Lower Silurian polychaetaspid and ramphoprionid polychaetes from Gotland: aspects on taxonomy and palaeoecology

Mats Eriksson
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MATS ERIKSSON


The Silurian strata of Gotland yield a wide variety of polychaete jaws. The investigated polychaetes include the family Polychaetaspidae with the two genera Polychaetaspis and Kozlowskiprion, and the monotypic family Ramphopriridae with the genus Ramphopriion. The fauna derives from the sections at Lusklint and Lickershamn 2 which comprise the three stratigraphically oldest units on Gotland: the Lower Visby Beds, the Upper Visby Beds, and the Högklint Beds. These Beds are exposed in the northeastern part of the island and range in age from Late Llandovery to Early Wenlock. Identification of the species is based on isolated jaw elements (scolecodonts) and apparatuses, utilizing a biological species concept. Of the elements forming an apparatus only the first maxillary pieces (MI), have been studied. Three new species are introduced: Polychaetaspis olofi n. sp., Ramphopriion anderssoni n. sp., and R. ? bergmani n. sp. The remaining seven taxa are all polychaetaspids and include P. marleneidae (Eller, 1942), P. "obliquus" (Eichwald, 1854), P. cf. tuberculatus Kielan-Jaworowska, 1966, P. cf. latus Kielan-Jaworowska, 1966, P. wyszogrodensis Kozlowski, 1956, P. cf. gadomskae Kielan-Jaworowska, 1966, and Kozlowskiprion cf. longicavernosus Kielan-Jaworowska, 1966. The taxonomic diversity is highest in the Högklint Beds and most of the investigated species indicate a preference for warm and shallow marine environments. Only the two species K. cf. longicavernosus and P. cf. latus are present from the Lower Visby Beds to the Högklint Beds, and these are presumably more tolerant to environmental changes and show a preference for deeper water strata. This study presents an extended range for the raphroporionids into the Silurian, so now both Ordovician and Silurian strata are included. One transposed, left jaw element probably of P. marleneidae was found. □ Annelida, polychaetes, polychaetaspids, raphroporionids, scolecodonts, palaeoecology, taxonomy, Lusklint, Lickershamn 2, Lower Visby Beds, Upper Visby Beds, Högklint Beds, Wenlock, Llandovery, Silurian, Gotland, Sweden.

The study of fossil polychaete annelid jaws was introduced in the middle of the nineteenth century by Eichwald (1854), Massalongo (1855) (cited not seen), and Pander (1856). However, these pioneers were not certain of the affinity. Some years later, Hinde contributed with four works (1879, 1880, 1882, 1896) on the subject. By this time it was obvious that the jaws were annelid remains. According to Hinde (1882), referring to a letter, the Swedish professor Angelin studied polychaete jaws, and as early as 1864 he was certain about the proper taxonomic place. In the beginning of the twentieth century only sparse research on these fossils occurred (cf. Bergman 1989), until Croneis & Scott (1933) presented an abstract, in which the isolated jaw elements were given the name "scolecodonts". This term has been accepted since then. For a more comprehensive historical review, see Bergman (1989).

Although scolecodonts have been investigated for almost 150 years, and in spite of the fact that they are among the most common microfossils in Lower Palaeozoic sediments [especially from Lower Ordovician and onwards (Kielan-Jaworowska 1966)], fairly little work has been done on them compared to other fossil groups. Kielan-Jaworowska (1968) discussed this "lack of interest" and made two conclusions; (1) scolecodonts are considered to be negligible in stratigraphy and (2) because the use of parataxonomy. The former reason is probably a consequence of the hitherto limited research (Kielan-Jaworowska 1968; Underhay & Williams 1995). For the latter reason, there has been a lot of arguing whether parataxonomy should be used or not. At present, two systems of classification exist, one dealing with isolated elements (morphological species) which violates the rules of ICZN, and another based on entire apparatuses (biological species) (Martinsson 1960; Bergman 1979, 1989, 1991a). Formerly, it was believed impossible to identify isolated elements at the species level. However, due to improved laboratory techniques it is now possible to dissolve large quantities of rocks and obtain high amounts of both well preserved isolated elements, and occasionally entire apparatuses. This makes the identification possible at the species level (Bergman 1995a), though, careful precautions should be taken into consideration when naming scolecodonts. In the future the aim should be "to sort out the synonyms of the isolated jaws and merge the two taxonomical systems into one biological classification following the rules of ICZN" (Bergman 1995a).

When reading about scolecodonts, it is apparent that different authors have individual views of what should be called left and right elements in the dorsal maxillary apparatus. Some researchers e.g., Hinde (1882), Eller (1945, 1946), and Olive (1980) named the elements after their original anatomical position in the mouth of the animal, i.e., right elements if seen in dorsal view, were named left, and vice versa. In addition, Eller (1945, 1946) called the dorsal side "under side" while the ventral side was named "upper side". Far more common among researchers is to name the elements left and right as seen when pictured with dorsal side facing the reader (cf. plates I-IV). Clearly this is a matter of dispute. Today most researchers use the latter method, which also has been advocated in this study.

Jawed polychaetes display a range from Early Ordovician (latest Tremadoc according to Underhay & Williams (1995)), to the present. Apart from trace fossils, the isolated jaws are the most common fossil remains of these benthic animals in the Lower Palaeozoic (Bergman 1995a). Scolecodonts are in contrast to
conodonts hollow (with the exception of the mandibles and the carriers). The colour of the jaws varies from dark brown and yellowish-red to black. The dorsal side and parts of the ventral side (the cover of the MI's) of the maxillary pieces are smooth and shiny, whereas the ligament scar and the myoecoele are dull and rough.

Different opinions concerning the composition of polychaete jaws are presented in the literature. According to Hinde (1880), Stauffer (1939), and Schwab (1966) the jaws are made of chitinous material. However, Olive (1980) showed that the composition of the jaw material in Recent polychaetes varies, does not contain chitin and differs among various taxa. Olive (1980) states that the jaws are made of hardened proteins, aromatic amino acids, hystadine, glycerine, iron, and copper. Despite brittleness, the elements have a good preservation potential. Eh and compaction of the sediment are the most important factors for preservation (Bergman 1995a).

The dorsally placed maxillary apparatus of a Palaeozoic polychaetous annelid consists of a number of maxillary pieces and a pair of carriers. Two supporting mandibles were present in the ventral part of the mouth. The number of maxillary pieces varies strongly between the families. The animals probably melted their jaws during growth, which is one of the reasons for the abundance in many samples (Kielan-Jaworowska 1966; Olive 1980; Bergman 1989, 1995a). Shedding of jaws could also explain the abundance of isolated jaws relative to the sparse record of intact apparatuses. Thus, the apparatuses were presumably deposited at death (Olive 1980).

Except for detailed studies of parts of the Gotland fauna (i.e. the paulinitids and Symmetrapiron spatiosus Bergman (1989, 1995a)), little previous work has been done on the island concerning scolocodonts, though accounts of the subject have been made by e.g., Hinde (1882), Hede (1921, 1925), Regnèll (1951), Martinsson (1960), Laufeld (1975), Eisenack (1975), and Bergman (1979, 1980, 1981, 1995b).

The main objective in this study is to present descriptions of species belonging to the family Polychaetaspidae and the, according to Kielan-Jaworowska (1966), closely related family Ramphopriionidae. The present investigation also includes aspects on the palaeoecology of these species, in a stratigraphical range from Late Llandovery to Early Wenlock. The samples are derived from the sections at Lusklint and Lickerhamn 2, and have been gathered mostly by Lennart Jeppsson and put to my disposal. Complementary sampling was made from the section at Lickershamn 2. MI rights and lefts have been the greatest concern because of their characteristic features and abundance.

Geological setting

Gotland is the largest island of Sweden, and is situated in the Baltic Sea (Östersjön) (Fig. 1). During the Silurian, Gotland was located close to the palaeoequator (Creer 1973). The bedrock is entirely composed of Silurian rocks. The exposed succession on Gotland is about 500 m thick (Hede 1921; Laufeld 1974a), and consists mostly of limestone and calcareous shale with subordinate intercalations of oolitic limestone, claystone, and sandstone. In addition, bioherms and bioherm-complexes of variable size occur abundantly. However, according to Hede (1960), these structures are missing in the Lower Visby Beds, the Tofta Beds, and the Mulde Beds. The surface of the Precambrian crystalline basement on which the Cambro-Silurian rocks were deposited, strikes roughly northeast-southwest and dips 0.15-0.3° towards the southeast (Laufeld 1974a). The oldest Silurian rocks are found along the northwestern coast of the island, and the strata get successively younger towards the southeast. The lithological characters and the fossil content indicate a tropical, shallow marine depositional environment (Hede 1921; Laufeld 1974a). Hede (1960) argued that the sediments were deposited predominantly during regressions which only occasionally were interrupted by transgressions. Stratigraphically the rocks range in age from Late Llandovery to Ludlow (Hede 1921, 1960). The exposed succession on Gotland shows a wide variety of excellently preserved fossils. This is due to the fact that the sequence is only weakly compacted.
and almost escaped thermal alteration (Bergman 1995a). According to Hede (1960), the strata were frequently affected by small-scale folding, however, negligible in respect to the sequential order.

In the beginning of the twentieth century Hede mapped almost the entire island, whereby he described and subdivided the Silurian of Gotland into 13 topostratigraphical units (Fig.1), (cf. Hede 1921, 1925, and 1960). This division is still adequate with the exception of some minor changes.

The Lower Visby Beds comprise the oldest rocks exposed on Gotland and are of Late Llandovery and Early Wenlock age (Hede 1960). According to Laufeld (1974a) the L. Visby Beds have a minimum thickness of 9 m, and consist of bedded marlstone with irregular nodules and alternating thin lenses of grey dense or fine-grained argillaceous limestone. The small solitary coral *Palaeocyclichis porpitia* is one of the index fossils in the L. Visby Beds.

The Upper Visby Beds are of Early Wenlock age, and have according to Laufeld (1974a) a thickness of about 9 to 16 m. The lithology is similar to that of the L. Visby beds but with the first indication of reef formation (Bergman 1989). The sequence is thought to have been deposited in shallower water than the L. Visby Beds.

