1	T2	T3	T4	T5	T6			
PMO 109.558	2	6	10	14	19		0.9	24	7
PMO 109.980	2	6	11	16	19		1.3	20+	8
PMO 109.982	2	6	10	14	19	24	0.7	24	-
PMO 109.983	2	6	11				-	-	-
PMO 109.985	2	5	8	12	16		1.2	21+	8
PMO 109.986	5	9	13	18			0.8	20+	8
PMO 109.993	2	6	9				-	-	-
PMO 109.994	2	6	10	14			-	-	-

Appendix 16

Glabellar tubercle formulae for specimens of *Encrinurus mullochensis* (Reed, 1931), from Norway.

Specimen no.	1L	2L	3L
Rytteråker Formation (Kiær's etage 7a), Gjettum station, Asker district			
PMO 110.049	0	1, $\underline{2}$.	0^{f}_{r}, 1, 2^{f}, $\underline{3}$.
PMO 110.059	0	1, 2, $\underline{3}$.	0, 1^{f}_{r}, 2, $\underline{3}$.
PMO 110.061	1	1^{f}_{r}, $\underline{2}$.	0^{f}_{r}, 1, 2^{f}_{r}, $\underline{3}$.
Solvik Formation (Kiær's ếtage 6b), Malmøya, Oslo district			
PMO 70597	1	1, 2, $\underline{3}$.	1_{r}, 2, $\underline{3}$.
PMO 110.009	1	1, 2, $\underline{3}$.	?
PMO 110.019	1	1, 2, $\underline{3}$.	1, 2, $\underline{3}$.
Solvik Formation, Kiær's (ếtage 6c), Skytterveien, Asker district			
PMO 109.517	1	1, 2, $\underline{3}$.	0^{f}_{r}, 1, 2^{f}_{r}, $\underline{3}$.
PMO 109.554	1	1, 2_{r}, $\underline{3}$.	1, 2^{f}_{r}, 3, 4^{f}_{r}.
PMO 109.559	1	0, 1, 2.	1^{f}_{r}, 2^{f}_{r}, $\underline{3.}$.
PMO 109.911	1	0^{f}_{r}, 1, 2, $\underline{3}$.	0^{f}_{r}, 1, 2^{f}_{r}, 3^{f}, $\underline{4}$.
PMO 109.912	1	1, 2^{f}, $\underline{3}$.	1^{f}_{r}, 2_{r}, 3^{f}, $\underline{4}$.
PMO 110.044	1	0, $\underline{1}$.	0_{r}, 1, 2^{f}_{r}, $\underline{3}$.
Solvik Formation (Kiær's etages 6b & 6c) Spirodden, Asker district			
PMO 110.021	1	1, 2, $\underline{3}$.	1^{f}_{r}, $2^{f}m$, $\underline{3}$.
PMO 110.828	1	1, 2^{f}, $\underline{3}$.	1^{f}_{r}, $2m_{f}$, $\underline{3}$.

Pygidial tubercle disposition, number of axial rings, number of pleurae and sagittal length of specimens of *E. mullochensis* from the southern Norway.

Specimen No.	No. of axial ring occupied by tubercle T1	T2	T3	T4	T5	Sag. length mm.	No. of axial rings.	No. of pleural ribs.
Rytteråker Formation (Kiær's êtage 7a), Gjettum Station, Asker district.								
PMO 110.054	2	5	8	11	14	8	16+	8
PMO 110.067	3	5	10?			-	-	-
PMO 110.077	?	5	8	13	16	8	16+	8
PMO 110.078	3	5	9	10		-	-	-
PMO 110.087	2	5	8	11	14	4	16	8
Solvik Formation (Kiær's êtage 6b), Malmøya, Oslo district								
PMO 41750	3	7	11	16	-	13	20	8
PMO 42176	2	5	9	13	17	11	21	8
Solvik Formation (Kiær's êtage 6b), Malmøykalven, Oslo district								
PMO 110.000a	2	6	11	16	-	9	21	8
PMO 110.001	2	6	10	11	16			
PMO 110.002	2	5	14	19		5	19	8
PMO 110.012	2	6	9	12	-	7	16+	8
Solvik Formation (Kiær's êtage 6c), Skyttervien, Asker district								
PMO 103.650	2	5	-	-	-	13	13+	7?
PMO 109.516	4	7	16	-	-	-	-	-
PMO 109.548	4	6	9	13	14	8	13+	8
PMO 109.551	2	5	10	15	20	10	19	8

PMO 109.553	2	5	9	13	18	7	19	7
PMO 109.560	2	6	10	-	-	5	-	-
PMO 109.561	2	6	11	-	-	9	-	-
PMO 109.562	2	5	9	14	-	10	20	8
PMO 110.103	2	5	9	13	-	15	-	-
PMO 110.106	3	7	-	-	-	-	17+	8
PMO 110.109	2	5	9	13	-	15	-	-
PMO 110.111	2	6	-	-	-	7	16+	7
PMO 110.115	2	5	9	13	-	13	13+	7?
PMO 110.117	2	6	10	15	19	6	20	7
PMO 110.121	2	6	11	16	-	12	19	7
PMO 110.122	2	6	10	15	20	-	-	-
PMO 110.129	4	8	12	-	-	7	20	7

Appendix 17

Relative abundances of trilobite elements at localities from which specimens were collected by the author or for which large samples are available.

Garntangen (locality 6)

Species.	No. of Specimens.	% of total.
Acernaspis labronios	44	73.33
Encrinurus anthus	13	21.66
Calymene frontosa	2	3.33
Leonaspis sp.	1	1.66

(Total no. of specimens = 60).

Gjettum Bus Stop (locality 7)

Species.	No. of specimens.	% of total.
Proetus (Lacunoporaspis)		
conctoratus	9	60.00
Calymene tetartos	5	33.33
Ekwanoscutellum platyactin	1	6.67

(Total no. of specimens = 15).

Gjettum Station (locality 9)

Species.	No. of specimens.	% of total.
Encrinurus mullochensis	41	91.11
Youngia aff *Y. globiceps*	2	4.44
Stenopareia longispinosa	1	2.22
Calymene sp.	1	2.22

(Total no. of specimens = 45).

Hönefoss Road (locality 12)

Species.	No. of specimens.	% of total.
Acernaspis elliptifrons	246	93.18
Leonaspis varbolensis	13	4.92
Cyphoproetus externus	4	1.56
Stenopareia glaber	1	0.37

(Total no. of specimens = 263).

Langøya (locality 19)

Species.	No. of specimens.	% of total.
Warburgella (Warburgella) baltica	212	70.43
Calymene sp.	26	8.63
Encrinurus punctatus	22	7.31
Proetus (Lacunoporaspis) confossus	17	5.65
Eophacops euthymos	8	2.66
Choneliobarges sp.	6	1.99
Calymene pholeteros	4	1.33
Opsypharus convexus	4	1.33
Calymene aff. *C. pholeteros*	1	0.33
Pseudotupolichas ornatus	1	0.33

(Total no. of specimens = 301).

Leangbukta (locality 20)

Species.	No. of specimens.	% of total.
Acernaspis elliptifrons	35	85.36
Stenopareia glaber	3	7.32
Leonaspis varbolensis	2	4.88
Hadromeros elongatus	1	2.44

(Total no. of specimens = 41).

Malmøykalven & Solvik (Localities 22 & 32)

Species.	No. of specimens.	% of total.
Acernaspis elliptifrons	44	25.88
Opsypharus maccallumi	40	23.52
Stenopareia glaber	23	13.52
Encrinurus mullochensis	21	12.35
Calymene planicurvata	12	7.05
Arctinurus norvegicus	12	7.05
Hedstroemia simpulum	9	5.29
Leonaspis varbolensis	6	3.53
Hadromeros elongatus	3	1.76

(Total no. of specimens = 170).

Skytterveien (locality 31)

Species.	No. of specimens.	% of total.
Acernaspis elliptifrons	307	64.23
Encrinurus mullochensis	85	17.78
Hedstroemia simpulum	24	5.02
Opsypharus maccallumi	17	3.55
Cyphoproetus externus	15	3.13
Calymene ubiquitosus	14	2.92
Leonaspis varbolensis	12	2.51
Arctinurus norvegicus	2	0.41
Dudleyaspis aff.		
D. (D.) unicifera	2	0.41

(Total no. of specimens = 478).

Spirodden (locality 33)

Species.	No. of specimens.	% of total.
Cyphoproetus externus	156	36.29
Acernaspis elliptifrons	80	18.10
Harpidella chermasera	47	10.63
Hadromeros elongatus	29	6.56
Stenopareia glaber	24	5.43
Calymene ubiquitosus	22	5.21
Leonaspis varbolensis	22	5.21
Encrinurus mullochensis	21	4.75
Arctinurus norvegicus	21	4.75
Opsypharus maccallumi	14	3.16
Platylichas scoticus	4	0.90
Ekwanoscutellum platyactin	1	0.22
Hedstroemia simpulum	1	0.22

(Total no. of specimens = 442).

Top of Malmøya (locality 35)

Species.	No. of specimens.	% of total
Proetus (Proetus) concinnus	37	58.73
Warburgella (Warburgella) brutoni	15	23.81
Bumastus bouchardi	5	7.94
Bumastus? inflatus	3	4.76
Encrinurus punctatus	2	3.17
Eophacops euthymos	1	1.58

(Total no. of specimens = 63).

Appendix 18

Occurrence of trilobite species at localities not collected by the author or for which the number of specimens is small.

Billingstad (locality 2)

Arctinurus norvegicus, *Stenopareia glaber*.

Bjerkøya (locality 3)

Acernaspis sp. B, *Arctinurus norvegicus*, *Eccairos dolabratus*, *Hadromeros*? sp. A, *Hedstroemia simpulum*, *Opsypharus maccallumi*, *Stenopareia glaber*, *Stenopareia longispinosa*.

Christian Skredsvik Veien (locality 4)

Stenopareia glaber.

Feikarodden (locality 5)

Calymene frontosa, *Warburgella (Warburgella) gongrus*.

Gjettum locality 2 (locality 7)

Proetus (Lacunoporaspis) sp.

Gulleråsen (locality 10)

Stenopareia glaber, *Dicranopeltis galbinus*, *Diacalymene crassa*.

Herøya (locality 11)

Warburgella (Warburgella) gongrus.

Hoyerholmen (locality 13)

Stenopareia glaber.

Hvalsbakken (locality 14)

Stenopareia glaber

Kampbråten (locality 15)

Youngia aff. *Youngia inermis.*

Kommersøya (locality 16)

Encrinurus punctatus, Proetus (Lacunoporaspis) baarlii, Warburgella (Warburgella) baltica.

Kunglungen (locality 17

Leonaspis sp., *Stenopareia glaber.*

Langåra (locality 18)

Stenopareia glaber

Limovnstangen (locality 21)

Acernaspis elliptifrons, Encrinurus mullochensis, Leonaspis varbolensis, Platylichas scoticus.

Nesbru (locality 23)

Hadromeros elongatus

Porsgrund (locality 24)

Warburgella (Warburgella) gongrus

Purkøya (locality 25)

Ekwanoscutellum platyactin.

Rambergøya (locality 26)

Stenopareia sp.

Semsvatnet (locality 27)

Diacalymene crassa.

Sjursøya (locality 28)

Acernaspis phyxis, Diacalymene gibberosa, Leonaspis sp., *Lichas sylvestris.*

Skinnerbukta (locality 29)

Opsypharus longicaudatus, Stenopareia longispinosa.

Storøya (locality 34)

Acernaspis labronios, Encrinurus anthus.

Ulvøya (locality 36)

Hedstroemia simpulum, Stenopareia glaber, Stenopareia longispinosa.

Utøya (locality 37)

Calymene frontosa

Våkas (locality 38)

Diacalymene crassa

Plate 1

Fig.

Lichas latifrons Angelin, 1854

Högklint Formation, Galgberget, Visby parish

1a,b Pygidium; dorsal & lateral views, Ar2410, x2 & x1.

Slite Group, Unit c, Lansa, Fårö parish

4 Pygidium; dorsal view, Ar5010, x2.

9 Cranidium; dorsal view, Ar 2389, x2.

11 Pygidium; dorsal view, Ar 5031, x2.

Unknown locality

5 Lectotype pygidium; dorsal view, Ar2384, x1; figured Angelin 1854, pl. 37, fig. 3.

6 Paralectotype cranidium; dorsal view, Ar2397, x2; figured Angelin 1854, pl. 36, fig. 9.

Högklint Beds, Väskinde parish

7a-c Cranidium; dorsal, anterior & lateral views, Ar2402, x2.

Lichas marginatus Lindström, 1885

Slite Group, unit c, Lansa, Fårö parish

2a,b Paralectotype cranidium; dorsal & lateral views, Ar2367, x3; figured Lindström 1885, pl. 14, fig 8.

10 Cranidium; dorsal view, Ar2485, x3.

Högklint Formation?, drainage ditch, Hall parish

3a,b Cephalon; dorsal & anterior views, Ar2475, x3.

Högklint Formation, Lutterhorn, Fårö parish

8a,b Lectotype cranidium; dorsal & anterior views, Ar2366, x3; figured Lindström 1885, pl. 14, fig. 9.

Slite Group, Coast North of Storungs, Lärbro parish

12a,b Cranidium; dorsal & anterior views, Ar51747, x2.

Slite Group, Sandsviken, Fårösund, Fårö parish

13 Cranidium; dorsal view, Ar2495, x2.

Plate 1

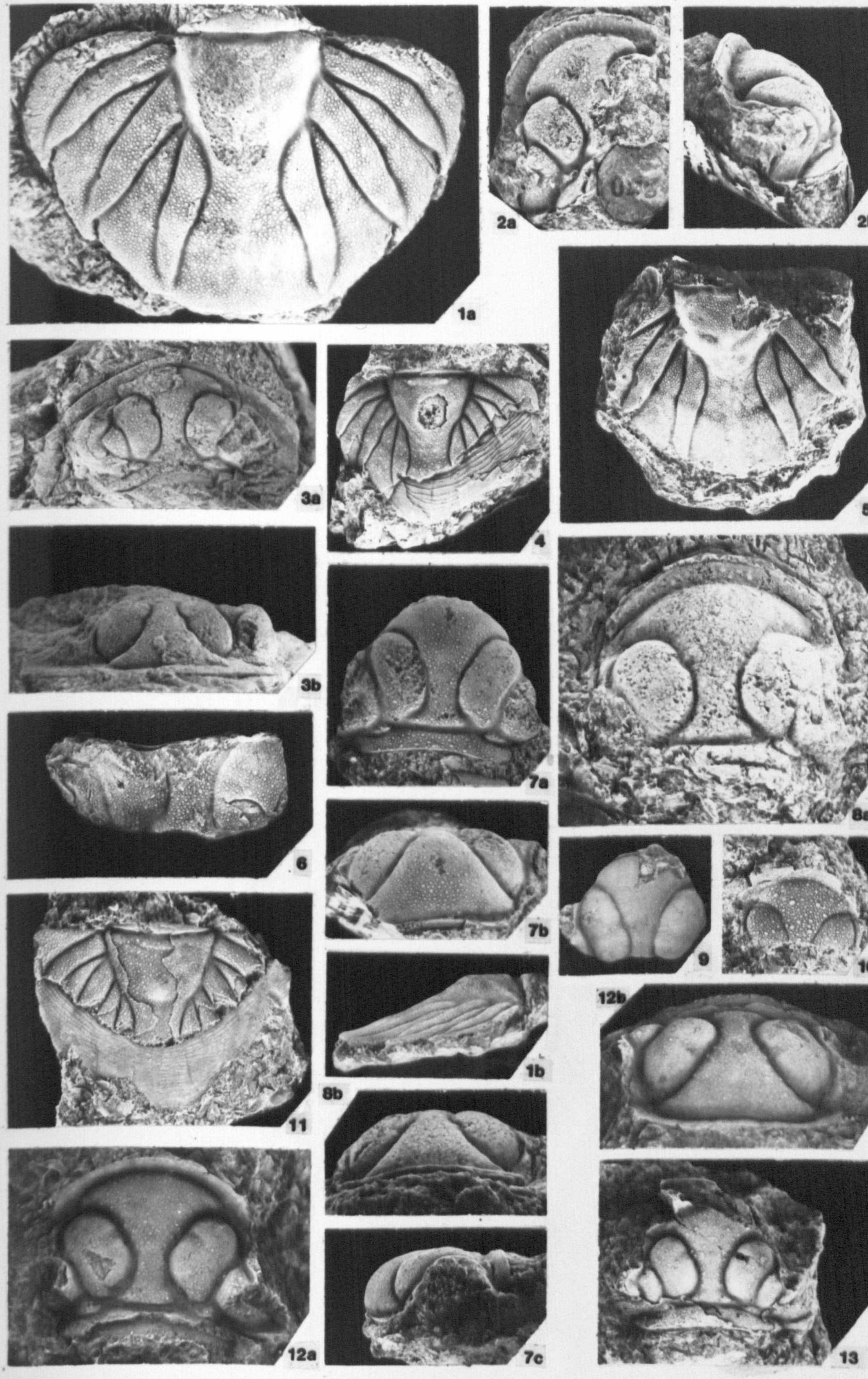


Plate 2

Fig.

Lichas latifrons Angelin, 1854

Högklint Formation?, Visby parish

1 Hypostome; ventral view, internal mould, Ar2479, x1.

16 Hypostome; ventral view, internal mould, Ar5020, x1.

Slite Group, Lansa, Fårö parish

11 Pygidium; dorsal view, Ar2361, x2.

Lichas arenaeus Lindström, 1885

Slite Group, unit c, Lansa, Fårö parish

2 Holotype pygidium; dorsal view, Ar5072, x2; figured Lindström 1885, pl. 15, fig. 30.

7 Pygidium (paralectotype of *L. palifer*) dorsal view, Ar 2329, x2; figured Lindström 1885, pl. 14, fig. 10.

12 Pygidium; dorsal view, Ar2364, x2.

Högklint Formation, Unit d, Vattenfallet, Visby parish

4 Pleuron; dorsal view, Ar2394, x2.

6 Pygidium; dorsal view, Ar2374, x2.

13 Pygidium; dorsal view, Ar2372, x2.

Högklint Formation, Unknown locality, Visby parish

10 Pygidium (lectotype *L. palifer*), dorsal view latex, Ar2331, x2; figured Lindström 1885, pl. 14, fig. 11.

Pseudotupolichas ornatus (Angelin, 1854)

Slite Group, unit c, Lansa, Fårö parish.

3a,b Cranidium; anterior & dorsal views, Ar2396, x1.

9 Neotype pygidium; dorsal view, Ar2390, x1; figured Lindström, 1885, pl. 15, fig. 13.

14 Cranidium; dorsal view, internal mould, Ar2379, x2.

Högklint Formation, Visby parish

5 Hypostome; ventral view, Ar2467, x1; figured as *Lichas* sp. by Lindström 1885, pl. 4, figs 44-46.

Högklint Formation?, Hangvars Kanal, Hangvar parish.

8a-c Cranidium; anterior, dorsal & lateral views, Ar2375, x2.

Högklint Formation, unit d, Vattenfallet, Visby parish

15 Cranidium; dorsal view, Ar5148, x2.

Slite Group, unit g, Coast at Storungs, Lärbro parish

17 Pygidium; dorsal view, Ar5032, x2.

Plate 2

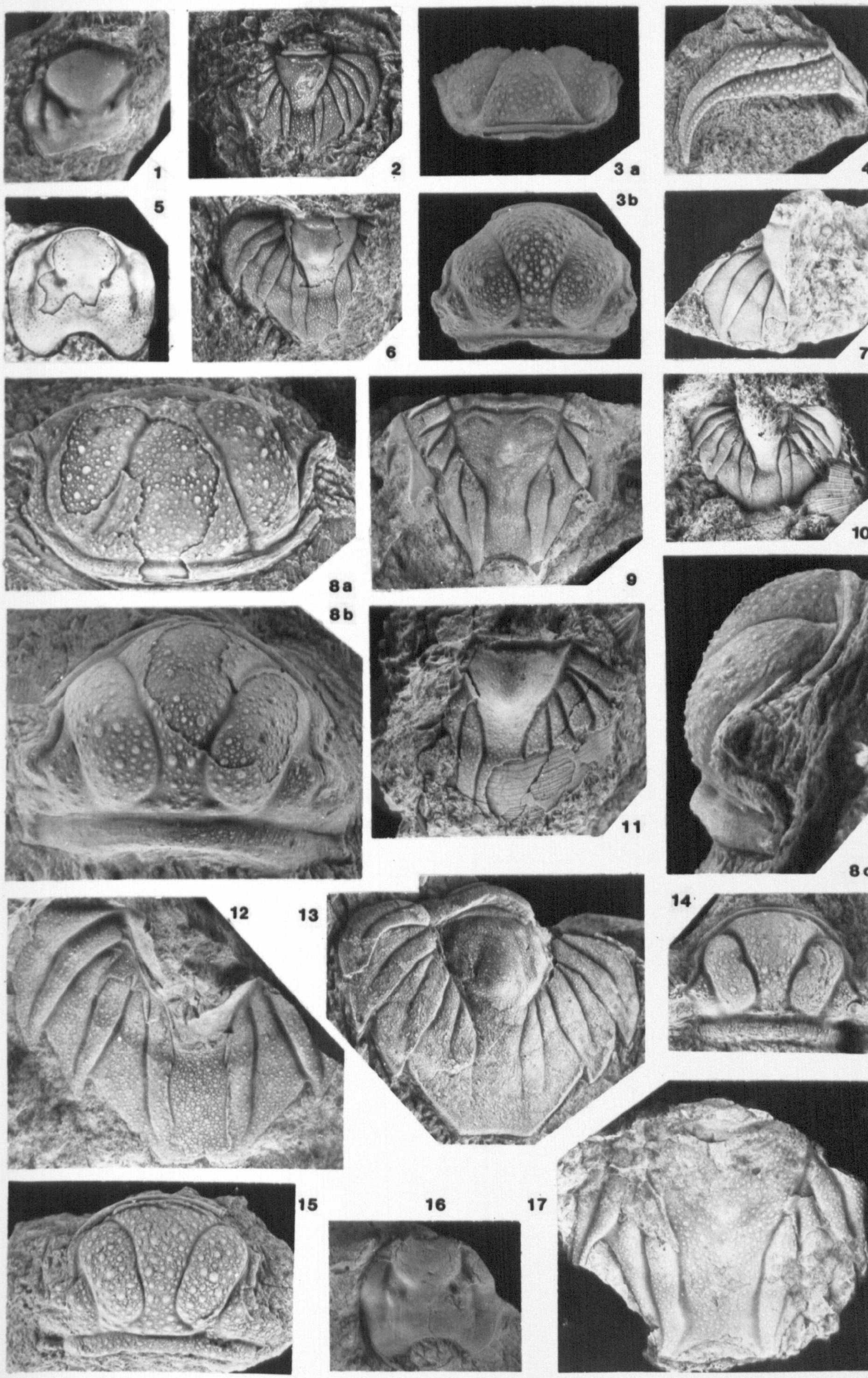


Plate 3

Fig.

Pseudotupolichas ornatus (Angelin, 1854)

J2, Jaagarahau stage (Wenlock), Islands of Vaika, east Baltic

1	Cranidium; dorsal view, Tr2967, x2
2	Pygidium; dorsal view, Tr1932, x2.
3	Cranidium; dorsal view, internal mould, Tr2968, x2.
4	Cranidium; anterior view, Tr2970, x2.
5	Cranidium; dorsal view, Tr2529, x2.
6	Hypostome; ventral view, internal mould, Tr2869, x2.
7	Pygidium; dorsal view, Tr2971, x2.

Slite Group, unit c, Lansa, Fårö parish

12	Pygidium; dorsal view, Ar2362, x2.

Pseudotupolichas plicatus (Lindström, 1885)

Slite Group, unit c, Lansa, Fårö parish

8	Holotype pygidium; dorsal view, latex of external mould, Ar2424, x2; figured Lindström 1885, pl. 16, fig 11.
9	Pygidium; dorsal view, latex external mould, Ar2425, x2.

Pseudotupolichas visbyensis (Lindström, 1885)

Visby Formation, Visby c, Norderstrand, Visby parish

10	Holotype pygidium; dorsal view, latex of external mould, Ar2419, x2; figured Lindström 1885, pl. 16, fig 11.
13	Pygidium; dorsal view, latex of external mould, Ar2392, x2.

Pseudotupolichas concinnus (Angelin, 1854)

Locality & horizon unknown

11a-c	Holotype cranidium; anterior, lateral and dorsal views, Ar2363, x2.

Dicranogmus sp.

Hamra Formation, unit a, Grötlingbo parish.

14a,b	Cranidium; dorsal and lateral views, Ar2358, x2.

Plate 3

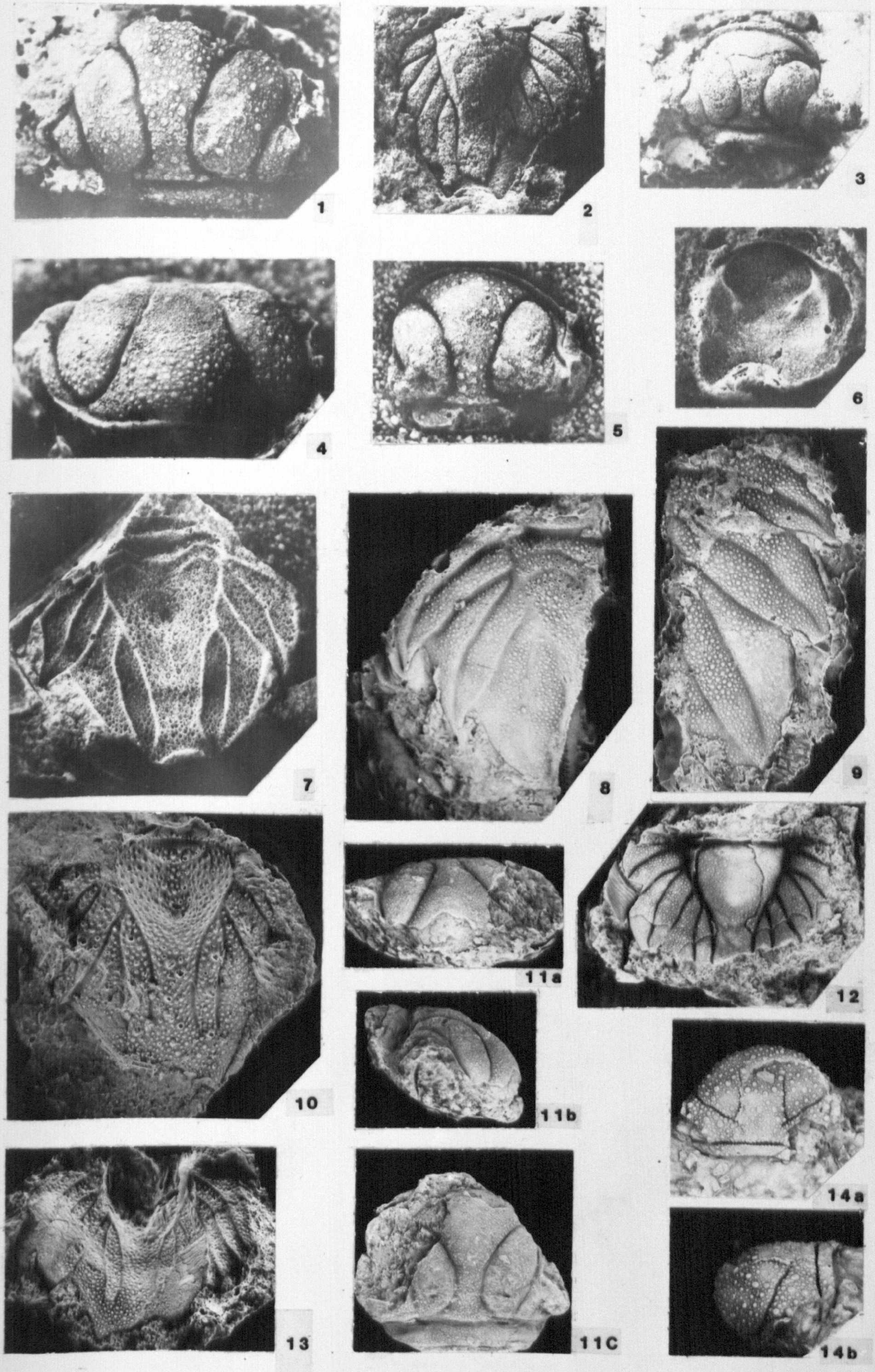


Plate 4

Fig.

Dicranopeltis salteri (Fletcher, 1850)

Lickershamn, Stenkyrka parish

1a-c Cranidium; external mould, anterior, dorsal & lateral views, Ar2447, x3.

Upper Visby Formation, Visby b, Visby parish

2 Pygidium; dorsal view, internal mould, Ar2454, x3.

7a-c Cranidium; anterior, lateral and dorsal views, Ar5083, x3.

9 Pygidium; ventral view, external mould, Ar2429, x3.

Slite Group, unit c, Lansa, Fårö parish

3 Cranidium; dorsal view, Ar5082, x3.

12 Cranidium; dorsal view, Ar2436, x3.

Slite Group, Slite Marl, Valbytte 1, Sanda parish

4 Hypostome; ventral view, Ar51467, x3

Högklint Formation, Visby parish

6a,b Pygidium; lateral and dorsal views, Ar2428, x3.

Slite Group, unit g, Samsugn, Othem parish

8 Hypostome; ventral view, Ar2457, x3.

Högklint Formation or Slite Group?, Lummelunda canal, Lummelunda parish

10 Cranidium; dorsal view, Ar5034, x3.

Platylichas grayii (Fletcher, 1850)

Visby b, Visby parish, Upper Visby Formation

5a-c Cranidium (syntype of *Lichas rotundifrons* Angelin, 1854); dorsal, anterior and lateral views, Ar2460, x3; figured Angelin 1854, pl. 36, figs 7, 7a & 7b.