The Högklint Beds (Early Wenlock) are according to Hede (1921), compositionally heterogeneous in both vertical and horizontal directions and the approximate thickness is 35 m. Bergman (1989) states that the most unambiguous rocks are large bioherms and argillaceous limestones, intermixed with marlstone. The water depth was probably even shallower than during deposition of the Lower and Upper Visby Beds. According to Hede (1921) the Högklint Beds probably were deposited in the beachzone.

For a more detailed description see Hede (1921, 1925, 1960), Laufeld (1974a), and Bergman (1989). The subdivision of the Lower and Upper Visby Beds into lettered units used in this investigation (Fig. 2), is largely based on the datum planes of the Ireviken Event (see Jeppsson & Männik 1993).

**Localities**

The two localities Lickershamn 2 and Lusklint (not visited), are both situated in the northeastern part of Gotland (Fig. 1).

Lickershamn 2, coordinates: 6414600 1660492 (Swedish National Grid system), CK 5199 1239 (UTM system). The stream section is located ca. 4080 m NNW of Stenkyrka.
church and ca. 260 m NW of the northwesternmost house at Lickershamn. Topographical map sheet 7J Fårösund SV & NV. Geological map sheet Aa 183 Visby & Lummelunda. The section is situated 100 m W of the bridge to the sea. Age: Upper Visby Beds and Höghklint Beds unit a-c?. Three samples are gathered from the Höghklint Beds unit a and b-c. The boundary between the Höghklint Beds units b and c is indistinguishable in the section and thus the interval is presented as "b-c" (Fig. 2). The samples from the section yield a fair amount of silicified fossils, mainly gastropods and fragments of corals. Since the reference level described by Laufeld (1974b) undulates, an auxiliary reference level was constructed by Lennart Jeppsson, which comprises a thin mud layer about 1.80 m below the former (Lennart Jeppsson, Lund, personal communication. 1996). The mud layer (ca. 6.5 m. a. s. l.), has been used
as reference level in this study. References: Hede 1940; Laufeld; 1974a, b; Larsson 1979; Bergman 1989.

Lusklint. coordinates: 640855 165567 (Swedish National Grid system), CK 4675 0680 (UTM system). The section is situated ca. 2.08 km WNW of Lummelunda church. Topographical map sheet 71 Färösund SV & NV. Geological map sheet Aa 183 Visby & Lummelunda. The reference level is the base of the Lusklint Bentonite ca. 8.28 m. a. s. l. Age: Lower Visby Beds, Upper Visby Beds and Högklint Beds. Unit a of the Lower Visby Beds is not exposed above sea level. The levels of the eight samples are shown in Figs. 2 and 3. The boundary between the L. Visby Beds units a and b is not based on any event and thus is slightly dubious. It is uncertain whether the Upper Visby Beds unit d is distinguishable within the section or not (Fig. 2). References: Lennart Jepsson, Lund, personal communication. 1996.

**Material and methods**

**Collecting**

In the field, standard stratigraphical and palaeontological methods were utilized. The section at Lickershamn 2 was measured, sketched, and photographically documented. Sampling...
of levels was performed taking previous sampling by Lennart Jeppsson into consideration, so that a continuous series of samples from the section was accomplished (Fig. 2). To obtain a sufficient amount of scolecodonts, large samples of at least 25-30 kilos each were taken. Sampling was further restricted to highly productive lithologies which is somewhere between the purest crinoid limestone and marlstone (Claes Bergman, Lund, personal communication, 1995). However, most of the samples used in this investigation are from the collection of Lennart Jeppsson. These comprise smaller samples of about 6-26 kg individually (Fig. 3). In the field, each sample was coded appropriate to the codes given by Lennart Jeppsson. For a code notation as G 95-01 ME, G stands for Gotland, 95 is the year of sampling, 01 is the sample number and ME designates the initials of the collector.

Laboratory techniques and picking
To dissolve the samples and extract the scolecodonts, standard micropalaeontological methods for retrieving phosphatic microfossils were used (cf. Jeppsson et al. 1985; Jeppsson & Fredholm 1987; Jeppsson 1987). Briefly, the procedures can be described as following: The sample is manually washed with a high-pressure cleaning equipment. One piece of the sample is stored, while the rest is weighted and the carbonate dissolved in buffered 7% acetic acid, which is harmless to phosphatic microfossils (Jeppsson et al. 1985). The clay particles are removed by sodium carbonate and by use of a sieve (0.063 mm). The residue is then tested for possible remaining carbonates with a drop of hydrochloric acid. The unsoluble residue is then washed through 1.0 mm and 0.063 mm screens (particles smaller than 0.063 mm are rejected). The residue between 0.063 and 1.0 mm is manually separated in one lighter, suspended fraction, and one heavier, using a method similar to gold washing. The separation is done in a large bowl (about 2-3 liter) filled with water and the sample residue. A careful spinning movement on the bowl generates a water whirl which suspends the lighter particles (mainly chitinozoans and small scolecodonts). When the heavier particles begin to sink, the lighter suspended particles are carefully poured through a 0.090 mm screen, washed, first with tap water and then with distilled water and finally dried. The procedure is repeated until practically no particles can be seen in suspension. The heavier fraction is washed through a filter paper and dried. The finer fraction had a strong tendency to stick together in a cohesive “cake” when dried. The best way to solve this problem is to boil the sample carefully in sodium carbonate dissolved in water. This provides free particles after drying without damaging the material.

The majority of the samples gathered by Lennart Jeppsson, had been separated by heavy liquid and/or magnetic separation. Some of the magnetic residues of these samples were rejected due to a limited yield of scolecodonts. However, the lighter fractions of these, and both the heavier and lighter fractions of samples G 9501 ME and G 9504 ME (Figs. 2 and 3) were hand picked, as well as the fractions larger than 1 mm. The elements were recovered from the dry samples by electrostatic picking, which is much more convenient than wet picking, as suggested by Kielan-Jaworowska (1966), when handling large faunas (cf. Barnes et al. 1987). In the smaller samples nearly all the elements were picked [in sample G 92-410 LJ (Figs. 2 and 3) every single scolecodont fragment was recovered], whereas in the larger samples, the picking was interrupted when a sufficient amount had been collected. As a consequence, the presented amount of elements in each sample (Fig. 3), is slightly misleading. Nevertheless, the relative amount of elements from each species (Fig. 4) should be approximately accurate. The picked elements were glued on a microfossil slide with the dorsal side up.

Illustrations, measurements and descriptions
A stereoscopic microscope equipped with a drawing devise was used when illustrating the specimens. Well preserved elements were glued on SEM stubs and photographs were taken. Because of their fragile nature, different specimens were used for dorsal and ventral views (cf. Bergman 1989). The magnification of the prints
Fig. 4. Relative frequency (%) and absolute frequency (number of Mi’s/kg) of the polychaetaspids and raphphronid fauna at Lickershamm 2 and Lus Klint. The data is based on counts of right and left Mi’s. Note that the curve representing the absolute frequency is reversed relative to the others and that it shows the entire polychaetaspid and raphphronid fauna (i.e. both identified and unidentified species). The uncertain identifications (cf. Figs. 2 and 3) are not included.

was chosen so that the individual fossils became of approximately equal size.

When measuring the elements, a microscope equipped with a measuring ocular was used. About four well preserved specimens of different size, from left and right elements respectively, were measured (sometimes a few more, when trying to locate the largest and smallest specimen). The maximum and minimum lengths of each species presented in the descriptions, are approximate values due to the picking and sieving methods described above. The length/width ratio should also be treated as an approximate number, as these parameters are variable due to compression. The rest of the measured features which are less affected by flattening (e.g. bight, myocoelse and dentary) are considered to be accurate and are therefore given as the
exact measured ranges, which should correspond fairly well with the variability within the species.

When trying to reconstruct apparatuses, the morphology of the MI’s, and numerical methods [i.e. the number of right and left MI’s (Fig. 3)] have been used. To identify the remaining elements forming an apparatus by use of dispersed jaws, a vast number of elements from lots of complementary samples would be needed. It is still uncertain whether all the minor elements can be identified at the species level. However, as Bergman (1989) states it should be more important to distinguish the different taxa on a specific level, even if only a few elements of an apparatus are identified, than to erect numerous formtaxonomic names of no use for any other studies. This study is focused on species where both the corresponding MI’s from an apparatus were identified. Thus, a number of polychaetaspids (approximately 4-6 species) and a few ramphopronions (approximately two species), are not described, but listed as unidentified material (Figs. 2 and 3).

No type material has been viewed (except for Polychaetaspis marlenediesae). The pictures available in the literature are commonly handmade drawings and not visualized by electron microscope images which makes the comparison difficult. Collections of type material from Poland, Great Britain, and North America must be studied for an absolute certain identification.

Terminology
The terminology is based mainly on Kielan-Jaworowska (1966), Jansonius & Craig (1971) and Bergman (1989). The descriptive terms are chosen in a suitable way for the polychaetaspids and ramphopronions, and the number of terms have been restricted to as few as possible in order to facilitate understanding. See also the complementary drawings (Fig. 5).

Basal plate - A small to medium-sized right-hand jaw, closely fitting into a posterior bight or concavity of the right MI (Figs. 5 and 6B). In some species the basal plate is paired; the left-hand element being called laeobasal plate.

Bight - A concavity in the margin of the outer face of the jaw, which is open to the posterior, especially in the right MI where it provides space for fitting of the basal plate, also used for ramal arch.

Carriers - Paired elements in the apparatus, situated behind the forceps and serving as a support for the posterior ends of the forceps or MI, (Figs 5 and 6A).

Cove - A concavity of the margin of the inner face, open to the anterior, as in some MI, where it allows space for the adjacent MII.

Cover - The part of the jaw wall enclosing (part of) the ventral side of the myocoeele.

Dentary - Series of denticles along the (inner) dorsal margin, in some forms part or all the dentary is edentulate (dentary without denticles), in which case the dentary is equal to the inner (dorsal) margin.

Denticles - The individual, more or less conical elements or teeth on the (inner) dorsal margin of a jaw. The denticles may be more or less densely spaced and differ in size and shape.

Dextral - Pertaining to the right-hand side of the jaw apparatus, e.g. MIr (right MI)= dextral forceps (Jansonius & Craig 1971). Used by the author as the right side of the MI’s (dorsal view).

Dorsal side - In conventional orientation, the side of the jaw carrying the dentary.

Face - Lateral side, either inner or outer, of a jaw between ventral margin and (dorsal) dentary. Slope alternatively used by Kielan-Jaworowska (1966).

Fang - Here used as the anteriormost enlarged denticle. To be compared with cusp/cuspid and falx (Jansonius & Craig 1971). If the anteriormost two denticles are of approximately equal size and larger than the rest, they have been referred to as twin-fang.

Forceps - Descriptive term for MI or first maxilla.

Inner margin - Ventral margin of the inner face. Inner wing - The posterior inner margin may be developed as a longitudinally elongated and laterally extended or downfolded and extended area (Bergman 1989). Note that the width of the inner wing may vary and is sometimes not detectable in dorsal view.
**Intercalary tooth** - A slender element consisting of a single large dentine, inserted immediately in front of the basal plate.

**Lateral tooth** - A slender element usually formed by a simple, single large dentine, and placed in front of any or all the regular jaws (MI-MV) of an apparatus.

**Length** - The largest dimension of a jaw parallel to the median axis (i.e. approximately parallel to the dентary) between posteriormost and anteriormost ends of the jaw.

**Ligament scar** - In Polychaetaspis-type jaws: small, dull roughened area just behind the posteriormost dentine, on shiny smooth surface of dorsal side of basal plate and MI (possibly marking an area of muscle attachment).

**Ligament rim** - A narrow structure (often a small ridge, groove or a combination of both) surrounding the mycooele opening along the anterior, the inner and outer sides (Bergman 1989).

**Mandibles** - A pair of supporting jaws placed in the ventral part of the mouth of the animal. Black in colour with a rough and dull appearance.

**Maxilla** - Any major (denticulated) jaw piece in dorsal position. The maxillas or maxillary pieces (M) are numbered from posterior to anterior with Roman numerals (MI-MVI).

**Mycooele** - The space inside (pulpal or muscle cavity), and more or less enclosed by the jaw, extending to the tip of the fang, hook or cusp. The surface within is very rough.

**Mycooele opening** - The outline of the ventral margins of the jaw enclosing the mycooele.

**Outer margin** - Ventral margin of outer face, opposite the inner margin.

**Ramus** - Any arm-like lateral extension of the face of a jaw projecting from the overall outline, usually pointing posteriorly, esp. in MII, MIII, and MIr; in some forms pointing anteriorly, esp. the basal plate. In this study, ramus is used for a similar feature in MII.

**Sinistral** - Pertaining to the left-hand side of the apparatus (when denticles facing up and anterior part directed away from the observer). Used here as the left side of the MI’s.

**Undenticulated ridge** - The posteriormost part of the dentary might be smooth, without denticles.

**Ventral side** - The side of the jaw to which the mycooele is open.

**Width** - The largest dimension of a jaw perpendicular to its long axis and on a plane parallel to the mycooele opening. The width of the MI is measured where the jaw is widest (from the ramus to the inner margin).

**Systematic palaeontology**

Systematic position.- Phylum Annelida Lamarck 1809; Class Polychaeta Grube 1850; Order Eunicida Dales 1963; Superfamily Eunicea Grube 1852; Subdivision Eunicea labidognathia Ehlers 1864-1868;

Family Polychaetaspidae Kielan-Jaworowska, 1966

**Discussion.** - The polychaetaspids are varied in respect to size and shape of the elements forming the apparatuses. Throughout the Ordovician and Silurian they were, according to Kielan-Jaworowska (1966) very successful and diversified, represented only in the Baltic region.
by some dozen species. Kozlowski (1956) erected the genus Polychaetaspis and described two species (Polychaetaspis wyszogrodensis and Polychaetaspis warke). Later, Kielen-Jaworowska (1966) described numerous new species of polychaetaspids from erratic boulders of Ordovician and Silurian age in the Baltic region. Further, Kielen-Jaworowska (1966), erected the genus Kozlowskiprion. The greatest differences of the MI elements between these two genera is the myooeole, which in Polychaetaspis is slightly enclosed, while in Kozlowskiprion it is almost gaping and the myooeole opening very much follows the outline of the jaw. Further, the dentary in Kozlowskiprion represents almost the entire jaw length which is slightly more than for most species of Polychaetaspis. The ligament scar is often more distinct in Polychaetaspis. Polychaetaspids have been reported from Europe, North America and Siberia. Kielen-Jaworowska (1966) gives the family a tentative phylogenetic range from Ordovician to Carboniferous.

The polychaetaspids have asymmetrical jaw apparatuses of labiodognatha type. The dorsal maxillary apparatus (Fig. 5), consists of two large MI elements, about three pairs of comlementary maxillary pieces, one single MIII element, a pair of carriers (Fig. 6A), one basal plate, a couple of small lateral teeth and one intercalary tooth (Fig. 6B). Polychaetaspids have for instance been assigned to the genera Lumbriconereites and Enunicites erected by Ehlers in the middle of the nineteenth century. According to Jansonius & Craig (1971), these are regrettable choices of names and no disper jaws should be assigned to Lumbriconereites or Enunicites as comparison with the type material is very difficult due to extremely poor preservation. In Ehlers (1868), the type species Enunicites aviatus is shown by a handmade drawing visualizing an indistinct imprint of the whole body of the animal with poorly preserved fragments and imprints of the jaw apparatus. Despite this, the use of these names has been advocated by several authors e.g., Hinde (1882), Eller (1940), and Stauffer (1933). Edgar (1984) did a multi-element analysis of Palaeozoic polychaetes, in which he suggests that the families Polychaeturidae and Ramphoprionidae should be included as genera within the family Polychaetaspidae. In this study however, the ramphoprionids are treated as a family, as proposed by Kielen-Jaworowska (1966).

Genus Kozlowskiprion Kielen-Jaworowska, 1966

Type species.- Kozlowskiprion longicavernosus Kielen-Jaworowska, 1966 from erratic boulder, Mochty, province of Warsaw. ?Silurian age.


Left MI: Jaw tapers both anteriorly and posteriorly but not as strong posteriorly as in the right MI. Subellipsoid in overall shape. Sharp denticles and an almost gaping myooeole. The dentary represents about 9/10 of the jaw length. Rather wide and short inner wing. Poorly defined ligament scar.

Remarks.- This is not the full diagnosis for the apparatus. For further details see Kielen-Jaworowska (1966).

Kozlowskiprion cf. longicavernosus
Kielen-Jaworowska, 1966
Plate I, Fig. A1-4.

Synonymy.- cf. 1966 Kozlowskiprion longicavernosus n. sp. Kielen-Jaworowska, pp. 98-100. Pl. 20, Figs. 1 and 2, almost entire apparatus and isolated jaws.

Material.- Fig. 3; 63 right MI, 34 left MI.

Occurrence.- Fig. 2; Late Llandovery to Early Wenlock, Lower Visby Beds unit a to Höglint Beds unit b-c. Lusklint and Lickershann 2.

Diagnosis.- As for the genus.
Description. - Right MI, dorsal view: The length varies between 0.29-1.12 mm and the width is about 1/3 (to slightly more), of the jaw length. From the anteriormost part of the jaw, the outer margin runs straight to somewhat concavely, posterolaterally. Shortly after, it makes a turn and runs straight posteriorly until about one third of the jaw length where a sharp sinistral turn (directed towards the dentary) is made, and thus the outer margin runs straight transversally, surrounding a subquadrangular ramus. Below the ramus the outer margin tapers strongly posteriorly and becomes hidden by the last denticles and the undenticated ridge. The bight measures 0.56-0.59 of the length of the jaw. There are 13-15 sharply pointed, triangular and posterodextrally directed denticles which decrease in size towards the posterior end of the jaw. The second denticle is smaller than the surrounding ones, which makes the first denticle to have the appearance of a fang which is slightly twisted out of alignment with the rest of the denticles. The first and third denticle are often of approximately the same size. The dentary extends for 0.90-0.94 of the jaw length. The ligament scar is fairly small and hardly visible. The inner margin is straight to somewhat convex, and runs almost parallel to the dentary anteriorly. However, in the anteriormost third of the jaw it turns sinistral (out from the dentary), followed shortly after by a sharp dextral turn approximately beside the third denticle, surrounding a prominent cove. Above this feature, the inner margin tapers strongly anteriorly.

Ventral view: The gaping to slightly enclosed myocele represents 0.90-0.96 of the length of the jaw. The outline of the myocele opening corresponds to the general shape of the jaw, except for the anterior most part where a small cover is present. A deep furrow with large pits corresponding to the denticles is clearly visible. The anterior part of the myocele opening might possess a narrow ligament rim.

Left MI, dorsal view: The jaw has a subellipsoid, elongated appearance. The length of the jaw varies between 0.25-1.17 mm and the width is about 1/3 (to slightly less), of the jaw length. The outer margin is slightly concave and at first directed posterolaterally, but on approximatively the same level as the third to fourth denticle, it makes an angular, posterior and slightly dextral directed turn, and tapers in a straight line towards the posterior end of the jaw. A series of 13-14 sharp, pointed, fairly large, and triangular denticles decrease in size posteriorly. The first denticle is the longest and developed as a fang. The following two to three are much smaller. The denticles then increase in size only to decrease again posteriorly, from about mid-length. All of the denticles are pointing posterodextrally. The fang may however, be slightly twisted out of alignment with other denticles. The dentary represents 0.87-0.93 of the jaw length. To the rear of the last denticle a small and indistinct ligament scar is present. The inner margin runs subparallel to the dentary and has an overall convex appearance. Posteriorly, from about mid-length, the inner margin turns dextral (out from the dentary), followed shortly after by a posteriorly directed turn. Then it runs parallel to the dentary, surrounding a fairly wide but relatively short (longitudinally) inner wing, which does not taper posteriorly. Thus the jaw ends in a rather wide straight line.