11a-c Cranidium; dorsal, lateral & anterior views, Ar2448, x3.

Plate 4

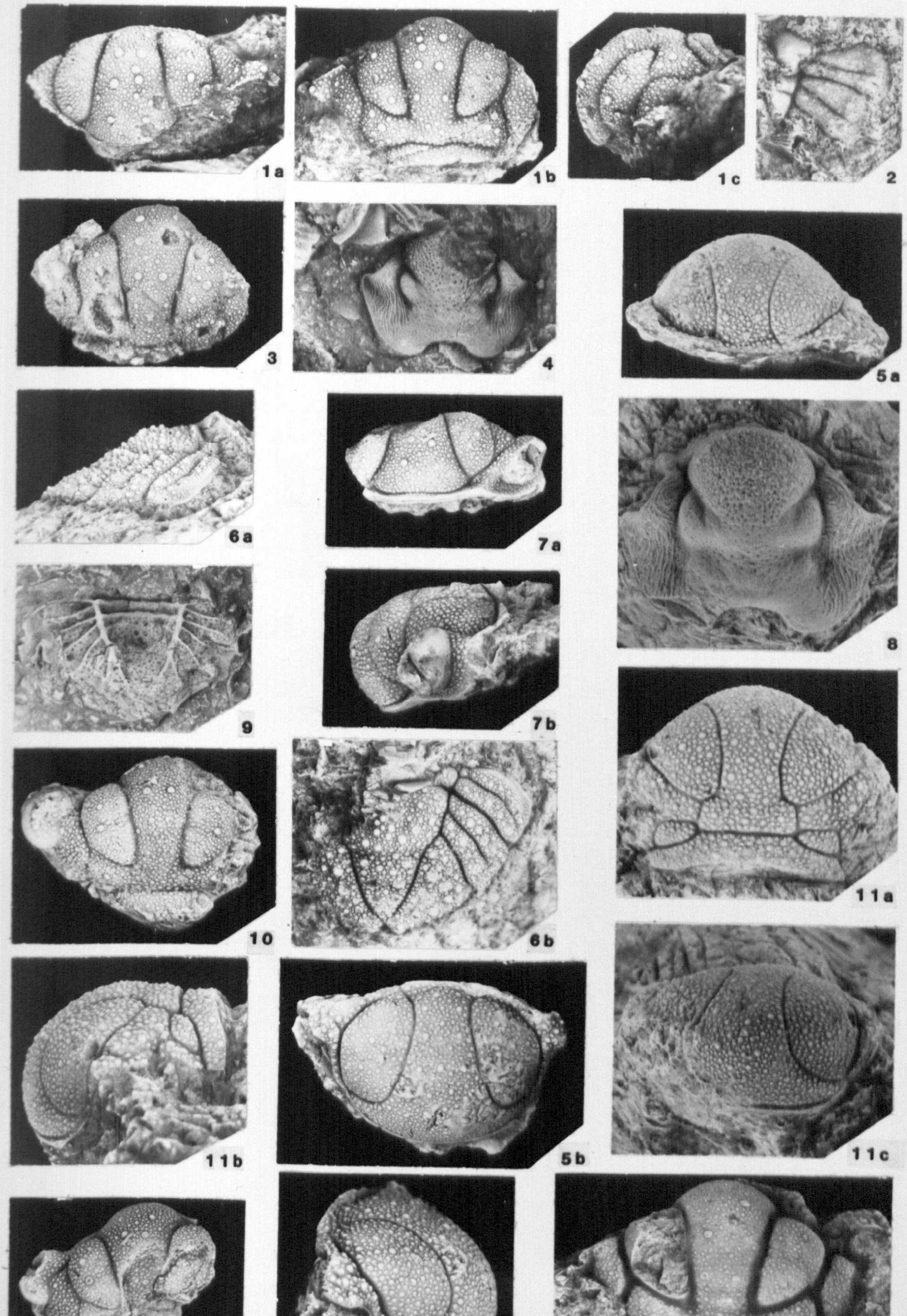


Plate 5

Fig.

Chonelliobarges bucklandii (Milne-Edwards, 1840)

Hemse Group, Hemse Marl, N.W. part, Urgude 2, Sproge parish

1a-d Complete specimen; lateral, dorsal cranidial, ventral & dorsal pygidial views, Ar51620, x3.

2a-c Complete specimen; lateral & two dorsal views, Ar51711, x4.

Slite Formation, Slite Marl, Valbytte 1, Sanda parish

7 Hypostome; ventral view, Ar51481, x4.

12 Hypostome; ventral view, Ar51482, x4.

Slite Group, Slite Marl, Valbytte 1, Sanda parish

11 Pygidium & partial thorax; dorsal view, Ar 51329, x4.

Platylichas grayii (Fletcher, 1850)

Upper Visby Beds, Visby, Visby parish.

5 Cranidium; dorsal view, Ar2466, x3.

Upper Visby Beds, Tofta parish

8 Cranidium; dorsal view, Ar2422, x3.

Chonelliobarges deptus sp. nov.

Eke Formation, Upper part, Lau backar 1, Lau parish

3 Pygidium; dorsal view, internal mould, Ar2450 x2.

Horizon & locality unknown, Ostergarn parish

4 Pygidium; dorsal view, internal mould, Ar2341, x2.

Hemse Group?, unit c?, Fårsviken?, (Grogarnshuvud 1?), Ostergarn parish

6 Paratype cranidium; dorsal view, Ar51424, x3.

9a-c Paratype cranidium; lateral, anterior & dorsal views, Ar51423, x3.

Chonelliobarges sp. A

Slite Group, *Pentamerus gothlandicus* Beds, Boge parish

10a-c Cranidium; lateral, anterior & dorsal views, Ar5094, x3.

Chonelliobarges sp. aff. *C. bucklandii* Milne-Edwards, 1840

Eke Formation, upper part, Lau Backar 1, Lau parish

13a,b Cranidium; external mould, lateral & dorsal views, Ar51743, x3.

Plate 5

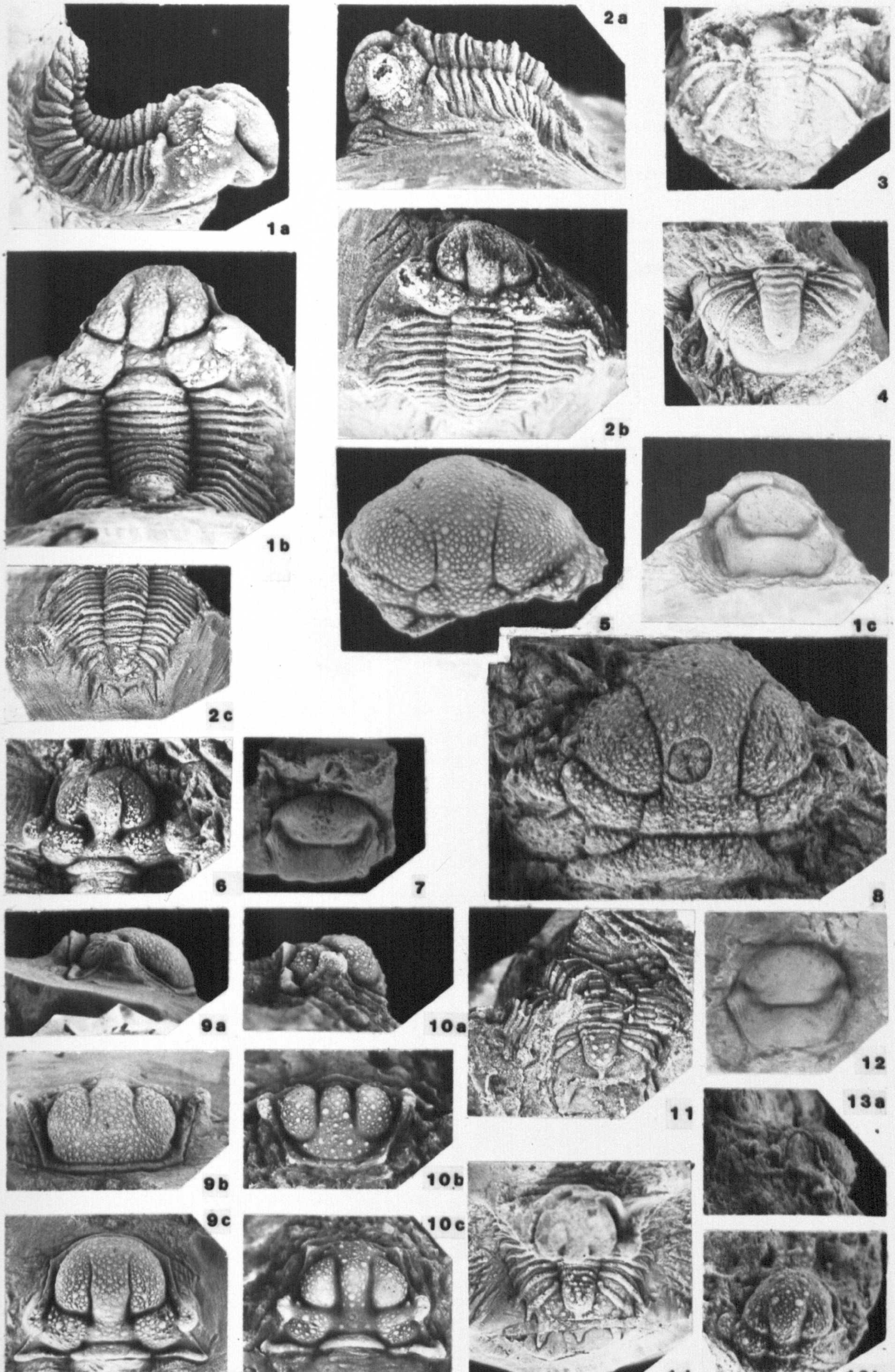


Plate 6

Fig.

Craspedarges? sp. nov. aff *C. maia* (Reed, 1920)

Högklint Formation, unit c?, Visby parish

1a-c Cranidium; lateral, dorsal & anterior views, Ar5087, x3.

Craspedarges scutalis (Salter, 1873)

Slite Group, Slite Marl, Valbytte 1, Sanda parish

2 Free cheek; dorsal view, Ar51433, x3.

5a-c Cephalon; lateral, dorsal & anterior views, Ar51427, x3.

Slite Group, Slite Marl, unknown locality, Vastergarn parish

7a-c Cranidium; anterior, lateral & dorsal views, Ar2369, x3.

Slite Group, Slite Marl undifferentiated, Valve 2, Eskhelm parish

9a,b Pygidium; internal mould, dorsal & lateral views, Ar51575, x3.

10 Pygidium; dorsal view, 51578, x3.

13 Pygidium; dorsal view, 51577, x3.

Slite Group, Slite Marl, Valbytte 3, Sanda parish

14 Hypostome; ventral view, Ar51465, x5.

Choneliobarges deptus sp. nov.

Hemse Group, upper part, Bulbro, Alskog parish

3 Paratype pygidium; dorsal view, Ar2426, x3.

Hemse Group, lower part, Ostergarn, Ostergarn parish

4 Paratype pygidium; dorsal view, Ar2440, x3.

Eke Formation, upper part, Lau Backar 1, Lau parish

6 Holotype pygidium; dorsal view, Ar51736, x3.

Craspedarges? sp. nov. aff. *C. maia* (Reed, 1920)

Slite Group, unit c, Lansa, Fårö parish

8a,b Pygidium; internal mould, dorsal & lateral views, Ar2349, x3.

11 Pygidium; internal mould, dorsal & lateral views, Ar2450, x3.

Acanthopyge rotundifrons (Angelin, 1854)

Unknown locality & horizon, Visby?

12a,b Holotype pygidium; dorsal & lateral views, Ar2397, x9; figured Angelin 1854, pl. 37, fig. 4.

Plate 6

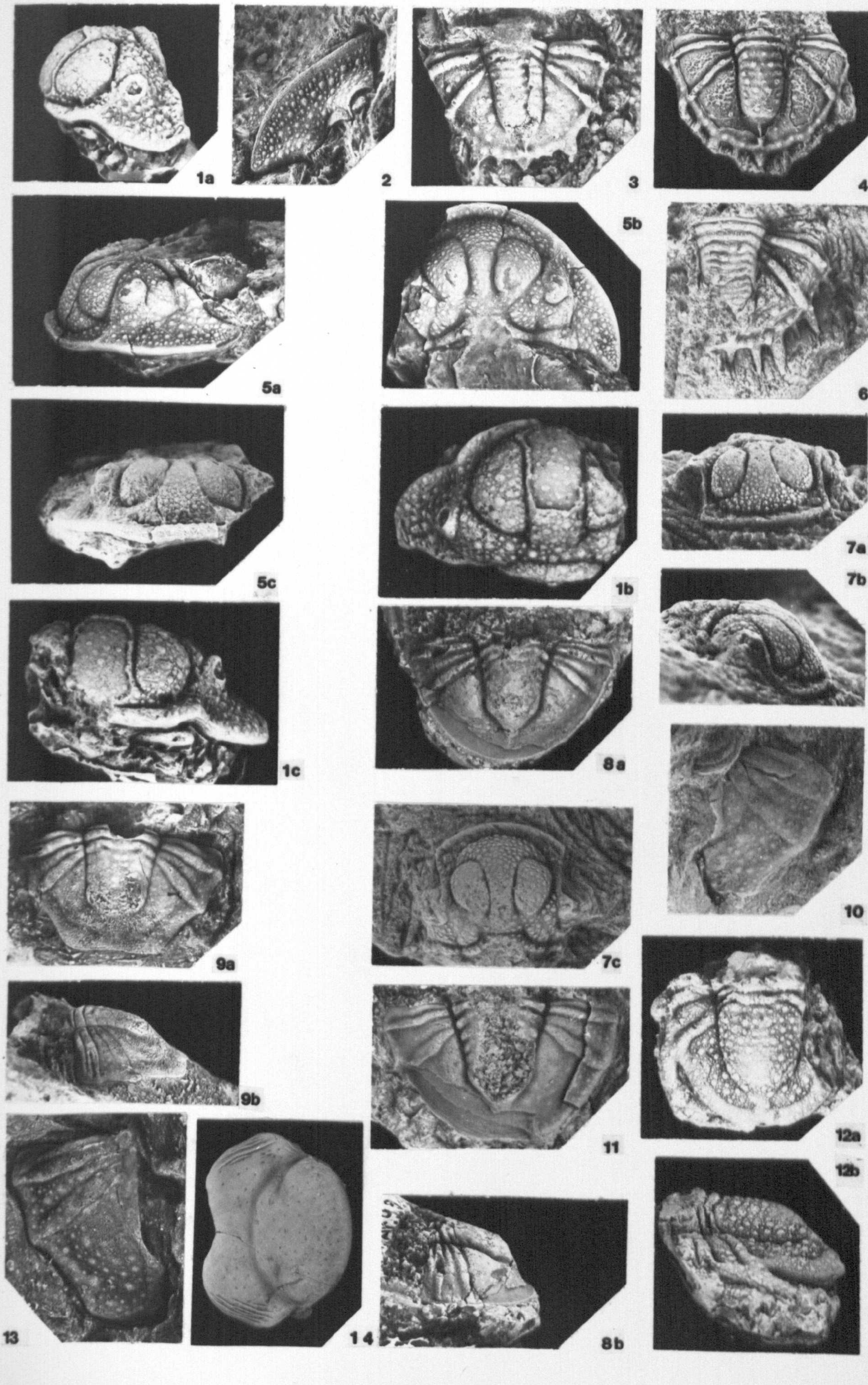


Plate 7

Fig.

Acanthopyge calcitripa sp. nov.

Mulde Formation, undifferentiated, Nordervik, Eksta parish

1a,b Holotype pygidium; dorsal & lateral views, Ar51729, x5.

2 Paratype pygidium; dorsal view, Ar51726, x5.

19 Paratype pygidium; dorsal view, Ar51727, x5.

Mulde Formation, uppermost part, Mulde 2, Fröjel parish

3 Paratype pygidium; dorsal view, Ar51402, x5.

4 Paratype pygidium; dorsal view, Ar51401, x10.

Mulde Formation, lower part, Djupvik, Eksta parish

5a-c Paratype cranidium; anterior, lateral & dorsal views, Ar5090, x5.

11a,b Paratype cranidium & hypostome, ventral & dorsal views, Ar5096, x5.

Mulde Formation, undifferentiated, Mulde tegelbruk 1, Fröjel parish

6 Paratype free cheek; dorsal view, Ar51408, x5.

8 Paratype free cheek; dorsal view, Ar51409, x5.

12 Paratype free cheek; dorsal view, Ar51410, x5.

Slite Group, Slite Marl, Valve 2, Eskhelm parish

16 Paratype hypostome; ventral view, Ar51580, x5.

Craspedarges sp. nov. aff. *C. maia* (Reed, 1920)

Eke Formation, Lau backar 1, Lau parish

7 Pygidium; dorsal view, Ar2349, x3.

Högklint Group, unit b, Kappelshamn 1, Hangvar parish

14 Pygidium; dorsal view, Ar51718, x3.

Craspedarges scutalis (Salter, 1873)

Slite Group, Slite Marl, Valbytte 1, Sanda parish

9 Pygidium; dorsal view, Ar51456, x3

10 Hypostome; ventral view, Ar51579, x5.

13 Pygidium; dorsal view, Ar51457, x3.

17 Cranidium; dorsal view, Ar51431, x3.

Mulde Formation, lower part, Blåhäll 1, Eksta parish

18 Cranidium & partial thorax; dorsal view, Ar51515, x1.

Chonelliobarges bucklandii (Milne-Edwards, 1840)

Hemse Group or Eke Formation, Bomunds i Burgen

15 Hypostome; ventral view, internal mould, Ar2457, x5; figured as *Trochurus* sp. by Lindström 1885, pl. 4, figs 54, 55.

Dicranogmus? sp.

Sundre Formation, middle to upper part, Holmhällar 1, Hamra parish

20 Hypostome; ventral view, Ar2458, x3.

Hemse Group, upper part, Sandarve Kalle, Fardhem parish

Plate 7

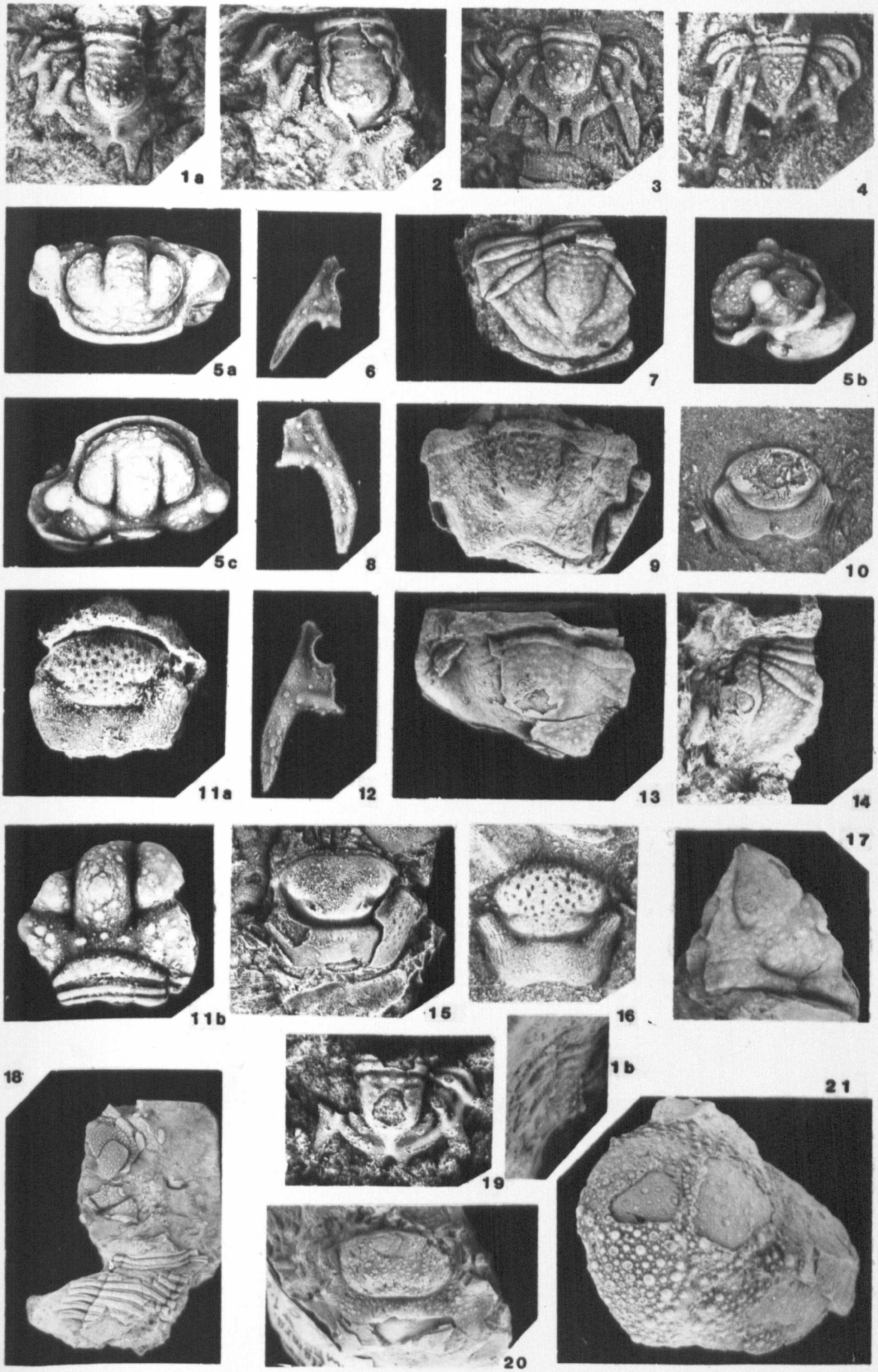


Plate 8

Fig.

Stenopareia glaber (Kjerulf, 1865)

Solvik Formation (Kiær's étage 6ab), Spirodden, Asker district

1a-c Pygidium; lateral, dorsal & posterior views, PMO 52515, x3.

7 Pygidium; dorsal view, internal mould, PMO 19139, x2.

Solvik Formation (Kiær's étage 6c), Billingstad, Asker district

2a,b Free cheek; internal mould, dorsal & lateral views, PMO 110.163, x3. Paralectotype of *S. rotunda* (Kiær, 1908).

3a-c Cranidium; dorsal, lateral & anterior views, PMO 19422, x2. Lectotype of *S. rotunda* Kiær 1908; figured Whittard 1940, pl. 1, fig 1.

4a-c Pygidium; dorsal, lateral & dorsal views, PMO 19425, x2, x2, x3 & x2 respectively. Paralectotype of *S. rotunda* (Kiær, 1908); figured Whittard 1940, pl. 1, fig. 8.

5a,b Cranidium; dorsal & anterior views, PMO 110.164, x3. Paralectotype of *S. rotunda* (Kiær, 1908).

6 Paralectotype cranidium; dorsal view, PMO 110.165, x2.

8a-c Cranidium; dorsal & anterior views, PMO 110.166, x3. Paralectotype of *S. rotunda* (Kiær, 1908).

9a,b Cranidium; lateral anterior & dorsal views, PMO 19421, x1. Paralectotype of *S. rotunda* (Kiær, 1908); figured Whittard 1940, pl. 1, figs 2, 3.

11a,b Whole specimen (lacking free cheeks); lateral and dorsal views, PMO 19262. Paralectotype of *S. rotunda* (Kiær, 1908); figured Whittard 1940, pl. 1, fig. 7.

Saelabonn Formation (Kiær's étage 6c), Hönefoss road, Ringerike

10a-c Cranidium; dorsal, lateral & anterior views, PMO 109.915, x2.

Plate 8

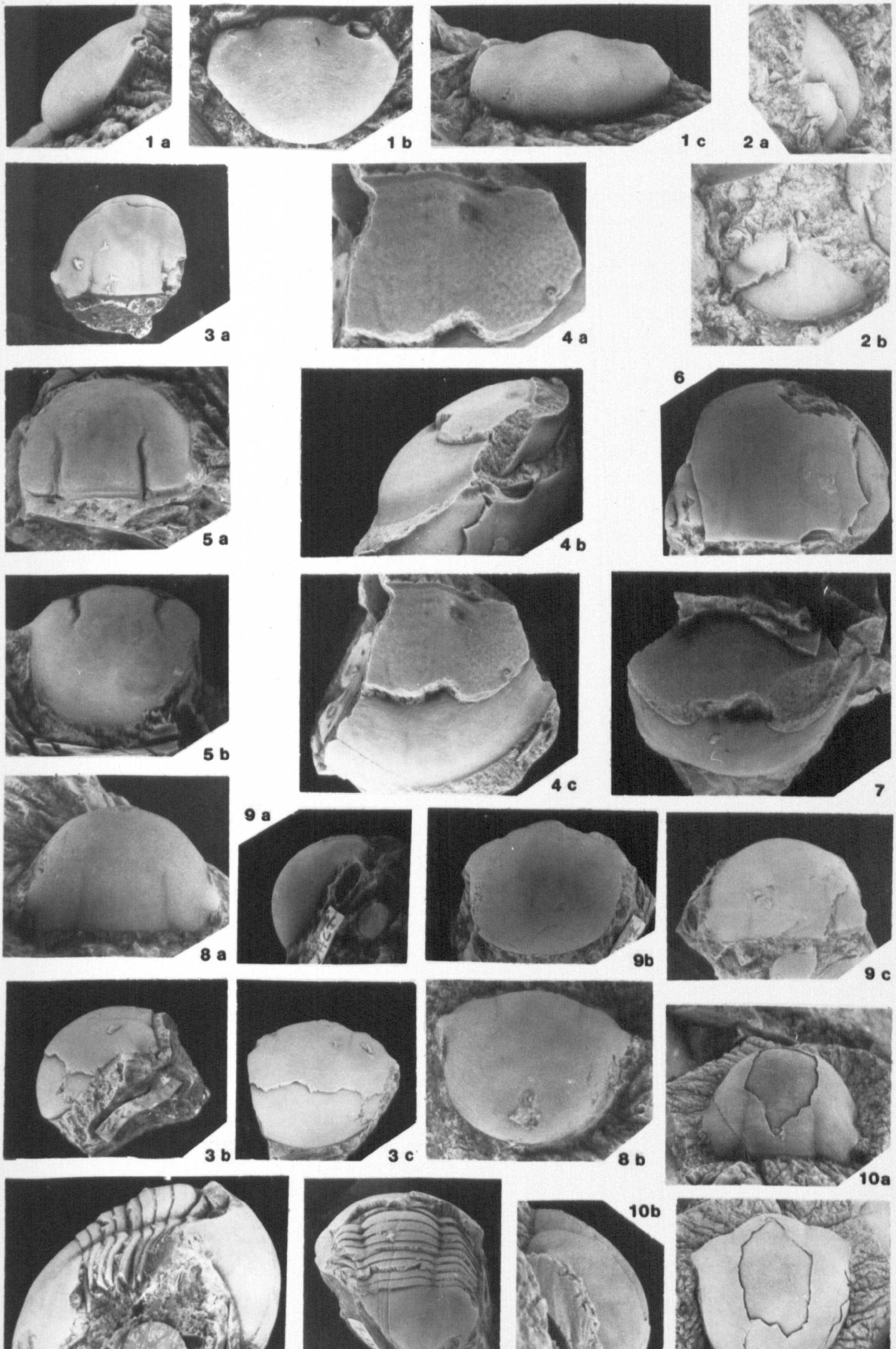

1 a
1 b
1 c
2 a
3 a
4 a
2 b
5 a
4 b
6
5 b
4 c
7
8 a
9 a
9b
9 c
3 b
3 c
8 b
10a
11a
11b
10b
10c

Plate 9

Fig.

Stenopareia glaber (Kjerulf, 1865)

Solvik Formation (Kiær's étage 7), Leanghagda, Asker district

1a-c Cranidium; internal mould, anterior, dorsal & lateral views, electron scanning micrograph, PMO 110.161, x25.

Solvik Formation (Kiær's étage 6), Spirodden, Asker district

2a-d Cephalon; internal mould, lateral, anterior, dorsal & ventral views, PMO 19135, x2. Lectotype *S. sculpta* (Kiær, 1908); figured Whittard pl. 1, figs 9-11.

3a-d Cephalon; internal mould, lateral, ventral, dorsal & anterior views, PMO 19139, x2.

5 Cranidium; internal mould, dorsal view, PMO 110.177, x2.

Solvik Formation (Kiær's étage 6), Hvalbakken

4a-c Cephalon; internal mould, dorsal, lateral & anterior views, PMO 19247, x3. Paralectotype of *S.rotunda* (Kiær 1908); figured Whittard, 1940, pl. 1, fig. 4.