Discussion. - The investigated material is tentatively assigned to Kozłowskijprion longicavernosus Kielan-Jaworowska, 1966, but the right MI of the specimens from Lusklint and Lickersham 2 seems to exhibit a slightly more prominent cove than those figured by Kielan-Jaworowska (1966). A closely related species to K. longicavernosus is according to Kielan-Jaworowska (1966), Kozłowskijprion brevialatus Kielan-Jaworowska, 1966 (also shown in Männil & Zaslavskaya 1985). The main differences are according to Kielan-Jaworowska (1966) that the former exhibits a longer bight in the right MI and a shorter inner wing in both the right and left MI.
Genus *Polychaetaspis* Kozlowski, 1956

*Type species:* *Polychaetaspis wyszogrodensis* Kozlowski, 1956 from erratic boulder, Wyszogród, province of Warsaw. Middle Ordovician

*Emended diagnosis.* - Right MI: Jaw tapers both anteriorly and posteriorly but far more posteriorly. More or less prominent ramus. A bight extending for about half the jaw length. Slightly enclosed myocone, representing about 3/4 of the jaw length. Ligament scar often visible. Denticles decrease in size posteriorly.

Left MI: Jaw tapering both anteriorly and posteriorly but usually not as much posteriorly, as in the right MI. Slightly enclosed myocone representing about 3/4 of the jaw length. Inner wing often prominent. Denticles decrease in size posteriorly.

*Remarks.* - This is not the full diagnosis for the apparatus. For further details see Kielan-Jaworowska (1966).

*Polychaetaspis* cf. *gadomskae* Kielan-Jaworowska, 1966

Plate I, Fig. B1-4.

*Synonymy.* - cf. 1966 *Polychaetaspis gadomskae* n. sp. Kielan-Jaworowska, pp. 81-83. Pl. 15, Figs. 1-3. and Text fig. 8C. Almost complete apparatus and isolated jaws.

*Material.* - Fig. 3; 98 right MI, 80 left MI.

*Occurrence.* - Fig. 2; Early Wenlock. Hökglint Beds unit a to b-c. Lickershamn 2.

*Diagnosis.* - Right MI- Strongly concave outer margin in the anterior half of the jaw. Narrow, club-shaped and distinct ramus at about mid-length. Large inflated ligament scar. Knob-like feature on anterior inner face. Narrow inner wing seen in ventral view.

Left MI- Shows similarities to Mr. Fairly prominent and thin ramus but not as distinct as in Mr. Inner wing terminates slightly after the posteriormost part of the undenticated ridge. Large ligament scar similar to that in Mr.

*Description.* - Right MI, dorsal view: The length varies between 0.47-1.70 mm. The greatest width is at approximately mid-length and represents about 1/3 (to slightly more) of the jaw length. The outer margin is strongly concave above the ramus. At first the outer margin runs almost straight posteriorly, but very soon it turns and continues postero-laterally, only to make a sinistral, somewhat anteriorly directed turn shortly after. This gives the ramus a thin, club-shaped, and smoothly rounded appearance. Just below the ramus a more or less anteriorly concave bight, measuring 0.36-0.44 of the jaw length, is present. The outer margin then tapers strongly posteriorly and becomes hidden in this view by the last denticles and the undenticated ridge. A series of 13-15 fairly sharp denticles beginning with a fang, or sometimes almost twin-fang, decrease in size posteriorly. The first two denticles or more are often very worn down and look like mere stubs. The denticulated ridge measures 0.78-0.90 of the jaw length. From about mid-length, towards the posterior end of the jaw the denticles get more slender and conical in shape, and point more and more postero-dextrally. To the rear of the last denticle, somewhat to the right, there is a clearly visible, elongated, ellipsoid (longitudinally), and slightly inflated ligament scar. The inner margin very much follows the dentary in a straight to smoothly convex line. The very narrow inner wing is hidden in this view. The inner face widens slightly in the posterior and anterior parts of the jaw. In the anterior part of the inner face a little to the left, there is a round, wart-like feature.

Ventral view: The myocone measures 0.76-0.85 of the jaw length. In this view it becomes obvious that the very narrow inner wing extends for about the length of the myocone opening. A furrow with pits corresponding to the denticles can be seen, but it is often partly hidden by the inner wing.

Left MI, dorsal view: Many details similar to those of right MI. The length varies between 0.38-1.81 mm and the width is approximately 1/3 (to slightly more), of the jaw length. The outer margin runs straight to slightly concave posteriorly. On about mid-length a ramus is present,
which is fairly similar to the one in the right MI but not as prominent. The outer margin tapers below the ramus and terminates at the posteriormost part of the jaw (to slightly above). A series of 11-12 fairly sharp denticles decrease in size posteriorly. In the posterior half of the jaw the denticulated ridge is distinct and pronounced on the outer face. Sometimes the anteriormost denticle is developed as a fang. The third or fourth denticle might be slightly smaller than the surrounding ones. The dentary represents 0.83-0.88 of the jaw length. As in the right jaw the denticles are often worn down. In the posteriormost part of the jaw a little to the left is a large ligament scar present, similar to that in the right jaw. The inner margin is hidden in the anterior part of the jaw. The prominent inner wing widens slightly posteriorly from approximately the same level as the third to fifth denticle, and ends just below the undenticulated ridge. This gives the posteriormost part of the jaw a slightly wider appearance than the width of the undenticulated ridge. A knoblike feature is sometimes seen on the antero-dextral side of the jaw but not as distinct as in the right jaw.

Ventral view: The myocoel measures 0.76-0.78 of the jaw length. A rather indistinct furrow with pits corresponding to the denticles is partly hidden by the inner wing.

Discussion.—Unfortunate choice of right MI specimen photographed in ventral view. (Pl. 1, Fig. B3), in which the distance between the anterior part of the ramus and the anteriormost part of the jaw looks longer than the same for the right MI in dorsal view. The investigated material corresponds well with the description of Polychaetaspis gadomskae given by Kielan-Jaworowska (1966). However, the characteristic knob-like feature on the anterior inner margin of the right MI is not mentioned and the ligament scar of P. gadomskae is described as being just a dull area or lacking. The material is therefore tentatively assigned to P. gadomskae. It should be mentioned though, that the material investigated by Kielan-Jaworowska (1966) comprises fairly small specimens, where the features are more indistinct than in larger specimens.

Polychaetaspis marlendediesae (Eller, 1942)
Plate I, Fig. C1-5.

Synonymy.—1942 Lumbriconereites marlendediesae n. sp. Eller, Pl. I, Figs. 1-2, right MI.

Material.—Fig. 3; 13 right MI, 18 left MI.

Occurrence.—Fig. 2; Early Wenlock, Höglint Beds unit b-c. Lickershamn 2

Emended diagnosis.—Right MI—Small, slender and narrow jaw. Posterior end turns dextral. Subrectangular ramus. Transverse posterior part of the ramus. A narrow inner wing is seen in ventral view.

Left MI—Angular anterior part of the ramus. Sinistral pointing posterior part of the jaw. Prominent inner wing. Forked posteriormost part of undenticulated ridge.

Emended description.—Right MI, dorsal view: The jaw is narrow and elongate in overall shape. The length varies between 0.33-0.88 mm and the width is slightly more than 1/3 of the length. The greatest width is at mid-length (to slightly above). The outer margin runs almost straight posteriorly above the ramus. The ramus is rectangular in shape, and the outer margin tapers strongly beneath this and becomes hidden by the undenticulated ridge. The shallow, insignificantly anteriorly concave bight extends for 0.41-0.44 of the jaw length. A hooked, rather sharp, posteriorly pointing fang is a continuation of the outer margin. A series of 13-16 fairly sharp denticles decrease in size posteriorly. The third or fourth denticle might be slightly smaller than the surrounding ones. The dentary measures 0.89-0.94 of the jaw length. Posteriorly the denticles get thinner and more conical in shape and are more postero-dextrally directed. The posteriormost part of the jaw has a distinct dextral turn. The ligament scar is small and not easily detected. The inner margin runs almost parallel to the dentary; the width of the inner face widens, though, slightly in the anterior part of the jaw.
Ventral view: The myocele is narrow but widens slightly towards the anterior part of the jaw. It represents 0.74-0.78 of the jaw length. In this view a very narrow inner wing can be detected, extending from approximately the same level as the anterior part of the ramus to the posteriormost part of the jaw. A deep and narrow furrow with indistinct pits corresponding to the denticles can be seen. The furrow is often hidden by the anterior part of the inner wing.

Left MI, dorsal view: The length varies between 0.60-0.88 mm and the width represents about 1/3 of the length. The outer margin runs in a straight posterior direction for about one third of the jaw, where a sharp (approximately 90°) sinistral turn is made, followed shortly after by an equally sharp, posteriorly directed turn. The outer margin runs parallel to the dentary for a short while but at about mid-length of the jaw it starts to taper slowly towards the posterior part of the jaw. This gives the ramus an angular appearance, at least in the anterior part. A series of 14-17 fairly sharp denticles which starts with a fang, decrease in size posteriorly. At approximately mid-length the denticles are slightly bigger than the surrounding ones. The dentary measures 0.86-0.91 of the jaw length. In the posteriormost end of the jaw, which has a distinct sinistral turn, the undenticulated ridge is forked in two smoothly rounded ends. Ligament scar is not detected. The sigmoidal inner wing at first widens posteriorly, but then tapers slightly, just before the last denticle. Anteriorly, the inner wing tapers and finally disappears on the same level as the anterior part of the ramus (to slightly above).

Ventral view: The myocele measures 0.64-0.70 of the length of the jaw. The inner wing and outer face are sometimes fused together in approximately the posteriormost 1/5 of the jaw, only separated by small pits. Anteriorly the inner wing and outer face diverge, showing the furrow with pits corresponding to the denticles. The cover terminates approximately at the same level as the anterior part of the ramus.

*Discussion.* The left MI of Polychaetaspis marlenediesae shows strong similarities to the left MI of *P. cf. tuberculatus*. However, the anterior part of the ramus in *P. marlenediesae* is much more angular, and as a whole the ramus is in a slightly more anterior position. The right MI of *P. marlenediesae* resembles the right MI of *P. cf. tuberculatus*, but the ramus of the former is more angular in comparison and the posteriormost part of the jaw is not forked. Whether the element shown in Plate I, Fig. C5, is a variation within the species, another species, or subspecies is still uncertain. It shows strong similarities though, but has a “chubbier” overall appearance and the ramus is in a slightly more anterior position. Plate I, Fig. D, shows a transposed left jaw element, probably of *P. marlenediesae*. A transposed scolecodont is when the jaw in left position shows a morphology of a mirror image of the right jaw and vice versa (Bergman 1995b). This is a very rare phenomenon, Bergman (1995b) presents a frequency of 1 out of 5838 jaws being transposed of the Polychaetaspis species “Lumbriconereites” proclivis.