Plate 9

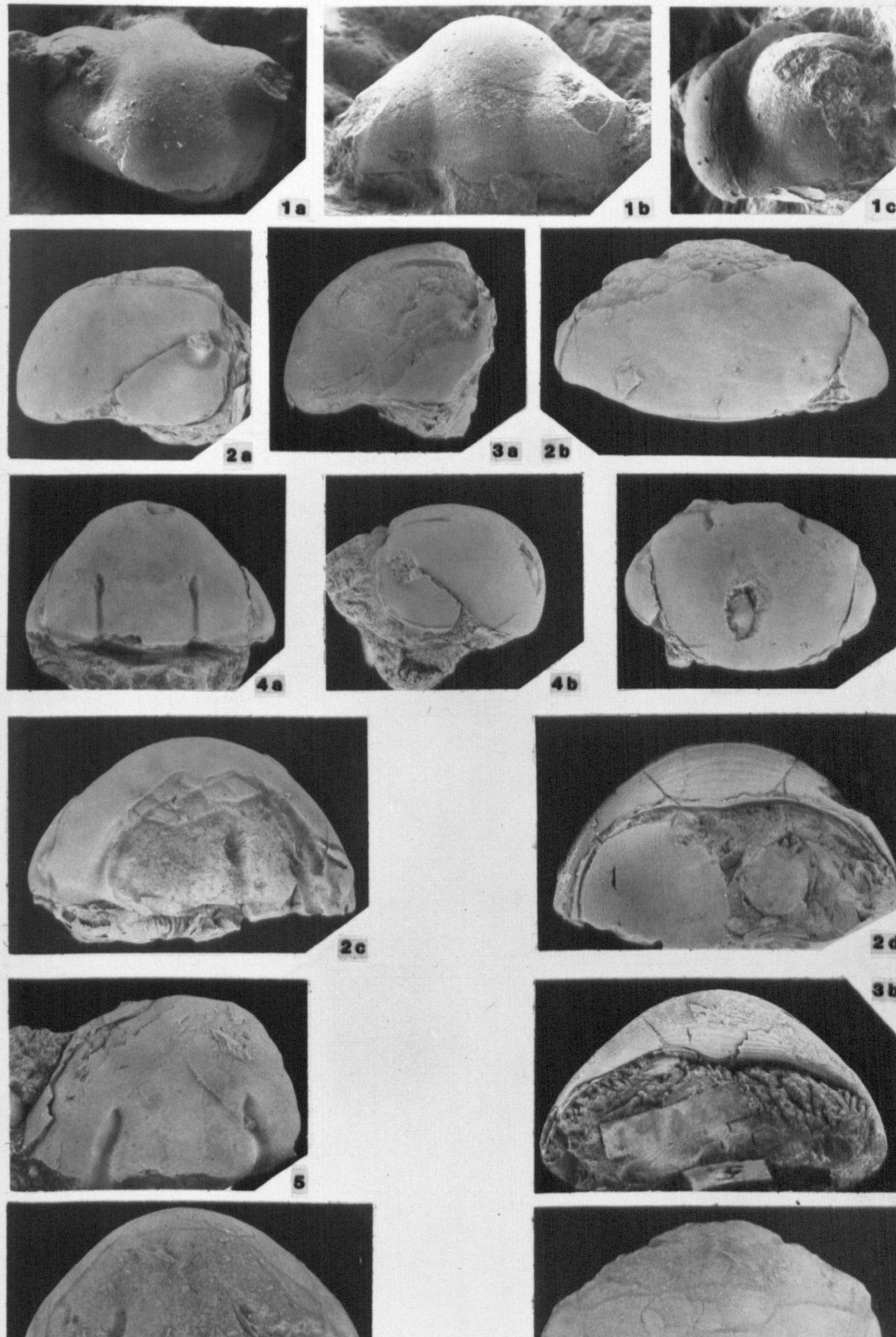


Plate 10

Fig.

Stenopareia glaber (Kjerulf, 1865)

Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand

1 Rostral plate; partially exfoliated, ventral view, PMO 19411, x1. Paralectotype *S. norvegica* (Whittard, 1940); figured Whittard 1940, pl. 2, fig. 1.

Solvik Formation (Kiær's étages 6b & 6c), Spirodden, Asker

3a-c Cranidium; internal mould, dorsal, anterior & lateral views, PMO 52549, x1.

4a-c Cranidium; internal mould, anterior, dorsal & lateral views, PMO 19164, x1. Lectotype of *S. norvegica* (Whittard, 1940); figured Whittard 1940, pl. 2, figs 3, 4.

Stenopareia sp.

Upper Chasmops Limestone (Arenig, Kiær's étage 5b), Rambergøya, Oslo District

2a-c Cranidium; internal mould, lateral, anterior & dorsal views, PMO 19191, x3; figured as *S. rotunda* (Kiær, 1908) by Whittard 1940, pl. 1, fig 6.

Plate 10

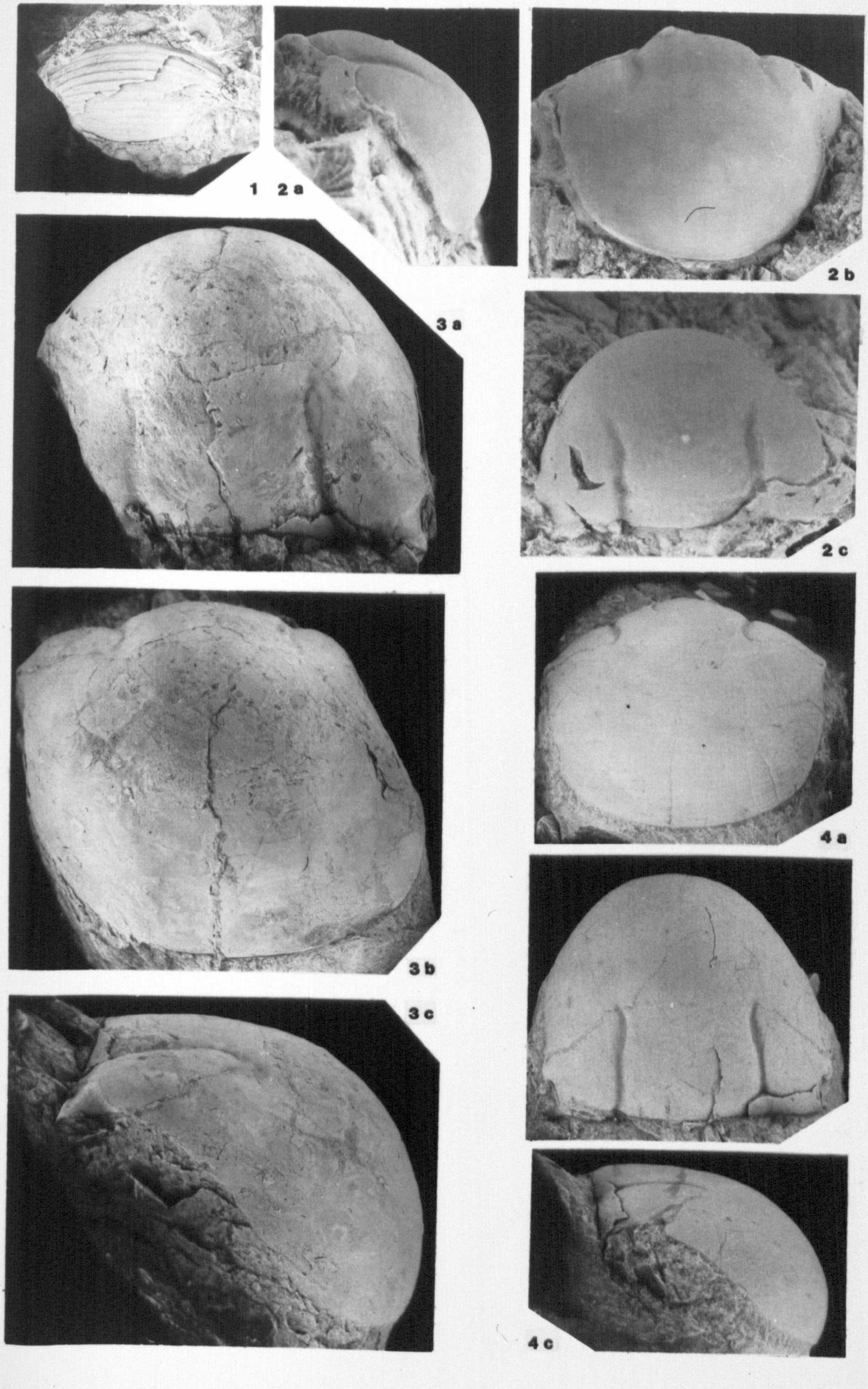


Plate 11

Fig.

Stenopareia glaber (Kjerulf, 1865)

Solvik Formation (Kiær's étage 6), Sandvika, Asker

1 Pygidium; internal mould, dorsal view, PMO 53312, x1.

2a-c Pygidium; internal mould, dorsal, posterior & lateral views, PMO 89243, x1.

5a-c Cranidium; internal mould, anterior, dorsal & lateral views, PMO 19174, x1. Paralectotype of *S. norvegica* (Whittard, 1940); figured Whittard 1940, pl. 2, fig. 2.

Solvik Formation (Kiær's étage 6), Langara, Asker

4a-c Complete specimen; internal mould, dorsal pygidial, lateral & dorsal cephalic views, PMO 19280, x2. Paralectotype of *S. sculpta* (Kiær, 1908).

Stenopareia postrema (Kiær, 1908)

Braksøya Formation (Kiær's étage 8c), Ringerike

3a-c Lectotype cranidium; dorsal, anterior & lateral views, PMO 21757, x1; figured Whittard 1940, pl. 1, figs 18-20.

Plate 11

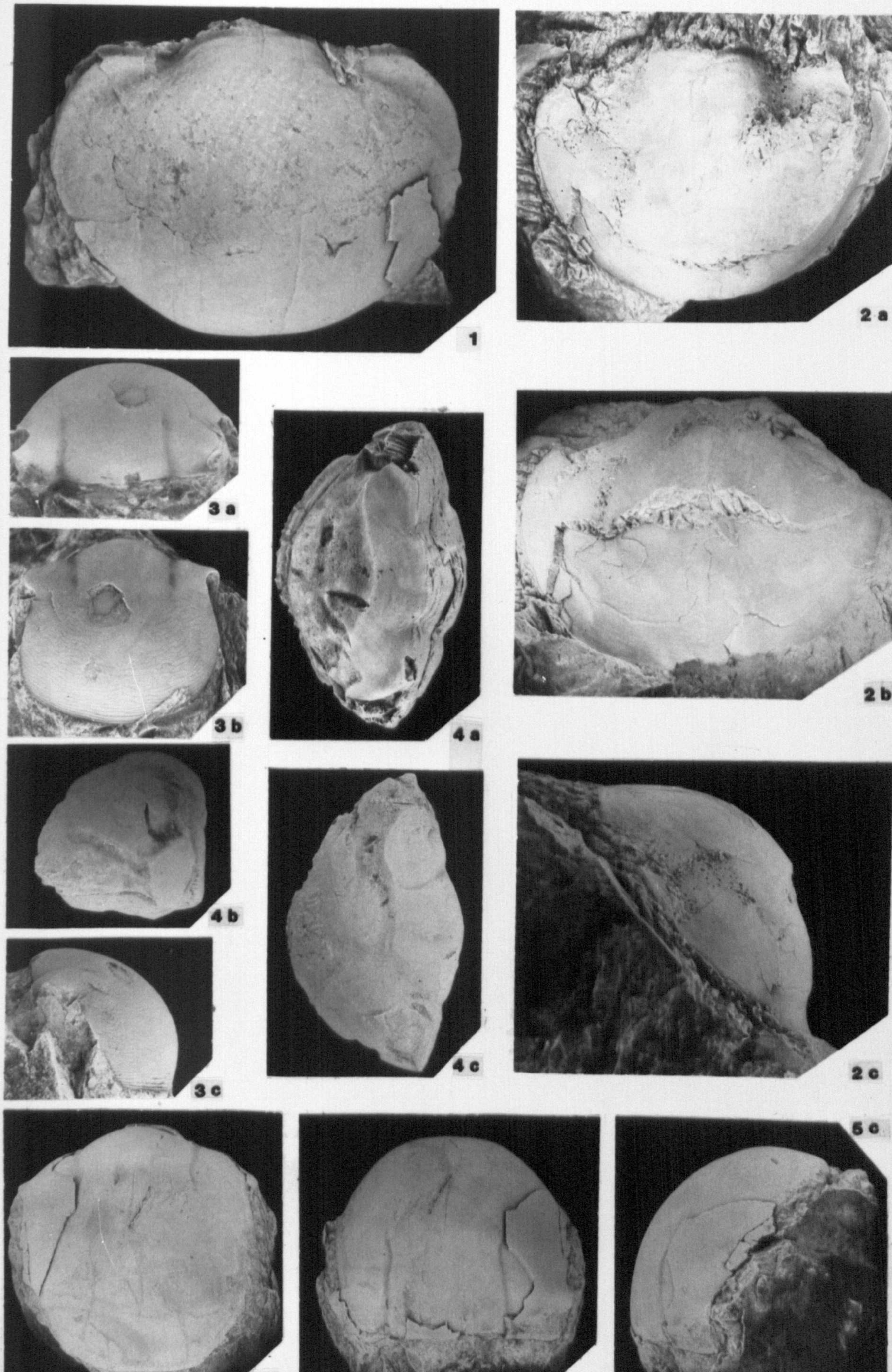


Plate 12

Fig.

Stenopareia longispinosa (Kiær, 1908)

Rytteråker Formation (Kiær's étage 7b), Malmøya, Oslo

1a,b Pygidium; internal mould, dorsal & lateral views, PMO 19546, x1; figured as *Pygidium* type B By Whittard 1940, pl. 4, fig. 1.

3a,b Pygidium; internal mould, dorsal & lateral views, PMO 19547, x1; figured as *Pygidium* type B by Whittard 1940, pl. 4, figs 2, 3.

Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand

2 Pygidium; internal mould, dorsal view, PMO 19439, x2.

5 Pygidium; dorsal view, PMO 19447, x2.

7 Pygidium; internal mould, dorsal view, PMO 19446, x2.

8 Pygidium; internal mould, dorsal view, PMO 19439, x2.

Locality & horizon unknown

4 Pygidium; internal mould, dorsal view, PMO 43603, x2.

6a-c Cranidium; internal mould, lateral, dorsal & anterior views, PMO 19272, x2.

Stenopareia glaber (Kjerulf, 1865)

Solvik Formation (Kiær's étage 6c), Spirodden, Asker

9 Free cheek; lateral view, PMO 19136, x3. Paralectotype of *S. sculpta* (Kiær, 1908); figured Whittard 1940, Pl. 1, fig. 12.

10 Cranidium; dorsal view, PMO 19137, x4.

Plate 12

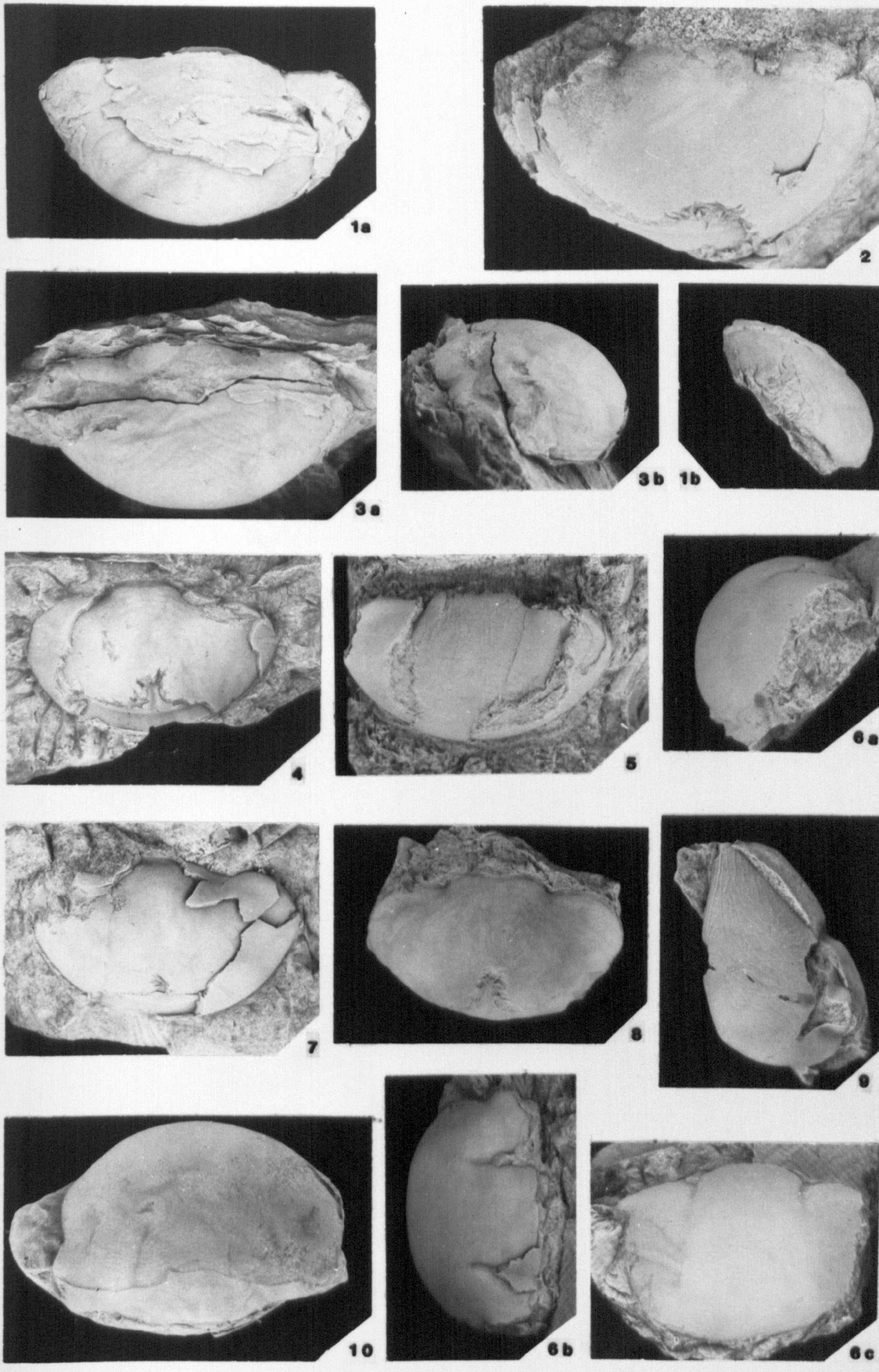


Plate 13

Fig.

Stenopareia longispinosa (Kiær, 1908)

Rytteråker Formation (Kiær's étage 7b), Ulvøya, Oslo

1a-c Cranidium; internal mould, dorsal, anterior & lateral views, PMO 21305, x2.

2a-c Paralectotype cranidium; internal mould, lateral, dorsal & anterior views, PMO 21307, x1; figured Whittard 1940, pl. 1, fig. 16.

6 Paralectotype free cheek; internal mould, lateral view, PMO 21306, x2; figured Whittard 1940, pl. 1, fig. 17.

Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand

3a-c Lectotype cranidium; external mould, lateral, anterior & dorsal views, PMO 19483, x2; figured Whittard 1940, pl. 1, figs 13-15.

Solvik Formation (Kiær's étage), Malmøya, Oslo

5a,b Pygidium; internal mould, dorsal & posterior views, PMO 21239, x1.

Rytteråker Formation (Kiær's étage 7c), Malmøya, Oslo

7a,b Pygidium internal mould, dorsal & lateral views, PMO 19632, x3; figured as *Pygidium* type B by Whittard 1940, pl. 4, fig. 4.

Opsypharus maccallumi (Salter, 1867)

Rytteråker Formation (Kiær's étage 7ab), Ulvøya, Oslo

4 Hypostome; internal mould, ventral view, PMO 42898, x4.

Plate 13

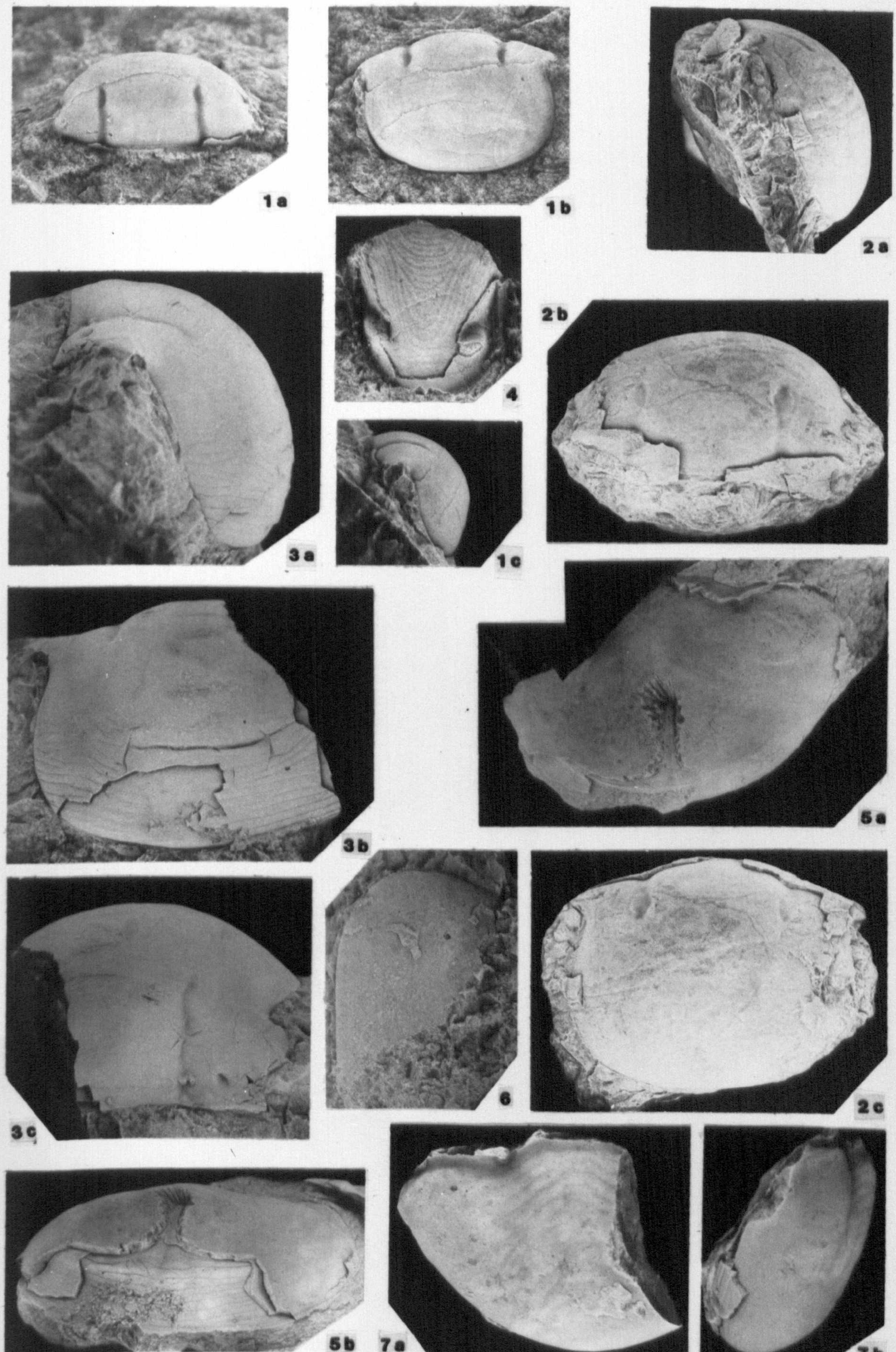


Plate 14

Fig.

Bumastus bouchardi (Barrande, 1846)

Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo

1a-c Cephalon; internal mould, anterior, dorsal & lateral views, PMO 19682, x2. Paralectotype of *B. praeruptus* Kiær 1908; figured Whittard 1940, pl. 3 figs 1-3.

2a-c Cephalon; lateral, dorsal & ventral views, PMO 19681, x2. Lectotype of *B. praeruptus* Kiær 1908; figured Whittard 1940, pl. 2, figs 11-14.

3a,b Pygidium; dorsal & lateral views, PMO 19680, x2.

4 Pygidium; internal mould, dorsal view, PMO 110.294, x2.

6 Free cheek; lateral view, PMO 19678, x5. Paralectotype of *B. praeruptus* Kiær, 1908; figured Whittard 1940, pl. 3, fig 4.

Bumastus inflatus Kiær, 1908

Malmøya Formation (Kiær's étage 8), Malmøya, Oslo

5a-c Lectotype cranidium; dorsal, anterior & lateral views, PMO 21399, x3; figured Whittard 1940, pl. 3, figs 5-7.

Plate 14

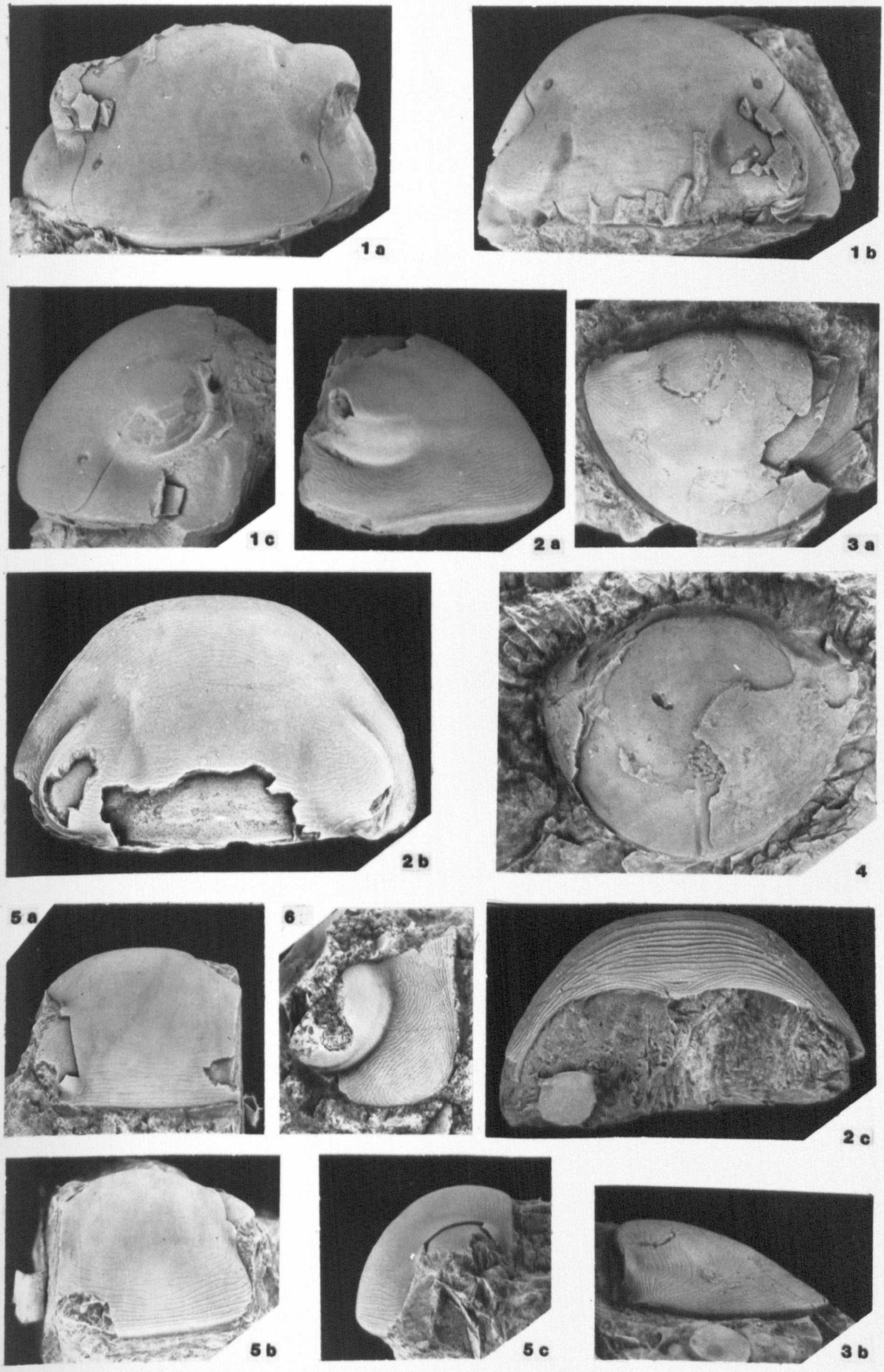


Plate 15

Fig.

Bumastus inflatus (Kiær, 1908)

Malmøya Formation (Kiær's étage 8), Malmøya, Oslo

1 Paralectotype free cheek; lateral view, PMO 21400, x2; figured Whittard 1940, pl. 3, fig 8.

2 Free cheek; lateral view, PMO 109.477, x3.

Eccairos dolabratus gen. et sp. nov

Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand

3 Holotype cranidium; internal mould, dorsal view, PMO 54753, x2.

7 Paratype pygidium; internal mould, dorsal view, PMO 110.284, x5.

8 Paratype pygidium; internal mould, dorsal view, PMO 110.261, x10.

9 Paratype free cheek; internal mould, lateral view, PMO 110.285, x3.

Ekwanoscutellum platyactin (Angelin, 1854)

Rytteråker Formation (Kiær's étage 7c), Purkøya, Ringerike

4 Cranidium; internal mould, dorsal view, PMO 110.205, x2.

6 Pygidium; internal mould, PMO 45564, x1.

10 Pygidium; external mould, dorsal view PMO 45714, x1.

Lower Visby Formation, Norderstrand, Visby Parish, Gotland

11 Two cranidia; one thorax & one pygidium, Ar29520, x1.

Bumastus bouchardi (Barrande, 1846)

Malmøya Formation (Kiær's étage 8c), Malmøya

5a,b Pygidium; internal mould, lateral & dorsal views, PMO 19679, x2; figured Whittard 1940, pl. 4, fig. 7.