*Polychaetaspis “obliquus”* (Eichwald, 1854)

Plate II, Fig. A1-7.

*Synonymy.* □1854 *Sphagodus obliquus*; Eichwald, pp. 110-111, Pl. 2, Figs. 9-10, isolated elements? □1856 *Aulacodus obliquus*; Pander, p. 72, Pl. 4, Figs. 16a-d, left and right MI. □1882 *Lumbriconereites obliquus*; Hinde, pp. 21-22. Pl. 3, Figs 64-67, left and right MI. □1979 “*Lumbriconereites* “obliquus”; Bergman, pp. 95-99. Pl. 28, Figs. 74-C, left and right MI.

*Material.* Fig. 3; 88 right MI, 64 left MI.

*Occurrence.* Fig. 2; Early Wenlock, Högklint Beds unit a-bc, Lickershamn 2.

*Emended diagnosis.*- Right MI- Large jaw with a prominent club-shaped ramus at about mid-length. The jaw has a wide anterior part and a narrow posterior part. Large ligament scar.

Left MI- Fairly similar to the right MI, but not as prominent and big ramus. Exhibits a fairly
wide inner wing, which tapers both anteriorly and posteriorly but terminates on the same level as the undenticulated ridge terminates, posteriorly. Large ligament scar.

**Emended description.-**Right MI, dorsal view: The length varies between 0.63-2.17 mm and the jaw is about three times as long as it is wide. The widest part is at approximately mid-length. The anterior part of the jaw is wide in comparison to the posterior part. The outer margin runs posteriorly, sub-parallel to the inner margin. Slightly above mid-length it widens dextrally, and a little later, turns in a smoothly rounded curve, which is directed towards the inner margin. This outline gives the ramus a club-shaped and very prominent appearance. The outer end of the ramus points more or less posteriorly. The outer margin tapers strongly posteriorly below the ramus and is hidden in this view by the last denticles and the undenticulated ridge. The bight which is more or less concave anteriorly measures 0.38-0.42 of the jaw length. A series of 14-17 rather sharp denticles, which in the anterior part starts with a prominent, posteriorly hooked fang, decrease gradually in size posteriorly, from the second denticle to the last. From anterior to posterior the denticles become thinner and more and more postero-dextrally directed. The denticles are often very worn down and consequently they look like blunt stubs. The dentary measures 0.85-0.90 of the jaw length. To the rear of the last denticle and slightly dextral in position there is a large, somewhat inflated, and oval-shaped (longitudinally) ligament scar. The inner margin follows the dentary quite well in the anterior part of the jaw. Posteriorly from about mid-length however, the width of the inner face increases.

Ventral view: The slightly gaping pulp cavity measures 0.75-0.80 of the jaw length. The row with pits corresponding to the denticles is distinct. In this view a very narrow inner wing is also visible. It extends from the posterior-most part of the jaw to about the same level as the anterior-most part of the ramus.

Left MI, dorsal view: The left MI reminds strongly of MIr. The length varies between 0.52-2.07 mm and the width is about 1/3 of the jaw length. The greatest width is at approximately mid-length. The outer margin runs almost straight posteriorly. At about one third of the jaw, the outer margin turns sinistral and shortly after, postero-dextral, surrounding a smoothly rounded, club-shaped ramus, similar to the one in the right MI, but not as large and prominent. Below the ramus the outer margin tapers posteriorly and terminates approximately beside the last denticle and follows the outline of the undenticulated ridge. To the rear of the last denticle a fairly large ligament scar is visible. A series of 13-17 fairly sharp denticles decrease in size posteriorly. The anterior-most denticle might be developed as a posteriorly pointing fang. The dentary measures 0.86-0.90 of the jaw length. In contrast to the right MI, the left MI has an inner wing, which is fairly wide. The inner wing has an overall convex appearance, thus tapers both anteriorly and posteriorly, but far more anteriorly where it becomes hidden approximately beside the third to fourth denticle.

Ventral view: The myooeole represents 0.70-0.76 of the jaw length. A distinct furrow with pits corresponding to the denticles is clearly visible. The anterior part of the pulp opening might possess a ligament rim.

**Discussion.-** According to Bergman (1979), the name *obliquus* was used by Hinde even though he had not studied the type material and from the pictures and descriptions presented by Pander (1856) and Eichwald (1854) it is impossible to tell if it is the same species. Therefore the name *obliquus* is kept as a tentative name pending further studies. Further, Hinde (1882) presented the complementary synonyms *Eunices contortus* Hinde, 1879, *E. clitonensis* Hinde, 1879, and *Lumbriconerites basalis* Hinde, 1880. Because of the extremely poor quality of the illustrations it is impossible to tell whether these are synonyms or not. Thus, until the types of these have been studied the name *obliquus* can not be changed. *P. "obliquus"* is a rather variable taxon considering the size and shape of the ramus and the denticles (cf. Pl. II, Figs. A 5-7).
Polychaetaspis olofi n. sp.
Plate II, Fig. B1-4.

Etymology.- Named after my brother Olof Magnus Eriksson.

Type specimen.- Holotype, right MI, Pl. II, Fig. B2.

Type locality.- Lickershamn 2.

Type stratum.- Högklintr Beds unit b-c.

Material.- Fig 3; about 77 right MI, 32 left MI.

Occurrence.- Fig 2; Late Llandovery? to Early Wenlock, Lower Visby Beds? and Högklintr Beds unit b-c. Lusklint? and Lickershamn 2.

Diagnosis.- Right MI- Relatively wide anterior part of the jaw. Outer margin tapers strongly posteriorly below the ramus. Ovaly shaped (longitudinally) and long ramus. Sharp denticles.

Left MI- Wide jaw which tapers mainly posteriorly but not as much as the right MI due to the presence of an inner wing. Sharp sinistral turn of outer margin at about 1/3 of the jaw length. Below this the outer margin tapers in a straight line posteriorly. Sharp denticles.

Description.- Right MI, dorsal view: The jaw tapers to a greater extent posteriorly than anteriorly. The length varies between 0.47-1.0 mm and the width is about 1/3 of the jaw length. The outer margin is concave above the ramus. At first the outer margin runs almost straight posteriorly, but at about one third of the jaw length it makes a rather sharp dextral turn followed by a posteriorly directed turn. Then it runs subparallel to the dentary in a slightly convex manner. In the posterior one third of the jaw a sinistral turn is made. This outline surrounds a long and ovaly-shaped (longitudinally) ramus. Below the ramus there is a straight to slightly anteriorly concave bight, which measures 0.36-0.40 of the jaw length. The outer margin tapers posteriorly and becomes hidden by the last denticles. A somewhat inflated ligament scar is present a little to the right on the undeculated ridge. A row of 14-16 sharp and triangular denticles decrease in size posteriorly, and in the anterior part there is a large fang (sometimes almost developed as a twin-fang), which is posteriorly hooked. The dentary measures 0.86-0.95 of the jaw length. Posteriorly the denticles get more slender and postero-dextrally pointing. The slightly convex inner margin tapers both posteriorly and anteriorly. Sometimes a narrow inner wing can be seen.

Ventral view: The myocoel measures 0.80-0.82 of the jaw length. The anterior part of the myocoel opening is wide and smoothly rounded, and may exhibit a narrow ligament rim. The furrow with pits corresponding to the denticles is rather narrow and in a dextral position in the myocoel. A narrow inner wing is visible which extends from the anterior part of the myocoel opening to about the last denticle.

Left MI, dorsal view: As for the right jaw, the left MI has a very wide anterior part and a narrow posterior end, but it does not taper so strongly posteriorly as the right jaw. The length varies between 0.38-0.91 mm and the width is slightly more than 1/3 of the jaw length. The outer margin runs posteriorly and slightly sinistral. At about one third of the jaw it makes a sharp sinistral turn, runs transversal for a short while and then bends and tapers gently posteriorly in a straight to slightly convex manner. The outer face as a whole is very wide (especially the anterior two thirds of the jaw). The dentary represents 0.86-0.90 of the jaw length. The 14-15 denticles are sharp and the anteriormost denticle is often developed as a sharp, hooked fang, which is twisted out of alignment (posteriorly hooked) with the rest of the denticles. They decrease in size posteriorly. The inner wing is convex and tapers both posteriorly and anteriorly, but to a lesser extent posteriorly. Anteriorly the inner wing becomes hidden by the denticles on approximately the same level as the sharp sinistral turn of the outer margin. The ligament scar is insignificant.

Ventral view: The myocoel measures 0.74-0.77 of the jaw length. A distinct furrow with pits corresponding to the denticles is present and placed far to the left in the myocoel. The
anterior part of the myocoele opening is wide and well rounded and might exhibit a ligament rim.

Discussion.- The closest related species of Polychaetaspis olofi seems to be Lumbricoretis perdentatus Hinde, 1882, known from the Silurian of Gotland. However, in L. perdentatus the dental ridge in the right MI is much more strongly curved while being almost straight (apart from the anteriormost one fourth of the jaw) in P. olofi and the ramus of L. perdentatus is more posteriorly pointing. The outer margin in left MI of L. perdentatus does not make the typical, sharp sinistral turn in the anteriormost one third as in the left MI of P. olofi. Instead the former exhibits a smoother postero-dextral turn which is made at about mid-length of the jaw. Further, the left MI of L. perdentatus has a shorter inner wing which also is wider in the anterior part than the corresponding feature in P. olofi.

Polychaetaspis cf. tuberculatus Kielan-Jaworowska, 1966
Plate II, Figs. C1-3 & Plate III, Fig. A1-4.

Synonymy.- □cf. 1966 Polychaetaspis tuberculatus n. sp. Kielan-Jaworowska, pp. 78-81, Pl. 14, Figs. 1-4, entire apparatus and isolated elements. □1980 Polychaetaspis tuberculatus Kielan-Jaworowska; Wolf, Pl. 8, Figs. 62-63, Pl. 9, Figs. 76-78, extreme close-ups on myocoele opening and ligament scar.

Material.- Fig. 3; about 49 right MI, 34 left MI and one incomplete apparatus.

Occurrence.- Fig. 2; Late Llandovery? to Early Wenlock, Lower Visby Beds? and Höglkint Beds unit b-c. Lusklint? and Lickershamm 2.

Diagnosis.- Right MI- Outer margin is straight to smoothly concave in the anterior part of the jaw, it tapers strongly below the ramus. Posteriormost part of the jaw is dextrally turned and forked in two ends. Insignificant ligament scar. Narrow inner wing.

Left MI- Subrectangular to subrounded ramus at about mid-length. Fairly wide inner wing. Posterior part of the jaw makes a sinistral turn and is forked in two ends, to a greater extent than in the right MI. Indistinct ligament scar. Very shallow posterior part of myocoele.

Description.- Right MI, dorsal view: The length varies between 0.26-0.57 mm and the width represents slightly more than 1/3 of the length. The outer margin runs straight to slightly concave, postero-laterally. At about mid-length there is a fairly well pronounced ramus which points slightly postero-dextrally. The outer margin tapers strongly posteriorly below this feature and becomes hidden in this view by approximately the four posteriormost denticles. The bight is almost straight to slightly anteriorly concave and represents 0.39-0.43 of the jaw length. The posteriormost part (approximately the posteriormost 1/4) of the jaw points distinctly in a dextral direction. The posteriormost tip of the jaw is forked in two rounded, small ends (but to a much lesser extent than in MII). The anteriormost denticle might be developed as a fang. A series of 14-17 fairly sharp denticles decrease in size posteriorly, approximately the 6-8th denticles might be slightly larger than the surrounding ones. The denticate measures 0.86-0.91 of the jaw length. The ligament scar is small and indistinct. The inner face is very narrow, and only parts of the inner wing can be seen in this view.

Ventral view: A row with pits is visible close to the inner wing. The myocoele represents 0.72-0.80 of the whole length of the jaw. A narrow inner wing can be seen in this view, which terminates anteriorly, just before the anteriormost part of the myocoele opening. The anteriormost part of the myocoele opening might exhibit a narrow ligament rim.

Left MI, dorsal view: The length of the jaw varies between 0.23-0.58 mm and the width measures slightly more than 1/3 of the jaw length. The outer margin runs in a posterior and slightly sinistral direction. At approximately mid-length a ramus is present which is subrectangular in shape. Thus, the posterior and anterior parts of the ramus can be more or less angular. Below this, the outer margin tapers smoothly, in a
straight to slightly concave line posteriorly. The undenticulated ridge which turns to the left approximately behind the last denticle is forked in two smoothly rounded ends. A series of 16-18 rather sharp denticles decrease in size posteriorly (the 6-7 th denticles might be bigger than the surrounding ones). A fairly large fang is present. The dentary measures 0.91-0.94 of the jaw length. No ligament scar is detected. The inner margin follows the dentary in the anterior part of the jaw but widens posteriorly and surrounds a prominent inner wing. It then tapers moderately in the posteriormost part of the jaw.

Ventral view: The myocoel represents 0.64-0.74 of the length of the jaw. A shallow furrow with small pits corresponding to the denticles is present. The inner wing and outer face might be fused in the posteriormost part of the jaw, only separated by small pits.

**Discussion.** The studied material shows strong similarities to *Polychaetaspis tuberculatus* Kielan-Jaworowska, 1966. However, it is not clear whether *P. tuberculatus* exhibits the characteristic forked posterior part of the left MI (and to a lesser extent on the right MI) or not. However, it is mentioned that *P. tuberculatus* has a knob-like feature in the posteriormost part of the left MI and the overall shape, size and remaining features of the MI’s shows strong similarities to the present material. Therefore it has been tentatively assigned to *P. tuberculatus*. (See also discussion of *Polychaetaspis marlenedi-sae*).

*Polychaetaspis wyszogrodensis* Kozlowski, 1956
Plate III, Fig. B1-6.

**Synonymy -** □1956 *Polychaetaspis wyszogrodensis* n. sp. Koslowski pp. 175-176, Figs. 3, 4, entire apparatus. □1966 *Polychaetaspis wyszogrodensis* Kozlowski, Kielan-Jaworowska, pp. 76-78. Pl. 13, Figs. 1-3, almost entire apparatus and isolated jaws *non*. Pl. 19, Fig. 4, almost complete jaw apparatus.

**Material.** - Fig. 3; about 114 right MI, 49 left MI.

**Occurrence.** - Fig. 2, Late Llandovery to Early Wenlock, Lower Visby Beds?, Upper Visby Beds to Höglkvist Beds unit b-c. Lusklint and Lickershamn 2.


Left MI- Slender jaw which tapers almost as strongly posteriorly as anteriorly. Fairly long inner wing which terminates posteriorly at the same level as the undenticulated ridge. Narrow wrinkles on outer face. Slightly inflated ligament scar.

**Emended description.** - Right MI, dorsal view - The jaw tapers strongly anteriorly as well as posteriorly. The length varies between 0.22-2.0 mm and the width measures about 1/3 of the jaw length. The outer margin runs more or less concavely in a postero-dextral direction. The ramus is almost triangular in shape and in the posterior part of the ramus the outer margin runs almost straight transversally. Below the ramus the outer margin tapers strongly posteriorly and becomes hidden in this view by the undenticulated ridge. The bight measures 0.50-0.60 of the jaw length. In the posteriormost part of the jaw an elongated and slightly inflated ligament scar is clearly visible, and placed in a slightly dextral position. A series of 14-16 sharp, triangular denticles decrease in size from anterior to posterior. The third and fourth denticles however are much smaller than the surrounding ones. A rather large, posteriorly hooked fang exists (sometimes almost developed as a twin-fang). The dentary measures 0.83-0.90 of the jaw length. The shape of the denticles changes slowly posteriorly, to become thinner and more postero-dextrally twisted. The inner margin is straight to slightly convex from anterior to posterior and a small cove
might be seen in the anterior part. Sometimes a narrow inner wing can be detected in this view. The width of the inner face is narrow in the anterior part and widens slightly posteriorly.

Ventral view: The myocoel measures 0.80-0.85 of the jaw length. A distinct furrow with pits corresponding to the denticles is seen. In this view it becomes obvious that the narrow inner wing extends for almost the entire length of the myocoel opening and tapers posteriorly.

Left MI, dorsal view: The jaw is rather narrow in the anterior part, sometimes even narrower than the posterior end. The length varies between 0.52-2.17 mm and the width measures about 1/3 of the jaw length. The outer margin runs postero-sinistrally and is slightly concave, until about mid-length, where it smoothly changes direction and gently tapers posteriorly. A small, insignificant and rounded ramus feature can be seen at approximately mid-length. Narrow wrinkles are present on the outer face, directed both transversally and longitudinally. A large, somewhat inflated ligament scar is present in the postero-sinistral part of the undenticulated ridge. A series of 16-19 fairly sharp, subtriangular denticles decrease in size posteriorly. The third to seventh denticles are usually much smaller than the surrounding ones. The boundaries between the denticles are prolonged, especially on the outer face. The denterary measures 0.83-0.86 of the jaw length. The inner margin is in this view hidden by the denticles in the anterior part of the jaw. Posteriorly from about mid-length, the inner margin turns dextrally (out from the denterary), surrounding a prominent inner wing. The inner wing reaches all the way down to the posteriormost part of the jaw and terminates at the same level as the undenticulated ridge terminates, which makes the posteriormost part of the jaw look fairly wide. The inner wing is rather wide but disappears at approximately mid-length, anteriorly.

Ventral view: The myocoel measures 0.74-0.78 of the jaw length. In this view a deep furrow with pits corresponding to the denticles is clearly visible.

Discussion: With more material it might be possible to further subdivide this taxon. At
present though, the differences shown in Plate III, Figs. B5-6, are considered to be variations within the species. B5 is a variety of a right MI with a slightly more convex inner margin, deeper bight and a more convex anterior part of the outer margin. B6 is a left MI with a narrower posterior part and a wider anterior part with a fang which is strongly twisted out of alignment with the other denticles. The left MI of Polychaetaspis wyszogrodensis shows some similarities to the left MI of P. "obliquus". However, P. "obliquus" exhibits a more distinct ramus, slightly bigger denticles and the anterior part of the jaw is wider than in P. wyszogrodensis.

Polychaetaspis cf. latus Kielan-Jaworowska, 1966
Fig. 7. Plate III, Fig. C1-4 & Plate IV, Fig. C1-7.

Synonymy.- cf. 1966 Polychaetaspis latus n. sp. Kielan-Jaworowska, pp. 89-90, Pl. 17, figs. 2-4 and Text fig. 8 F. Incomplete apparatus and isolated jaws.

Material.- Fig. 3; about 93 right MI, 71 left MI and one incomplete apparatus.

Occurrence.- Fig. 2; Late Llandovery to Early Wenlock, Lower Visby Beds unit a to Högklint beds unit b-c. Lusklint and Lickershamn 2.

Diagnosis.- Right MI- Prominent and wide anteriorly placed ramus. Inner wing which is fairly narrow. Narrow posteriormost half of jaw. Slender, sharp denticles. Fang, to twin-fang is present.

Left MI- Prominent inner wing and wide outer face. Narrow posterior end of jaw. Sharp fang, followed by small denticles which later increase and finally decrease in size posteriory.

Description.- Right MI, dorsal view: As a whole the jaw is very wide anteriorly and very narrow posteriorly. The length varies between 0.23-0.74 mm, and the width measures slightly more than 1/3 of the length. The outer margin at first runs in a slightly concave, postero-dextral direction. A fairly sharp turn is soon made, so that the outer margin runs almost parallel to the dentary in a straight posterior direction. At about mid-length a sharp turn towards the dentary is made, surrounding a wide, prominent, and a rather anteriorly placed ramus. The outer margin runs straight transversely to slightly anteriorly concave in the posterior part of the ramus. The bight measures 0.43-0.54 of the jaw length. Below the ramus the outer margin tapers strongly towards the posterior and becomes hidden by the dentary and the undenticated ridge. The posteriormost part of the jaw often points slightly dextrally, but it may exhibit a small knob which is sinistrally pointing. A series of 12-17 sharply pointed denticles decrease in size towards the posterior part of the jaw, but approximately the third denticle is slightly smaller than the surrounding ones. A prominent fang (sometimes twin-fang), is present, and it is twisted out of alignment with the rest of the denticles. The denticles get more slender and conical in shape and are postero-dextrally directed in the posterior half of the jaw. A more or less narrow inner wing is seen in this view but is often hidden both in the posterior and anterior parts of the jaw.