Plate 15

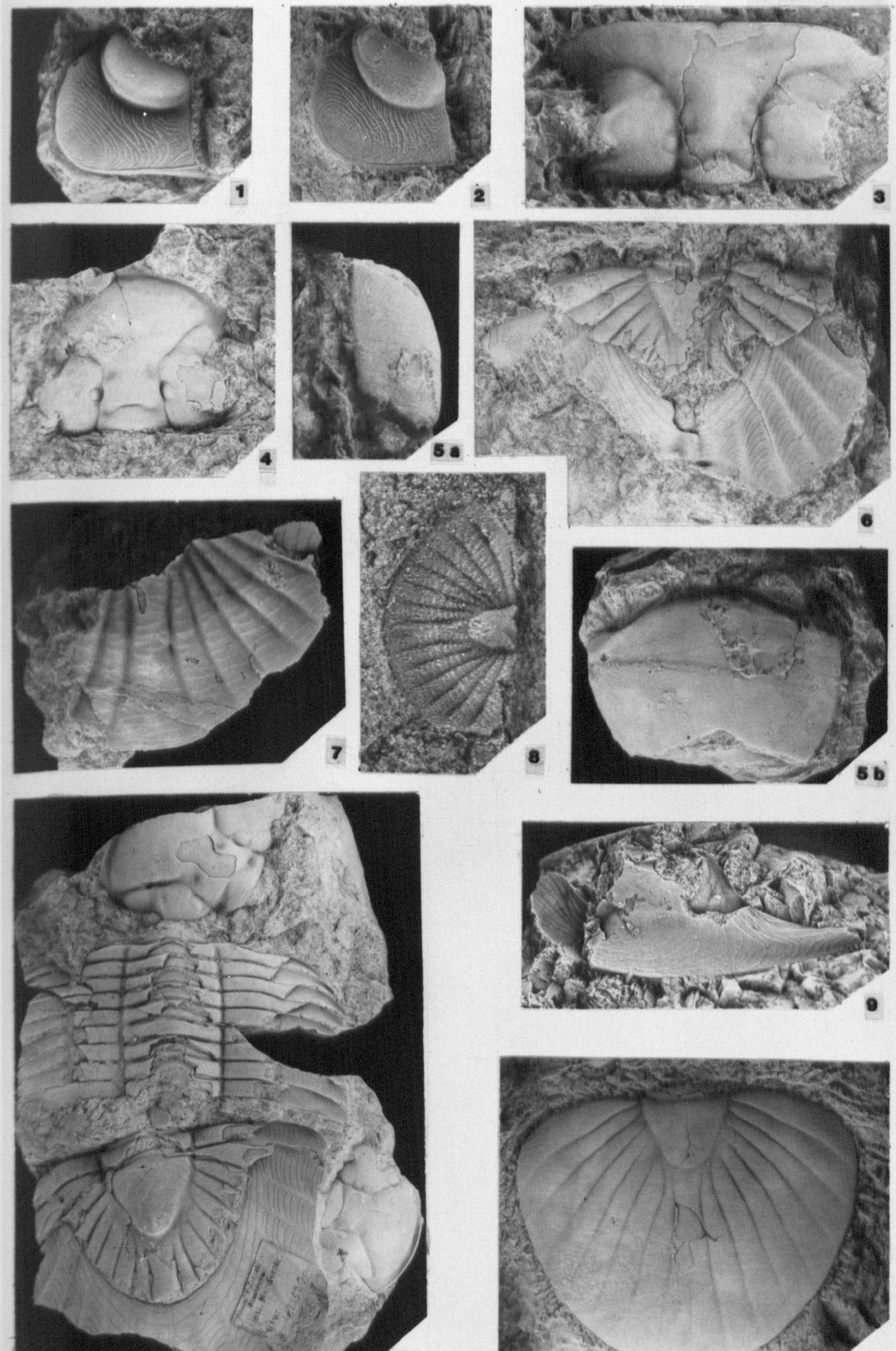


Plate 16

Fig.

Ekwanoscutellum platyactin (Angelin, 1854)

Lower Visby Formation, Norderstrand, Visby Parish, Gotland

1 One complete specimen lacking free cheeks & two pygidia with thoracic segments; latex of external mould, dorsal view, Ar29469, x1; figured Lindström 1885, pl. 14, fig. 1.

5 Free cheek; latex, dorsal view, Ar29519, x2.

7 Pygidium & thorax; latex of external mould, dorsal view, Ar29520, x1.

8 Pygidium; latex of external mould, dorsal view, Ar29521, x1.

9 Holotype pygidium & thorax; latex, dorsal view, Ar29470, x1; figured Angelin 1854, pl. 33, fig. 3. Lindström 1885, pl. 14, fig. 3.

Unknown locality & horizon, Oslo region

2a,b Pygidium; internal mould, dorsal & lateral views, PMO 42721, x1.

10 Cranidium; dorsal view, PMO 45574, x2.

12 Pygidium; internal mould, dorsal view, PMO 110.265, x1.

Rytteråker Formation (Kiær's étage 7b), Malmøya, Oslo

3 Pygidium; internal mould, dorsal view, PMO 51655, x2.

Braksøya Formation (Kiær's étage 8c), Purkøya, Ringerike

4 Pygidium; dorsal view, PMO 21673, x3.

6 Pygidium; dorsal view, PMO 43221, x3.

Opsypharus maccallumi (Salter, 1867)

Solvik Formation (Kiær's étage 6), Spirodden, Asker

11a,b Hypostome; partially exfoliated, lateral & ventral views, PMO 109.537, x5.

Plate 16

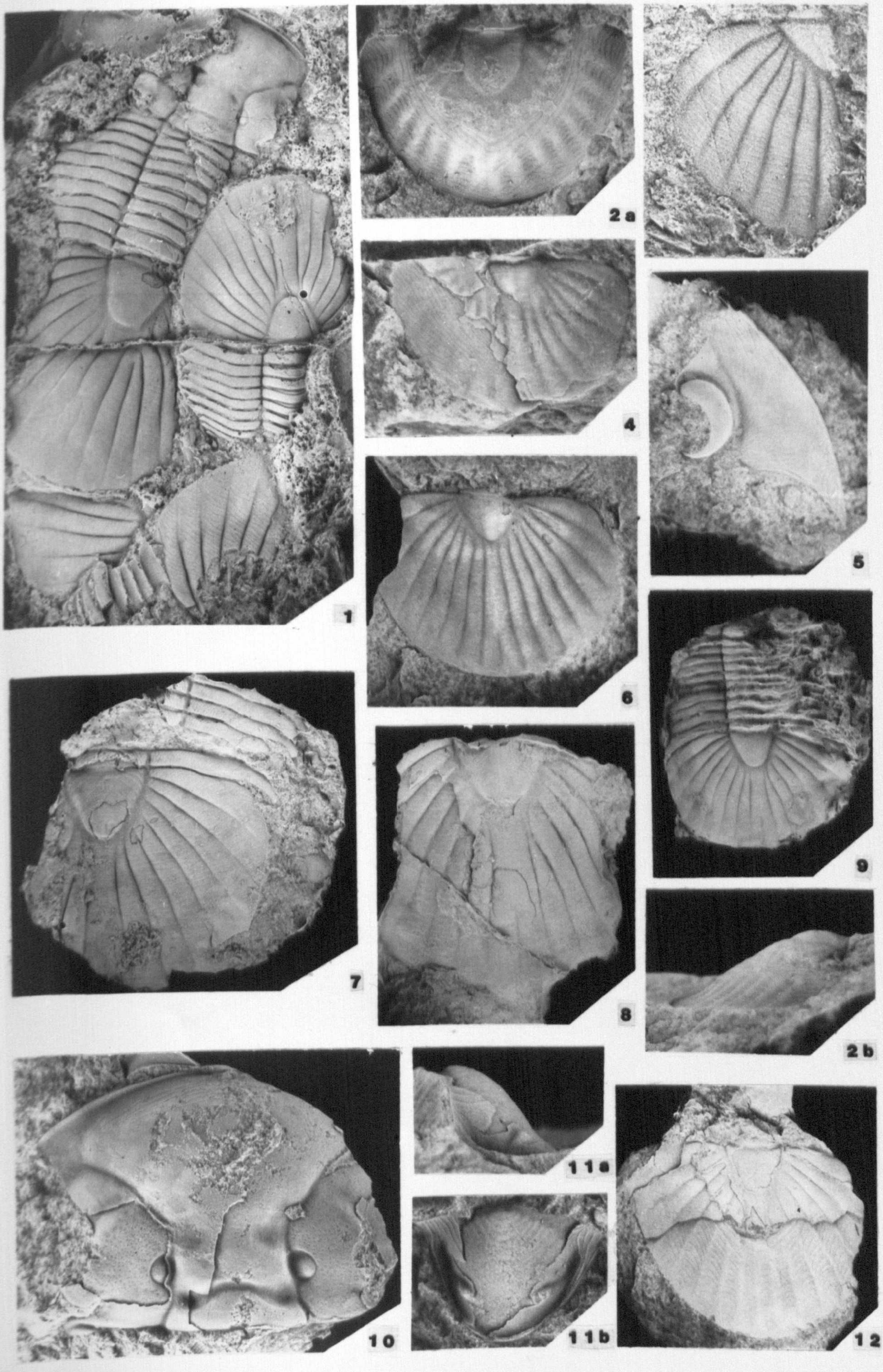


Plate 17

Fig.

Opsypharus maccallumi (Salter, 1867)

Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand

1a-c Cranidium; internal mould, anterior, lateral & dorsal views, PMO 19369, x2. Paralectotype of *B. depressus* Kiær, 1908; figured Whittard 1940, pl. 2, fig. 8.

5 Thoracic segment; dorsal view, PMO 110.297, x2. Paralectotype of *B. depressus* Kiær, 1908.

Solvik Formation (Kiær's étages 6b & 6c), Spirodden, Asker

2 Cranidium; latex, dorsal anterior & lateral views, PMO 110.296, x2.

6a,b Pygidium; internal mould, dorsal & lateral views, PMO 19180, x2; figured as *Pygidium* type F by Whittard 1940, pl. 4, fig 13.

7a,b Pygidium; dorsal & lateral views, PMO 110.298, x2; figured as *Pygidium* type F by Whittard 1940, pl. 4, figs 12, 13.

Rytteråker Formation (Kiær's étage 7a), Malmøykalven, Oslo

3a-c Cranidium; internal mould, lateral, anterior & dorsal views, PMO 60618 x2. Paralectotype of *B. depressus* Kiær, 1908; figured Whittard 1940, pl. 2, figs 6, 7.

Rytteråker Formation (Kiær's étage 7), Malmøya, Oslo

4 Hypostome; internal mould, ventral view, PMO 42711, x5.

Plate 17

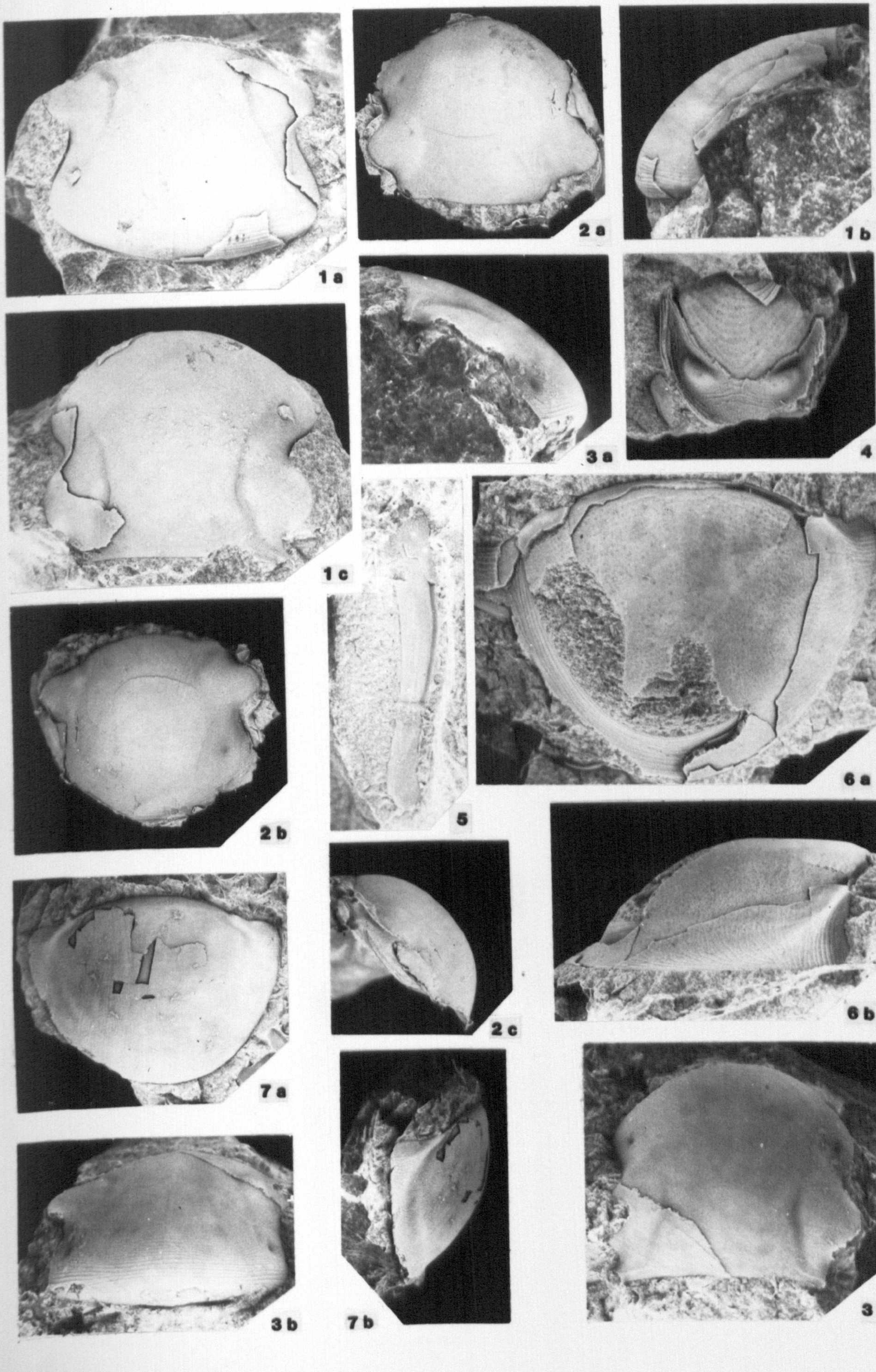


Plate 18

Fig.

Opsypharus longicaudatus (Kiær, 1908)

Ytteråker Formation (Kiær's étage 7), Leanghagda, Asker

1 Paralectotype rostral plate; internal mould, ventral view, PMO 19577, x7.

7 Pygidium; internal mould, dorsal view, PMO 19739, x1.

9a,b Holotype pygidium; lateral & dorsal views, PMO 19606, x1; figured Whittard 1940, pl. 4, figs 8, 9.

Steinsfjorden Formation (Kiær's étage 9d), Guserumpa, Holmestrand

10 Cranidium; dorsal view, PMO 19741, x1.

Rytteråker Formation (Kiær's étage 7b), Malmøya, Oslo

13 Pygidium; dorsal view, PMO 19543, x1.

Opsypharus convexus (Kiær, 1908)

Steinsfjorden Formation (Kiær's étage 9d), Langøya, Holmestrand

2a,b Paralectotype pygidium; partially exfoliated, dorsal and lateral views, PMO 19754, x2; figured as *B. sulcatus* var. *kiaeri* by Whittard 1940, pl. 3, fig. 12.

6 Paralectotype pygidium; partially exfoliated, lateral view, PMO 60617, x2; figured Whittard 1940 (as *B. sulcatus* var. *Kiaeri*), pl. 3, figs 13, 14.

Opsypharus maccallumi (Salter, 1867)

Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand

3 Free cheek; internal mould, lateral view, PMO 119.785, x4.

4 Pygidium; partially exfoliated, dorsal view, PMO 43329, x1.

5 Pygidium; partially exfoliated, dorsal view, PMO 110.289, x2.

8 Pygidium; partially exfoliated, dorsal view, PMO 19516, x1.

11 Cranidium; internal mould, dorsal view, PMO 19411, x2.

12 Free cheek; internal mould, lateral view, PMO 19481, x1. Paralectotype of *B. depressus* Kiær, 1908; figured Whittard 1940, pl. 2, fig. 10.

14 Free cheek; internal mould, lateral view, PMO 110.025, x2.

15 Hypostome; partially exfoliated, ventral view, PMO 42711, x5

Plate 18

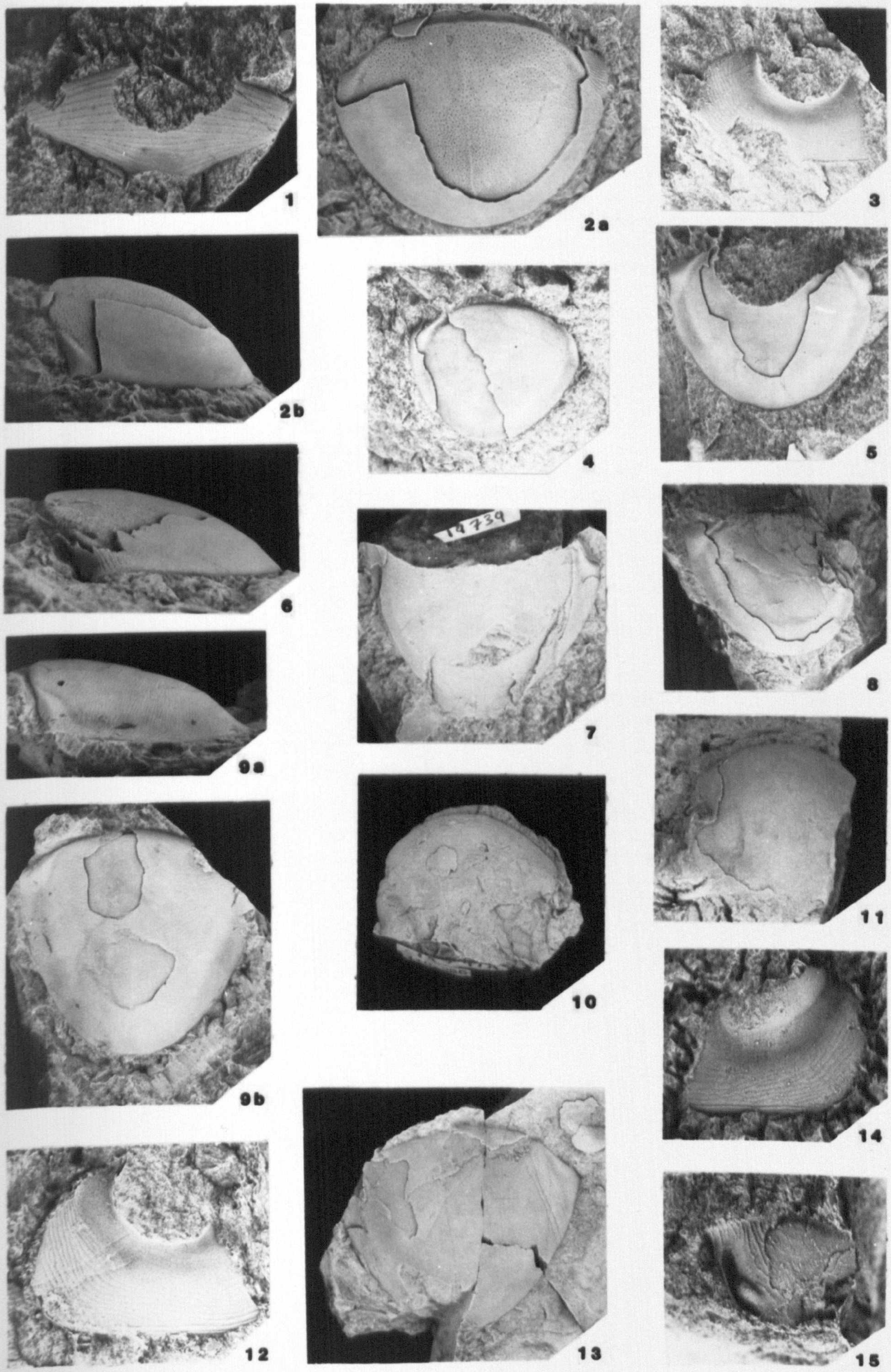


Plate 19

Fig.

Opsypharus maccallumi (Salter, 1867)

Rytteråker Formation (Kiær's étage 7a), Malmøykalven, Oslo

1 Pygidium; dorsal view, PMO 60618, x2.

2 Cranidium; anterior view, PMO 110.786, x2.

Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand

6 Free cheek; lateral view, PMO 19231, x3. Paralectotype of *B. depressus* Kiær, 1908; figured Whittard 1940, pl. 2, fig. 9.

Rytteråker Formation (Kiær's étage 7a), Ulvøya, Oslo

3a-c Cranidium; internal mould, lateral, dorsal & anterior views, PMO 19365, x2. Lectotype of *B. depressus* Kiær, 1908; figured Whittard 1940, pl. 2, fig. 5.

Opsypharus convexus (Kiær, 1908)

Steinsfjorden Formation (Kiær's étage 9d), Langøya, Holmestrand

4a-d Lectotype cephalon; partially exfoliated, anterior, lateral, dorsal & ventral views, PMO 60616, x2; figured as *B. sulcatus* var. *kiaeri*, by Whittard 1940, pl. 3, figs 9-11.

8 Pygidium; internal mould, dorsal view, PMO 19754, x2.

Opsypharus longicaudatus (Kiær, 1908)

Rytteråker Formation (Kiær's étage 7), Leanghagda, Asker

5 Paralectotype free cheek; partially exfoliated, lateral view, PMO 110.282, x2.

7 Paralectotype pygidium; internal mould, dorsal view, PMO 19580, x1.

Proetus (Proetus) concinnus Dalman, 1827

Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo

9a-c Cranidium; anterior, dorsal & lateral views, PMO 21401, x8.

10 Pygidium; dorsal view, PMO 44671, x5.

Plate 19

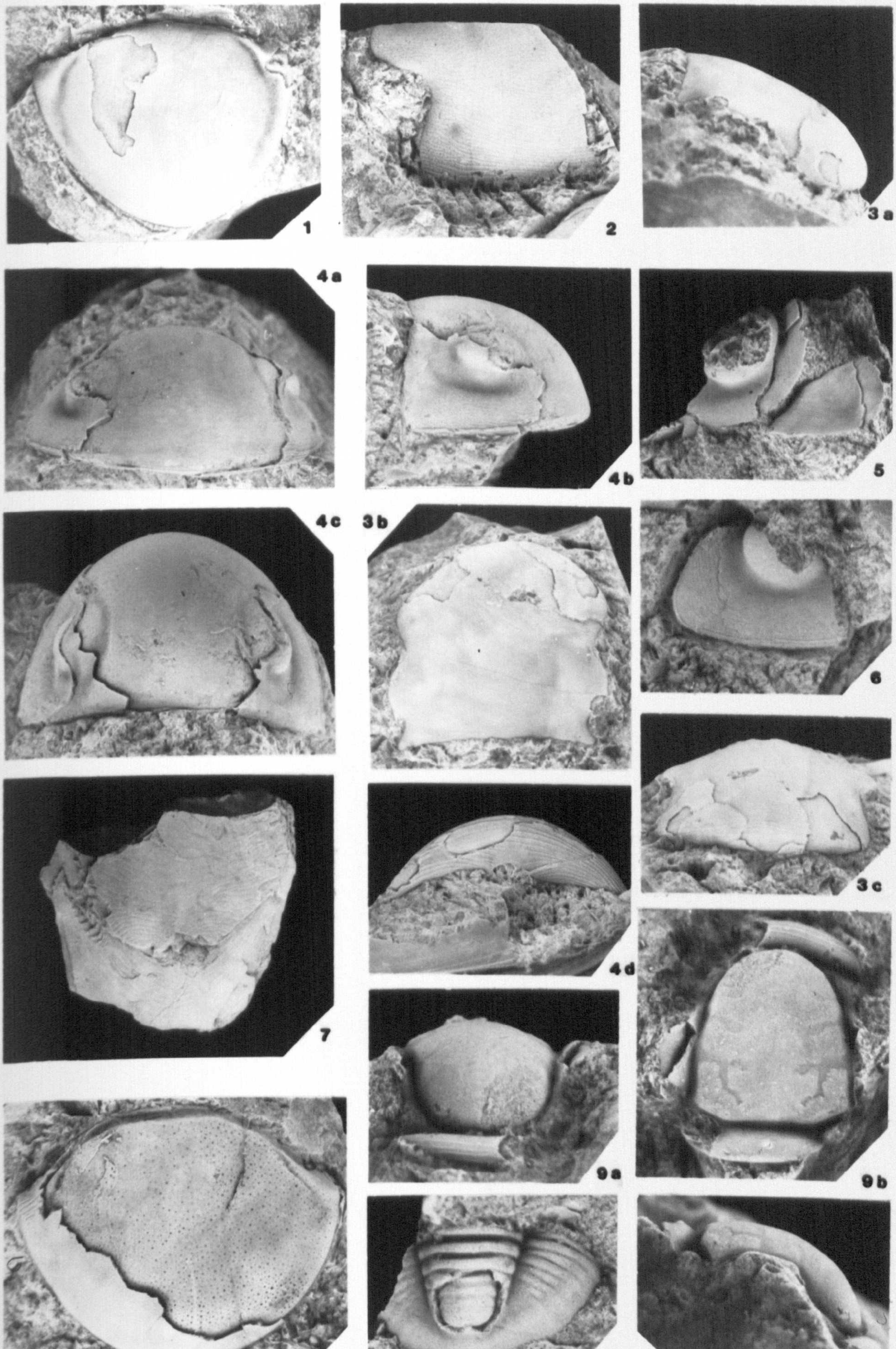


Plate 20

Fig.

Proetus (Proetus) concinnus Dalman, 1827

Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo

1a,b	Cranidium; dorsal & anterior views, PMO 44725, x5.
2a,b	Pygidium; dorsal & lateral views, PMO 44724, x6.
3	Cranidium; dorsal view, PMO 44716, x5.
4	Free cheek; dorsal view, PMO 44792, x2.
5	Free cheek; dorsal view, PMO 44809, x5.
7a-c	Cranidium; dorsal, anterior & lateral views, PMO 44736, x5.
8	Pygidium; dorsal view, PMO 44808, x5.
9	Pygidium; dorsal view, PMO 44667, x5.
10	Pygidium; dorsal view, PMO 110.306, x6.
11	Cranidium; dorsal view, PMO 44668, x5.
12	Pygidium; dorsal view, PMO 44722, x5.
13	Pygidium; dorsal view, PMO 44687, x5.
14	Hypostome; ventral view, PMO 110.304, x15.
15	Free cheek; dorsal view, PMO 109.543, x5.
16	Pygidium; dorsal view, PMO 21402, x10.

Proetus (Lacunoporaspis) confossus Owens, 1973

Steinsfjorden Formation (Kiær's étage 9), Langøya, Holmestrand

6	Cranidium; dorsal view, PMO 44721, x5.

Plate 20

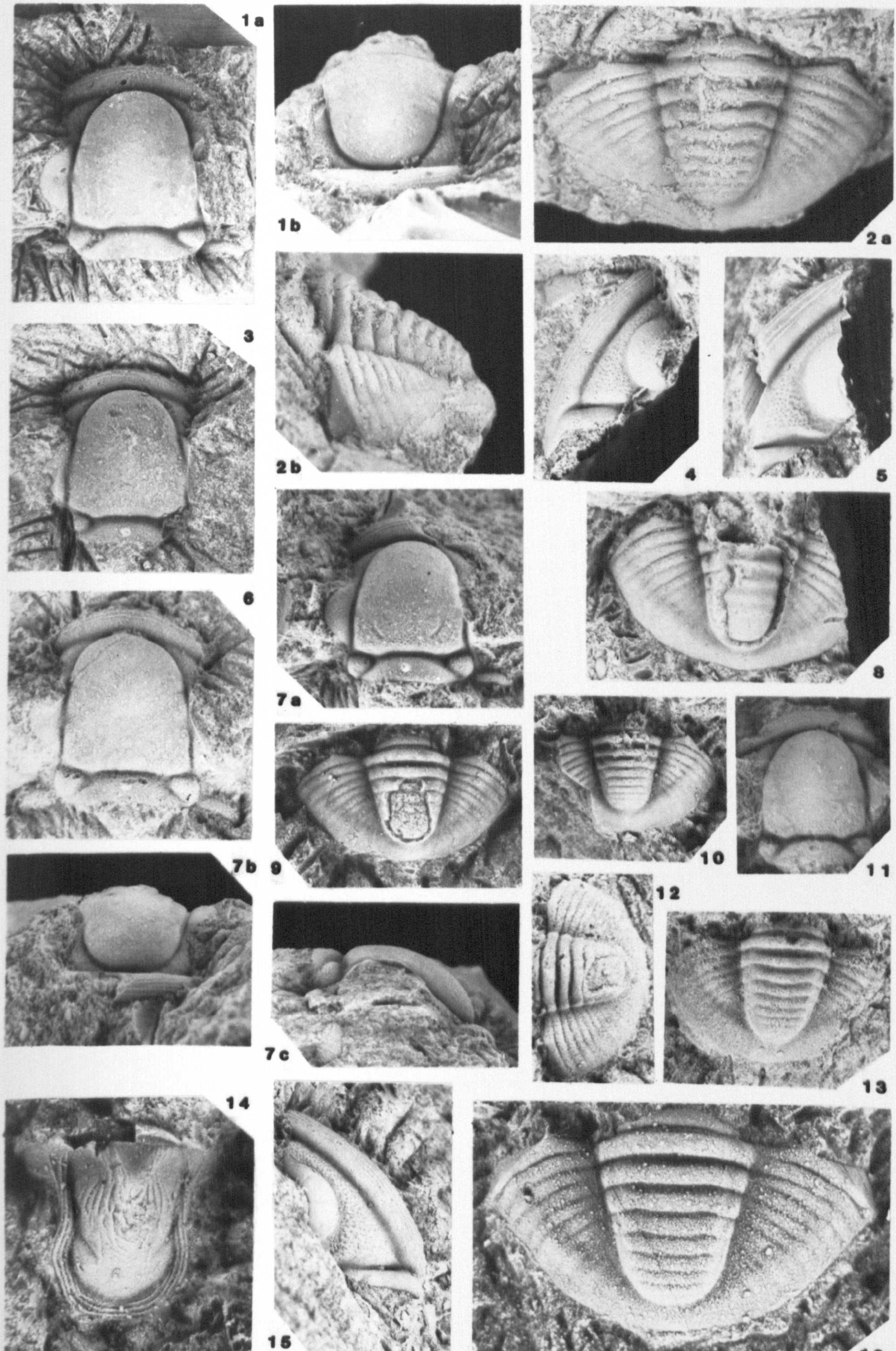


Plate 21

Fig.