Ventral view: The myocele represents about 0.81-0.88 of the jaw length. The narrow inner wing extends for almost as much as the length of the myocele. A distinct furrow with pits corresponding to the denticles is visible.

Left MI, dorsal view: The whole jaw has a slender appearance in the anterior and posterior parts. The length varies between 0.27-0.63 mm and the width is slightly less than 1/3 of the jaw length. The outer margin runs almost straight posteriorly (and slightly sinistrally); at approximately the same level as the third to fourth denticle the outer margin turns more sinistrally, then it makes a smoothly rounded, postero-dextrally directed turn and tapers gently posteriorly, and becomes hidden by approximately the last three denticles and the undenticated ridge. Thus, the outer face is wide anteriorly and strongly tapers posteriorly. The 12-17 sharp, triangular denticles decrease slowly in size posteriorly. However, the 3-6 th denticles are usually much smaller than the surrounding ones. The anteriormost denticle is developed as a
prominent, sharp, and slender fang, slightly twisted out of alignment with the rest of the denticles. The dentary measures 0.87-0.93 of the jaw length. The inner margin follows the dentary in the anterior part of the jaw but widens on about mid-length, surrounding a prominent inner wing which runs subparallel to the dentary and terminates at the posteriormost part of the jaw. Thus, the posteriormost part of the jaw is approximately twice as wide as the width of the denticulated ridge. To the rear of the last denticle there is a poorly defined ligament scar.

Ventral view: The myocoeele represents 0.79-0.91 of the length of the jaw. A furrow with pits corresponding to the denticles is clearly visible.

Discussion.- The description of Polychaetaspis latus presented in Kielan-Jaworowska (1966) corresponds well with the investigated specimens. The closest related species to P. latus is P. inconstans and Polychaetaspis sp. a described by Kielan-Jaworowska (1966). The differences between these are insignificant considering the MI elements. However, differences between the rest of the elements forming the apparatuses are mentioned and seem to be greater. Due to these facts the material was tentatively assigned to P. latus.

This seems to be a highly varied taxon with lots of morphological forms (see Pl. III, Figs. C1-4 and Pl. IV, Figs. C1-7.). The right MI’s show differences in denticulation (i.e. direction, size, and shape of the denticles), size of inner wing and shallowness of the bight. The left MI’s are not as varied as the right elements. However, the width of the outer face varies as well as the length and width of the inner wing. The denticles may vary slightly in size and shape. All the characters mentioned above are at present considered to be intraspecific variations. The possibility of subdivision into different taxa though, should not be excluded (especially when considering the above described close relationship to Polychaetaspis inconstans and Polychaetaspis sp. a).

Family Ramphoprionidae Kielan-Jaworowska, 1966

Discussion.- The family was monotypically erected by Kielan-Jaworowska (1966) to include the genus Ramphoprion Kielan-Jaworowska, 1962, only. Finds of ramphoprionids have been reported from Europe and North America. According to Kielan-Jaworowska (1966), ramphoprionids have not been found higher than Ordovician strata. Ramphoprionids are asymmetrical jaw apparatuses of labidognatha type. The apparatuses remind strongly of those of the polychaetaspids (cf. description in Polychaetaspidae discussion). However, the myocoeele is more strongly enclosed in the MI elements of ramphoprionids than in polychaetaspids. Further, the posterior part of the left MI in ramphoprionids is typically wide and almost straight in a transversal line, while in polychaetaspids it tapers strongly posteriorly (Kielan-Jaworowska 1966).

Genus Ramphoprion Kielan-Jaworowska, 1962

Type species.- Ramphoprion elongatus Kielan-Jaworowska, 1962 from an erratic boulder, Mochty, province of Warsaw. Middle Ordovician age.

Emended diagnosis.- Right MI: Subtriangular wide jaw with a short bight. Prominent fang and a fairly narrow inner wing. The denticles represent almost the entire jaw length. Myocoeele represents about 2/3 of the jaw length. Large ramus.

Left MI: Wide jaw with a wide and almost straight posterior part. Prominent fang but otherwise small denticles which represent almost the entire jaw length. Myocoeele represents about half the jaw length. Ligament rim in the anterior part of the myocoeele opening.

Ramphoprion ? bergmani n. sp.
Plate IV, Fig. A1-4.

Synonymy.- □ 1979 Ramphoprion sp. Bergman, pp. 95-99. Pl. 28, Fig. 8A, left MI.
Etymology.- Named after Claes Bergman, who first published a picture of the taxon.

Type specimen.- Holotype: right MI, Pl. IV, fig. A2.

Type locality.- Lickershamn 2.

Type stratum.- Högklint Beds unit b-c.

Material.- Fig. 3; 51 right MI, 56 left MI.

Occurrence.- Fig. 2; Early Wenlock, Högklint Beds unit a to b-c. Lickershamn 2.

Diagnosis.- Right MI- A slender, ellipsoid jaw with a prominent posteriorly pointing ramus. Large, blunt, and spaced denticles. The cover extends for about 1/3 of the jaw length.

Left MI- Very slender jaw. Wide but (longitudinally) short inner wing. Subrectangular ramus. Spaced, rather blunt denticles which begin with a fang. The myocele represents about 0.55 of the jaw length. Posteriormost part of the jaw ends with a round knob.

Description.- Right MI, dorsal view: The jaw tapers both anteriorly and posteriorly but slightly more towards the anterior end. The length varies between 0.47-1.50 mm, and the width is close to 1/3 of the length. The outer margin runs almost straight posteriorly. At about one third of the jaw, the outer margin makes a dextral turn surrounding a large, posterodextrally directed, club-like ramus. A distinct bight, anteriorly concave, extends for 0.35-0.40 of the length of the jaw. Beneath this, the outer margin tapers posteriorly and becomes in this view hidden by the undenticated ridge. A row of 9-11 rather large, blunt, and spaced denticles decrease in size posteriorly. The third to fifth denticles might be slightly smaller than the surrounding ones. The anteriormost denticle might be developed as a fang which points almost straight anteriorly. Posteriorly, the remaining denticles point towards the inner margin (which for a stretch is hidden by these denticles), but at about mid-length they get more and more posterodextrally twisted. The dentary measures 0.78-0.84 of the jaw length. In the posteriormost part of the jaw there is a large, oval-shaped (longitudinally), and slightly inflated ligament scar. The width of the inner face widens posteriorly.

Ventral view: A rather narrow inner wing can be observed, which extends for almost the length of the myocele opening. The myocele represents 0.69-0.72 of the jaw length. On the antero-dextral side of the cover there is an oval shaped, somewhat compressed area which towards the inner margin give rise to a ridge, which sometimes can be detected in dorsal view as well. A deep furrow with pits corresponding to the denticles can be seen.

Left MI, dorsal view: The length varies between 0.57-1.29 mm and the width is slightly more than 1/4 of the length. The widest part is at approximately mid-length. The outer margin runs in a straight posterior direction until about mid-length where it makes a sharp sinistral turn, followed by an equally sharp posteriorly directed turn. For a while the outer margin runs parallel to the dentary but slightly below mid-length it tapers strongly posteriorly. This outline surrounds a subrectangular ramus. The undenticated ridge is fairly long and the posterior-most part of the jaw ends with a round knob-like feature which is slightly wider than the width of the undenticated ridge. Slightly to the left placed on the undenticated ridge there is a long and narrow ligament scar but not as distinct as in the right jaw. A series of 8-12 rather sharp, sometimes straggling, and widely spaced denticles which in the anterior end starts with a fang, decrease in size towards the posterior part of the jaw. The fang is twisted out of alignment with the rest of the denticles. The third to fifth denticles might be slightly smaller than the surrounding ones. The dentary measures 0.76-0.81 of the jaw length. A rather wide but short (longitudinally) inner wing is clearly visible in this view. It tapers anteriorly and becomes hidden by the dentary just below mid-length. Consequently, the posteriormost part of the jaw is rather wide and straight just above the knob-like feature.

Ventral view: The myocele represents 0.57-0.64 of the jaw length, and the myocele opening very much follows the outline of the ramus.
and the inner wing. The furrow with pits corresponding to the denticles is hidden for most parts, and only a few pits are detectable.

**Discussion.**- More material would be needed to determine whether the species belongs to the genus *Polychaetaspis* or *Rampophorion*. The myocele is slightly more strongly enclosed than most of the polychaetaspids but the left MI of *R. ? bergmani* (n. sp.) lacks the wide and transverse posterior part typical for rampophorionids.

*Rampophorion anderssoni* n. sp.
Plate IV, Fig. B1-4.

**Synonymy.**- □1966 *Rampophorion* sp. b Kielan-Jaworowska, p. 111, Pl. 24, Fig. 4, left MI.
□1979 *Rampophorion* sp. Bergman, pp. 95-99, Pl. 28. Figs 8B-C, left and right MI's.

**Etymology.**- Named after my dear friend Jenny Andersson.

**Type specimen.**- Holotype: left MI, Pl. IV, fig. B1.

**Type locality.**- Lickershamn 2.

**Type stratum.**- Höglint Beds unit b-c.

**Material.**- Fig. 3; 14 right MI, 11 left MI.

**Occurrence.**- Fig. 2; Early Wenlock, Höglint Beds unit a-bc.

**Diagnosis.**- As for the genus.

**Description.**- Right MI, dorsal view: The whole jaw has a subtriangular appearance. The length of the jaw varies between 0.63-1.23 mm and the width measures slightly more than 1/3 of the length of the jaw. The widest part of the jaw is slightly below mid-length. The outer margin runs postero-laterally in a straight to slightly concave line. Slightly below mid-length the outer margin makes a smooth, postero-dextrally directed turn. The posterior part of the ramus is almost transverse and the shallow bight represents 0.26-0.28 of the jaw length. Below the ramus the outer margin tapers posteriorly and runs subparallel to the dentary. Thus the outer face is very wide and prominent especially at mid-length and slightly above. A large rather sharp fang which is twisted out of alignment with the other denticles is followed by considerably smaller denticles, which slowly decrease in size posteriorly. The third denticle might be smaller than the surrounding ones. The (15-18) fairly sharp denticles extend for 0.90-0.95 of the length. In the posterior part of the jaw the denticles get more conical in shape and point postero-dextrally. The ligament scar is hardly detectable. The inner margin is slightly convex in overall shape, tapering posteriorly and anteriorly. The inner wing is in a posterior position.