Proetus (Lacunoporaspis) confossus Owens, 1973

Steinsfjorden Formation (Kiær's ètage 9), Langøya, Holmestrand

1	Cranidium; dorsal view, PMO 50210, x5.
2a,b	Cranidium; dorsal & lateral views, PMO 50010, x8.
3	Cranidium; dorsal view, PMO 50009, x5.
5	Pygidium; dorsal view, PMO 110.342, x5.
15	Cranidium; dorsal view, PMO 110.332, x6.
16	Free cheek; dorsal view, PMO 110.781, x5.
17	Cranidium; dorsal view, PMO 50007, x6.

Proetus (Lacunoporaspis) baarlii sp. nov.

Steinsfjorden Formation (Kiær's ètage 9), Kommersøya, Holmestrand

4a-c	Paratype cranidium; dorsal, lateral & anterior views, PMO 53893, x5.
7a,b	Paratype free cheek; lateral & dorsal views, PMO 49319, x3.
8a,b	Holotype cranidium; dorsal & anterior views, PMO 49320, x3.
11	Paratype pygidium; dorsal view, PMO 19659, x5.
12	Paratype cranidium; dorsal view, PMO 49294, x3.
13	Paratype pygidium; dorsal view, PMO 49327, x3.
14	Paratype pygidium; dorsal view, PMO 89318, x5.

Proetus (Lacunoporaspis) sp.

Malmøya Formation, Gjettum locality 1, Asker

6	Free cheek; dorsal view, PMO 110.330, x3.
9	Pygidium; dorsal view, PMO 110.523, x6.
10a,b	Pygidium; dorsal & lateral views, PMO 110.317, x5.

Plate 21

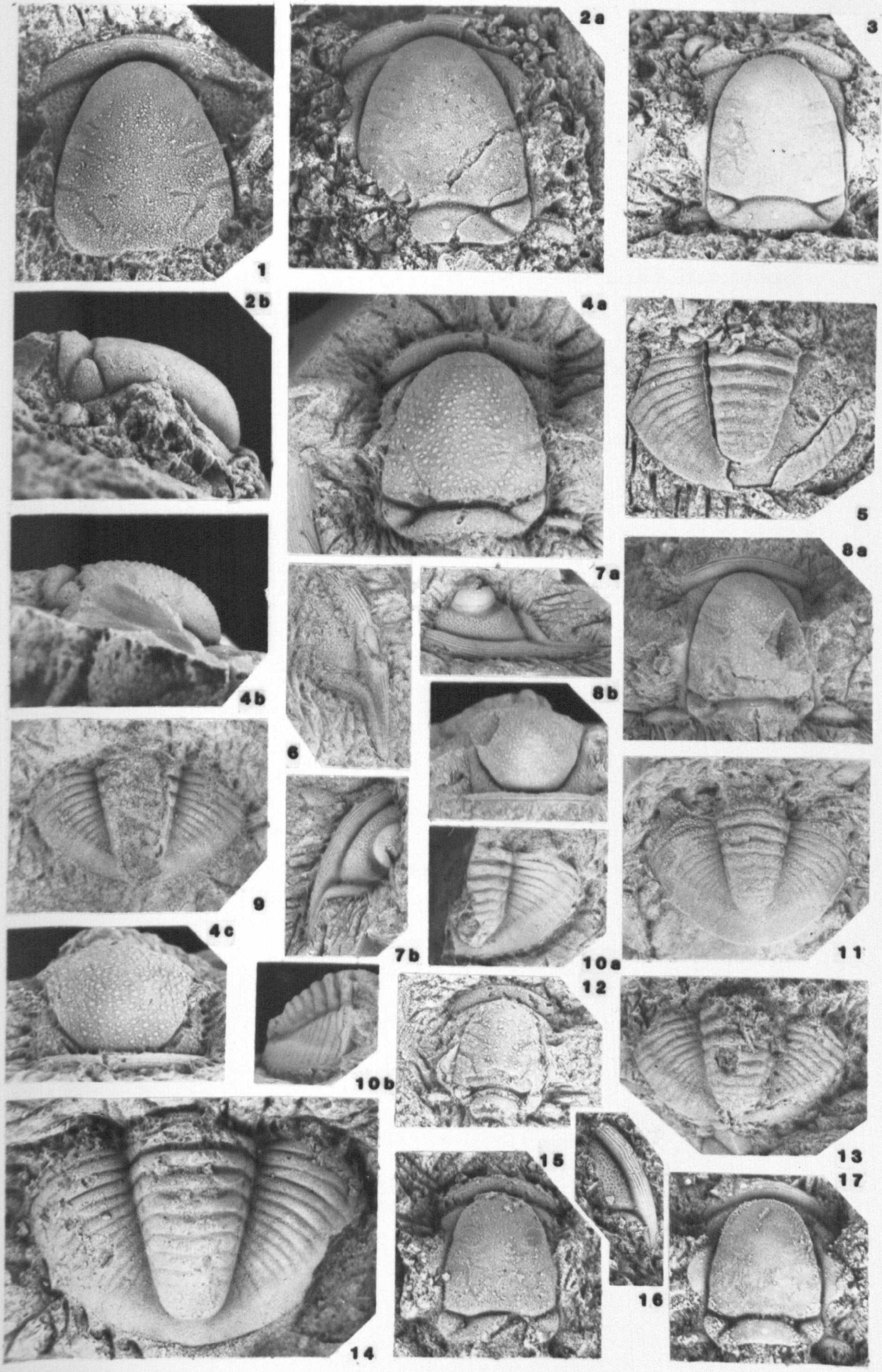


Plate 22

Fig.

Proetus (Lacunoporaspis) sp.

	Malmøya Formation (Kiær's ètage 8), Gjettum locality 1, Asker
1	Cranidium; dorsal view, PMO 110.331, x5.
2a,b	Pygidium; lateral & dorsal views, PMO 110.316, x3.
3	Pygidium; dorsal view, PMO 110.314, x5.

Proetus (Lacunoporaspis) conctoratus sp. nov.

	Malmøya Formation (Kiær's ètage 8d), Gjettum bus stop, Asker
4a,b	Paratype cranidium; lateral & dorsal views, PMO 110.334, x3.
6a,b	Paratype cranidium; lateral & dorsal views, PMO 110.336, x5.
7a,b	Paratype pygidium; lateral & dorsal views, PMO 110.339, x3.
10a,b	Paratype pygidium; lateral & dorsal views, PMO 110.340, x3.
11	Holotype cranidium; dorsal view, PMO 110.335, x5.
14	Paratype pygidium; dorsal view, PMO 110.341, x3.
16	Paratype free cheek; dorsal view, PMO 110.337, x3.

Cyphoproetus externus (Reed, 1935)

	Solvik Formation (Kiær's ètages 6b & 6c), Spirodden, Asker
5	Free cheek; dorsal view, PMO 88750, x5.
8	Cranidium; dorsal view, PMO 110.465, x5.
9a-c	Cranidium; dorsal, lateral & anterior views PMO 88759, x5.
12a,b	Pygidium; dorsal & lateral views, PMO 52762, x3.
13	Hypostome; ventral view, PMO 88860, x10.
15	Cranidium; dorsal view, PMO 88841, x8.

Plate 22

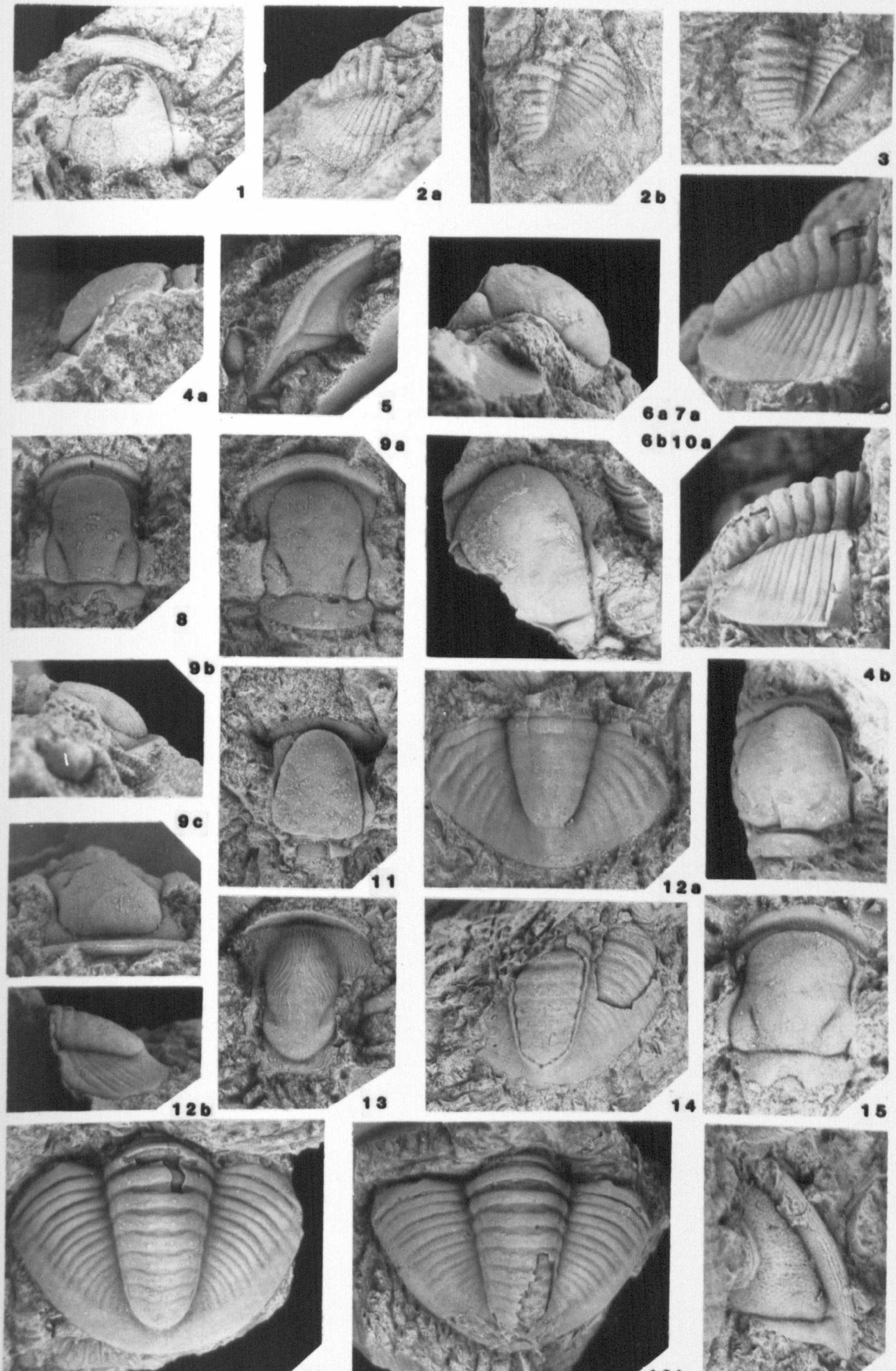


Plate 23

Fig.

Cyphoproetus externus (Reed, 1935)

Solvik Formation (Kiær's étages 6b & 6c), Spirodden, Asker

1	Pygidium; dorsal view, PMO 88855, x3.
4	Pygidium; dorsal view, PMO 52774, x3.
5	Pleuron; dorsal view, PMO 110.464, x8.
11a,b	Cranidium; internal mould, lateral & dorsal views, PMO 52509, x5.

Saelabonn Formation (Kiær's étage 6c), Hönefoss road, Ringerike

7	Free cheek; dorsal view, PMO 110.470, x5.

Harpidella chermasera sp. nov.

Solvik Formation (Kiær's étages 6b & 6c), Spirodden, Asker

2a,b	Holotype cranidium, dorsal & anterior views, PMO 88904, x10.
3	Paratype free cheek; dorsal view, PMO 110.508, x5.
9	Paratype hypostome; ventral view, PMO 109.542, x10.
12	Paratype cranidium; dorsal view, PMO 110.788, x5.
13	Paratype cranidium; dorsal view, PMO 52540, x5.
18	Paratype free cheek; dorsal view, PMO 110.491, x10.

Harpidella sp.

Solvik Formation (Kiær's étage 6a), Sjursøya, Oslo

6	Free cheek; dorsal view, PMO 112.922, x10.
15a,b	Cranidium; lateral & dorsal views, PMO 112.878, x10.

Warburgella (Warburgella) baltica Alberti, 1963

Steinsfjorden Formation (Kiær's étage 9), Langøya, Holmestrand

8	Cranidium; anterior view, PMO 110.545, x6
10a-c	Cranidium; lateral, dorsal & anterior views, PMO 110.549, x6.
14	Free cheek; dorsal view, PMO 110.652, x4.
16	Cranidium; dorsal view, PMO 110.677, x10.
17a,b	Hypostome; ventral & lateral views, PMO 110.681, x10.
19	Hypostome; ventral view, PMO 110.682, x10.

Plate 23

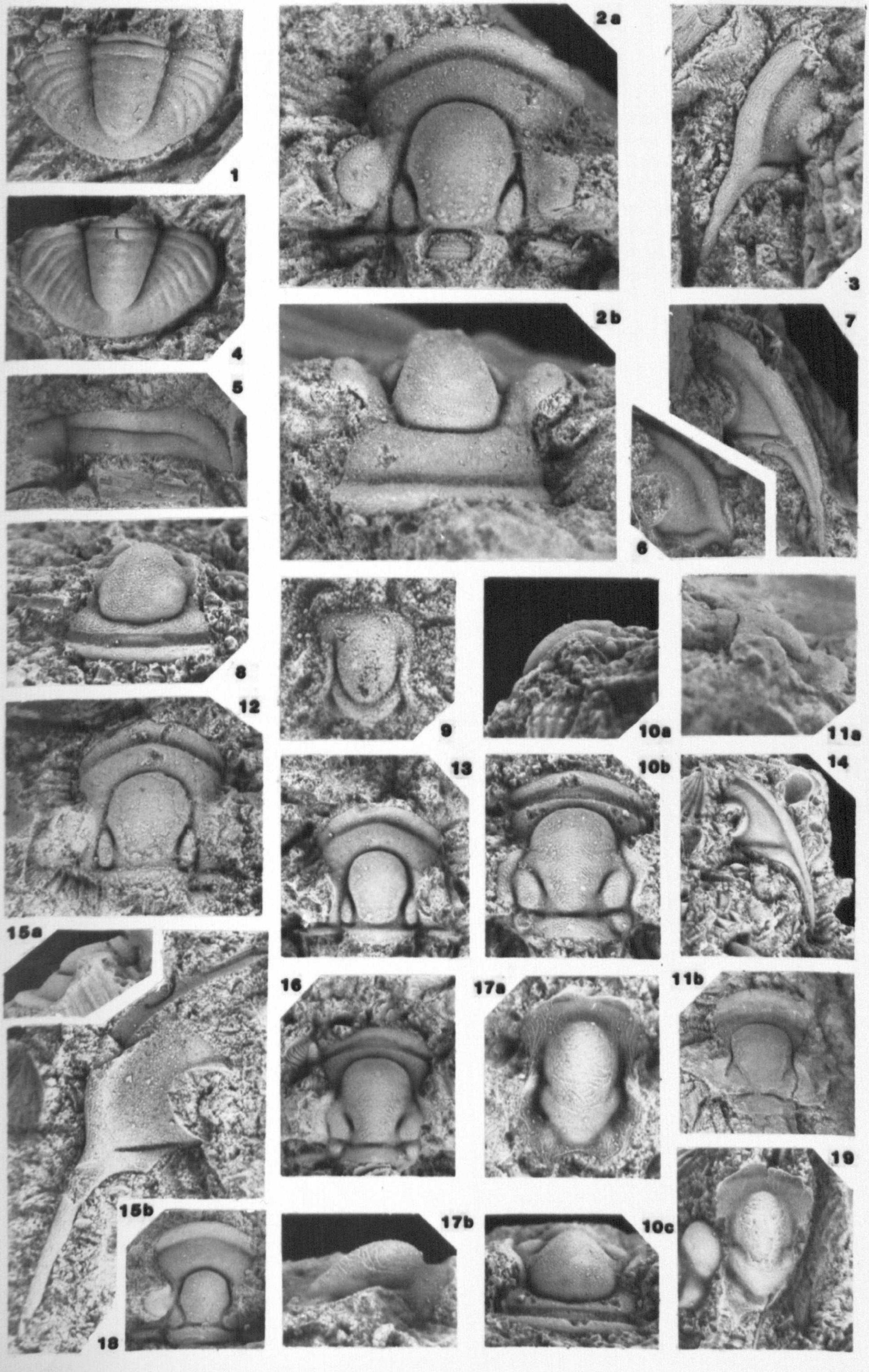

1
2a
3
4
2b
7
5
6
8
9
10a
11a
12
13
10b
14
15a
16
17a
11b
19
15b
17b
10c
18

Plate 24

Fig.

Warburgella brutoni sp. nov.

Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo

1 Paratype cranidium; dorsal view, PMO 44707, x8.
4 Paratype free cheek; dorsal view, PMO 44415, x4.
7 Paratype pygidium; dorsal view, PMO 89317, x6.
9 Paratype pygidium; dorsal view, PMO 44652, x6.
10a,b Paratype cranidium; lateral & dorsal views, PMO 89306, x6.
16 Holotype cranidium; dorsal view, PMO 89288, x5.
17 Paratype cranidium; dorsal view, PMO 89294, x5.
20 Paratype cranidium; dorsal view, PMO 89291, x5.

Warburgella baltica Alberti, 1963

Steinsfjorden Formation (Kiær's étages 9c to g), Langøya, Holmestrand

2 Cranidium; dorsal view, PMO 110.545, x6.
3 Cranidium; dorsal view, PMO 110.676, x6.
5 Pygidium; dorsal view, PMO 50150, x5.
6 Pygidium; dorsal view, PMO 110.700, x5.
8a,b Pygidium; dorsal & lateral views, PMO 110.725.
11 Pygidium; dorsal view, PMO 49869, x5.
12 Hypostome; ventral view, PMO 110.684, x10.
13 Free cheek; dorsal view, PMO 110.639, x5.
14 Pygidium; dorsal view, PMO 89283, x5.
18 Cranidium; dorsal view, PMO 110.592, x6.
19 Cranidium; dorsal view, PMO 110.548, x5.

Warburgella gongrus sp. nov.

Steinsfjorden Formation (Kiær's étage 9), Hæroya, Ringerike

15 Paratype pygidium; dorsal view, PMO 44651, x5.

Plate 24

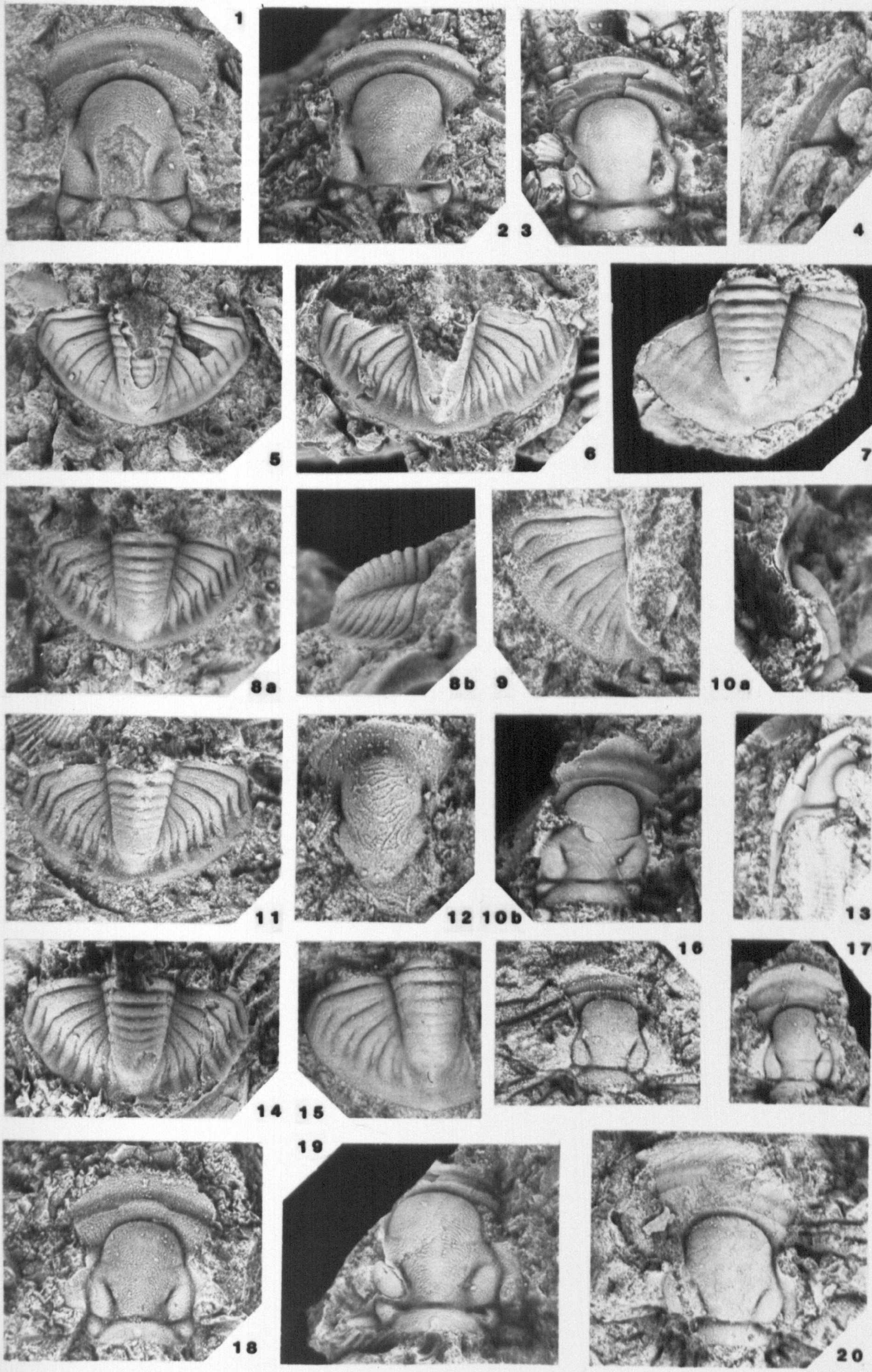


Plate 25

Fig.

Warburgella gongrus sp. nov.

Horizon unknown, Steinsfjorden Formation (Kiær's étage 9), Porsgrunn, Skien

1a,b Holotype cranidium; dorsal & lateral views, PMO 51777, x4.

Steinsfjorden Formation (Kiær's étage 9), Feikarodden, Ringerike

17 Paratype free cheek; dorsal view, PMO 49098, x3.

Hedstroemia simpulum sp. nov.

Solvik Formation (Kiær's étage 6c), Skytterveien, Asker

2 Paratype free cheeks; dorsal view, PMO 110.774, x6.
5a,b Paratype cranidium; lateral & dorsal views, PMO 110.756, x6.
7 Paratype cranidium; dorsal view, PMO 110.759, x6.
10 Paratype free cheek; dorsal view, PMO 110.766, x6.

Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand

3 Paratype cranidium; dorsal view, PMO 54849, x3.
11a,b Holotype cranidium; lateral & dorsal views, PMO 54838, x2.
15 Paratype pygidium; dorsal view, PMO 54837, x2.

Rytteråker Formation (Kiær's étage 7), Malmøya, Oslo

4a,b Paratype pygidium; dorsal & lateral views, PMO 93820, x3.
8 Paratype pygidium; dorsal view, PMO 93826, x3.
12 Paratype pygidium; dorsal view, PMO 43611, x2.
14 Paratype cranidium; dorsal view, PMO 93816, x3.

Solvik Formation (Kiær's étage 6ca), Malmøya, Oslo

6a,b Paratype cranidium; dorsal & lateral views, PMO 41905, x3.

Youngia aff. *Youngia globiceps* Lindström, 1885

Rytteråker Formation (Kiær's étage 7b), Gjettum Station, Asker

9 Cranidium; latex of external mould, dorsal view, PMO 82040, x4.
13 Cranidium; dorsal view, PMO 110.257, x4.

Youngia aff. *Youngia inermis* Lindström, 1885

Rytteråker Formation (Kiær's étage 7b), Kampbråten, Sandvika, Asker

16 Cranidium; dorsal view, PMO 110.093, x4.

Plate 25

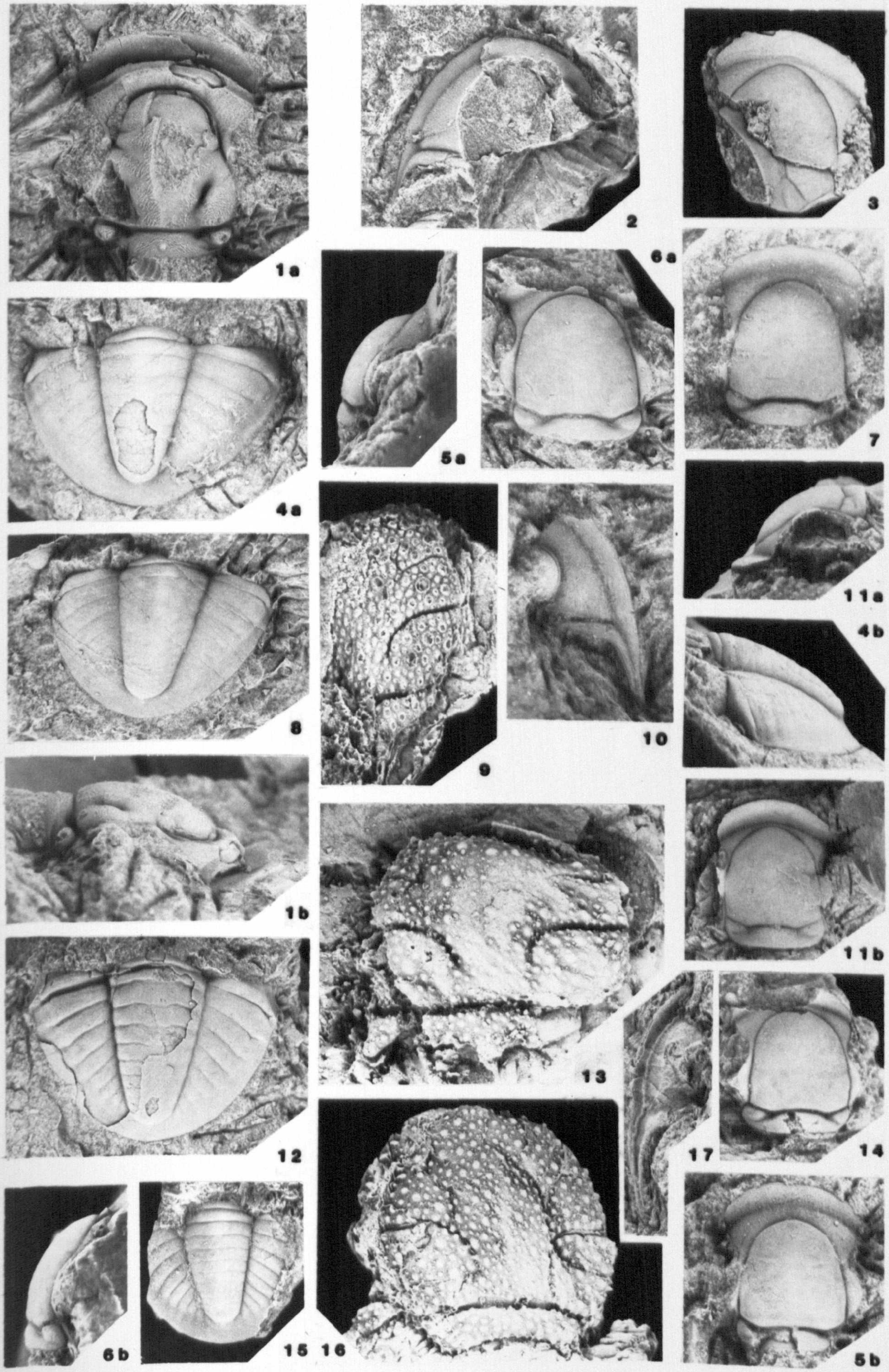


Plate 26

Fig.

Hadromeros elongatus (Reed, 1931)

	Solvik Formation (Kiær's étages 6b & 6c), Spirodden, Asker
1a-c	Cranidium; anterior, lateral & dorsal views, PMO 110.804, x10.
2	Hypostome; internal mould, ventral view, PMO 85827, x3.
3	Pygidium; internal mould, dorsal view, PMO 110.792, x3.
4	Free cheek; internal mould, lateral view, PMO 110.807, x5.
5	Hypostome; internal mould, ventral view, PMO 51951, x5.
7	Cranidium; internal, mould, dorsal view, PMO 110.478, x3.
9	Pygidium; dorsal view, PMO 109.507, x5.
10a,b	Cranidium; lateral & dorsal views, PMO 109.479, x5.
11a,b	Hypostome; ventral & lateral views, PMO 110.793, x5.
12	Pygidium; internal mould, dorsal view, PMO 109.791, x5.
	Solvik formation (Kiær's étage 6c), Malmøya
6	Pygidium; internal mould, dorsal view, PMO S2423, x5.
13	Cranidium; dorsal view, PMO 109.480, x1.