Ventral view: A fairly large cover is present in the anterior part and the myocele represents 0.61-0.78 of the jaw length. The furrow with pits corresponding to the denticles is deep and the pits are small. A ligament rim is present in the wide anterior part of the myocele opening.

Left MI, dorsal view: The jaw has a subrectangular appearance. Both the anteriormost and posteriormost parts of the jaw are wide and almost straight, although the posterior part is slightly wider. The length varies between 0.47-1.16 mm and the width is slightly more than 1/3 of the jaw length. The outer margin is convex in overall shape. Posteriorly, the outer margin runs postero-laterally in a straight to slightly convex manner. At approximately the posteriormost one third of the jaw it slowly starts to taper posteriorly. In the posteriormost part of the jaw the outer margin turns sharply to the right. Thus the jaw ends in a wide, straight, and almost transversally directed line. A series of 19-23 fairly small denticles slowly decreases slowly in size posteriorly. The anteriormost denticle might be developed as a pointed fang which is slightly twisted out of alignment with the rest of the denticles. The denticles have the appearance of representing the entire jaw length, and when measured, the dentary represents 0.92-0.99 of the jaw length. The denticulated ridge is distinctly marked on the outer face. No ligament scar is detectable. The inner margin is hidden by the dentary in the anteriormost part of
the jaw. At about the posteriormost one third of the jaw it widens and surrounds a short (longitudinally) but prominent inner wing. The outline of the inner wing is shaped almost like a reversed s.

Ventral view: The slightly enclosed myococele measures 0.53-0.54 of the jaw length. A deep furrow can be seen but the denticle pits are small and indistinct. A ligament rim is present in the wide and smoothly rounded anterior part of the myococele opening.

Discussion.- *Rhamphorhynchus anderssoni* n. sp. might be related to the species *Protoarabellites concavus*, *P. delectus*, *P. glnwoodensis*, and *P. productus* described by Stauffer (1933), from the Ordovician of Minnesota. However, the pictures are sketchily drawn and the descriptions are too brief to make a correct comparison. The type material would have to be studied for an accurate judgement.

**Discussion**

The number of right MI's and corresponding left MI's differs significantly among some of the investigated species (Fig. 3). Similar results can be noted in Bergman (1989; Figs. 2 and 3). Especially *Polychaetaspis wyszogrodensis*, *Kozlowskiornis* cf. *longicavernosus*, and *P. olofi* n. sp. show a very uneven distribution. This may be explained by the picking methods used, the preservation of the specimens, and the fact that it in most cases is much easier to identify the right element than the left one. With a larger amount of samples the number of MII and MI would probably become more alike. Complementary samples would probably also make it possible to adequately identify the hitherto unidentified material (Fig. 3), which in some samples form a significant amount of elements.

The abundance of the investigated polychaete fauna varies prominently from the Lower Visby Beds to the Högklint Beds. Roughly, the depositional environment changes from deeper towards shallower water. The absolute frequency (Fig. 4), of the polychaetaspids and rhamphorhynchids is extremely low within the Upper Visby Beds, whereas parts of the L. Visby. Beds (unit b), and the Högklint Beds show a relatively high abundance. In the Högklint Beds there is a pronounced increase in both abundance and taxonomic diversity from unit a to unit b-c (Fig. 2 and 4). A similar trend can be observed at the Vattenfallet section on Gotland (cf. Bergman 1979). *Symmetroprion spattosus* is only found in the Högklint Beds (Fig. 2). Bergman (1995a, 1991b) suggests that *S. spattosus* is restricted to specific environments and shows a preference for shallow and warm water, which according to Jaanusson (1979) is the interpreted depositional environment of the Högklint Beds unit b. This appears to be the most suitable environment for many of the investigated polychaetes. Even though the absolute frequency is higher in the L. Visby Beds (unit b) than in the Högklint Beds, the taxonomic diversity is significantly lower. The abundance would probably be higher in the Högklint Beds than in the L. Visby Beds if every single scolecodont was picked.

The samples from the Högklint Beds are extremely rich in chitinozoans and it seems to be a close relationship regarding the abundance of polychaetes and chitinozoans. Laufeld (1975) showed that the distribution of these groups is bathymetrically controlled and that they show similar response to ecological parameters. However, the taxonomic diversity of chitinozoans decreases from deeper to shallower water environments (Laufeld 1975), which is the reversed response of the investigated polychaete fauna.

The best preserved material and the largest specimens are found within the samples derived from the Högklint Beds. The preservation of polychaete jaws seems to be improved by a high content of silicified material present within the rocks.

Only two species, *Kozlowskiornis* cf. *longicavernosus* and *Polychaetaspis* cf. *latus* are identified as ranging from the base of the Lower Visby Beds to the Högklint Beds (Figs. 2 and 4). These two species show a very similar "abundance pattern" through the sections with the exception of the lowermost unit of the L. Visby Beds where *P. cf. latus* totally dominates (Fig. 4). *Polychaetaspis* cf. *latus* and *Kozlowskiornis* cf. *longicavernosus* are thus more common
in slightly deeper water deposits and probably more resistant towards environmental changes. These species have comparably small jaw elements which might reflect a deeper water environment and not optimum living conditions (cf. Bergman 1989). The first appearance of *P. wyszogrodensis* (i.e. the first truly identified specimen) is in the U. Visby Beds, unit c. It strongly increases in abundance in the Hökglint Beds unit b-c. The remaining polychaetaspids, *P. olofi* n. sp., *P. cf. gadomskae*, *P. "obliquus"*, *P. marinediesae* and *P. cf. tuberculatus* have only been identified with certainty in the Hökglint Beds (Fig. 2).

The ramphopronids are neither as abundant nor as taxonomically diverse as the polychaetaspids. The two new species *Ramphopron anderssoni* n. sp. and *Ramphopron bergmani* n. sp. are restricted to the Hökglint Beds and are most abundant in unit a (Figs. 2 and 4). Clearly, the ramphopronids exist in Silurian strata (although as far as this study concerns, sparsely), which is in contrast to previous views (cf. Kielan-Jaworowska 1966). It is likely that this range will be further extended with increased research.

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Explanation of plate II: □A1-7 Polychaetaspis "obliquus"; G 95-04 ME, Högklint Beds unit b-c, Lickershamn 2 section. 1. left MI, x 50, dorsal view; 2. right MI, x 35, dorsal view; 3. right MI, x 50, ventral view; 4. left MI, x 50, ventral view; 5. variation of right MI, x 50, dorsal view; 6. variation of left MI, x 50, dorsal view; 7. variation of left MI, x 70, dorsal view; □B1-4 Polychaetaspis cf. n. sp.; G 95-04 ME, Högklint Beds unit b-c, Lickershamn 2 section. 1. left MI, x 100, dorsal view; 2. holotype, right MI, x 65, dorsal view; 3. right MI, x 85, ventral view; 4. left MI, x 110, ventral view; □C 1-3 Polychaetaspis cf. tuberculatus; G 95-01 ME, Högklint Beds unit b-c, fused right and left MI, magnification: x 130; 1. ventral view of MI right slightly tilted; 2. ventral view of MI right; 3. lateral view.
Explanation of plate III: □A 1-4 *Polychaetaspis cf. tuberculatus*; all from sample G 95-04 ME, Högklint Beds unit b-c, Lickershamn 2 section, except for A2, G 95-01 ME, Högklint Beds unit b-c, Lickershamn 2 section; 1. left Mi, x130, dorsal view; 2. right Mi, x135, dorsal view; 3. right Mi, x155, ventral view; 4. left Mi, x 130, ventral view. □B 1-6 *Polychaetaspis wyszogrodensis*; all from sample G 95-04 ME, Högklint Beds unit b-c, Lickershamn 2 section, except for B5, G 91-61 LJ, Lower Visby Beds unit c, Lusklint section; 1. left Mi, x 55, dorsal view; 2. right Mi, x 50, dorsal view; 3. right Mi, x 55, ventral view; 4. left Mi, x 50, ventral view; 5. variation? of right Mi, x 55, dorsal view; 6. variation? of left Mi, x 60, dorsal view. □C 1-4 *Polychaetaspis cf. latus*; all from sample G 89-707 LJ, Lower Visby Beds unit b, Lusklint section, except for C1, G 89-701 LJ, Lower Visby Beds unit b, Lusklint section; 1. left Mi, x 190, dorsal view; 2. right Mi, x 165, dorsal view; 3. slightly compressed right Mi, x 120, ventral view; 4. left Mi, x 260, ventral view.
Explanation of plate IV. □A 1-4 Ramphoprion ? bergmani n. sp.; G 95-04 ME, Hökglint Beds unit b-c, Lickershamn 2 section; 1. left Mi, x 65, dorsal view; 2. holotype, right Mi, x 170, dorsal view; 3. right Mi, x 135, ventral view; 4. slightly tilted left Mi, x 90, ventral view; □B 1-4 Ramphoprion anderssoni n. sp.; G 95-04 ME, Hökglint Beds unit b-c, Lickershamn 2 section; 1. holotype, left Mi, x 60, dorsal view; 2. right Mi, x 60, dorsal view; 3. right Mi, x 85, ventral view; 4. slightly tilted left Mi, x 65, ventral view; □C 1-7 variations? of Polychaelaspis cf. latus; all in dorsal view, 1-3 sample G 89-707 LJ Lower Visby Beds unit b, Lusklint section; 1. right Mi, x 150; 2. right Mi, x 110; 3. right Mi, x 170; 4-6 sample G 89-701 LJ Lower Visby Beds unit b, Lusklint section; 4. right Mi, x 145; 5. left Mi, x 180; 6. left Mi, x 140; 7. left Mi, x 170. G 88-613 LJ Lower Visby Beds unit a, Lusklint section.
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