Hadromeros sp. A

	Rytteråker Formation (Kiær's étage 7a), Bjerkøya, Holmestrand
8	Hypostome; internal mould, ventral view, PMO 54653, x5.

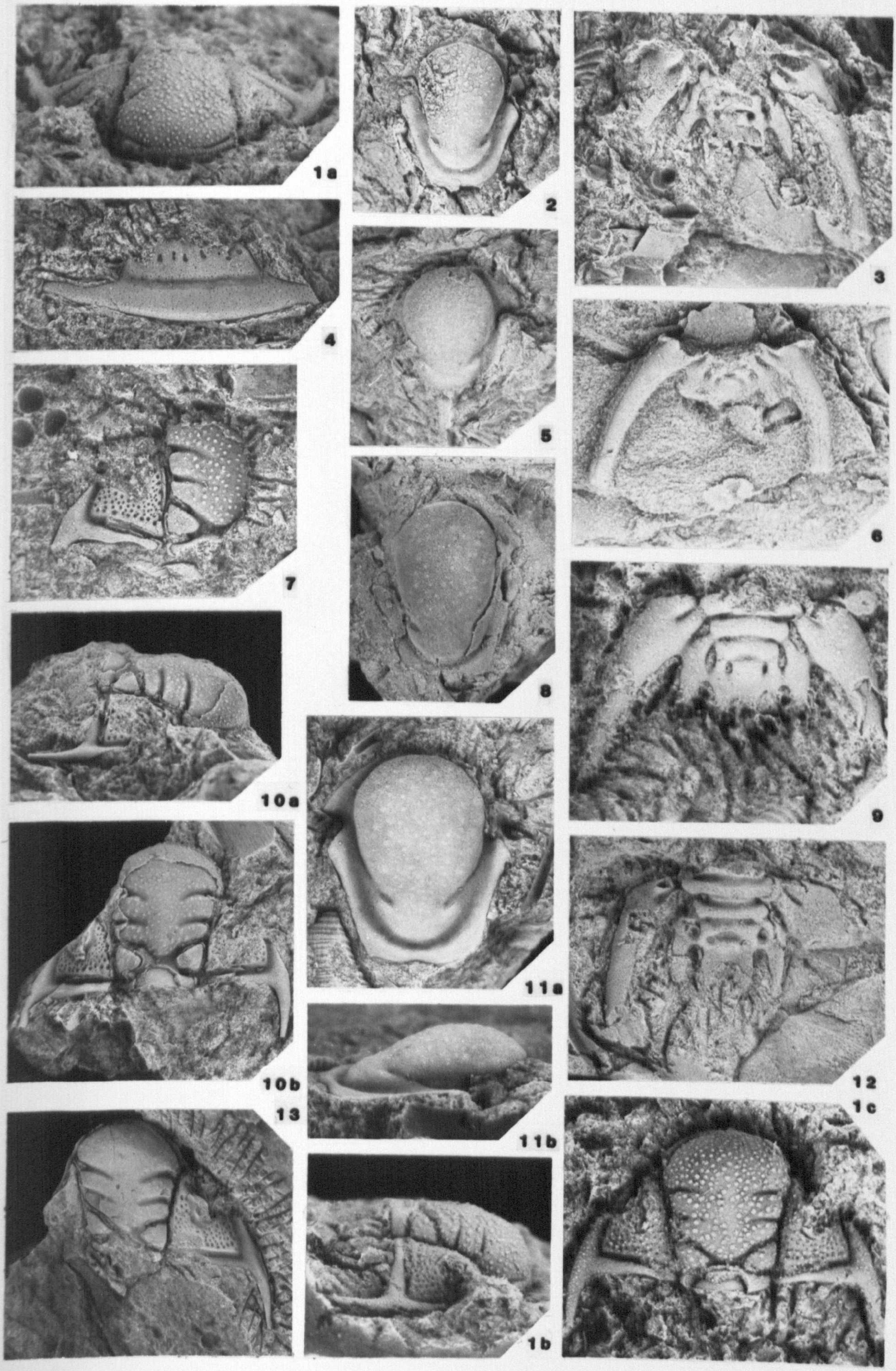

1a
2
3
4
5
6
7
8
9
10a
11a
10b
12
13
1c
11b
1b

Plate 27

Fig.

Hadromeros sp. B

Rytteråker Formation (Kiær's étage 7a), Malmøya

1 Hypostome; partially exfoliated, ventral view, PMO 43242, x2.

Encrinurus punctatus (Wahlenberg, 1818)

Steinsfjorden Formation, (Kiær's étage 9), Langøya, Holmestrand

2 Free cheek; internal mould, lateral view, PMO 109.996, x2.

4 Hypostome; internal mould, ventral view, PMO 109.995, x3.

7 Pygidium; partially exfoliated, dorsal view, PMO 109.985, x3.

8 Pygidium; internal mould, dorsal view, PMO 109.980, x2.

9a,b Pygidium; dorsal & lateral views, PMO 109.558, x3.

12 Pygidium; internal mould, dorsal view, PMO 109.994, x5.

13a,b Hypostome; lateral & ventral views, PMO 109.991, x5.

14 Cranidium; internal mould, dorsal view, PMO 109.979, x5.

15 Cranidium; internal mould, dorsal view, PMO 109.984, x5.

Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo

5 Pygidium; internal mould, dorsal view, PMO 110.829, x3.

Encrinurus anthus sp. nov.

Bruflat Formation (Kiær's étage 8a), Garntangen, Ringerike

3 Paratype whole specimen; latex of external mould, dorsal view, PMO 110.812, x3.

6 Paratype thorax & pygidium; latex of external mould, dorsal view, PMO 110.814, x3.

10 Paratype cephalon; partial thorax & pygidium, latex of external mould, dorsal view, PMO 110.815, x3.

11 Paratype thorax & pygidium; latex of external mould, dorsal view, PMO 110.816, x3.

16 Holotype whole specimen; internal mould, dorsal view, PMO 110.529, x2.

17 Paratype thorax & pygidium; latex of external mould, dorsal view, PMO 110.817, x3.

Plate 27

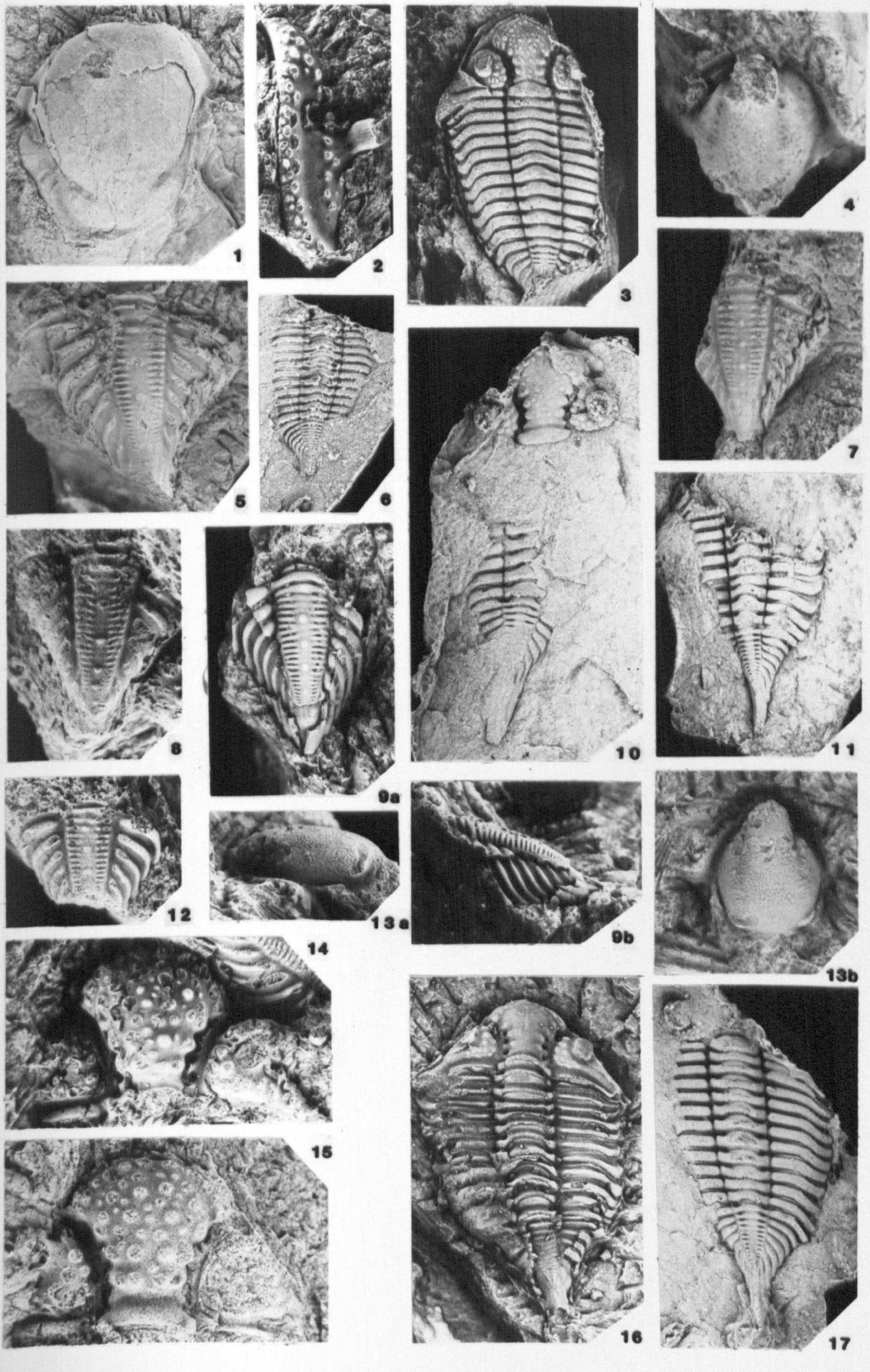


Plate 28

Fig.

Encrinurus anthus sp. nov.

Bruflat formation (Kiær's étage 8c), Garntangen, Ringerike

1	Paratype pygidium; internal mould, dorsal view, PMO 110.037, x3.
2	Paratype cranidium; internal mould, dorsal view, PMO 110.040, x3.
13	Paratype pygidium; internal mould, dorsal view, PMO 110.036, x3.

Braksøya Formation (Kiær's étage 8a), Storøya, Ringerike

3a,b	Paratype pygidium; partially exfoliated, dorsal & lateral views, PMO 46455, x3.
10	Paratype cranidium; dorsal view, PMO 46453, x5.
17	Paratype pygidium; partially exfoliated, dorsal view, PMO 46088, x3.

Encrinurus mullochensis Reed, 1931

Rytteråker Formation (Kiær's étage 7a), Gjettum Station, Asker

4	Free cheek; internal mould, PMO 110.550, x3.
7	Pygidium; internal mould, dorsal view, PMO 110.074, x3.

Solvik Formation (Kiær's étages 6b & 6c) Spirodden, Asker

5a-c	Enrolled specimen; partially exfoliated, lateral, dorsal pygidial & dorsal cephalic views, PMO 109.547, x3.
6a,b	Pygidium; partially exfoliated, dorsal & lateral views, PMO 110.032, x3.
16	Hypostome; internal mould, ventral view, PMO 110.005, x5.

Solvik Formation (Kiær's étage 6c), Skytterveien, Asker

8	Cranidium; internal mould, dorsal view, PMO 110.044, x2.
9	Cranidium; dorsal view, internal mould, PMO 109.911, x2.
15	Pygidium; latex of external mould, dorsal view, PMO 51974, x2.

Solvik Formation (Kiær's étage 6bb), Malmøya, Oslo

11	Cranidium; partially exfoliated, dorsal view, PMO 110.009, x3.
12	Free cheek; internal mould, lateral view, PMO 110.094, x2.
14	Enrolled specimen; internal mould, dorsal cephalic view, PMO 70597, x3.

Plate 28

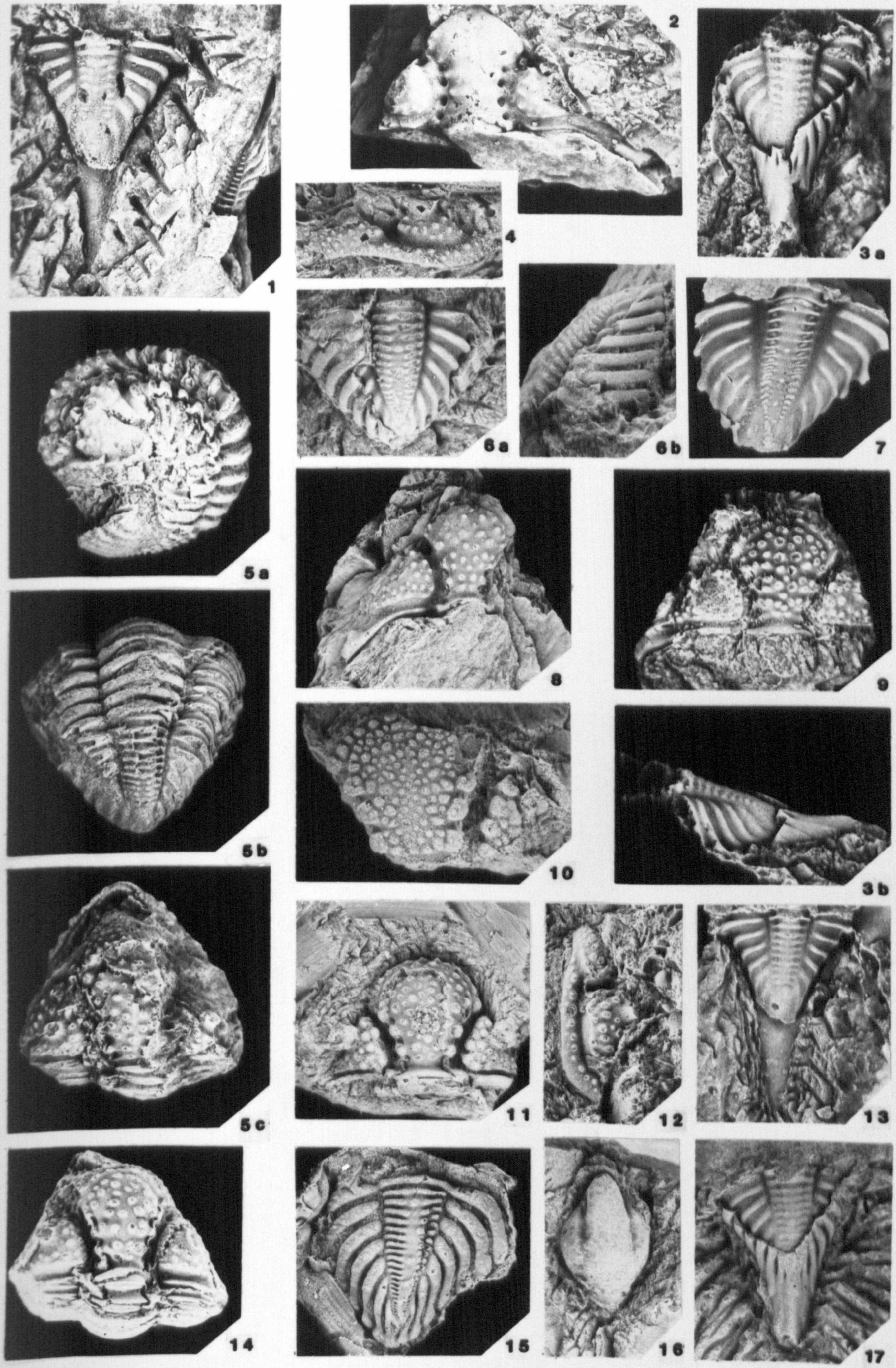


Plate 29

Fig.

Calymene sp.

Steinsfjorden Formation (Kiær's étage 9), Langøya, Holmestrand

1a-c Pygidium; internal mould, posterior, dorsal & lateral views, PMO 50232, x2.

2a-c Pygidium; internal mould, posterior dorsal & lateral views, PMO 50193, x2.

Calymene frontosa Lindström, 1885

Bruflat Formation (Kiær's étage 8b), Garntangen Kiosk, Ringerike

3a,b Cranidium; internal mould, dorsal & lateral views, PMO 91110, x3.

5 Cranidium; internal mould, dorsal view, PMO 48645, x2.

Bruflat or Braksøya Formation (Kiær's étage 8), Feikarodden, Ringerike

6 Pygidium; dorsal view, PMO 48838, x3.

12a,b Cranidium; internal mould, dorsal & lateral views, PMO S2683, x3.

Rytteråker Formation (Kiær's étage 7a) Ulvøya, Oslo

7a-c Cranidium; lateral, anterior & dorsal views PMO 42726, x3.

Kiær's étage 8c, locality unknown.

9 Cranidium; dorsal view, PMO 51360, x3.

Bruflat or Braksøya Formations (étage 8), Utøya, Ringerike

10 Cranidium; dorsal view, PMO 48747, x10.

13 Cranidium; dorsal view, PMO 48627, x2.

Calymene tetartos sp. nov.

Malmøya Formation (Kiær's èage 8c), Gjettum Bus Stop, Asker

4 Paratype cranidium; dorsal view, PMO 109.922, x3.

11 Paratype free cheek; lateral view, PMO 109.503, x3.

Calymene planicurvata Shirley, 1936

Solvik Formation (Kiær's étage 6c), Malmøya, Oslo

8 Whole specimen; dorsal view, PMO 41614, x1.

Plate 29

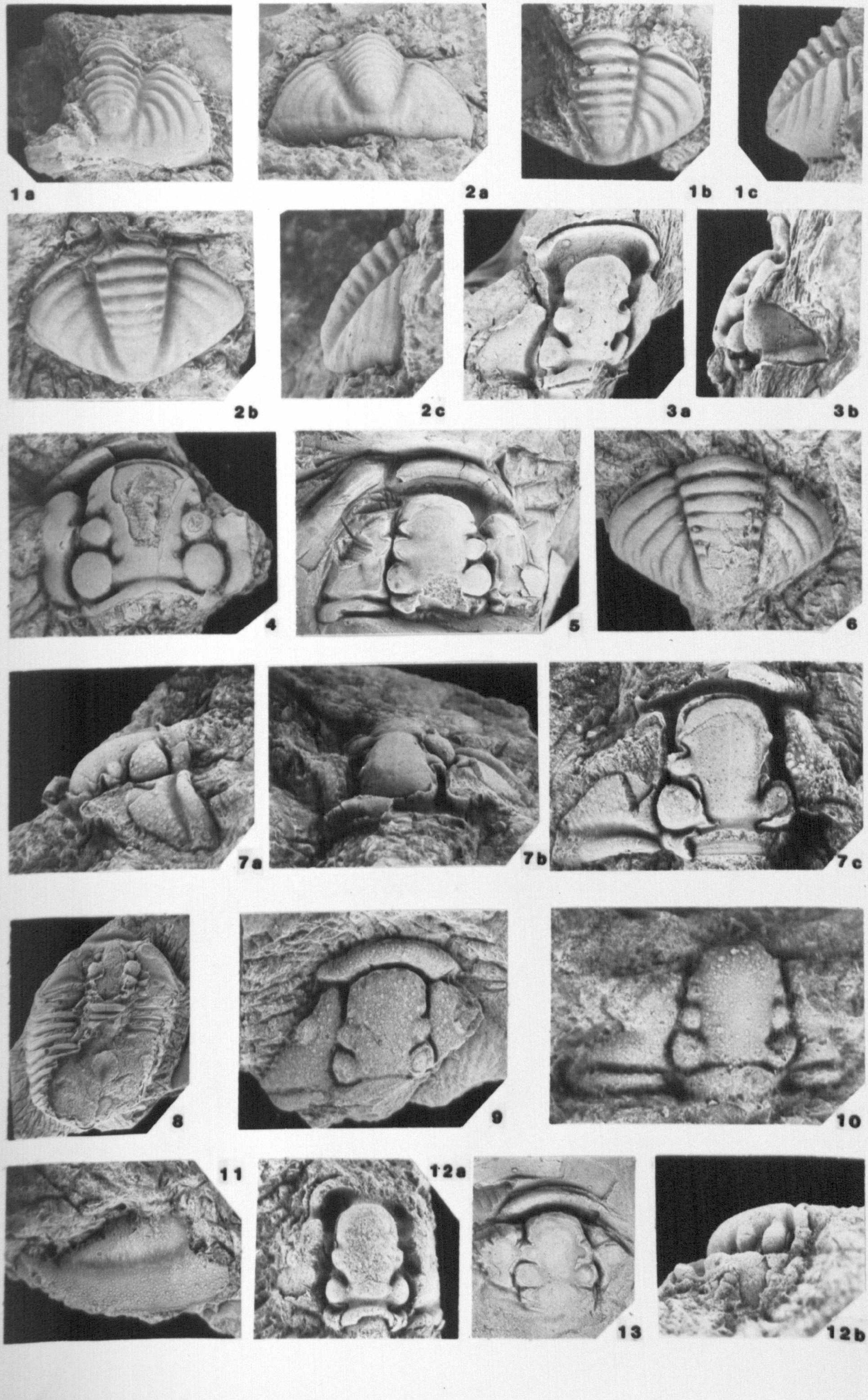


Plate 30

Fig.

Calymene planicurvata Shirley, 1936

Solvik Formation (Kiær's étage 6c), Malmøya, Oslo

1a,b Pygidium; internal mould, dorsal & lateral views, PMO 109.978, x2.

Calymene pholeteros sp. nov.

Steinsfjorden Formation (Kiær's étage 9c), Langøya, Holmestrand

2a-d Holotype cranidium & free cheek; dorsal, anterior & two lateral views, PMO 49987, x2; figured Whittington, 1971, pl. 84, figs 1-4, 6.

6a,b Paratype cranidium; partially exfoliated, dorsal & anterolateral views, PMO 50596, x2.

7 Paratype cranidium; partially exfoliated, dorsal view, PMO 50597, x2.

Calymene ubiquitosus Howells, 1982

Solvik Formation (Kiær's étage 6bb), Spirodden, Asker

3a,b Cranidium; partially exfoliated, dorsal & lateral views, PMO 52629, x3.

4a-d Whole specimen; lateral, dorsal, anterior & posterior views PMO 53093, x3.

5 Free cheek; lateral view, PMO 109.972, x5.

Plate 30

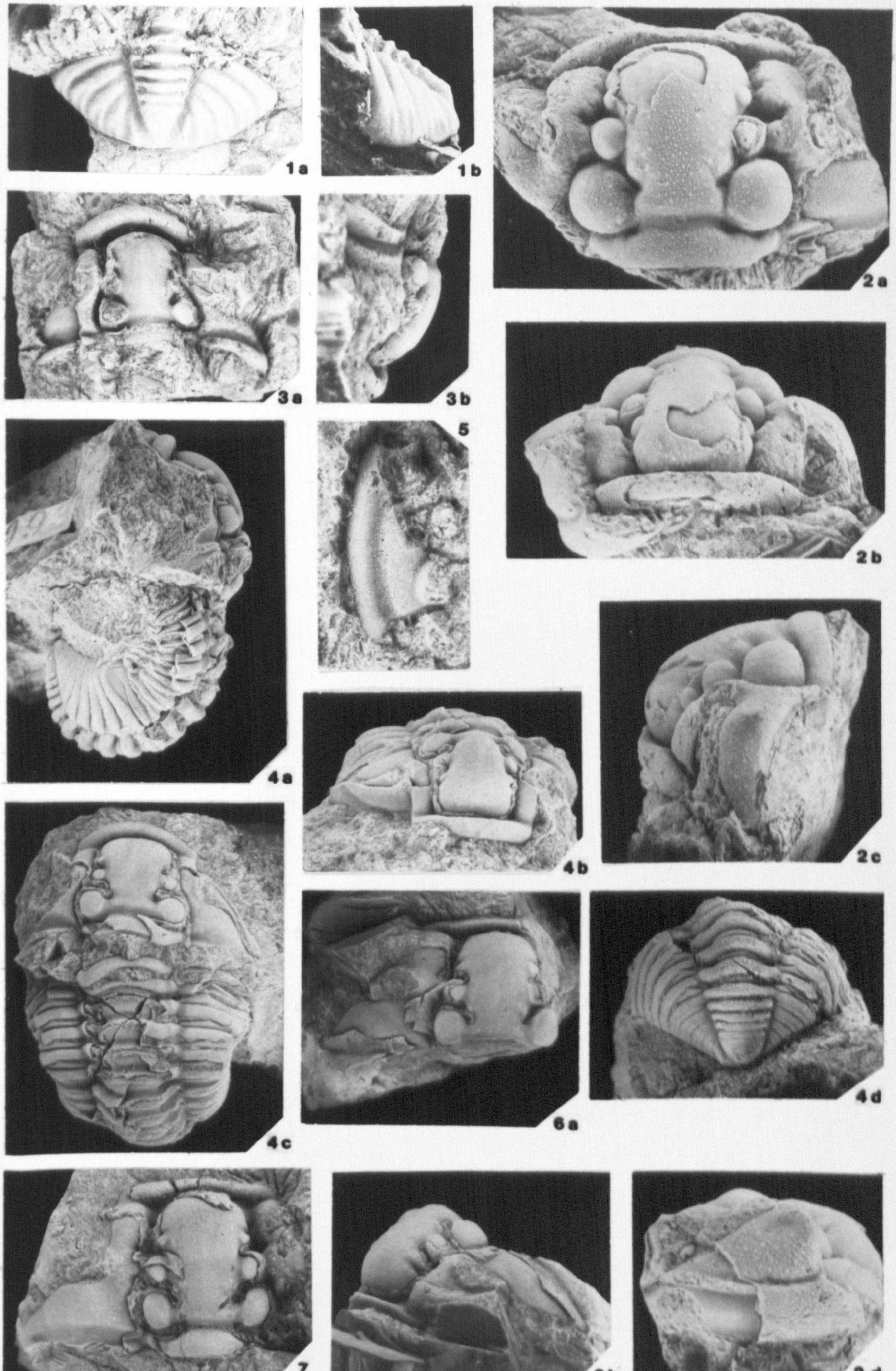


Plate 31

Fig.

Calymene sp.

Steinsfjorden Formation (ētage 9), Langøya, Holmestrand

1a,b	Whole specimen; dorsal & lateral views, PMO 49667, x2.
10a,b	Pygidium; internal mould, lateral & dorsal views, PMO 50228, x5.
11	Cranidium; partially exfoliated, dorsal view, PMO 89324, x2.

Steinsfjorden Formation (Kiær's ētage 9b), Langøya, Holmestrand

2a,b	Cephalon & partial thorax; partially exfoliated, dorsal & lateral views, PMO 50025, x2.
3a,b	Cranidium; dorsal & lateral views, PMO 50022, x3.
8a-c	Cranidium; anterior, lateral & dorsal views, PMO 110.838, x5.

Steinsfjorden Formation (Kiær's ētage 9c), Langøya, Holmestrand

5a-c	Cranidium; partially exfoliated, dorsal anterior & lateral views, PMO 89321, x3.
6	Free cheek; lateral view, PMO 109.961, x3.
7	Pygidium; internal mould, dorsal view, PMO 109.961, x3.
9	Cranidium; partially exfoliated, dorsal view, PMO 109.916, x1.
12	Free cheek; lateral view, PMO 109.923, x2.

Calymene aff. *Calymene pholeteros* sp. nov.

Steinsfjorden Formation (Kiær's ētage 9c), Langøya, Holmestrand

4	Cranidium; partially exfoliated, dorsal view, PMO 109.917, x3.

Plate 31

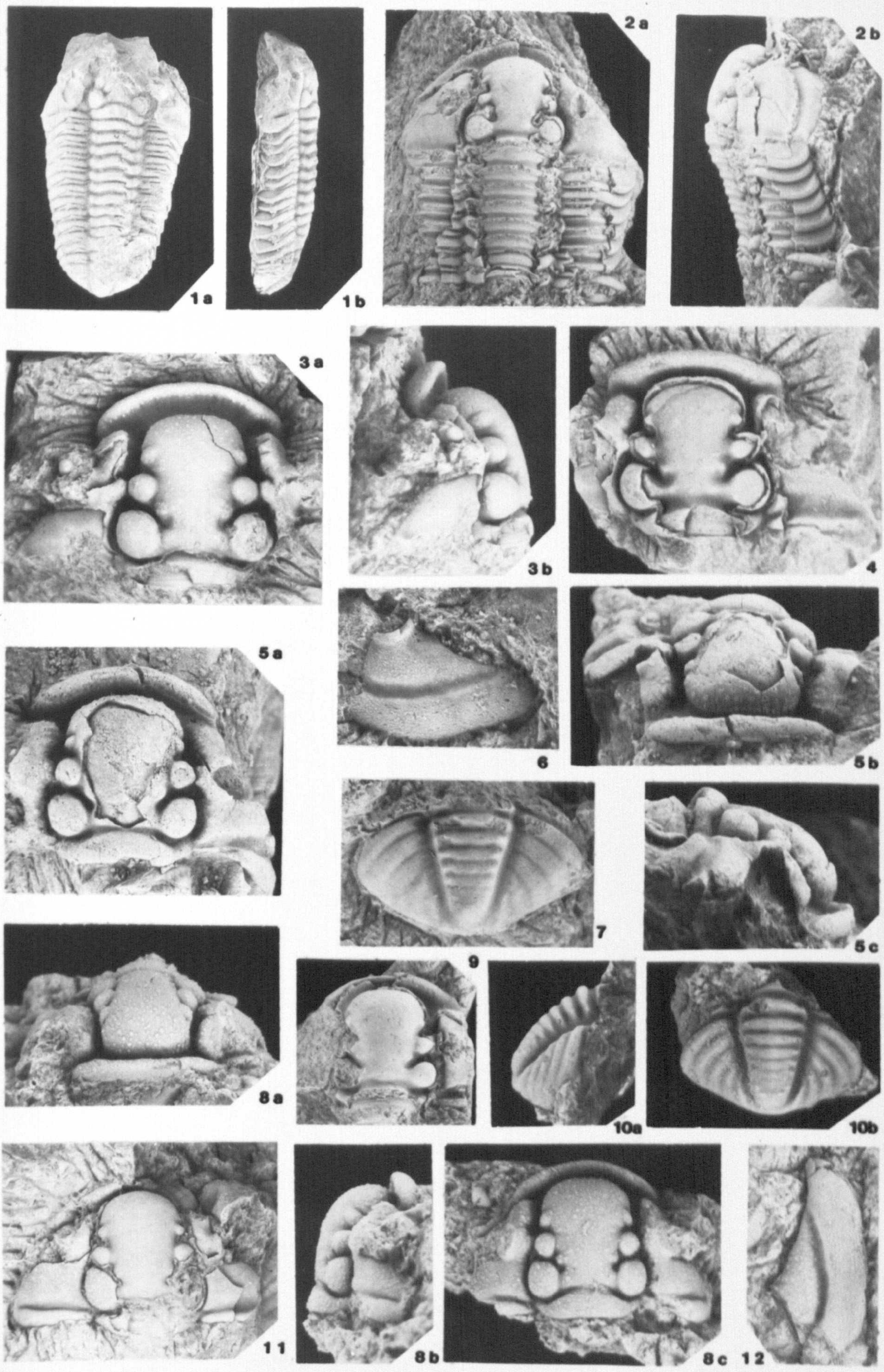


Plate 32

Fig.

Calymene sp. aff. *Calymene frontosa* Lindström, 1885

Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo

1a-c	Cranidium; partially exfoliated, lateral, dorsal & anterior views, PMO 44419, x3.
2a,b	Cranidium; partially exfoliated, lateral & dorsal views, PMO 44420, x5.

Calymene planicurvata Shirley, 1936

Solvik Formation (Kiær's étage 6c), Malmøya, Oslo

3a,b	Cranidium partially exfoliated, lateral & dorsal views, PMO 109.975, x2.
4	Whole specimen; lateral view, PM0 41614, x1.
5a-c	Cranidium & pleurae, lateral dorsal & anterior views, PMO 41606, x3.
6a,b	Whole specimen; dorsal cranidial & dorsal views, PMO 41727, x3, x1.

Solvik Formation (Kiær's étage 6c), Malmøykalven, Oslo

7	Whole specimen; internal mould, dorsal view, PMO 20918, x2.
8	Whole specimen; dorsal view, PMO 41614, x1.

Rytteråker Formation (Kiær's étage 7a), Malmøya, Oslo

9a,b	Cranidium; partially exfoliated, dorsal & anterolateral views, PMO 89200, x2.

Plate 32

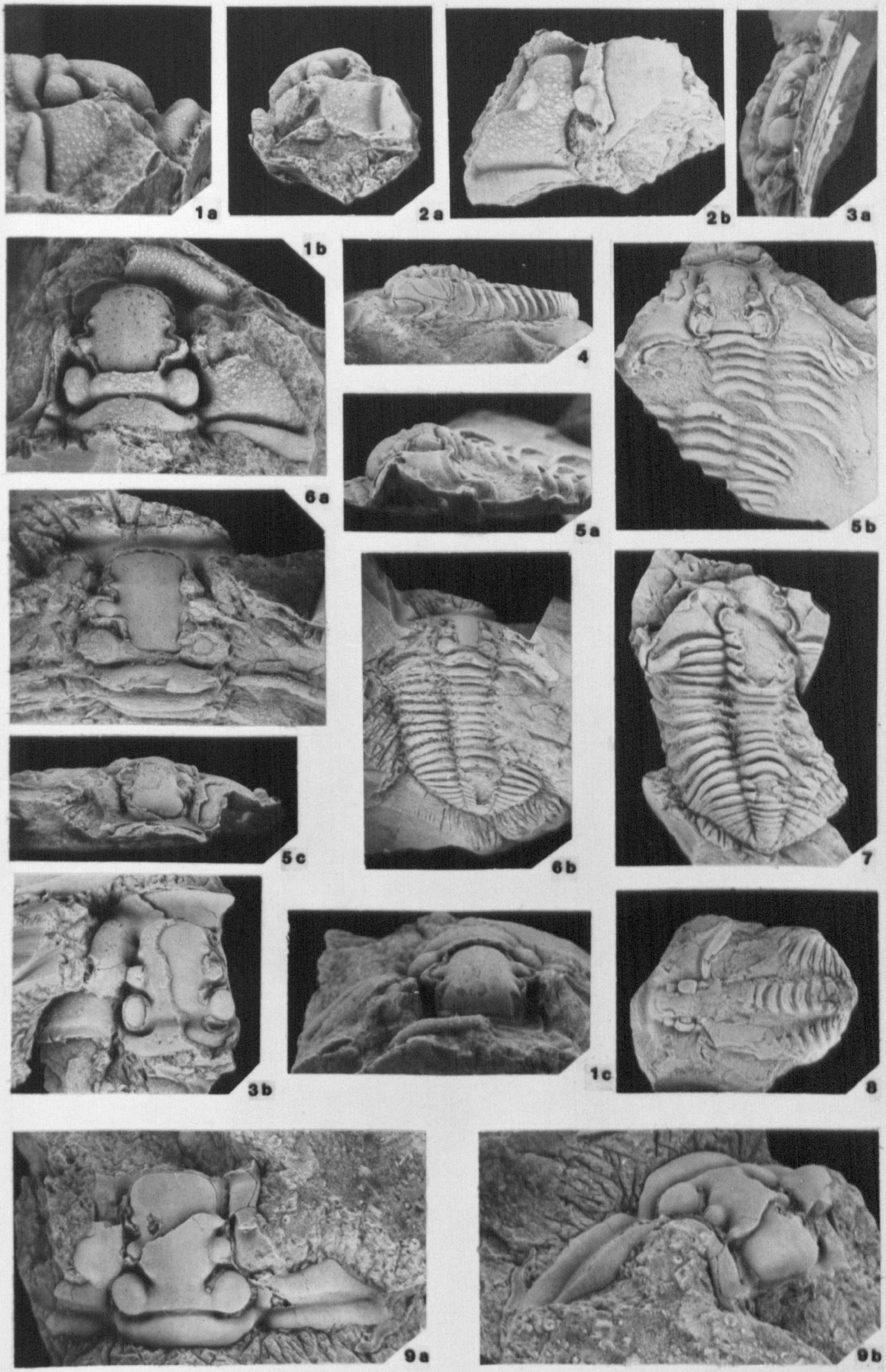


Plate 33

Fig.

Calymene ubiquitosus Howells, 1982

Solvik Formation (Kiær's étage 6c), Skytterveien, Asker

1 Cranidium; internal mould, dorsal view, PMO 109.974, x3.

16 Hypostome; partially exfoliated, ventral view, PMO 110.832, x10.

Solvik Formation (Kiær's étage 6b), Semsvatnet, Asker

2 Cranidium; internal mould, dorsal view, PMO 91102, x3.

3a,b Pygidium; internal mould, dorsal and lateral views, PMO 110.859, x5.

9 Cranidium, latex of internal mould, dorsal view, PMO 91106, x3.

12 Cranidium; internal mould, dorsal view, PMO 91096, x3.

Solvik Formation (Kiær's étage 6b), Spirodden, Asker

8 Cranidium; dorsal view, PMO 88845, x5.

10 Cranidium; dorsal view, PMO 108.493, x5.

14a,b Cranidium; internal mould, lateral & dorsal views, PMO 52783, x5.

15 Hypostome, ventral view, PMO 88658, x5.

Calymene tetartos sp. nov.

Malmøya Formation (Kiær's étage 9c), Malmøya, Oslo

4 Paratype free cheek; lateral view, PMO 109.499, x5.

6a,b Paratype cranidium; partially exfolited, dorsal & lateral views, PMO 44656, x2.

7a-c Holotype cranidium; partially exfoliated, lateral, anterior & dorsal views, PMO 44655, x2.

Malmøya Formation (Kiær's étage 8c), Gjettum bus stop, Asker

5 Paratype cranidium; internal mould, dorsal view, PMO 109.500, x3.

11 Paratype cranidium; partially exfoliated, dorsal view, PMO 109.968, x3.

Diacalymene crassa Shirley, 1936

Solvik Formation (Kiær's étage 6b) Gulleråsen, Asker

13 Cranidium; internal mould, dorsal view, PMO 65547, x3.

Plate 33

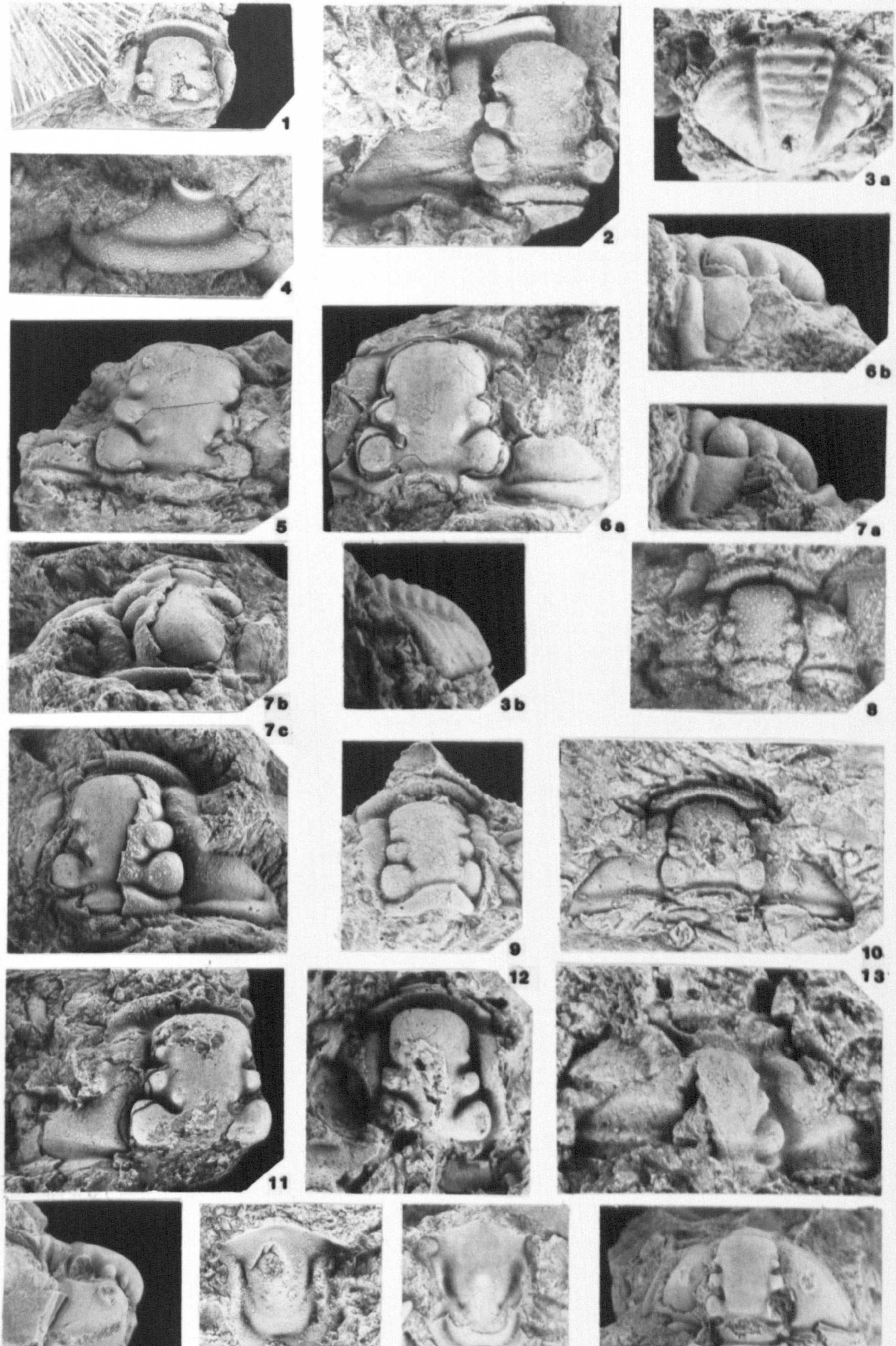


Plate 34

Fig.

Diacalymene crassa Shirley, 1936

Gasworks Mudstone (Upper Rhuddanian), Llandovery, half mile S.E. of Haverfordwest, South Wales, side of Frolic path 383-390 yards from Higgins Well

1a,b Holotype cranidium; internal mould, dorsal & lateral views, GSM 54910 (formerly GSM pg2364), x3; figured Shirley, 1936, pl. 29, figs, 21, 22.

Gasworks Mudstone (Upper Rhuddanian), Llandovery, 1.5 miles east of Haverfordwest, South Wales, from a brook 400 yards s.e. of Cotts Park

2a-c Cranidium; internal mould, anterior, dorsal & lateral views, GSM 54911 (formerly TCC 1776), x3.

Solvik Formation (Kiær's êtage 6), Haldu, Asker

3a,b Cranidium; partially exfoliated, dorsal & anterior views, PMO 53094, x2.

Solvik Formation (Kiær's êtage 6), Våkas ved Jerbanlingen

4a-c Cranidium; internal mould, dorsal, anterior & lateral views, PMO 91112, x3.

Solvik formation (Kiær's êtage 6b), Gulleråsen

5a,b Cranidium; internal mould, anterior & dorsal views, PMO 65535, x2.

7 Two cranidia; internal moulds, dorsal view, PMO 88872, PMO 110.860, x3.

8 Cranidium; internal mould, dorsal view, PMO 88881, x5.

9 Cranidium; internal mould, dorsal view, PMO 88873, x2.

Diacalymene gibberosa [Siveter, 1973]

Solvik Formation (Kiær's êtage 6a), Ousto, west coast of Silurian area

6 Paratype pygidium; dorsal view, PMO 88740, x3.

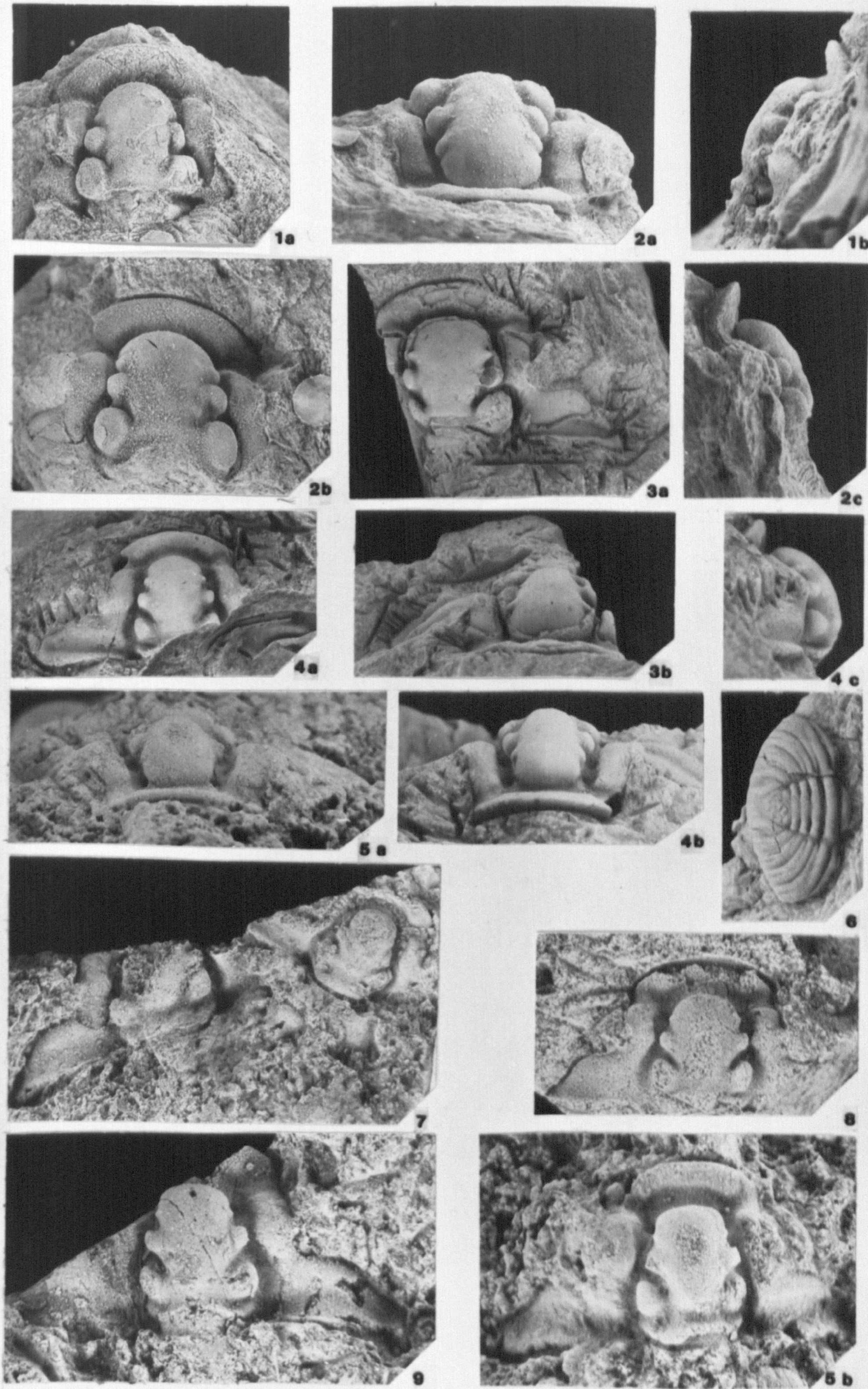

1a
2a
1b
2b
3a
2c
4a
3b
4 c
5 a
4b
6
7
8
9
5 b

Plate 35

Fig.

Diacalymene gibberosa [Siveter, 1973]

Solvik Formation (Kiær's étage 6a), Sjursøya, Oslo

1	Paratype cranidium; dorsal view, PMO 110.841, x5.
2a,b	Paratype pleuron; lateral & dorsal views, PMO 110.851, x3.
3a,b	Paratype cranidium; partially exfoliated, dorsal & lateral views, PMO 41626, x5.
4	Paratype pygidium; dorsal view, PMO 88740, x5.
5a-c	Paratype cranidium; lateral, anterior & dorsal views, PMO 20945, x3.
6a-c	Paratype cranidium; lateral, dorsal & anterior views, PMO 110.852, x3.
7a,b	Paratype cranidium; dorsal & lateral views, PMO 41624, x3.
8	Two paratype pygidia; posterior & dorsal views, PMO 110.858, -861, x5.
9	Paratype cranidium; partially exfoliated, dorsal view, PMO 41625, x3.
10a,b	Paratype pygidium & pleurae; lateral & dorsal views, PMO 110.845, x3.
11	Paratype hypostome; internal mould, dorsal view, PMO 41634, x5.
12	Paratype cranidium; dorsal view, PMO 110.852, x3.

Plate 35

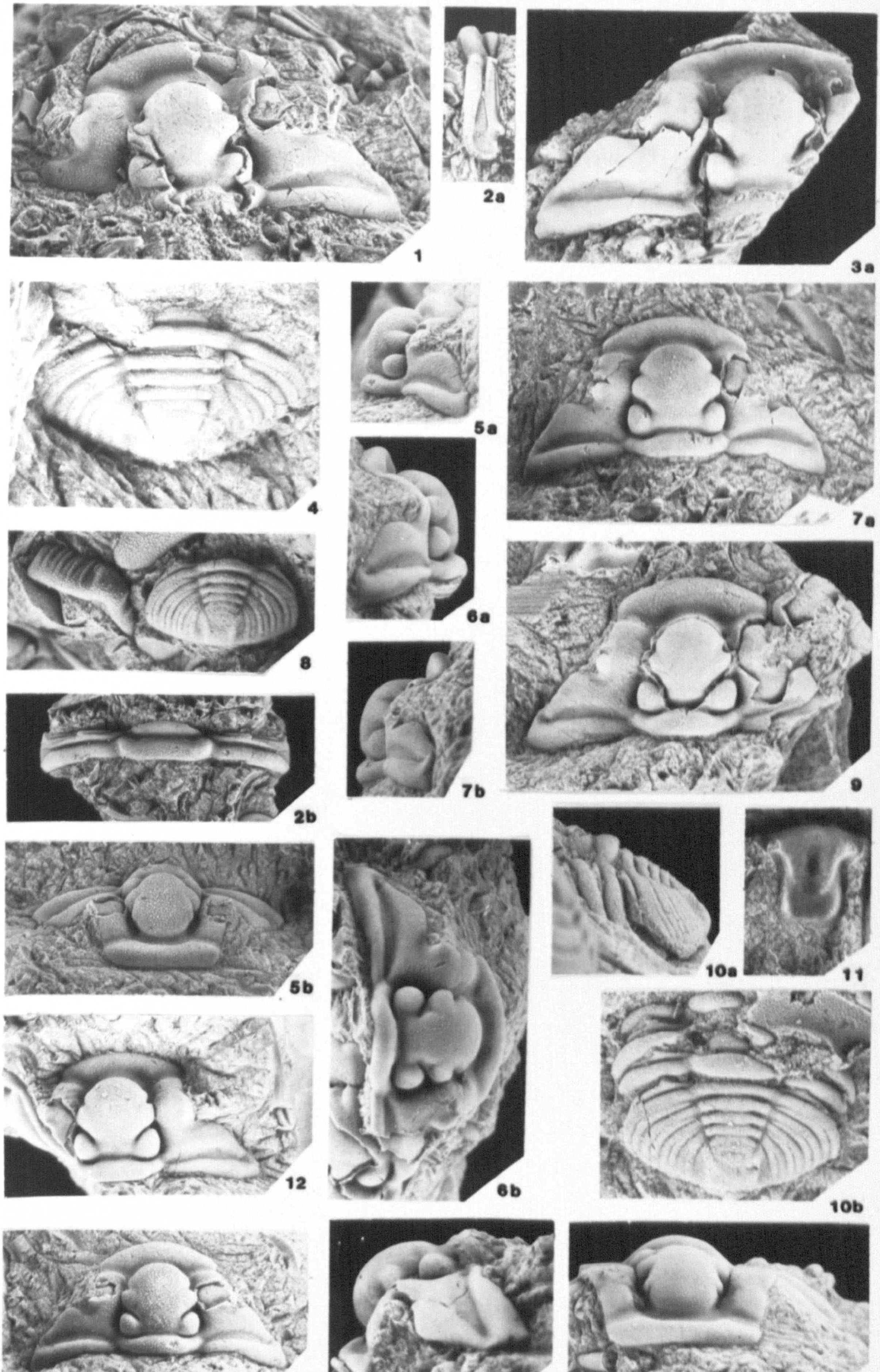


Plate 36

Fig.

Diacalymene gibberosa [Siveter, 1973]

Solvik Formation (Kiær's étage 6a), Sjursøya, Oslo

1a,b	Holotype cranidium; dorsal & lateral views, PMO 41620, x3.
2	Paratype free cheek; internal mould, lateral view, PMO 41634, x3.
3	Paratype hypostome; partially exfoliated, ventral view, PMO 112.921, x5.

Acernaspis elliptifrons (Esmark, 1833)

Solvik Formation (Kiær's étages 6b & 6c), Malmøya, Oslo

4	Cephalon; latex external mould, lateral view, PMO 89473, x3.
9a,b	Whole specimen; dorsal pygidial & lateral views, PMO 70596, x5.
10a-d	Neotype whole specimen; dorsal cephalic, dorsal pygidial, anterior & lateral views, PMO 20966, x5.
11a-c	Whole specimen; dorsal pygidial, dorsal cephalic & lateral views, PMO 70595, x5.
12	Whole specimen; internal mould, lateral view, PMO 41566, x3.

Solvik Formation (Kiær's étage 6c), Skyttereveien, Asker

5	Cephalic doublure; ventral view, internal mould, PMO 110.871, x5.
6	Hypostome; ventral view, PMO 110.867, x10.
7	Hypostome; ventral view, PMO 110.866, x10.

Solvik Formation (Kiær's étage 6b), Spirodden, Asker

8a,b	Cephalon; internal mould, lateral & dorsal views, PMO 112.745, x5.

Plate 36

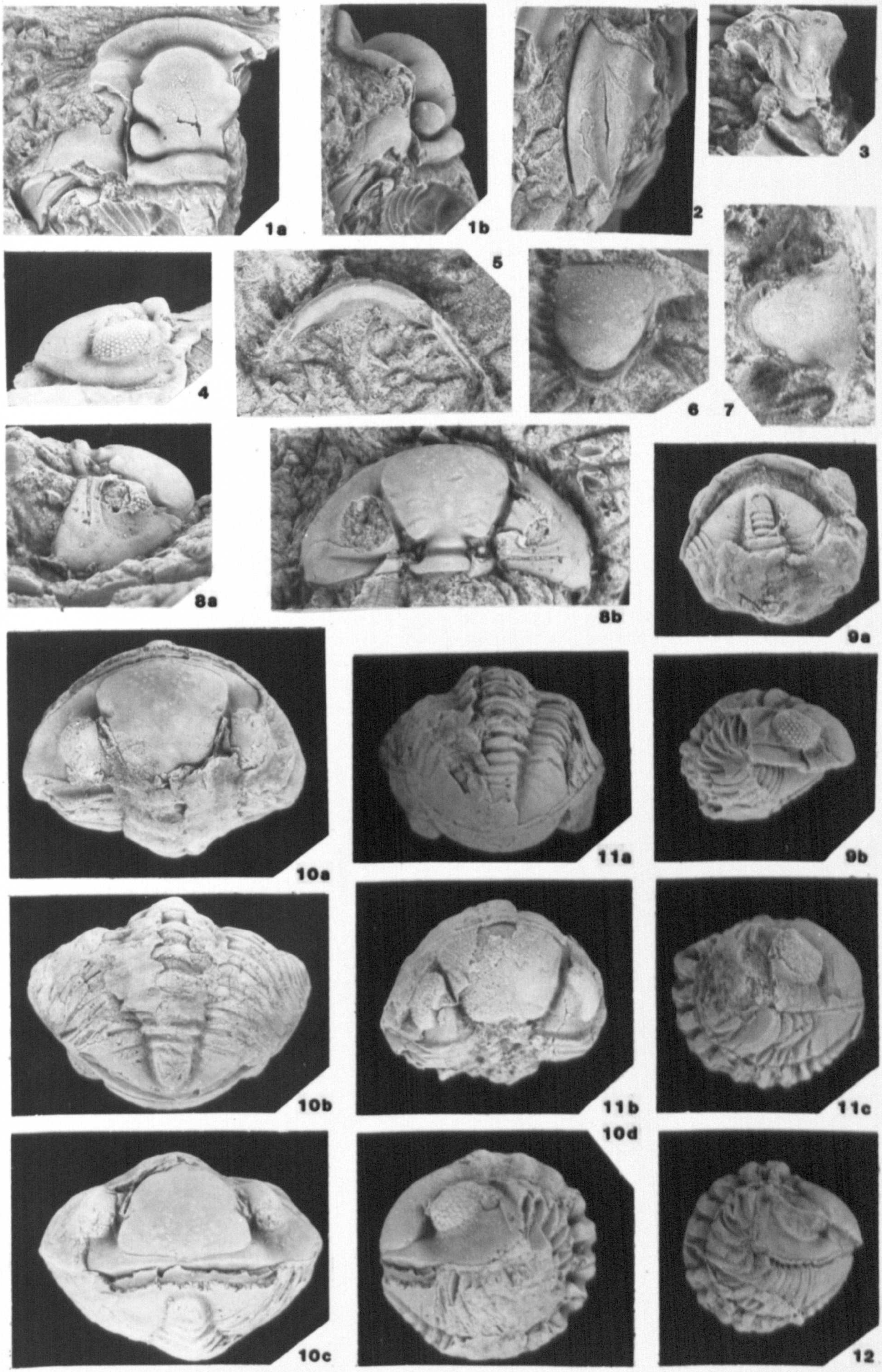


Plate 37

Fig.

Acernaspis elliptifrons (Esmark, 1833)

Solvik Formation (Kiær's étages 6b & 6c), Malmøya, Oslo

1 Cranidium; internal mould, dorsal view, PMO 21257, x5.

10 Whole specimen; dorsal view, PMO 112.773, x5.

Solvik Formation (Kiær's étage 6c), Skytterveien, Asker

2 Cranidium; internal mould, dorsal view, PMO 110.885, x5.

3 Cranidium; internal mould, dorsal view, PMO 110.891, x5.

5 Cranidium; internal mould, dorsal view, PMO 110.863, x5.

6 Cranidium; internal mould, dorsal view, PMO 110.889, x5.

8 Cephalic doublure; internal mould, ventral view, PMO 110.868, x5.

11 Cephalic doublure; internal mould, ventral view, PMO 110.871, x5.

13 Pygidium; internal mould, dorsal view, PMO 110.876, x5.

14 Pygidium; internal mould, dorsal view, PMO 110.873, x5.

15 Whole specimen; internal mould, dorsal view, PMO 112.769, x5.

17 Pygidium; internal mould, dorsal view, PMO 110.880, x5.

18 Pygidium; internal mould, dorsal view, PMO 110.874, x5.

19 Pygidium; internal mould, dorsal view, PMO 110.875, x5.

Solvik Formation (Kiær's étage 6), Spirodden, Asker.

12 Cranidium; internal mould, dorsal view, PMO 112.679, x5.

Saelabonn Formation (Kiær's étage 6c), Hönefoss road, Ringerike

16 Cranidium & free cheek; internal mould, dorsal view, PMO 112.360, x4.

Acernaspis phyxis sp. nov.

Solvik Formation, (Kiær's étage 6a), Sjursøya, Oslo

4 Paratype pygidium; partially exfoliated, dorsal view, PMO 112.872, x5.

9 Paratype cephalic doublure; internal mould, ventral view, PMO 112.877, x5.

Acernaspis sp. A

Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo

7 Whole specimen; partially exfoliated, dorsal view, PMO 21406, x2.

Plate 37

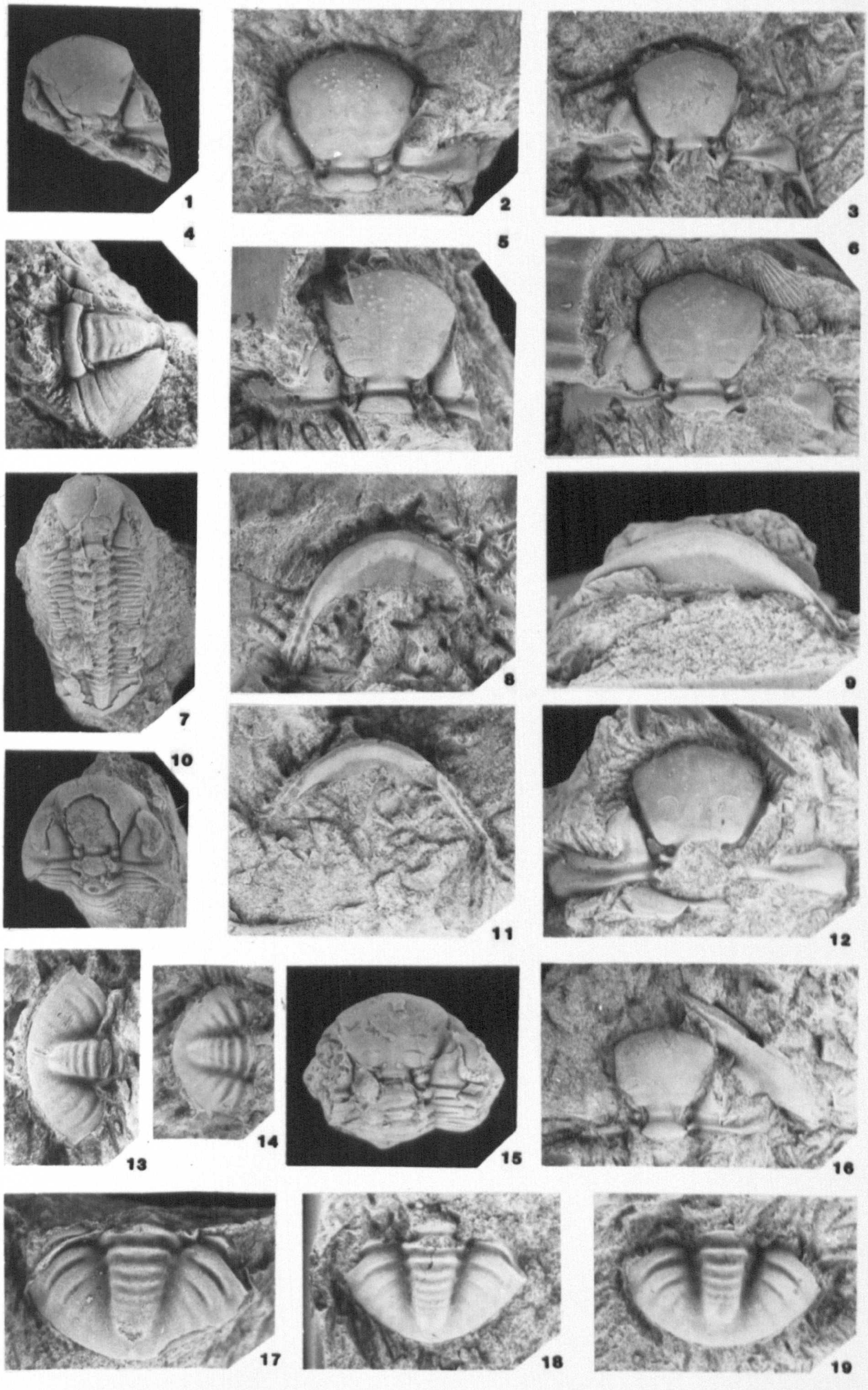


Plate 38

Fig.

Acernaspis elliptifrons (Esmark, 1833)

Solvik Formation (Kiær's étage 6c), Skyttervien, Asker

1 Cranidium; internal mould, dorsal view PMO 110.881, x5.

Saelabonn Formation (Kiær's étage 6c), Honefoss Road, Ringerike.

8 Pygidium; internal mould, dorsal view, PMO 112.803, x5.

Solvik Formation (Kiær's étage 6b), Spirodden, Asker

11 Cranidium internal mould; dorsal view, PMO 112.187, x5.

Eophacops euthymos sp. nov.

Steinsfjorden Formation (Kiær's étage 9b), Langøya, Holmestrand

2a-c Paratype cephalon; internal mould, lateral, dorsal & anterior views, PMO 50600, x5.

4 Paratype cephalon; internal mould, dorsal view, PMO 50647, x5.

6a,b Paratype pygidium; partially exfoliated, lateral & dorsal views, PMO 50644, x3.

7a,b Paratype pygidium; partially exfoliated, lateral & dorsal views, PMO 50645, x3.

9 Paratype cephalon; internal mould, dorsal view, PMO 50648, x5.

12a-c Paratype cephalon; partially exfoliated, dorsal, anterior & lateral views, PMO 21529, x4.

15 Holotype cephalon; internal mould, dorsal view, PMO 50006, x5.

Malmøya Formation (Kiær's étage 8c), Malmøya, Oslo

3a-d Paratype cephalon; lateral, dorsal, ventral & anterior views, PMO 21530, x5.

Acernaspis sp. C

Rytteråker Formation (Kiær's étage 7a), Ulvøya, Oslo

5 Pygidium; internal mould, PMO 42843, x3.

Acernaspis labronios sp. nov.

Bruflat Formation (Kiær's étage 8), Storøya, Ringerike

10a,b Paratype pygidium; internal mould, lateral & dorsal views, PMO 21529, x4.

14 Paratype cephalon; dorsal view, PMO 46117, x5.

Braksøya Formation (Kiær's étage 8c), Garntangen, Ringerike

13 Paratype pygidium; internal mould, dorsal view, PMO 112.890, x5.

Plate 38

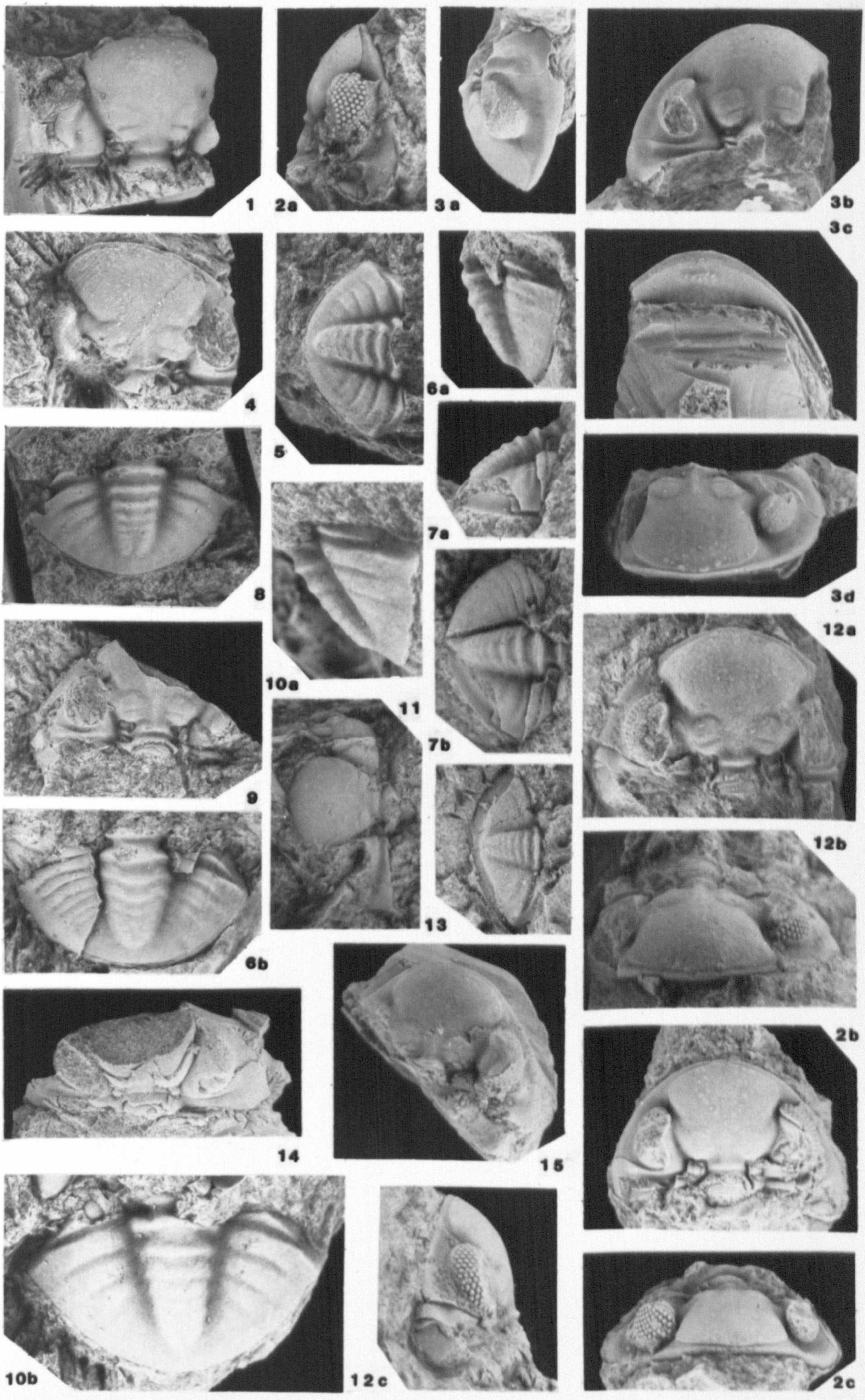

1
2a
3a
3b
3c
4
5
6a
7a
8
3d
10a
11
7b
12a
9
12b
13
6b
2b
14
15
10b
12c
2c

Plate 39

Fig.

Acernaspis labronios sp. nov.

Braksøya Formation (Kiær's étage 8c), Garntangen, Ringerike

1a,b Holotype whole specimen; internal mould, dorsal & ventral views, PMO 112.819, x4.

2 Paratype cephalic doublure; internal mould, ventral view, PMO 112.822, x4.

3 Paratype whole specimen; internal mould, dorsal view, PMO 100.530, x4.

6 Paratype cephalic doublure; internal mould, ventral view, PMO 112.830, x4.

7 Paratype pygidium & thorax; internal mould, dorsal view, PMO 112.814, x4.

13 Paratype whole specimen; internal mould, dorsal view, PMO 100.538, x2.

16 Paratype cranidium and visual surface; internal mould, dorsal view, PMO 100.539, x5.

21 Paratype whole specimen; internal mould, dorsal view, PMO 112.817, x3.

Bruflat Formation (Kiær's étage 8a), Storøya, Ringerike

4 Paratype pygidium; internal mould, dorsal view, PMO 49662, x3.

11 Paratype cranidium; internal mould, dorsal view, PMO 45967, x4.

Bruflat Formation (Kiær's étage 8a), unknown locality, Ringerike

22 Paratype pygidium; internal mould, dorsal view, PMO 40100, x3.

Acernaspis phyxis sp. nov.

Solvik Formation (Kiær's étage 6a) Sjursøya, Oslo

5 Paratype cranidium; partially, exfoliated, dorsal view, PMO 112.870, x5.

8 Paratype pygidium; dorsal view, PMO 112.876, x5.

9 Paratype cranidium; dorsal view, PMO 112.873, x5.

12 Paratype pygidium; dorsal view, PMO 112.881, x10.

14 Paratype cranidium; dorsal view, PMO 112.883, x5.

15 Paratype visual surface; lateral view, PMO 112.877, x5.

17 Holotype cranidium; partially exfoliated, dorsal view, PMO 112.880, x5

18 Paratype pygidium; partialy exfoliated, dorsal view, PMO 112.874, x5.

20 Paratype cranidium; dorsal view, PMO 112.871, x5.

23 Paratype cranidium; partially exfoliated, dorsal view, PMO 112.872, x5.

Eophacops aff. *Eophacops euthymos* sp. nov.

Malmøya Formation (Kiær's étage 8b), Kommersøya, Holmestrand

10 Whole specimen; internal mould, dorsal view, PMO 54469, x2.

Acernaspis sp. B

Plate 39

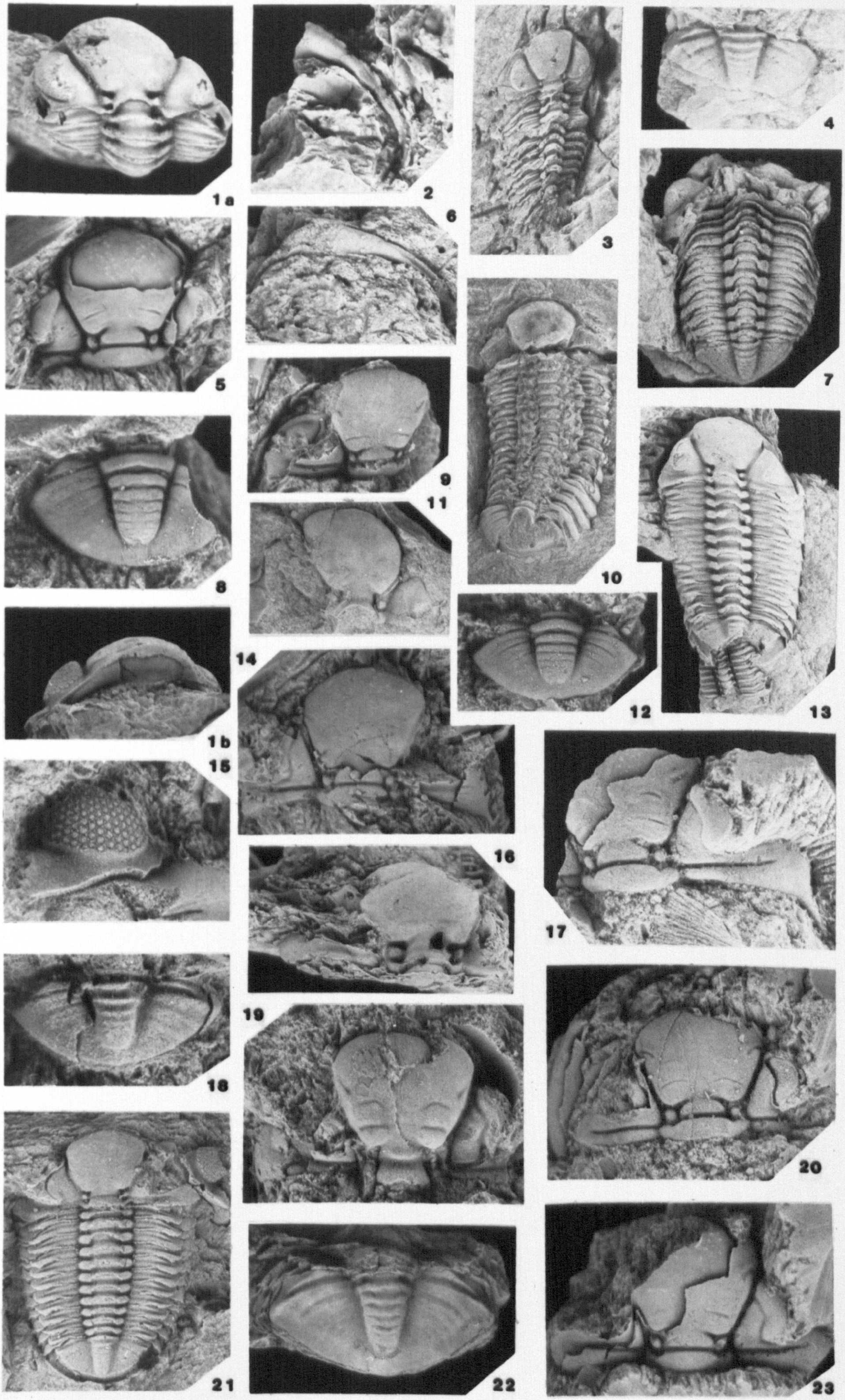


Plate 40

Fig.

Lichas sylvestris Reed, 1925

Solvik Formation (Kiær's étage 6a), Sjursøya, Oslo

1a,b Pygidium; dorsal & lateral views, PMO 112.879, x5.

Arctinurus norvegicus (Angelin, 1854)

Solvik Formation (Kiær's étage 6), Malmøya, Oslo

2a-c Cranidium; dorsal, lateral & anterior views, PMO H2570, x1; Warburg 1937, text-fig. 2.

3 Pygidium; dorsal view, PMO H2550, x1; Warburg 1937, text-fig. 4.

5 Pygidium; dorsal view, PMO H2577, x1; Warburg, 1937, text-fig. 3.

6 Pygidium; dorsal view, PMO H2569, x1.

8 Hypostome; internal mould, ventral view, PMO 42241, x1.

Saelabonn Formation (Kiær's étage 7a), Ringerike

4 Pygidium; dorsal view, PMO H2565, x3.

Solvik Formation (Kiær's étage 6), Spirodden, Asker

7 Cranidium; dorsal view, PMO 88786, x3.

Solvik Formation (Kiær's étage 6c), Malmøykalven, Oslo

9 Free cheek; dorsal view, PMO 109.900, x1.

Dicranopeltis galbinus sp. nov.

Solvik Formation (Kiæ's étage 6b), Gulleråsen, Asker

10 Paratype hypostome; internal mould, ventral view, PMO 6558, x5.

Plate 40

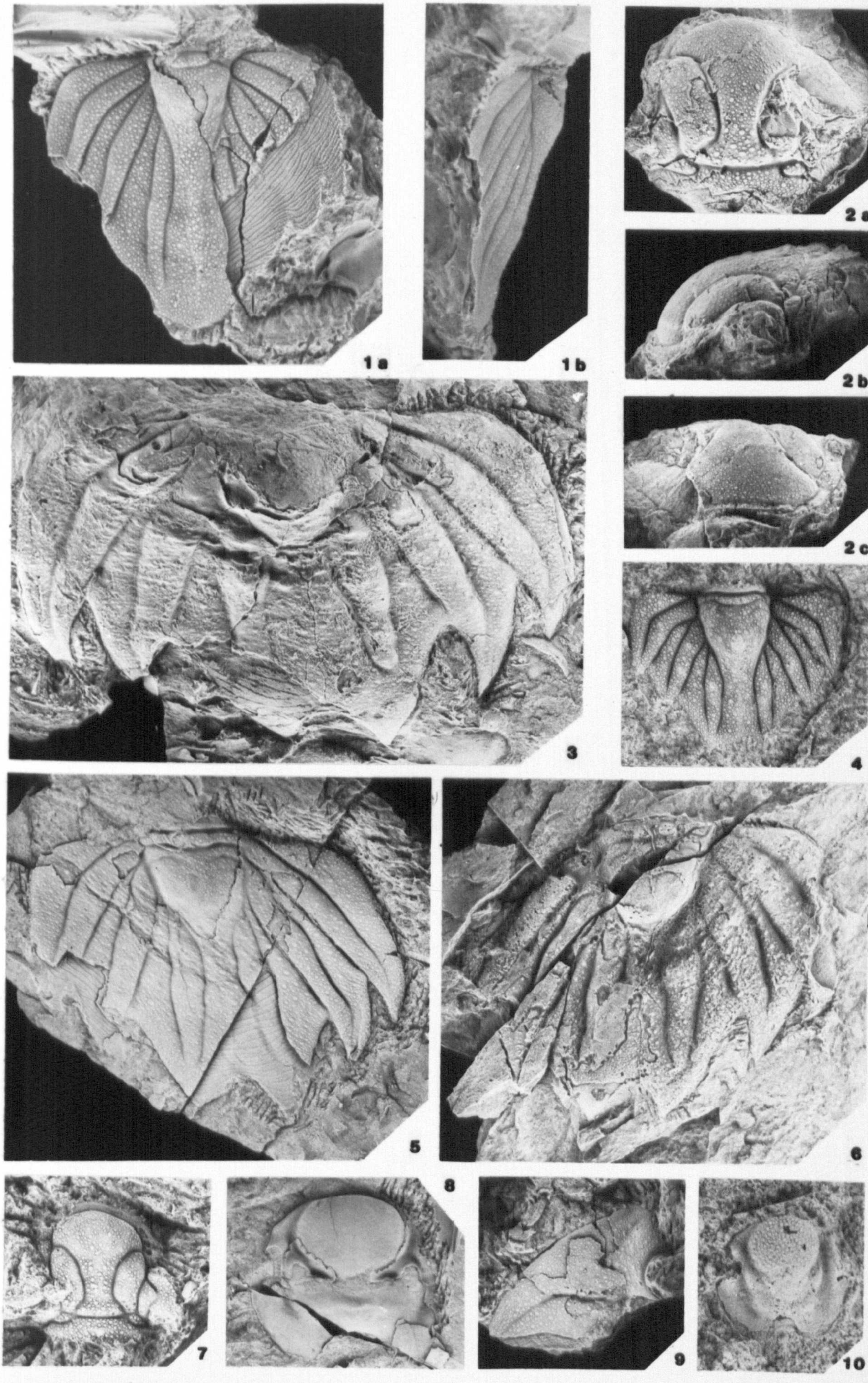


Plate 41

Fig.

Arctinurus norvegicus (Angelin, 1854)

Huk?

1 Holotype pygidium; dorsal view, PMO H2553, x1; Angelin 1854, pl. 38, fig. 4; Warburg, 1937 text-fig. 1.

Solvik Formation (Kiær's étage 6b or 6c), Malmøya

2 Hypostome; internal mould, ventral view, PMO 44795, x3.

Solvik Formation (Kiær's étage 6b), Spirodden, Asker

6 Pathological pygidium; dorsal view, PMO 2572, x3.

Solvik Formation (Kiær's étage 6b), Malmøykalven, Oslo

17 Thoracic segment; dorsal view, PMO 109.902, x3.

Dicranopeltis galbinus sp. nov.

Solvik Formation (Kiær's étage 6b), Gullaråsen, Asker

3 Paratype cranidium; dorsal view, PMO 88700, x3.

7 Paratype hypostome; internal mould, ventral view, PMO 65557, x3.

9 Holotype cranidium; dorsal view, PMO 88650, x3.

10 Paratype cranidium; internal mould, dorsal view, PMO 88646, x3.

11 Paratype cranidium; internal mould, dorsal view, PMO 88701, x3.

Pseudotupolichas ornatus (Angelin, 1854)

Steinsfjorden Formation (Kiær's étage 9b), Langøya, Holmestrand

4 Pathological pygidium; dorsal view, PMO H2554, x2.

Choneliobarges sp. nov.?

Steinsfjorden Formation (Kiær's étage 9), Langøya, Holmestrand

5 Hypostome; internal mould, ventral view, PMO 109.545, x10.

13 Hypostome; internal mould, ventral view, PMO 109.544, x10.

14 Pygidium; internal mould, dorsal view, PMO 112.893, x5.

16 Cranidium; internal mould, dorsal view, PMO 109.546, x5.

Platylichas scoticus (Reed, 1906)

Saelabonn Formation (Kiær's étage 6c), Limovnstangen, Ringerike

8a-c Cranidium; anterior, dorsal & lateral views, PMO 108.496, x5.

Solvik Formation (Kiær's étage 6b or 6c), Spirodden, Asker

12 Pygidium; dorsal view, PMO 109.541, x10.

15 Hypostome; latex of external mould, ventral view, PMO 112.892, x5.

Leonaspis varbolensis Bruton, 1967

Solvik Formation (Kiær's étage 6c), Spirodden, Asker

18 Free cheek; lateral view, PMO 109.921, x5.

Plate 41

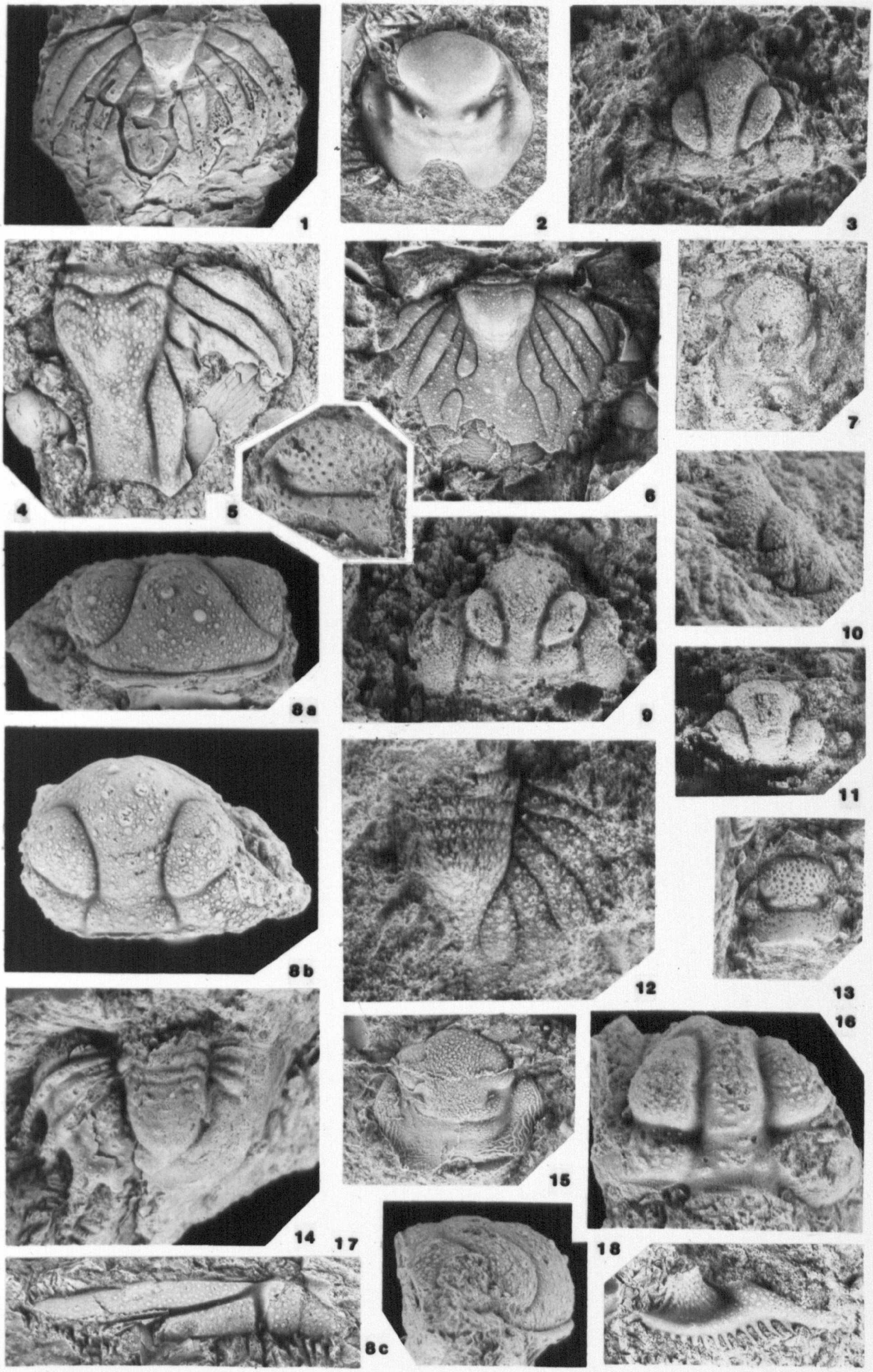


Plate 42

Fig.

Leonaspis sp.

Braksøya Formation (Kiær's étage 8c), Garntangen, Ringerike

1 Cranidium; internal mould, dorsal view, PMO 112.907, x3.

Dudleyaspis aff. *Dudleyaspis (Dudleyaspis) unicifera* Ramsköld, 1984

Solvik Formation (Kiær's étage 6c), Skytterveien, Asker

3 Pygidium; dorsal view, PMO 112.916, x5.

14 Pygidium; dorsal view, PMO 112.917, x10.

Choneliobarges sp. nov.?

Steinsfjorden Formation (Kiær's étage 9), Langøya, Holmestrand

5a-c Cranidium; internal mould, lateral, anterior & dorsal views, PMO 50355, x3.

Leonaspis varbolensis Bruton, 1967

Solvik Formation (Kiær's étage 6b & 6c), Spirodden, Asker.

2 Free cheek; lateral view, PMO 112.908, x5.

4a,b Cranidium; anterior & dorsal views, PMO 109.429, x5.

11 Pygidium; dorsal view, PMO 109.920, x5.

18 Hypostome; ventral view, PMO 109.918, x10.

20 Cranidium; dorsal view, PMO 109.928, x5.

Solvik Formation (Kiaer's étage 6c), Malmøya, Oslo

6 Pygidium; dorsal view, PMO 109.523, x5.

10a,b Whole specimen; dorsal & lateral views, PMO 44389, x5.

Solvik Formation (kiaer's étage 6c), Skytterveien, Asker

7 Pygidium; internal mould, dorsal view, PMO 112.906, x5.

8 Cranidium; dorsal view, PMO 109.533, x5.

13 Whole specimen; ventral view, PMO 108.464, x2.

15 Free cheek; lateral view, PMO 109.536, x8.

16 Pygidium; dorsal view, PMO 112.905, x5.

17 Cranidium; dorsal view, PMO 108.494, x8.

19 Free cheek; lateral view, PMO 109.531, x8.

21 Pygidium; dorsal view, PMO 109.530, x5.

Saelabonn Formation (Kiær's étage 6c), Honeföss road, Ringerike

9 Cranidium; dorsal view, PMO 109.913, x5.

12 Pygidium; dorsal view, PMO 109.914, x5.

Plate 42